

JOURNAL OF ATHLETIC TRAINING

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Dear Colleagues:

On behalf of the National Athletic Trainers' Association Research & Education Foundation and the Free Communications Sub-Committee, I would like to thank all the authors who submitted abstracts to the Free Communications Program. We received over 400 peer-reviewed submissions this year. This year's Free Communications Program is exciting, as it contains a fantastic mix of high caliber research reports and clinical case studies delivered in live and on-demand sessions as well as e-posters. We appreciate the presenters' time and commitment to quickly adapt their presentations for a virtual meeting and offer amazing content to attendees.

I would also like to take this opportunity to extend a special thanks to all of the NATA and NATA Foundation staff and especially Velma Meza, who works tirelessly behind the scenes and 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, I would like to thank and recognize the efforts of the Free Communications Committee for their long hours of abstract reviews and creativity in developing this year's virtual Free Communications program. The Free Communications subcommittee members are:

Michelle Boling, PhD, ATC

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

Our Committee looks forward to seeing you in Philadelphia. Please take the opportunity to attend the Free Communications Forums, peer-reviewed oral and poster sessions. Please note that projects funded by the NATA Research & Education Foundation are specified in this *Supplement*. Finally, if you have the opportunity, please offer your thanks to those recognized above.

Sincerely,



Jeffrey Driban, PhD, ATC, CSCS

Vice Chair for Free Communications

NATA Research & Education Foundation Research Committee

Free Communications, Oral Presentations: Socio-Cultural Examination in Patient-Centered Care

June 22, 2021, 11:15 AM-12:15 PM

Relationship Between Racial Identity and Concussion Care-Seeking Behaviors in Collegiate Student-Athletes

Cosby Jr. AS, Nedimyer AK, Kerr ZY, Callahan CE, Register-Mihalik JK: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Timely concussion care-seeking behaviors are imperative for optimal post-concussion management. Racial and ethnic health disparities are prevalent throughout the United States, yet little is known about such disparities as they relate to concussion care-seeking behaviors. As such, identifying disparities in concussion care-seeking behaviors may support Athletic Trainers in providing equitable care. The purpose of this study was to examine concussion care-seeking behaviors across racial identities and the association between the two among collegiate student-athletes. **Methods:** A cross-sectional survey design included a convenience sample of collegiate student-athletes from a single institution [n=343, median age=19 (Interquartile Range=9, 18); response=94%]. Participants completed a pre-validated (face and content validity) questionnaire (online or paper) assessing concussion care-seeking behaviors and determinants of care-seeking. Concussion disclosure outcomes of interest included: 1) disclosure of concussive symptoms (yes/no); 2) continued athletic participation despite concussion symptoms (yes/no); 3) self-removal from participation due to concussion symptoms (yes/

no); and 4) witnessed a teammate reporting another teammate's possible concussion (yes/no). Reported racial identity categories included: African-American/Black, American Indian/Alaskan Native, Asian/Native Hawaiian/Pacific Islander, White, Unknown, or Other. For further analyses, identified race was categorized as two groups: 1) identified as white or 2) did not identify as white. Proportions were calculated for the primary concussion disclosure outcomes across racial identities. A multivariable log-binomial regression was utilized for each concussion disclosure outcome where race category (identifying versus not identifying as white) served as the primary predictor; gender and concussion history served as covariates. Resulting Prevalence Ratios (PRs) and 95% Confidence Intervals (CI) excluding 1.00 were deemed statistically significant. **Results:** Overall, 64/343 (18.7%) respondents identified with a race other than white, 175/343 (51.0%) identified as male, 108/343 (31.5%) were first-years, and 94/343 (27.4%) had a previous concussion. The current sample, with nearly 80% identifying as white, differs from collegiate reports by the NCAA where approximately 60% identify as white. Table 1 outlines the prevalence of the four care-seeking behaviors across racial identities. When collapsing racial identification categories (identifying versus not identifying as white), a higher prevalence of respondents identifying as a race other than white indicated witnessing a teammate report another teammate's concussion symptoms (PR=1.34; 95%CI: 1.02, 1.78). No other associations were observed between race and care-seeking outcomes in the binary race

category analyses. **Conclusions:** Care-seeking experiences differ across racial identity groups, especially related to observing teammate behaviors. Athletic trainers should consider cultural and racial identities when designing and implementing concussion initiatives. Future research should include more participant-directed racial and ethnic identity reporting to more accurately reflect the uniqueness of cultural identity and its influence on concussion care-seeking.

Table 1. Lifetime Prevalence of Concussion Care-Seeking Outcomes by Racial Identify Groups

Racial Identity Reported	Removed Self from Play (n=327)	Reported Symptoms (n=327)	Participated with Symptoms (n=327)	Witnessed Teammate Report a Teammate's Symptoms (n=326)
Identifying as Non-White (n=64)	17 (26.6%)	20 (31.3%)	19 (29.7%)	34 (53.1%)
African-American/Black (n=30)	12 (40.0%)	14 (46.7%)	9 (30.0%)	16 (55.3%)
Other (n=34) ^a	5 (14.7%)	6 (17.6%)	10 (29.4%)	18 (52.9%)
Identifying as White (n=263)	58 (22.1%)	75 (28.5%)	57 (21.7%)	99 (37.6%)

^aSample collapsed across other racial identities due to small sample size.

Preliminary Investigation Between Race as a Social Determinant of Health and Symptom Endorsement Following a Sport-Related Concussion

Brewer C, Delfin D, Carrasquilla L, Hereford W, Wallace JS: University of Alabama, Tuscaloosa, AL

Context: Racial minorities face barriers to health equity, yet few sports medicine studies have focused on race as a social determinant of health. Research has shown Black/African American adolescents have poorer knowledge of concussion symptoms, and endorse a greater number of symptoms at baseline than White adolescents. No research has examined racial differences following a sport-related concussion (SRC). The purpose of this study was to examine the association between race, total symptom severity scores and individual symptom endorsements by adolescents following a SRC.

Methods: A prospective cohort design was utilized. A total of 66 (24 White, 42 Black/African American) concussed adolescent participants were enrolled over a single year from 10 high schools. Race was self-identified on demographic materials and athletes that did not identify as White or Black/African American were excluded. Concussed adolescents completed a 22-item post-concussion symptom checklist as part of a computerized neurocognitive test within 1 week after sustaining a SRC. Adolescents were asked to identify individual symptoms he/she was experiencing and also rank the severity of each symptom on a scale

of 0-6. Demographic data were analyzed using descriptive statistics. Racial differences in total symptom severity scores were evaluated using a multiple linear regression adjusting for sex. The relationship between race and individual symptom endorsement, using symptoms endorsed as a binary (yes/no) variable were evaluated using chi-square statistics. Statistical significance was set a priori $p \leq .05$. **Results:** Mean total symptom score among Black/African American adolescents was 19.5 ± 22.25 versus 28.46 ± 22.05 among White adolescents. The overall regression model did not yield a significant association between race and total symptom severity scores ($F_{2,63} = 1.71$, $p = .09$). Chi-square analyses determined significant group differences in 5 individual symptoms, representing 2 symptom clusters: somatic (headache, balance problems, dizziness) and cognitive (difficulty concentrating, difficulty remembering). Headache was endorsed by 61.9% of Black/African American versus 95.8% of White adolescents ($p < .01$). Balance problems were endorsed by 31% of Black/African American versus 58.3% of White adolescents ($p = .03$). Dizziness was endorsed by 38.1% of Black/African American versus 66.7% of White adolescents ($p = .03$). Difficulty concentrating was endorsed by 40.5% of Black/African American versus 66.7% of White adolescents ($p = .04$), and difficulty remembering was endorsed by 23.8% of Black/African American versus 50% of White adolescents ($p = .03$). The remaining 17 symptoms did not yield significant proportional differences. **Conclusions:** Differences between total symptom severity scores were not significant; however, White adolescents averaged 9-points higher than Black/African American adolescents. White adolescents also endorsed more symptoms within

the somatic and cognitive clusters compared to Black/African American athletes. Post-SRC symptom reporting and patterns of symptom clusters are important to contextualize in light of noted disparities in concussion symptom knowledge and baseline symptom endorsement within Black/African American adolescents as underreporting could lead to premature return to play.

Understanding Foundational Patterns of Concussion History and Nondisclosure Between Black/African American and White College Athletes

Wallace JS, Beidler E, Kerr ZY, Bretzin A, Hibbler T, Register-Mihalik JK: University of Alabama, Tuscaloosa AL; Duquesne University, Pittsburgh, PA; University of North Carolina at Chapel Hill, Chapel Hill, NC; University of Pennsylvania, Philadelphia, PA; Michigan State University, East Lansing, MI

Context: Over 50% of college athletes participating in higher-risk concussion sports identify as Black/African American. Race is a primary social determinant of health, and racial disparities in concussion knowledge and nondisclosure have been identified in high school-aged athletes. Currently it is unclear if similar disparities exist in collegiate athletes; however, understanding patterns of concussion history and nondisclosure is a crucial first step for the delivery of equitable concussion resources and healthcare. The purpose of this study was to evaluate differences in concussion nondisclosure based on concussion history between Black/African American and White college athletes. **Methods:** This study utilized a cross-sectional design. A total of 737 (623 White, 114 Black/African American) college athletes from 6 institutions were enrolled and completed a concussion reporting behavior and nondisclosure questionnaire that included self-report of diagnosed concussion history. The instrument

was tested for face validity by 3 content experts and pilot tested with 10 undergraduate students. Race was self-identified on demographic materials. Only athletes identifying as White or Black/African American were included. Demographic data were analyzed using descriptive statistics. Frequencies and percents were calculated for diagnosed and nondisclosed concussion history and nondisclosure items, including 16 reasons for nondisclosure. Comparison of concussion history and nondisclosure by race was calculated using chi-square statistics. Finally, differences in reasons for nondisclosure by race were calculated for athletes that indicated nondisclosure using Fisher's exact tests. Statistical significance was set a priori $p \leq .05$. **Results:** The sample was mostly male (60%) and played contact sports (73%), notably football (24%) and lacrosse (14%). Most athletes were in Division II (50%) followed by Division I (38%) and III (12%). Overall, 217 (29%) reported having a diagnosed concussion history, of which 60 (8% of entire sample) also admitted having additional nondisclosed concussions. An additional 57 (8%) also noted having nondisclosed concussions despite never being diagnosed. There were no differences in the proportions between Black/African American and White athletes regarding having a diagnosed concussion history (25% vs. 30%, $X^2=1.04$, $p=0.31$) or admitting nondisclosed concussions (18% vs. 16%, $X^2=0.28$, $p=0.60$). However, there were differences by race for 2 reasons for nondisclosure. A higher percentage of Black/African American athletes reported the following reasons for nondisclosure: "At the time I did not know it was

a concussion" (65% vs 38%, $p=0.045$); and "I didn't want my teammates to think I was weak" (50% vs 25%, $p=0.03$). **Conclusions:** One in six athletes in our sample reported not disclosing concussions. No differences between Black/African American and White college athletes were found regarding proportions of diagnosed or nondisclosed concussion history. However, differences in reasons for nondisclosure by race may highlight the need for diverse approaches at individual and team levels to facilitate identification and disclosure of concussive symptoms to medical staff.

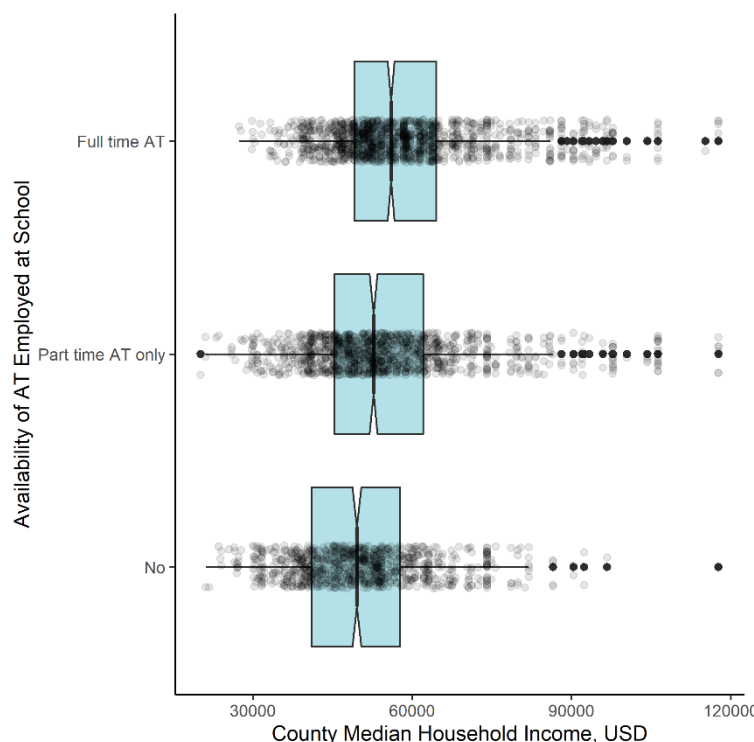
The Relationship Between Socioeconomic Status, Race/Ethnicity, and Access to Athletic Trainers in Public Secondary Schools

Barter EW, Post EG, Games KE, Eberman LE, Rivera MJ: Indiana State University, Terre Haute, IN

Context: Significant healthcare disparities exist in the United States based on socioeconomic status (SES) and race/ethnicity but have not been examined on a national scale. The purpose of this study was to identify whether differences exist in access to athletic training in the secondary school setting based on school-SES and race/ethnicity. **Methods:** This is a cross-sectional, database study using secondary analysis. Data were gathered from the Athletic Training Location and Services (ATLAS) database, the United States Census Bureau, and the National Center for Education Statistics (NCES). Public schools (n=3,482) with complete data from each database were included in this study. We included schools from 5 states the with highest, middle, and lowest poverty percentages (15 states total) to get a representative sample of diverse SES-schools in the United States. We collected county median household income (MHI), percentage of students eligible for free and reduced lunch, race/ethnicity demographics per school,

and access to athletic training services (full-time AT, part-time AT, no AT) for each school. We summarized the data using standard deviations, means, medians, interquartile ranges, and frequencies and proportions. We used independent t-tests and ANOVAs to investigate differences in the percentage of students eligible for free and reduced lunch, county MHI, and race/ethnicity, based on access to athletic training services. **Results:** There were significant differences in school-SES between schools with full-time, part-time, and no athletic training services. As the access to athletic training services increased, the percentage of students eligible for free and reduced lunch decreased (full time: $41.1\% \pm 22.3$, part time: $45.8\% \pm 24.3$, no AT: $52.9\% \pm 24.9$, $p < .001$). Similarly, as county MHI increased so did access to athletic training services as seen in Figure 1 (full-time: Median [IQR], \$56,026 [\$49,085-\$64,557], part-time: Median [IQR], \$52,719 [\$45,355-\$62,105], and No AT: Median [IQR], \$49,584 [\$41,094-\$57,688], $p < .001$). There were no significant differences in access to athletic training services based on school race/ethnicity demographics ($p > 0.05$). **Conclusions:** Socioeconomic disparities were present in access athletic training services in public secondary school settings. There were no significant differences between race/ethnicity and access to athletic trainers. Access to athletic trainers in the secondary school

setting positively influences the student-athlete's health care across a variety of measures. Pilot programs or government funds have been used in the past to fund athletic training services and allocating funds should be considered and ensure all schools have equitable access to athletic training services regardless of school-SES. The selection criteria for states chosen were focused for SES for this project and not on race/ethnicity which may explain why there were not significant differences. Therefore, future research should explore states with varying diversity to determine if there are disparities in access to athletic training because of race/ethnicity.



Secondary School Socioeconomic Status and Athletic Training Practice Characteristics

Robison HJ, Simon JE, Nelson EJ, Morris SN, Wasserman EB, Docherty CL: Indiana University-Bloomington, Bloomington, IN; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; Ohio University, Athens, OH; IQVIA, Durham, NC

Context: Socioeconomic status (SES) is a significant predictor of various health-related outcomes, yet limited research has investigated how school SES influences athletic training practices. This study aims to describe athletic trainer (AT) contact frequencies and service rates for secondary school student-athletes and assess how these differ by school SES. **Methods:** Data from the National Athletic Treatment, Injury, and Outcomes Network Surveillance Program (NATION-SP) during the 2014/15-2018/19 academic years were used. A convenience sample of ATs provided de-identified data on injury and treatments of student-athletes who sustained athletic and non-athletic injuries. Contact frequencies were expressed as Athletic Training Room (ATR) visit days per injury, athletic training services per injury, and athletic training services per ATR visit day. Rates for service type utilized were expressed as the total count

per 10,000 athlete-exposures. School SES was assigned using principal component analysis of community-based variables measured at the Zip Code Tabulation Area of the school, including the proportion of the population that is African-American, proportion of female-headed households, proportion of households receiving food stamps, types of health insurance coverage by age, and median household income (mean centered). Seventy-seven schools were included in the present study and separated into three school SES groups: affluent (n=31), average (n=29), and disadvantaged (n=17). One-way analysis of variance (ANOVA) tests were utilized (*a priori* alpha of $\alpha < 0.05$) followed by Bonferroni pairwise comparisons for variables found to be significant for the main effect in the ANOVA models. **Results:** ATs documented 1,191 services. Among affluent and average SES schools, ATs reported greater contact frequencies for injury-related care compared to disadvantaged schools, particularly by athletic training services/injury (7.10±13.08 versus average: 9.30±11.60 and affluent: 9.40±12.20; $p=0.020$). ATs at affluent schools reported greater rates of total modalities, AT evaluation/re-evaluation, and strapping (Table 1). Average schools were similar to disadvantaged schools for both AT evaluation/re-evaluation and strapping service rates. The three highest service rates were total modalities, strapping, and therapeutic exercises. There were no differences among rate of

therapeutic exercises, a crucial aspect of patient care, by school SES (disadvantaged: 250±900, average: 190±150, and affluent: 180±480; $P=0.2$). **Conclusions:** We found that as school SES decreased, so did athletic training contact frequencies. Athletic training services rates varied across service types and by school SES particularly, in modalities, strapping, and therapeutic exercises. The variability in service rates suggest that differences in AT practice characteristics by school SES exist, but that these differences do not necessarily imply the existence of inequities in AT interventions by school SES. Given the complexity and widespread effects of SES, future investigations should not only utilize robust measures of SES but should also aim to identify how SES may impact secondary school student athletes beyond AT practice characteristics.

Table 1. Injury Related Care by Service Type and Neighborhood Wealth of Schools (per 10,000 AEs).

	Neighborhood wealth of schools			p-value*
	Affluent	Average	Disadvantaged	
	Injury Related Services (n=474)	Injury Related Services (n=372)	Injury Related Services (n=345)	
Total modalities (Mean ±)	250 (± 480) ^a	280 (± 550) ^a	100 (± 210) ^b	<0.001
AT evaluation/re-evaluation (Mean ±)	54 (± 140) ^a	11 (± 71) ^b	25 (± 91) ^b	<0.001
Therapeutic exercises (Mean ±)	180 (± 480)	190 (± 510)	250 (± 900)	0.2
Strapping (Mean ±)	270 (± 680) ^a	130 (± 340) ^b	61 (± 240) ^b	<0.001
Crutch/gait training (Mean ±)	2.6 (±18) ^a	.39 (±6.2) ^b	1.4 (± 12) ^b	0.02
Wound care (Mean ±)	18 (± 110) ^a	7.1 (± 58) ^a	5.4 (± 41) ^b	0.01

*p-values were calculated using one-way ANOVA. ^{a-b} indicates Bonferroni pairwise comparisons.

Athletic Trainer Awareness and Needs as Providers for Transgender Student-Athletes

Walen DR, Nye EA, Winkelmann ZK, Granger K, Walker SE, Eberman LE: Indiana State University, Terre Haute, IN; Western Michigan University, Kalamazoo, MI; Drake University, Des Moines, IA; University of South Carolina, Columbia, SC; Ball State University, Muncie, IN

Context: Previous research has indicated that athletic trainers have a positive view of treating transgender patients, but feel unaware of the needs of transgender patients and student-athletes. The objective of this study was to gain more depth of information about athletic trainers' knowledge and experiences regarding the health care needs of transgender student-athletes. **Methods:** We used a sequential, explanatory mixed methods study with individual, semi-structured follow-up interviews. Fifteen athletic trainers who previously took part in a cross-sectional survey in April 2018 (male=8, female=7, age=24±2, years of experience=3±3) participated. We audio recorded the interviews using a video-conferencing software (Zoom®; San Jose, CA) and artificial intelligence software

automatically transcribed the interviews. The transcripts were corrected for errors and then shared with the participants to check for accuracy. Data were analyzed using a 3-member coding team following the consensual qualitative research tradition including a multi-phased process to identify domains and core-ideas. We then completed a cross-analysis to ensure the integrity of the coding process and conducted an audit of the analysis. The frequency for which each category was present in a transcript was calculated at the conclusion of the analysis process, and consistent with the consensual qualitative research tradition. Trustworthiness was established using member-checking, multiple-analyst triangulation, and auditing. **Results:** Four main domains were identified: 1) perceived deficiencies, 2) misconceptions, 3) concerns, and 4) creating safety (Table 1). Participants perceived deficiencies among other health providers responsible for transition care that may not do so safely or may do so by discriminating against the patient. They also felt they did not have sufficient knowledge to provide care themselves and felt the same for those that worked within their own healthcare unit. Although similar, the participants also sought to define terms like transgender and transitioning and were unable to do so accurately. In addition, the participants were unable to explain the

physiological response to hormone replacement therapy. Participants were able to recognize the potential healthcare disparities of transgender patients and expressed concern relative to mental health and wellness, self-image, and cost. Even with the feelings of deficiency about delivering patient care, participants described their efforts to create safety by validating transgender student-athletes and avoiding misgendering, instilling trust, adjusting the physical environment, and by engaging in professional development to improve their knowledge. **Conclusions:** Athletic trainers want to create a safe space for transgender student-athletes but lack the necessary knowledge to treat this patient population. Professional resources to improve athletic trainer knowledge, skills, and abilities in caring for transgender patients are a continued need. Specifically, athletic trainers must better understand the physiological response to gender affirming care and the common myths associated with transitioning.

Table. Frequencies of Categories

Domains and Categories	Counts	Frequency Label
Perceived Deficiencies		
AT Self Knowledge	12/15	Typical
Access to Safe Transition Care	11/15	Typical
Knowledgeable Providers	7/15	Variant
Misconceptions		
Definition of Transgender or Transitioning	10/15	Typical
Physiological Response to Hormone Replacement Therapy	7/15	Variant
Concerns		
Mental Health and Wellness	9/15	Typical
Self-Image	5/15	Variant
Cost	4/15	Variant
Creating Safety		
Validation	14/15	Typical
Trust	11/15	Typical
Environmental Factors	15/15	General
Professional Development	12/15	Typical

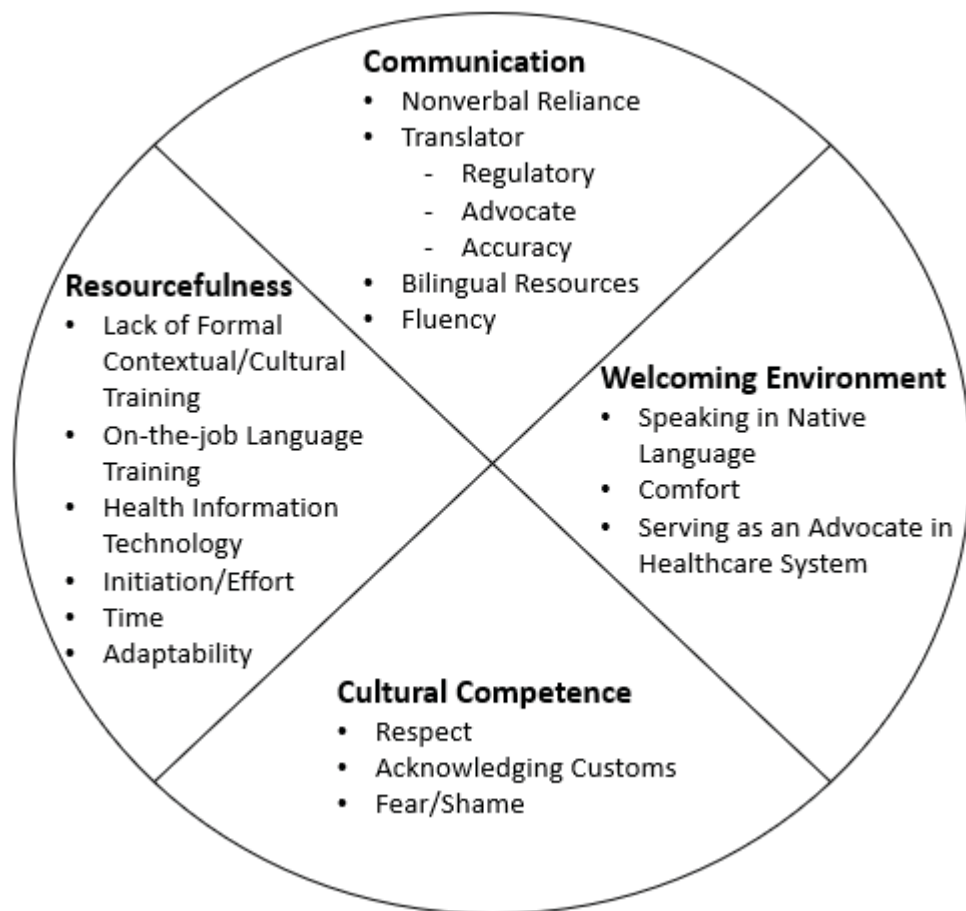
General = 15 cases represented; Typical = 8 to 14 cases represented; Variant = 3 to 7 cases represented.

The Impact of Non-Native English Speaking Patients and Support Systems on Patient Care Delivery Stanton BM, Rivera MJ, Winkelmann ZK, Eberman LE: Indiana State University, Terre Haute IN, and University of South Carolina, Columbia, SC

Context: The number of non-native English speakers (NNES) in the United States more than doubled since 1990 and continues to grow, increasing the likelihood of healthcare providers encountering NNES and subsequent language barriers. Language barriers in healthcare result in ineffective communication, decreased quality of treatment, and reduction in overall provider satisfaction. Athletic trainers must be aware of any healthcare disparities or potential negative patient outcomes language barriers may cause. The purpose of this study was to investigate experiences of secondary school athletic trainers who provided care to patients that were NNES or communicated with their support systems that were NNES. **Methods:** This study used a consensual qualitative research design. Fifteen secondary school athletic trainers with experience communicating with NNES patients or their support systems self-selected to participate in a semi-structured interview, which was audio-recorded and transcribed verbatim

(Zoom®, San Jose, CA). A data analysis team of three people used a multi-phased process to make a consensus codebook including domains and categories identified from the transcripts. Credibility and trustworthiness were established through member checking, multiple researcher triangulation, and auditing. **Results:** Four domains emerged from the experiences of participants caring for NNES which included: 1) communication, 2) welcoming environment, 3) cultural competence, and 4) resourcefulness. The participants shared that they enhanced communication with NNES patients and support systems relying on nonverbal communication strategies, bilingual resources, and translators to advocate for the patients, improve accuracy, and meet regulatory standards. The participants noted a difference in the delivery of care based on fluency. Participants explained creating a welcoming environment for the NNES by speaking in their native language, increasing comfort for NNES, and serving as an advocate for NNES within the healthcare system. The domain of cultural competence included participant responses of acknowledging customs and respect for NNES, as well as understanding that NNES may experience fear/shame associated with the language barriers and knowledge of their health status. When describing their resourcefulness, participants identified a lack of formal contextual and cultural training, which increased their

use of on-the-job language training and health information technology. Participants perceived spending an increased amount of time, having to initiate more, and putting more effort into providing care for and communicating with patients who were NNES. Overall, participants felt they needed to be more adaptable in these situations. **Conclusions:** Athletic trainers in the secondary school setting perceived they had little formal training to provide care for NNES patients and support systems, and in turn became more resourceful and increased communication strategies to provide more equitable care. The athletic trainers also indicated adapting their care to meet the cultural needs and creating a welcoming environment for the NNES patients and their support systems was important when cultivating a patient-centered experience.



Athletic Trainers' Viewpoints of Patient-Centered Care

Wilson CJ, Eberman LE, Redinger AS, Neil ER, Winkelmann ZK: University of South Carolina, Columbia, SC; Indiana State University, Terre Haute, IN; St. Luke's Health System, Boise, ID; Temple University, Philadelphia, PA

Context: The core competency of patient-centered care (PCC) states that for positive patient outcomes, the provider must respect the patient's views and recognize their experiences. The Athletic Training Strategic Alliance Research Agenda Task Force identified a profession wide belief that examining the extent to which athletic trainers (ATs) provide PCC in their clinical practice would benefit the profession. To first address this line of inquiry, we must study the subjectivity of how ATs view PCC. **Methods:** A total of 115 (males=62, females=53, age=37±10 y, experience=13±10 y) ATs dispersed between 11 job settings volunteer for this study using Q methodology. Q methodology allows the participant to share their viewpoints while not solely focusing on level of agreement scales, but simultaneously exploring the study aim from a quantitative and qualitative perspective. Participants were asked to pre-sort (agree, disagree, neutral) 36 validated

statements representing the 8 dimensions of PCC. Next, the participant completed a Q-sort where they dragged-and-dropped the pre-sorted statements based on perceived importance in providing PCC. The Q-sorts were analyzed using QMethod software. A factor analysis with a varimax rotation was used to identify statement rankings and factors. Factors were determined by an Eigenvalue > 1 and analyzed using a scree plot of the principal components in the analysis. The 6 highest selected statements per factor were assessed to create the distinguishing viewpoints and a consensus statement was identified for an area of improvement. **Results:** Four distinguishing viewpoints emerged from the Q-sorts: A) an informed viewpoint with a focus on respectful treatment and communication with varied populations, B) a holistic viewpoint with a focus on providing individualized support specific to quality of life and daily self-care, C) a gatekeeper viewpoint with a focus on skilled coordination of care and providing emotional support, and D) an interprofessional viewpoint with a focus on physical comfort related to the healthcare facility and management of pain. The statement "ATs treat patients with dignity and respect" appeared as the top ranked statement in 3 of the 4 distinguishing viewpoints (A, C, D), while the lowest ranked statement from 2 of the 4 distinguishing viewpoints (B, C) was "ATs integrate the International Classification

of Functioning, Disability, and Health (ICF) as a framework for delivery of patient care." The consensus statement yielded from the Q-sorts was "ATs involved patients in decisions about their care." **Conclusions:** ATs value patient's preferences and open communication. However, a lack of importance was identified for incorporating the ICF framework, which is a core competency and adopted framework by the NATA since 2015. Finally, most participants agreed it was important to involve patients in decisions about their care, yet most did not rank it of high importance despite it being the central tenant of PCC.

Health Literacy Levels of Collegiate Student-Athletes

Roberts JM, Rivera MJ, Winkelmann ZK, Niles TR, Eberman LE: Indiana State University, Terre Haute IN, and University of South Carolina, Columbia, SC

Context: Health literacy is the ability of individuals to obtain, understand, and use health care information for decision-making, which influences patients' healthcare cost and health outcomes. Health literacy is influenced by a variety of factors. Although health literacy is known for college students, previous investigations have not examined collegiate student-athletes. With a potential for greater ease of access to health care, by way of athletic training services, we sought to study the health literacy of collegiate student-athletes. **Methods:** We used a cross-sectional design with a web-based survey (Qualtrics®, Provo, UT) distributed to compliance officers at colleges and universities (n=1,380). We asked the compliance officers to forward the email invitation to participate to student-athletes. The survey consisted of a demographic questionnaire and the Short Test of Functional Health Literacy Assessment (STOFHLA), which is a 36-item multiple choice assessment that measures an

individuals' ability to understand and interpret relevant health care information. Performance is scored as inadequate (0-16), marginal (17-22), and adequate (23-36). We calculated descriptive statistics for demographic characteristics and STOFHLA scores. **Results:** A total of 160 participants responded (age=20±4 years), with a majority identifying as female (n=111, 70%). The majority of participants identified as "White" (n=133, 83%), followed by the identities of "Mixed Race" (n=17, 11%), "Black" (n=5, 3%), Hispanic/Latino/Spanish (n=4, 2.5%), and "Other" (n=1, 0.6%). The majority of participants reported having experiences with on-campus athletic training/sports medicine services (n=133, 83%), off-campus health clinics (n=81, 51%), on-campus student health services (n=76, 48%), off-campus sports medicine services (n=40, 25%), on-campus behavioral health services (n=23, 14%), and off-campus behavioral health (n=16, 1%). The collegiate athletes of this study displayed adequate health literacy (mean= 34±2; range=27-36; adequate=160/160, 100%). The mean STOFHLA for participants that identified as white was 34±2 (range=27-39; adequate=133/133, 100%), whereas those who were non-white was 34±2 (range=28-36, adequate=27/27, 100%). **Conclusions:** College student-athletes demonstrated adequate health literacy as a whole. The health literacy scores for college student-athletes are comparable to

traditional college students, indicating that college student-athletes are capable of understanding their own health care and making informed health care decisions. In striving to achieve a better patient-centered care environment, healthcare professionals should feel more confident in the capabilities of collaborating with their patients and incorporating the student-athlete into the decision-making process.

Ethnocultural Empathy in Athletic Training Students

Evans K, Moffit DM, Judge K: Idaho State University, Pocatello, ID

Context: Diversity in the United States is constantly changing. According to the Census Bureau, by 2044, more than half of all Americans are projected to belong to a minority group (any group other than non-Hispanic White alone). By 2060, nearly one in five of the nation's total population is projected to be foreign born. As the demographics continue to change, the importance of increased cultural competence among health professionals is becoming imperative. Empathy is an integral construct when providing patient-centered care. A healthcare professional may exhibit empathy easily toward those that are similar to them. However, it is often difficult for providers to put aside their own biases, beliefs, religious practices, languages, attitudes, and communication styles when caring for patients culturally different from their own. Therefore, the purpose of this study was to determine what level of ethnocultural empathy AT students have developed during their course of study. **Methods:** A basic interpretative study design was employed to generate descriptive data about AT student's beliefs in clinical education. The study population consisted of 55 participants (male [n=33%], female [n=67%]).

Participants consisted of undergraduate (n=25%), graduate (n=71%), and post-professional (n=4%) degree-seeking AT students from NATA District 10 CAATE-accredited programs. A demographic questionnaire was completed. The Scale of Ethnocultural Empathy (SEE) assessed the ethnocultural empathy of AT students in their program of study. The SEE consists of 31 items that measure empathy towards other racial and ethnic groups that are different from their own. A 6-point Likert Scale was used where participants rate their agreement of each statement from strongly agree to strongly disagree. Each item was placed into four factor-derived subscales: Empathetic Feeling and Expression; Empathic Perspective Taking; Acceptance of Cultural Differences; and Empathic Awareness. Higher scores indicate higher levels of ethnocultural empathy. The survey was distributed to all NATA District 10 AT program directors for distribution to their students. Data were collected for two weeks. **Results:** A total of 55 participants completed the survey. Participants ranged from 17-40 years of age with multiple races/ethnicities and religions represented. Education level ranged from sophomore year in undergraduate AT program to post-professional in AT. Averaged scores showed sophomore undergraduate AT students had the least amount of empathy (m=2.4). Junior undergraduate showed a low level of empathy (m=1.9), however there was only one participant. Senior undergraduate

students (m=2.0) scored more empathy than both year 1 (m=2.2) and year 2 (m=2.2) masters AT students. Post-professional students (m=1.4) showed the most empathy. **Conclusions:** Measuring cultural competence and ethnocultural empathy can be a valuable tool to aid in establishing effective curriculum. Identifying a disconnect will help to establish appropriate courses and experiences to assist AT students develop cultural competence and ethnocultural empathy.

Yes They Are Different Than Adults

June 22, 2021, 1:30 PM-2:30 PM; Moderator: Shane Caswell, PhD, ATC

Exploring the Effect of Family History of Anxiety on Clinical Outcomes in Adolescents With Sport-Related Concussion

Frascoia C, Stephenson K, Eagle S, Womble M, Schatz P, Elbin R: University of Arkansas, Fayetteville, AR; University of Pittsburgh Medical Center, Pittsburgh, PA; Inova Medical Group; Saint Joseph's University, Fairfax, VA

Context: Research examining the role that history of anxiety has on concussion recovery outcomes is equivocal. Some researchers report that a personal history of anxiety is linked to prolonged recovery while others have not supported these conclusions. Moreover, there is a strong link between parental history of anxiety and anxiety development in offspring. However, research investigating the role of family history of anxiety on concussion recovery outcomes for immediate family members is limited. The purpose of this study was to explore the effect of family history of anxiety (in immediate family members) on concussion clinical outcomes in adolescents. **Methods:** A prospective cohort study of patients (13-18 years) seeking care for a sport-related concussion (SRC) within 30 days of injury were recruited for study. Participants were required to complete at least two clinical visits, be accompanied by their parent/guardian, have complete health history and clinical assessment data, and endorse English as a primary language. All participants completed

demographics and health history questions (e.g., age, gender, concussion history) as well as assessments of symptom, neurocognitive, vestibular/ocular motor, and state anxiety. Family history of anxiety in immediate family members was obtained from the accompanying parent/guardian, and personal history of anxiety was self-reported by the patient and/or their parent/guardian. Based on these responses, patients were grouped into family, personal, or no history of anxiety groups, matched on gender and concussion history. A series of analyses of variance (ANOVAs) were performed to evaluate between-group differences on all outcome measures. Statistical significance was set at a $p < .05$ and a Bonferroni-correction was used to control for multiple comparisons where appropriate. **Results:** A total of 117 participants (15.20±1.39yrs, 70% female) were classified into family ($n=42$), personal ($n=33$), and no history ($n=42$) anxiety groups. There were no between-group differences for gender ($p=.71$), age ($p=.40$), days from injury until first clinical visit ($p=.21$), history of concussion ($p=.56$), migraine ($p=.17$), or learning disability ($p=.10$). The family history of anxiety group exhibited worse processing speed ($p<.001$) and reaction time ($p=.04$) performance than the no history group. In addition, the family history of anxiety demonstrated fewer total symptoms ($p=.05$) and faster processing speed ($p<.001$) and reaction time ($p<.001$) compared to the personal history of anxiety group. Family and personal history of anxiety groups were equivalent on verbal and visual memory, state anxiety, and vestibular/ocular motor outcomes. **Conclusions:** Although

family history of anxiety has been linked to the development of personal anxiety, it does not appear to influence concussion clinical outcomes directly. Therefore, clinicians should prioritize inquiry about personal history of anxiety and likely include self-report measures of anxiety during treatment of patients following concussion to fully understand clinical presentation.

Post-Concussion Visio-Vestibular Function in the Private Secondary School Setting

Roby PR, Arbogast KB, Master CL: Center for Injury Research and Prevention, The Children's Hospital of Philadelphia, Philadelphia, PA

Context: Visio-vestibular impairments are evident acutely following pediatric concussion in contrast to healthy controls. Few studies have described these outcomes in a cohort of concussed adolescent patients with pre-injury visio-vestibular examination (VVE) which is possible in a setting where an athletic trainer can provide both pre-injury assessments and timely post-concussion care. The purpose of this study was to describe VVE outcomes, relative to pre-injury measurements, in a secondary school setting staffed with athletic trainers. **Methods:** This prospective study recruited male and female middle and high school participants from a private suburban United States secondary school as control subjects for a larger study during 2017/18 – 2019/20 school years. Participants completed a pre-injury exam prior to their sport season. If the athletic trainer suspected a possible concussion (either through participating in sport or reported by the student as occurring outside of school sports), participants were then recommended for acute evaluation by an affiliated clinical sports medical physician. Participants

were included in the current analysis if they were diagnosed with a concussion. Post-injury evaluation included the VVE, consisting of 9 maneuvers: smooth pursuit, horizontal/vertical saccades and gaze stability, binocular convergence, left/right monocular accommodation, and complex tandem gait. Primary outcomes for this analysis included VVE subtests (normal/abnormal), and total VVE score (abnormal=2+ abnormal subtests). Descriptive statistics were used to examine the proportion of abnormal VVE outcomes across the recovery timeline. **Results:** Twenty-one participants were included in our study (male=14(66.7%), age=15.4 ± 1.6). Pre-injury, 2(9.5%) participants presented with abnormal total VVE score. At initial post-injury visit (median=3 days (IQR=2-7)), 5(23.8%) participants had abnormal total VVE score, with one (20.0%) recovering within 14 days, two (40.0%) recovering within 28 days, and one (20.0%) recovering within 60 days (Table 1). **Conclusions:** While all subjects in this analysis were diagnosed with a concussion, this sample had lower prevalence of VVE deficits (24%) than observed in cohorts of concussed youth presenting to a health care setting such as the emergency department or subspecialty sports medicine office. This may indicate that access to an on-site athletic trainer may increase the rate of reporting mild concussions with fewer VVE deficits, whether due to a lower threshold of reporting their concern for injury or the athletic trainer's presence at the event in which the

injury occurred enabling direct observation of a head impact. The availability of on-site athletic trainers has been associated with greater concussion knowledge in secondary school athletes and may result in greater levels of concussion surveillance, increased reporting of milder VVE symptoms, and earlier presentation for care which has also been shown to improve recovery outcomes. Future research should continue to investigate the interplay between on-site athletic trainer access, reporting behaviors, and clinical presentation in the acute phase post-concussion.

Table 1. Summary of patients who tested abnormally at baseline, initial visit, and across recovery.

	Baseline*	Initial Visit*	14 Days^	28 Days^	60 Days^
Pursuits	2 (9.5)	8 (42.1)	4 (50.0)	2 (25.0)	1 (12.5)
Saccades					
Horizontal	1 (4.8)	3 (15.0)	3 (100.0)	1 (33.3)	1 (33.3)
Vertical	1 (4.8)	6 (28.6)	4 (66.7)	1 (16.7)	0 (0.0)
VOR					
Horizontal	0 (0.0)	4 (19.1)	2 (50.0)	2 (50.0)	1 (25.0)
Vertical	0 (0.0)	3 (14.3)	2 (66.7)	2 (66.7)	1 (33.3)
NPC	0 (0.0)	0 (0.0)	-	-	-
Accommodation					
Left Eye	4 (19.1)	3 (14.3)	0 (0.0)	0 (0.0)	0 (0.0)
Right Eye	3 (14.3)	1 (4.8)	0 (0.0)	0 (0.0)	0 (0.0)
Tandem Gait	0 (0.0)	7 (35.0)	2 (28.6)	0 (0.0)	0 (0.0)
Total VVE Score	2 (9.5)	5 (23.8)	4 (80.0)	3 (60.0)	1 (20.0)

* Baseline and initial visit percentages are representative of the total sample (n=21)

^ Subsequent recovery percentages are representative those testing abnormally at initial visit

****Established Career Award Winner******Test-Retest Reliability of the Concussion Quality of Life-Youth Patient-Report Outcome Measure (Version 1)**

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

Context: Concussion affects multiple dimensions of health, including participation in sports, school, and activities of daily living. Symptoms resulting from concussion and the removal from sports participation following a concussion negatively impacts both physical and mental aspects of health-related quality of life (HRQOL). Understanding the patient's perspective regarding concussion on HRQOL is important, yet a concussion-specific patient-report outcome (PRO) measure does not exist. Our research team has been developing a concussion-specific PRO for youth athletes following best practices in outcome scale development including item generation, expert panel review, and readability. The purpose of this study was to evaluate the test-retest reliability of the Concussion Quality of Life Scale-Youth (CQOL-Y). **Methods:** Fifty-two interscholastic athletes (45 males, 7 females, age=16.0±1.1 years, grade=10.9±.9 level, 32.7% positive concussion history) completed the CQOL-Y on two separate occasions, approximately seven days apart. The CQOL-Y

is a concussion-specific PRO that includes 50 HRQOL items and 4 single-item questions in the following domains identified as important to adolescents following concussion: Cognitive and School (COG, 10 items), Social (SOC, 6 items), Mood and Emotions (ME, 12 items), Sleep (SLP, 5 items), and Activities of Daily Living and Sport Participation (ADLS, 4 items). Raw total scores were calculated by summing responses to domain-specific items. Two total scores were calculated, one that included the ADLS domain, and one that did not, because the ADLS items were completed only by individuals permitted to engage in physical activity or concussion rehabilitation. Lower scores indicate lower HRQOL. Test-retest reliability was calculated for the CQOL-Y total and subscale scores using ICC (two-way random effects, consistency and single measurements), and standard error of measurement (SEM). The ICCs were interpreted as follows: Poor-0.0-0.25, Fair-0.25-0.50, Moderate to Good-0.50-0.75, and Good to Excellent>0.75. **Results:** Table 1 summarizes the results of the test-retest reliability analysis. Good-to-excellent reliability was noted for the total score (with and without ADLS) and ME subscale. Moderate-to-good reliability was found for COG and SLP and fair reliability was noted for ADLS and SOC. Acceptable internal consistency was noted for both total score calculations and all subscales, except for SOC and ADLS. SEM scores appear promising. **Conclusions:** The initial version of the CQOL-Y demonstrated acceptable

test-retest reliability and internal consistency for the total score and most subscales. Findings suggest that the CQOL-Y may be a promising patient-reported outcome measure for use in interscholastic athletes following concussion. Further refinement of the outcome measure will address the social and activities of daily living subscales to improve their measurement properties. Additional measurement properties in patients with concussion, such as responsiveness and known group validity will be assessed.

Table 1: Test-retest reliability and internal consistency of the CQOL-Y domain and total scores. *ADLS may not be completed by those not currently participating.

	Initial, Mean (SD)	Retest, Mean (SD)	SEM	Alpha	ICC (95%CI)
Cognitive and School	35.2 (5.9)	36.2 (5.5)	3.1	.83	.72 (.55, .83)
Social	19.9 (1.9)	20.0 (2.4)	1.4	.63	.46 (.21, .65)
Mood	40.9 (7.1)	42.3 (7.0)	2.4	.94	.89 (.81, .93)
Sleep	15.5 (4.2)	16.0 (4.4)	2.2	.84	.72 (.55, .83)
Activities of Daily Living and Sports*	14.3 (2.6)	13.7 (3.9)	2.2	.47	.31 (-.05, .60)
Total	123.5 (14.4)	125.1 (14.7)	6.1	.90	.82 (.65, .91)
Total (no ADLS)	111.1 (15.8)	114.2 (16.8)	5.3	.94	.89 (.81, .94)

Children With Attention-Deficit/Hyperactivity Disorder Endorse Poorer Health-Related Quality of Life Than Their Counterparts

Washington EM, Kelshaw PM, Hacherl SL, Blackstone AM, Erdman NK, Caswell SV: Sports Medicine Assessment, Research & Testing Laboratory, ACHIEVES Project, George Mason University, Manassas, VA, and Athletic Training Program, Department of Kinesiology, University of New Hampshire, Durham, NH

Context: Approximately 60 million children between 6 and 18 years old participate in team sports annually and an estimated 11% have a diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD). Growing evidence suggests that individuals with a diagnosis of ADHD may be at risk for adverse Health-Related Quality of Life (HRQoL), which is defined as an individual's perception of their general health. However, research has shown that children who engage in team sports, such as middle school athletes, are likely to endorse higher HRQoL compared to their counterparts. The relationship between the endorsement of HRQoL among middle school age athletes with and without ADHD remains unknown. Therefore, we investigated the differences in measures of HRQoL among middle school age athletes with and without ADHD.

Methods: Certified athletic trainers administered the Pediatric Quality of Life 4.0 General Core Battery (PedsQL) to middle school age athletes participating in school-sanctioned sport in the 2017-2018 academic year. Athletes who self-reported having been diagnosed with ADHD were individually matched to athletes without ADHD (No ADHD) based on age, gender, primary language spoken at home, number of prior concussions, sport, and the school they attended. Our retrospective cohort included 58 athletes (74% boys, 26% girls, age = 12.6 ± 0.9 years) with ADHD and 58 matched comparisons (74% boys, 26% girls, age = 12.6 ± 0.9 years) without ADHD. Dependent variables included the overall PedsQL score, the Psychosocial Health Summary (PHS) score, and outcome scores related to the constructs of physical, emotional, social, school, and cognitive functioning. Higher scores were indicative of better perceived HRQoL. Mann-Whitney U tests were conducted to compare the two groups (ADHD, No ADHD) for each of the dependent variables. A nonparametric effect size ($r = \frac{z}{\sqrt{N}}$) was calculated to characterize the magnitude of observed effects. Alpha was set a priori at $p < 0.05$. **Results:** The ADHD group endorsed poorer HRQoL functioning as demonstrated by lower values for each of the outcome scores as compared to the No-ADHD group. (Table 1) More specifically, the school functioning scores ($p < 0.01$, $r = -0.48$), total PedsQL scores ($p < 0.01$, $r = -0.46$), and PHS ($p < 0.01$, $r = -0.44$)

scores were observed to have the largest magnitude of difference between the ADHD and No ADHD groups. **Conclusions:** Middle school age athletes with ADHD self-endorsed poorer HRQoL scores when compared to matched comparisons without ADHD. Specifically, the school, psychosocial, and cognitive functioning constructs were observed to have the greatest effect sizes. Further research is needed to better understand how middle school age athletes with pre-existing health conditions, such as ADHD, may perceive their HRQoL. The matched control methods from this study could be applied to other samples to better understand the impact of such conditions on HRQoL.

Table 1. Comparisons between children with and without ADHD on the Pediatric Quality of Life 4.0 General Core Battery (PedsQL).

PedsQL Components	ADHD (n=58)				No ADHD (n=58)				r*	Significance Test
	Mean	SD	Median	Range	Mean	SD	Median	Range		
Total Score	81.06	12.71	82.61	51.1-100.0	91.67	7.38	93.48	68.5-100.0	-0.46	U=794.5, $p < 0.01$
PHS	78.56	13.99	80.00	45.0-100.0	90.23	9.51	93.33	58.3-100.0	-0.44	U=826.5, $p < 0.01$
Physical	85.71	13.69	89.06	42.9-100.0	94.37	7.03	96.88	71.9-100.0	-0.35	U=1017.5, $p < 0.01$
Emotional	80.13	17.90	82.50	35.0-100.0	91.29	12.44	95.00	30.0-100.0	-0.35	U=1024.5, $p < 0.01$
Social	86.21	14.85	90.00	45.0-100.0	92.52	9.81	95.00	60.0-100.0	-0.21	U=1292.5, $p < 0.05$
School	69.40	18.57	70.00	10.0-100.0	86.88	12.48	90.00	60.0-100.0	-0.48	U=748.0, $p < 0.01$
Cognitive	70.10	20.45	70.83	0.0-100.0	84.91	15.13	89.58	37.5-100.0	-0.38	U=945.0 $p < 0.01$

Note. PedsQL = Pediatric Quality of Life Inventory 4.0, PHS = Psychosocial Health Summary.

*Nonparametric effect size (r) calculated from Mann Whitney U result ($r = \frac{z}{\sqrt{N}}$).

Assessing the Acute Effects of Concussion in Middle School Children With the Child SCAT5

Kelshaw PM, Cook NE, Iverson GL, Cortes N, Erdman NK, Hachert S, Caswell SV: Athletic Training Program, Department of Kinesiology, University of New Hampshire, Durham, NH; Sports Medicine Assessment, Research & Testing Laboratory, ACHIEVES Project, George Mason University, Manassas, VA; Department of Physical Medicine and Rehabilitation, Harvard Medical School; Spaulding Rehabilitation Hospital; Mass-General Hospital for Children™ Sport Concussion Program, Boston, MA

Context: The Child Sport Concussion Assessment Tool 5th Edition (Child SCAT5) is designed for healthcare providers to use in the acute assessment of concussion in children. One proposed method for interpreting the Child SCAT5 is to compare children's post-injury performance to their pre-injury (baseline) values. However, this method for clinical interpretation has not been investigated. Therefore, the purpose of this study was to compare pre-concussion (i.e., "baseline") to acute post-concussion (i.e., "sideline")

Child SCAT5 scores. **Methods:** A prospective cohort study was conducted from August 2017 to May 2019 as part of George Mason University's Advancing Healthcare Initiatives for Underserved Students (ACHIEVES) Project. Participants included forty-two middle school age children ($M=12.5\pm0.7$; 38.1% girls, 61.9% boys) who competed in scholastic sports within a large public-school division in Virginia, USA. Certified athletic trainers administered the Child SCAT5 during baseline assessments prior to the sport season and on the day of a diagnosed sports-related concussion (i.e., "sideline"). The Child SCAT5 components include the number of symptoms, symptom severity, the Modified Balance Error Scoring System (mBESS), and the Standardized Assessment of Concussion-Child Version (SAC-C), which includes the following tasks: immediate memory, digits backwards, concentration, and delayed recall. Wilcoxon Signed Rank tests were used to assess differences between baseline and sideline assessments for each Child SCAT5 component. A nonparametric effect size ($r=z/(\sqrt{N})$) was calculated to characterize the magnitude of observed effects. Alpha was set a priori at $p<0.05$. **Results:** Children endorsed significantly more symptoms (baseline: 6.2 ± 6.1 , sideline: 10.2 ± 6.0 ; $z=-2.72$, $P=0.01$, $r=-0.43$) and worse symptom severity (baseline: 9.4 ± 10.5 ; sideline: 17.4 ± 13.0 ; $z=-2.49$, $P=0.01$, $r=-0.39$) acutely following concussion as compared to baseline

assessments. Concussed children committed significantly more (worse) total balance errors (baseline: 5.7 ± 3.7 ; sideline: 8.4 ± 5.6 ; $z=-2.76$, $P=0.01$, $r=-0.46$) on the mBESS as well as the single leg (baseline: 4.5 ± 2.7 ; sideline: 5.8 ± 3.3 ; $z=-2.47$, $P=0.01$, $r=-0.41$) and tandem (baseline: 1.3 ± 1.7 ; sideline: 2.5 ± 2.6 ; $z=-2.60$, $P=0.01$, $r=-0.43$) stances during the sideline assessment as compared to baseline. There were no statistical significant differences from baseline performance on any SAC-C outcome scores ($P>0.05$) acutely following concussion, see Table 1. **Conclusions:** Middle school age children endorsed significantly more symptoms and performed worse on balance components of the Child SCAT5 acutely following concussion as compared to their individual baseline (pre-concussion) assessment. The greatest magnitude differences were noted on balance testing with the mBESS. Acutely concussed children did not perform significantly worse on the cognitive test components of the Child SCAT5 compared to their pre-season baseline measures. Further research on other clinical interpretation methods of the Child SCAT5 are needed, such as comparisons to reliable change scores and normative reference values.

Table 1. Sideline Child SCAT5 results compared to individual baseline and a sample of middle school normative reference values.

Child SCAT5 Component	Baseline Scores (n=42)	Sideline Scores (n=42)	Sideline compared to individual baseline	
			<i>p</i>	<i>r</i>
Symptoms				
Total Score	6.5 ± 6.2	10.2 ± 6.0	0.01	-0.43
Severity	10.0 ± 10.6	17.4 ± 13.0	0.01	-0.39
SAC-C				
Total Score	21.2 ± 1.8	19.9 ± 4.0	0.12	-0.25
Immediate Memory	13.7 ± 1.3	13.0 ± 2.5	0.31	-0.16
Digits Backwards	2.8 ± 0.9	2.7 ± 0.9	0.54	-0.10
Concentration	3.9 ± 0.9	3.7 ± 1.0	0.38	-0.14
Delayed Recall	3.8 ± 1.1	3.2 ± 1.5	0.13	-0.24
mBESS				
Total Score	5.8 ± 3.8	10.7 ± 8.3	<0.01	-0.57
Tandem Stance	1.4 ± 1.7	3.2 ± 3.4	<0.01	-0.53
Single Leg Stance	4.5 ± 2.8	6.3 ± 3.4	<0.01	-0.51

Note. Descriptive statistics ($M\pm SD$) provided per Child SCAT5 component by sample norms, baseline scores, and sideline scores. The sideline scores were compared to the baseline scores by Wilcoxon Signed Rank analyses. Sideline scores were compared to middle school sample norms using Mann-Whitney U analyses. Nonparametric effect sizes were estimated with ($r = \frac{z}{\sqrt{N}}$). Bolded values indicate statistical significance in score differences. SAC-C = Standardized Assessment of Concussion - Child Version, mBESS = Modified Balance Error Scoring System.

Concussion Rates in U.S. Middle School Athletes From the 2015-2016 to 2019-2020 School Years

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Context: Research describing concussion incidence and mechanisms is necessary to inform primary prevention efforts and improve clinical care. There is limited information regarding the incidence of concussions in middle school athletic settings. Our purpose was to investigate the epidemiology of concussions among middle school age athletes from the 2015-16 to 2019-20 school years. **Methods:** As part of the Advancing Healthcare Initiatives for Underserved Students (ACHIEVES) project, athletic trainers recorded injury and athlete exposure (AE) data from public middle schools in Virginia. Concussion rates per 1000 AEs with 95% confidence intervals (CIs) were calculated

for 12 school-sponsored sports (baseball, football, wrestling, boys' and girls' basketball, cheerleading, boys and girls' soccer, softball, boys' and girls' track, and volleyball). Due to COVID-19 data was not collected for boys' track, baseball, softball, and girls' soccer for 2019-2020. Injury rate ratios (IRR) were calculated to compare concussion rates between practice and competition. Sex-comparisons were conducted for sports played by boys and girls (e.g., soccer, basketball, track and field, and softball/baseball). IRRs with 95% CI excluding 1.00 were deemed statistically significant, consistent with prior protocols. **Results:** Overall, 339 concussions were reported across the five school years with 98 concussions (31.3%) occurring outside of school-sponsored sport participation and 8 occurring during unknown activities. A total of 233 concussions (68.7%) were reported during 390,562 AEs attributed to school-sponsored sport participation for an overall concussion rate of 0.60/1,000 AE (95% CI=0.56-0.64). Sports with the highest concussion rates were football (1.36/1000 AE, 95% CI= 1.05-1.67), girls' soccer (1.26/1000 AE, 95% CI= 0.77-1.75), and wrestling (1.12/1000 AE, 95% CI= 0.78-1.46). The overall concussion rate was higher in competition than practice (IRRcompetition/practice=2.45, 95% CI= 1.16-3.75). Among sex-comparable sports, concussion rates for girls were more than twice that for boys (overall: 0.49 vs. 0.23/1000 AE; IRR = 2.13, 95% CI = 0.40-3.86; competition:

girls: 1.36 vs. boys: 0.66/1000 AE, IRRgirls/boys=2.08, 95% CI= 0.29-3.86; practice: girls: 0.33 vs. boys: 0.16/1000 AE, IRRgirls/boys=2.09, 95% CI= 0.00-4.17). **Conclusions:** Using a large sample of middle school age athletes, we observed football had the highest overall concussion rate among all middle school sports. This finding is in consistent with prior literature that have reported that football has the greatest incidence of concussion in a similar population of athletes. Consistent with previous research, girls suffered concussions at a higher rate than boys when participating in sex-comparable sports. Collectively, our findings suggest that middle school sports have an overall higher rate of concussion than reported in high school and collegiate settings. Our findings reinforce the value and importance of onsite athletic training services within middle school sport settings.

Can Baseline Concussion Symptoms Predict Severity of Depression in Adolescent Athletes?

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Context: With depression rates continually rising in the adolescent population there is a dearth of empirical data on depression rates in diverse, adolescent, athletic populations. As part of a mandated routine in sports medicine, mental health screening during the pre-participation physical exam (PPE) has the potential to reach adolescent patients. Athletes are asked to rate symptoms during most baseline concussion tests and such testing has become common in athletics. Therefore, while it may not be practical to administer depression screening during the PPE, it is worth examining the utilization of baseline symptom scores as a predictor for depression symptoms in athletes. Many of these symptoms are similar or identical to depression assessment instruments. However, using symptoms reported in baseline concussion screening has not been examined as compared

to symptoms reported on a gold-standard adolescent depression screening tool, the Patient Health Questionnaire-Adolescent (PHQ-A). Therefore, the purpose of this study is to examine the ability of depression-related symptoms reported in concussion baseline screening to predict depression scores on the PHQ-A. **Methods:** 897 high-school aged (average 16 ± 1 years; male $n=633$, female $n=264$) athletes receiving sports PPE in both urban and suburban settings in North Carolina were participants in a retrospective chart review. Students completed an iPad version of the PHQ-A and a standardized baseline depression symptoms list. The PHQ-A includes nine questions that asks participants to scale their answer from 0 (not at all) to 3 (nearly every day). We utilized the recommended scoring interpretation, which categorizes scores 0-4 as negligible, 5-9 as mild, 10-14 as moderate, 15-19 as moderately severe, and 20-27 as severe depressive symptoms. The baseline symptoms portion of the concussion baseline had 23 concussion-related symptoms and participants rated each on a scale from 0 (none) to 6 (severe). The scores from the symptoms portion were analyzed as predictors for classification on the PHQ-A using an ordinal logistic regression.

Results: None of the baseline concussion

symptoms scores, individually or as a group, were found to be significant predictors of score ranges on the PHQ-A (all $p > .05$). **Conclusions:** While the baseline symptoms have similarities to the PHQ-A questions, concussion baseline symptom scores are not a valid predictor of self-reported depression in high school-aged athletes and should not be utilized as a substitute for a validated screening instrument for depression. It is therefore imperative that athletic trainers screen high school student athletes for mental health conditions using the PHQ-A or another validated adolescent depression screening tool. Baseline and post-concussion symptoms remain an essential component of the assessment and treatment of concussions but are not a strong predictor of depression symptoms.

Comparison of Sideline Performance of the Child SCAT5 Between Concussed and Non-Concussed Middle School Athletes

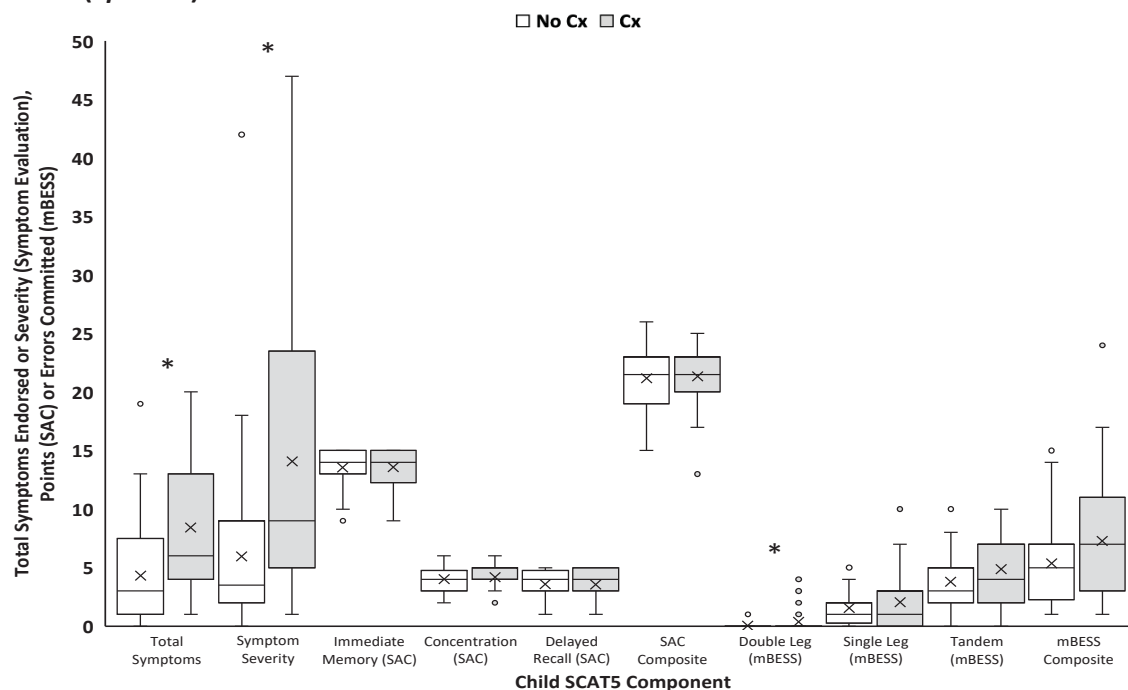
Erdman NK, Kelshaw PM, Hacherl SL, Caswell SV: Sports Medicine Assessment, Research & Testing Laboratory, ACHIEVES Project, George Mason University, Manassas, VA; Athletic Training Program, Department of Kinesiology, University of New Hampshire, Durham, NH

Context: The Child Sport Concussion Assessment Tool (Child SCAT5) is the child version of a commonly used multidimensional concussion assessment tool and was developed for clinical evaluation of children under the age thirteen. There is limited empirical evidence to demonstrate the value of the Child SCAT5 during an acute concussion assessment. The purpose of our study was to evaluate performance on the Child-SCAT5 by middle school age athletes that were or were not diagnosed with a concussion immediately upon suspicion of a concussion. **Methods:** Our convenience sample consisted of 32 concussed (59% male, age=12.3+/-0.53 years) and 52 non-concussed

(62% male, age=12.2+/-0.48 years) middle school age athletes participating in school-sanctioned sports. As part of the Advancing Healthcare Initiatives for Underserved Students (ACHIEVES) project, athletic training services were provided for school-sanctioned sports at sixteen middle schools in Virginia. As per the county's concussion management protocol, certified athletic trainers administered the Child SCAT5 to athletes upon suspicion of a concussive event. The Child SCAT5 consists of a symptom inventory, the child version of the Standardized Assessment of Concussion (C-SAC), and the modified Balance Error Scoring System (mBESS). For the symptom evaluation, the total number of symptoms endorsed and total symptom severity were calculated. For the C-SAC, points earned for the immediate memory (0-15 points), concentration (0-6 points), and delayed recall (0-5 points) domains were recorded and summed to calculate a composite score (0-31 points). For the mBESS, errors committed during each stance (double leg [0-10 errors], single leg [0-10 errors], tandem [0-10 errors]) were recorded and summed to calculate a composite score (0-30 errors). Median, first, and third interquartile values were calculated for each outcome score. Mann-Whitney U-tests and nonparametric effect sizes ($r=Z/\sqrt{n}$)

were used to assess for differences between the concussed and non-concussed groups for each outcome score. All analyses were assessed at $p=0.05$. **Results:** The concussed group endorsed significantly more (worse) symptoms (6.0 [4.0, 13.0] vs. 3.0 [1.0, 7.5], $p<0.001$, $r=0.40$), reported higher (worse) symptom severity (9.0 [5.0, 23.50] vs. 3.5 [2.0, 9.0], $p<0.001$, $r=0.41$), and committed significantly more errors (worse) in the double leg stance (0.0 [0.0, 0.0] vs 0.0 [0.0, 0.0], $p=0.02$, $r=0.26$) of the mBESS as compared to the non-concussed group (Figure 1). The concussed and non-concussed groups were not significantly different for any other mBESS outcome scores ($p's \geq 0.11$) or any outcome scores for the C-SAC ($p's \geq 0.38$). **Conclusions:** Concussed middle school age athletes endorsed more symptoms, greater symptom severity, and committed more errors in the double leg stance of the mBESS than athletes who were not diagnosed with a concussion. Our findings suggest that self-reported symptomology may be the most clinically meaningful component of the Child SCAT5 for differentiating between concussed and nonconcussed middle school athletes immediately following a suspected concussion.

Figure 1. Box plots representing the first, second, and third quartile values, maximum (third quartile + 1.5*Interquartile Range) and minimum (third quartile - 1.5* Interquartile Range) values, outlier data points, and the group mean (X) for the individual components (symptom evaluation, Standardized Assessment of Concussion [SAC], modified Balance Error Scoring System [mBESS]) of the Child Sport Concussion Assessment Tool (Child-SCAT5) by concussed (Cx) and non-concussed (No Cx) middle school age athletes upon suspicion of a concussive event. (* $p<0.05$)



Free Communications, Oral Presentations: Therapeutic Interventions for Ankle and Knee Injuries

June 22, 2021, 2:45 PM-3:45 PM

The Impact of Treatment Characteristics on Self-Reported Function at the Time of Return to Play Following an Ankle Sprain Injury: A Report From the Athletic Training Practice-Based Research Network

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Context: Not only is the ankle the most commonly injured body part in sports, it has also been reported that it is the most frequently treated by athletic trainers. While previous studies have described the treatment of sport-related ankle sprains by athletic trainers, it is unknown if treatment characteristics impact patient outcomes such as self-reported function. Our objective was to determine if treatment characteristics differed based on self-reported function at the time of return to play from ankle sprain. **Methods:** We retrospectively analyzed electronic patient records from the Athletic Training Practice-Based Research Network. Patient records were completed by 123 athletic trainers

(female=70, years certified=5.9±7.4) practicing in 58 athletic training clinics (high school=50, college=7, other=1) across 19 states between 2010-2020. Patient cases with a documented ankle sprain diagnosis (ICD-10=S93.409A: Sprain/Strain, Ankle) and Global Rating of Function scale (GROF) score at return to play were included. The GROF is single-item patient-reported outcome measure scored on a 0-100% scale, with higher scores indicating better function. Patient cases were grouped based on a GROF cutoff score of 90 (>90%= HIGH-FUNC, <90%=LOW-FUNC) as this threshold is frequently cited as a return to play criterion by sports medicine clinicians. Summary statistics (frequency, percentages, mean±standard deviation, median, range, interquartile range) were used to describe injury (sex, sport, age) and treatment characteristics. Treatment characteristics included the type (Current Procedural Terminology code), amount (number of services) frequency (number of visits), and duration (days between intake and last documented visit) of care. Independent t-tests were used to identify significant group differences (HIGH-FUNC, LOW-FUNC) in treatment characteristics. Significance was set at $p \leq .05$ a priori. **Results:** During the study period, 158 ankle sprains (male=87, 55.1%; age=16.3 ± 2.0 years)

were documented (HIGH-FUNC=75, LOW-FUNC=83). Injuries occurred most frequently in basketball (27.8%, n=44), football (27.8%, n=44), and soccer (19.6%, n=31). A total of 1257 services were recorded, with AT evaluation/re-evaluation (23.2%, n=291), hot/cold pack (20%, n=251), therapeutic exercise (18.1%, n= 228), and strapping (13.8%, n=174) used most commonly. The HIGH-FUNC group exhibited significantly greater number of services ($p=.002$), greater number of total visits ($p=.001$) and longer duration of care ($p=.002$) than the LOW-FUNC group (Table 1). **Conclusion:** Those with high self-reported function ($\geq 90\%$) at the time of return to play from ankle sprain received a greater number of services, attended a greater number of visits and had a longer duration of care than those with lower self-reported function ($<90\%$). These preliminary findings indicate that treatment characteristics may influence a patient's perception of their overall function when returned to play. Future investigations should aim to understand how specific services and overall treatment approaches impact long-term outcomes.

TABLE 1. Descriptives for Treatment Characteristic Variables by Group.

Variable	Mean± Standard Deviation	95% Confidence Interval	P-value	Median	Range	Interquartile Range
Number of Services						
HIGH-FUNC	9.8±7.5	8.1-11.5	.002*	8	2-41	4-13
LOW-FUNC	6.5±4.4	5.5-7.6		6	1-23	3-8
Number of Visits						
HIGH_FUNC	8.5±7.1	6.9-10.1	.001*	6	2-37	3-12
LOW-FUNC	5.3±4.1	4.3-6.3		4	2-21	3-6
Duration of Care (days)						
HIGH_FUNC	7.0±4.8	5.9-8.1	.002*	7	1-17	2-11
LOW-FUNC	4.8±3.7	3.9-5.6		4	1-15	2-6

*Significant at $p \leq .05$

Changes in Patient-Reported Outcome Measures Following Varied Interventions in Patients With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) therapeutic intervention studies frequently focus on mitigating ankle-foot impairments. While measuring treatment effects using impairment-level measures should be employed, it may also be clinically meaningful to assess changes in psychological factors that mediate function for a patient-centered care approach. Therefore, the use of patient-reported outcome measures (PROs) to assess a multi-dimensional profile of health-related quality of life (HRQoL) is imperative. Therefore, the purpose of this investigation was to evaluate improvements in HRQoL following multimodal interventions in patients with CAI. **Methods:** Data from 5 previously published studies were pooled by the Chronic Ankle Instability Outcomes Network (COALITION) for participant-level analysis, resulting in 95 physically active patients (Male=31, Age=22.23±4.75years, Height=170.08±10.01cm, Mass=71.34±13.85, Previous

Ankle Sprains=4.52±5.18, Identification of Functional Ankle Instability = 22.55±3.83 (n=47), Ankle Instability Instrument, #Yes=6.42±1.47 (n=48)) with CAI. Interventions included combinations of joint mobilizations, stretching, strengthening, balance training, and gait biofeedback targeted at the ankle and foot complex. Treatment volume varied with the inclusion of laboratory-based (n=18) or laboratory-based plus home-interventions (n=77) that ranged from 1-4 weeks in length (1-week=20, 2-week=18, 4-week=57) with 1-12 laboratory-based sessions (1-session=20, 6-session=28, 8-session=27, 12-session=20) and 0-7 home-interventions per week (0/week=18, 5/week=27, 7/week=50). Outcome measures included PROs to capture ankle-specific function, injury-related fear, and global wellbeing. The Foot and Ankle Ability Measure (FAAM) ADL and Sport subscale examined ankle specific function. Tampa Scale of Kinesiophobia 11 (TSK-11), and the Fear Avoidance Belief Questionnaire (FABQ) Physical Activity (PA) and Work subscale examined injury-related fear. Modified Disablement in the Physically Active Scale (mDPA) PA and Mental subscale captured global wellbeing. All studies examined pre- to post-intervention changes in PROs. Separate Wilcoxon Signed-Rank tests were used to examine pre- to post-intervention changes in each dependent variable. Non-parametric effect sizes (ES) were calculated ($r=z/N$) to examine the magnitude of changes. Alpha was set a-priori at $\alpha \leq 0.05$. **Results:** Ankle-specific function improved following intervention based on the FAAM-ADL (n=95, Pre=89.00[9.53], Post=95.24[9.52], $p < 0.001$, ES=0.62) and FAAM-Sport (n=95, Pre=75.00[20.09], Post=85.71[13.43], $p < 0.001$, ES=0.61). Injury-related fear improved post-intervention compared to pre-intervention as measured by the TSK-11 (n=65, Pre=21.00[7.50],

Post=20.00[6.50], $p=0.001$, ES=0.43), FABQ-PA (n=48, Pre=11.00[5.50], Post=7.00[6.00], $p < 0.001$, ES=0.72), and FABQ-Work (n=48, Pre=6.00[12.75], Post=2.00[7.75], $p < 0.001$, ES=0.52). Global wellbeing improved at post-intervention based on significant changes in the mDPA-PA (n=38, Pre=13.50[11.25], Post=5.00[11.50], $p < 0.001$, ES=0.78) and mDPA-Mental (n=48, Pre=3.00[2.25], Post=0.00[2.25], $p=0.002$, ES=0.51). **Conclusions:** Current treatment approaches for patients with CAI are capable of improving self-reported ankle function and global wellbeing and reducing injury-related fear. Strong effect sizes point to clinically meaningful improvements in the assessed aspects of HRQoL. Collectively, the assessment of five unique intervention protocols suggest broad efficacy for interventions in patients with CAI. Further research is still needed to examine optimal treatments, dosage, and parameters with a focus on the long-term outcomes in patients with CAI.

Differential Acute Effects of Whole Body and Local Muscle Vibration on Loading Rates During Walking in Individuals With Anterior Cruciate Ligament Reconstruction

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Context: Aberrant gait biomechanics have been linked to post-traumatic knee osteoarthritis (PTOA) development following anterior cruciate ligament reconstruction (ACLR). Greater vertical ground reaction force (vGRF) loading rates have been identified in the ACLR limb during walking and may influence PTOA risk, as higher loading rates produce more extensive cartilage damage in animal and explant models compared to lower loading rates. Conversely, lower loading rates early post-ACLR contribute to altered cartilage composition. Quadriceps dysfunction following ACLR is associated with greater loading rates during walking. Whole body (WBV) and local muscle (LMV) vibration acutely improve quadriceps function in individuals with ACLR, and may reduce loading rates. The purpose of this study was to determine the effects of WBV and LMV on loading rate during walking in individuals with

ACLR. We hypothesized that WBV and LMV would decrease loading rates. **Methods:** This laboratory-based randomized controlled trial enrolled 75 individuals 6 months to 5 years post-ACLR (21 males, 54 females; time since ACLR 27 ± 16 months). Participants were randomized to receive a WBV, LMV, or control intervention. Gait biomechanics were assessed immediately prior to and following the interventions. Instantaneous (peak of the first derivative of the time-force curve) and linear (slope from heel strike to weight acceptance peak) vGRF loading rates were calculated during the first 50% of stance and normalized to body weight (xBW/s). Change scores (post-pre) were compared between groups using one-way ANCOVA controlling for time post-ACLR, pre-test values, and gait speed. Change scores were considered significant if the 95% confidence interval did not include 0. **Results:** The group effect for instantaneous loading rate was significant ($P = 0.024$). Post hoc analyses identified a significant decrease in the LMV group (change = $-3.553 [-5.671, -1.434]$ xBW/s) compared to the control group (change = $0.473 [-1.587, 2.532]$ xBW/s; $P = 0.029$), but not compared to the WBV group (change = $-0.333 [-2.382, 1.715]$ xBW/s; $P = 0.105$). The group effect for linear loading rate approached significance ($P = 0.059$). Post hoc exploratory analyses indicated a significant increase in the WBV group (change = $0.276 [0.001, 0.550]$ xBW/s) that did not differ from the LMV (change = $-0.146 [-0.431, 0.138]$ xBW/s; $P = 0.121$) or control (change = -0.135

$[-0.409, 0.140]$ xBW/s; $P = 0.118$) groups. **Conclusions:** LMV decreased the instantaneous loading rate and may be a viable modality to improve gait biomechanics following ACLR and reduce PTOA risk. On the contrary, WBV increased the linear loading rate. Lower loading rates are associated with altered cartilage composition early post-ACLR, suggesting that increases in loading rate with WBV could minimize PTOA risk. The contrary nature of these findings supports the need for further investigation of the longitudinal effects of WBV and LMV on joint health following ACLR.

Two-Week Joint Mobilization Intervention Did Not Change Ankle Sagittal Biomechanics During Walking in Individuals With CAI

Jang J, Cain MS, Migel K, Song K, Pietrosimone BG, Blackburn JT, Franz JR, Wikstrom EA: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Individuals with chronic ankle instability (CAI) have decreased dorsiflexion range of motion (ROM) and increased plantarflexion moments during the stance phase of walking. These deficits are thought to contribute to the functional impairments observed in those with CAI. However, the interaction between the altered ankle ROM and moment is not fully understood. Dynamic joint stiffness (DJS) is a more comprehensive measure as it distinguishes ankle behaviors across three continuous sub-phases. Grade 3 anterior to posterior ankle joint mobilization can improve talar glide, dorsiflexion ROM, self-reported function, and balance. However, it remains unknown if joint mobilization improves gait biomechanics in those with CAI. Therefore, the purpose of this investigation was to determine the impact of a 2-week ankle joint mobilization intervention, relative to the state before the intervention, on gait biomechanics (i.e. ankle ROM, moment, and DJS in the sagittal plane) in those with

CAI. **Methods:** Nineteen individuals with CAI (age: 22 ± 4.04 years, weight: 66.90 ± 11.03 kg, height: 167.11 ± 8.82 cm) participated. CAI inclusion criteria were in accordance with the International Ankle Consortium guidelines. All participants completed a baseline gait analysis. Kinematic (120Hz) and ground reaction force data (1200Hz) were collected while participants completed five overground gait trials at a self-selected speed. Participants received 6, 5-minutes anterior to posterior ankle joint mobilization intervention sessions over 2 weeks. Identical gait analysis was conducted within 72 hours of the final treatment session. The sagittal ankle joint angle and moment during the stance phase was normalized to percentages of the stance phase. Waveform analyses were conducted for the ankle angle and moment in the sagittal plane to compare between pre and post-intervention using a Statistical Parametric Mapping (SPM) two-tailed paired-sample t-test. Significant differences were noted when the SPM{t} trajectory crossed the critical thresholds ($p < .05$) at any point in the curvature. Ankle dynamic joint stiffness was plotted as the slope of the joint moment as a function of the joint angle. The curve was split into three sub-phases of ankle behaviors during the stance phase: controlled plantar flexion (CPF), controlled dorsiflexion (CDF), and powered plantarflexion (PPF). Comparisons of DJS between pre and post-intervention were made using a paired t-test with a significance level of .05. **Results:** Waveform

analyses of ankle joint angle and moment in the sagittal plane were not significantly different at any point between pre and post-intervention ($p > .05$). Ankle dynamic joint stiffness in all three phases was not found to be significant ($p > .05$) (Table 1). **Conclusions:** Two-weeks of ankle joint mobilization did not change sagittal ankle biomechanics in individuals with CAI. This is consistent with other therapeutic interventions commonly used on those with CAI.

Table 1. Dynamic joint stiffness (Nm/kg/°) of the ankle (DJS) during the three sub-phases of gait. Data is presented as mean \pm SD.

Group	CDF	CPF	PPF
Pre	0.026 ± 0.006	0.098 ± 0.025	0.052 ± 0.006
Post	0.025 ± 0.007	0.096 ± 0.025	0.050 ± 0.005

CDF: controlled dorsiflexion, CPF: controlled plantar flexion, PPF: powered plantar flexion.

Verbal Feedback Delivered During A Multi-Component ACL Injury Prevention Program Produces Mixed Effects on Lower Extremity Biomechanics

Hawkinson LE, Begalle RL, Goto S, Blackburn JT, Padua DA: University of North Carolina at Chapel Hill, Chapel Hill, NC; University at Buffalo, SUNY, Buffalo, NY; Texas Health Sports Medicine, Fort Worth, TX

Context: Verbal feedback (FB) is an important component of injury prevention programs. Prior research demonstrates FB can improve lower extremity biomechanics while performing discrete tasks, such as landing and cutting. However, it is unknown if FB provided during injury prevention exercises transfers to landing and cutting tasks. Our objective was to evaluate the effects of FB focused on movement quality (MQ) or sport performance (SP) while performing injury prevention exercises on lower extremity biomechanics. **Methods:** Twenty-two healthy, physically active female volunteers (age=22±4yrs, height=171.45±13.95cm, mass=77±27.5kg) who displayed medial knee displacement during a single-leg squat participated in this crossover design laboratory-based study. Participants received verbal feedback focused on MQ or SP in a counterbalanced order on 2 occasions separated by 7-10 days. FB was

provided while performing exercises (stability, strength, and plyometric) that are commonly included as part of a multi-component ACL injury prevention program. Examples of MQ FB included “land softly” and “keep knees over toes.” Examples of SP FB included “quicker” and “jump higher.” Biomechanics data were collected during double-leg jump-landing (JL) and single-leg land and cut (SLC) tasks, pre and post each FB intervention. Dependent variables included dominant leg hip abduction, knee flexion, and knee valgus angles at initial contact (IC) and angular displacement, as well as peak vertical ground reaction force (vGRF). Separate time(pre, post) x condition(MQ, SP) repeated measures ANOVA were performed for each variable ($\alpha < 0.05$). Post-hoc tests included paired t-tests with Bonferroni correction. **Results:** Significant main effects for time were observed for knee flexion values. Knee flexion displacement was increased from pre- to post-test during both JL (Pre = 65.2±9.9, Post = 67.6±10.4; $p = 0.011$) and SLC (Pre = 37.1±9.5, Post = 40.1±8.8) tasks. In contrast, knee flexion at IC was decreased from pre- to post-test during both JL (Pre = 21.7±7.6, Post = 18.5±6.0; $p = 0.003$) and SLC (Pre = 19.7±7.6, Post = 16.7±6.3; $p = 0.006$) tasks. Hip adduction at IC during the JL task demonstrated a significant time x condition interaction ($p = 0.027$). Post-hoc testing revealed a significant increase in hip abduction following MQ FB (Pre = -4.7±6.6,

Post = -8.0±5.4; $p = 0.03$), but not SP FB (Pre = -5.7±5.1, Post = -5.8±5.6; $p = 0.92$). No other significant main effects for time or time x condition interactions were observed ($p > 0.05$). **Conclusions:** FB delivered during injury prevention exercises acutely transfers to landing and cutting tasks for knee flexion displacement and hip adduction at IC. However, knee valgus and vGRF were unchanged and there were mixed effects for knee flexion at IC. Further research is needed to examine how FB during a multi-component injury prevention program can produce more desirable and consistent changes in lower extremity biomechanics.

An Objectively Monitored 4-Week Home Exercise Plan Improves Single Leg Hop Performance After ACL Reconstruction

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Context: Plyometric-based home exercise plans (HEP) can improve quadriceps strength after ACL reconstruction (ACLR). However, lack of contact between patient and athletic trainer (AT) may limit HEP compliance. The G-VERTTM is a wearable device equipped with an inertial measurement unit that records jump height and count. The G-VERTTM is an ideal tool for monitoring compliance with a plyometric-based HEP because it provides real-time, effort-based feedback via smartphone application to the patient (jump height) and compliance with assigned exercises (jump count) to the AT via a cloud-based storage system. The purpose of this study was to assess the efficacy of a four-week plyometric HEP that included compliance monitoring using a G-VERTTM in improving quadriceps strength and single leg hop performance in individuals with quadriceps weakness after ACLR. **Methods:** Ten participants (9 female/1 male; BMI=24.9±3.3 kg/m²; age=18.0±2.3 years; months since surgery=20.4±1.3) were included in this non-randomized clinical intervention

study with two testing sessions pre- and post-4-week intervention. Quadriceps peak torque (PT) normalized to body mass (Nm/kg) was collected during a 60° isokinetic strength assessment. Normalized Hop distance (% leg) was averaged across 3 trials during the single and triple hop. Average completion time across 3 trials was calculated for the 6-meter hop. Limb symmetry indices (LSI, %) were calculated by dividing the ACLR limb values by the contralateral limb values and multiplying by 100, except for the 6-meter hop the contralateral limb value was divided by that of the ACLR limb. The 4-week HEP consisted of 4 sets of countermovement jumps (CMJ) performed twice per week progressing from 10 to 15 CMJ per set and from double-leg to single-leg CMJ. Participants were instructed to sync the G-VERTTM to its smartphone application to record jump height and count. Data were synced to a cloud-based storage system. Compliance was monitored using jump count and dividing by number of assigned CMJ. Friedman's test of differences among repeated measures with a Chi-square was used to evaluate changes in quadriceps strength and hop performance pre- to post-intervention. **Results:** Participants on average completed 62% of the assigned CMJ. Quadriceps PT ($p=0.26$) and LSI ($p=0.26$) did not significantly change pre- to post-intervention (Table 1). Triple hop distance ($p=0.02$) and 6-meter hop time ($p=0.02$)

significantly post-intervention. **Conclusions:** Objectively monitoring compliance using the G-VERTTM resulted in higher compliance (62%) than studies that report patient-reported compliance (30-60%). The plyometric-HEP significantly improved hop performance, an important clinical indicator of risk of second ACL injury. AT's maybe able to improve outcomes after ACLR using the G-VERTTM to monitor compliance with a plyometric-based HEP.

Effect of Externally-Focused Versus Internally-Focused Instructions on Dynamic Knee Valgus During a Single-Leg Squat

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Context: Dynamic knee valgus is commonly seen in females during functional tasks. Clinicians focus on reducing risk and recurrence of injury by correcting movement. Motor learning, with a focus on verbal instructions, has been utilized as an intervention to target such movements. Internally-focused instructions are most commonly used among clinicians and evidence exists for the use of externally-focused instructions to provide a greater benefit. However, this has not been investigated in a simple task like the single-leg squat (SLS). Therefore, the purpose of this study was to compare the effects of externally- and internally-focused instructions on lower extremity and trunk angles during a SLS. **Methods:** We used a repeated measures randomized controlled trial of females (n=18, 20.4±2.0years, 161.8±7.0cm, 60.0±8.0kg, Tegner Activity Scale=5.5±0.9) with dynamic knee valgus (measured as 2D knee abduction [KA]). Females with >10° of KA during SLS were provided either internally- or externally-focused instructions for correcting their squatting mechanics. Demonstration of the desired

movement was not provided. They were provided feedback on whether or not they corrected their KA with a pre-determined faded-feedback design. Their performance was measured before instructions (baseline), 0-minutes post-instructions, 20-minutes post-instructions, and 1-week retention. Dependent variables of KA, hip adduction, pelvic drop, ankle dorsiflexion, and lateral trunk lean were recorded using 2D video. Variables were extracted via Kinovea and analyzed over five trials. A 2X4 Repeated Measures ANOVA (group X time) was used for each dependent variable. Alpha level was set at p≤0.05. Cohen d effect sizes were reported as small (0.2-0.5), medium (0.5-0.8), and large (>0.8). **Results:** Hip adduction and ankle dorsiflexion resulted in significant interactions (p<.05), but no pairwise differences (Table 1). For hip adduction effect sizes, the external-instruction group had less adduction than the internal-instruction group at baseline (d=0.96, large), 0-minutes post-trial (d=0.66, medium) and 20-minutes post-trial (d=0.85, large). The internal-instruction group demonstrated an effect toward reduction in hip adduction from baseline to retention (d=0.54, medium). The external-instruction group demonstrated an effect toward an increase in hip adduction from 20-minutes post-trial to retention (d=0.59, medium) and a decrease in ankle dorsiflexion from 0-minutes post-trial to retention (d=0.52, medium). No significant interactions or main effects for instruction group or time groups were seen with KA, pelvic drop, or lateral trunk lean (p>.05). **Conclusions:** Verbal instructions and feedback alone, regardless of their internal or external

focus, are not effective in correcting KA or any other related 2D measures during a single leg squat. Alternate instructional approaches, such as visual demonstration and/or modeling in addition to verbal instructions, may be necessary for correction of this movement pattern. Exploration into different types of instructions and feedback is recommended in order to determine their effectiveness in changing altered biomechanics during a functional task.

Table 1: Two-Dimensional angles across internal and external instruction groups and time points

2D Angle		Baseline		0 min Post		20 min Post		Retention	
		External	Internal	External	Internal	External	Internal	External	Internal
Lateral Trunk Lean	Mean±SD	5.4±3.5	5.7±2.6	3.8±3.6	5.3±4.0	4.9±3.0	6.4±4.1	5.3±2.7	7.7±5.1
	95% CI	3.4-7.5	3.7-7.8	1.3-6.3	2.8-7.8	2.6-7.3	4.0-8.7	2.6-8.0	4.9-10.3
Pelvic Drop	Mean±SD	0.9±4.1	5.4±3.4	1.6±6.1	6.3±5.4	0.3±5.5	5.6±4.9	3.0±4.7	3.7±6.1
	95% CI	-1.5-3.4	2.9-7.8	-2.2-5.4	2.5-10.0	-3.2-3.7	2.1-8.9	-0.5-6.5	0.2-7.3
Hip Adduction*	Mean±SD	21.3±4.6	25.9±4.9	20.8±7.7	25.6±6.9	18.4±7.7	24.2±5.7	22.4±6.4	22.7±7.0
	95% CI	18.2-24.4	22.8-29.0	15.9-25.5	20.8-30.4	14.0-22.8	19.8-28.6	17.9-26.8	18.3-27.1
Knee Abduction	Mean±SD	22.8±4.6	25.3±4.1	23.9±5.5	25.2±3.1	22.2±5.1	24.7±2.5	24.6±4.4	26.1±1.1
	95% CI	19.9-25.6	22.5-28.1	20.9-26.8	22.3-28.1	19.6-24.9	22.1-27.3	22.5-26.7	24.0-28.2
Ankle Dorsiflexion*	Mean±SD	38.8±3.7	37.0±5.4	38.8±3.4	37.5±4.3	37.7±3.5	37.0±4.8	36.6±4.3	38.8±4.7
	95% CI	35.7-41.8	33.9-40.1	36.3-41.3	35.0-40.0	35.0-40.5	34.3-39.7	33.6-39.5	35.8-41.8

SD=standard deviation, CI=confidence interval, *significant interaction (p≤0.05)

Plantar Massage Alters Visual Reliance During Static Stance in Those With Chronic Ankle Instability

Cain MS, Migel K, Jang J, Song K, Pietrosimone BG, Blackburn JT, Franz JR, Wikstrom EA: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Lateral ankle sprains are highly prevalent, costly and often result in chronic ankle instability (CAI). Those with CAI have known postural control impairments which are thought to be caused, at least in part, by altered sensory organization strategies (e.g. an increased reliance on visual information). Unfortunately, traditional balance training does not restore sensory organization strategies in those with CAI. Targeting sensory neural pathways via manual plantar massage has improved balance and self-reported function, but their impact on sensory organization strategies in those with CAI remains unknown. Therefore, our purpose was to evaluate the impact of a 2-week plantar massage intervention on the reliance on visual information in those with CAI during static stance. **Methods:** Thirty-four individuals with CAI (Age: 20.65 ± 2.66 years, number of ankle sprains: 4.21 ± 2.12 , Giving way episodes within 6 months: 9.48 ± 13.25 , Foot and Ankle Ability Measure-Sport: $61.91 \pm 15.60\%$) volunteered to participate. Inclusion criteria followed International Ankle Consortium guidelines. All

patients performed 3, 10-second trials of eyes open and eyes closed single limb stance on a force plate standing on the self-reported CAI limb. After baseline postural control testing, patients were randomly allocated to either the plantar massage ($n=16$) or the control group ($n=18$). The massage intervention consisted of 6, 5-minute treatments over 2 weeks. The control group was instructed to continue their normal daily activities. An identical postural control assessment was conducted within 72 hours of the final treatment session. Time-to-boundary (TTB) minima means for both eyes open and closed were calculated in the mediolateral (ML) and anteroposterior (AP) directions. These variables were then used to calculate a 'percent modulation' which quantifies the loss of postural control when vision is removed using the following formula: $(\text{eyes open} - \text{eye closed}) / \text{eyes open} * 100$. Higher scores represent a greater postural decline from the eyes open to the eyes closed condition and is indicative of a greater reliance on visual information during the eyes open condition. The dependent variables (ML and AP 'percent modulation') were submitted to separate Group (massage and control) x Time (pre and post) ANOVAs with an a priori alpha level of 0.05 used to determine statistical significance. **Results:** Following the intervention, the plantar massage group (Pre: $55.76 \pm 11.19\%$, Post: $50.4 \pm 13.83\%$), relative to the control group (Pre: $48.53 \pm 12.20\%$, Post: $54.16 \pm 8.99\%$), had a significant reduction in the AP modulation score ($p=0.029$). A statistical trend was

noted for ML modulation score ($p=0.056$), suggesting that the plantar massage group (Pre: $49.65 \pm 23.35\%$, Post: $47.48 \pm 25.00\%$) reduced the ML modulation score relative to the control group (Pre: 47.32 ± 16.32 , Post: $55.66 \pm 9.20\%$). **Conclusions:** A 2-week plantar massage intervention altered sensory organization strategies used during static stance by those with CAI. More specifically, plantar massage appears to reduce visual reliance during single limb static stance.

The Effects of Blood Flow Restriction on Muscle Activation During Dynamic Balance Exercises in Individuals With Chronic Ankle Instability

Burkhardt MT, Burkholder E, Goetschius J: Bluefield College, Bluefield, VA; Adrian College, Adrian, MI; James Madison University, Harrisonburg, VA

Context: Dynamic balance exercises have been recommended and utilized as therapeutic exercises to improve ankle function in individuals with chronic ankle instability (CAI). Blood flow restriction (BFR) has been used to increase neuromuscular activity in patients with CAI during resistance exercises but have yet to been studied during more functional exercises. The purpose of this study was to determine whether BFR enhances muscle activation during Y-balance exercises in individuals with CAI. **Methods:** A convenience sample of 25 young-adults with a history of CAI participated (15 males, 10 females, 20.3 ± 1.5 years, 4.2 ± 2.3 ankle sprains). We used a cross-over design in a laboratory setting. Participants completed two study visits. At each study visit participants performed two trials of Y-balance exercises with one-of-two conditions, BFR or control (no BFR). Conditions order was randomized between visits. For the Y-balance exercise trials, participants balanced on their CAI ankle while cycling through reaches with their contralateral limb in the anterior, posteromedial, and posterolateral directions.

Each reach was performed at 80% of participants maximum reach distance, which was established on their first visit. Each trial included four sets with repetitions of 30-15-15-15 reaches. Each set was performed at a 2:1 second reach:relax ratio using electronic metronome. For the BFR condition, a pneumatic cuff was placed around the proximal thigh and inflated to 80% of the participant's arterial occlusion pressure. For the control condition, no cuff was worn. Muscle activation of the tibialis anterior, fibularis longus, soleus, and vastus lateralis was collected through surface electromyography (EMG) and normalized by maximum voluntary isometric contraction EMG (%MVIC). Average muscle activation across all four sets was calculated for each muscle and trial. We compared the effects of conditions and trials on muscle activation using separate 2 x 2 repeated-measures ANOVAs and Cohen's d effect sizes [95% confidence intervals]. Results below describe the conditions main-effects with effect sizes (ES).

Results: We observed significantly greater vastus lateralis ($P < .001$, BFR = $38.51 \pm 16.7\%$, Control = $27.2 \pm 8.9\%$, ES = 0.85 [0.44, 1.25]) and soleus ($P = .03$, BFR = $36.1 \pm 16.1\%$, Control = $31.5 \pm 12.8\%$, ES = 0.32 [-0.08, 0.71]) activation during the Y-balance exercises performed with BFR compared to the control condition across both trials. We observed no differences in tibialis anterior ($P = .33$, BFR = $21.9 \pm 11.2\%$, Control = $21.0 \pm 10.8\%$, ES = 0.09 [-0.30, 0.48]) or fibularis longus ($P = .13$, BFR = $31.9 \pm 10.5\%$, Control = $31.3 \pm 10.3\%$, ES = 0.06 [-0.33, 0.45])

activation between the BFR and control conditions during the Y-balance exercises. **Conclusions:** Patients with CAI demonstrated increased soleus and vastus lateralis muscle activation when performing Y-balance exercise with BFR; however, there was no effect of BFR on activation in the smaller tibialis anterior and fibularis longus muscles. Incorporating BFR into dynamic balance exercises may provide an opportunity to enhance muscle activity during exercises. Future research is warranted to examine the training effects of dynamic balance exercises with BFR on clinical outcomes.

Two Weeks of Plantar Massage Treatments Do Not Change Frontal Plane Ankle Kinematics in Those With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) is characterized by repeated episodes of ankle giving way and persistent pain following an index lateral ankle sprain.¹ People with CAI demonstrate decreased plantar cutaneous sensation,¹ and therefore thought to receive less afferent feedback regarding plantar contact pressures² and, therefore, foot position during walking. This may contribute to the inverted foot position noted during gait in those with CAI.¹ Modulating activity of the plantar cutaneous receptors has been shown to improve postural control in those with CAI,³ however its effects on gait have not been established. Therefore, the purpose of this study was to determine the impact

of two weeks of plantar massage treatments on frontal plane gait kinematics at heel strike and midstance in those with CAI. **Methods:** Seventeen participants with CAI volunteered for this laboratory study (Age: 21.12 ± 3.46 yrs, Height: 176.16 ± 7.62 cm, Weight: 78.14 ± 11.01 kg, No. ankle sprains: 4.53 ± 2.45 , Ankle Instability Index: 6.94 ± 1.20 , Foot and Ankle Ability Measure (FAAM), Activities of Daily Living Subscale: $79.76 \pm 13.10\%$, FAAM-Sport Subscale: 61.66 ± 12.19). All participants received 6, 5 minute plantar massage treatments over two weeks. Treatments consisted of 2 minutes of mixed petrissage and effleurage techniques, 1 one minute of rest, and another 2 minutes of massage. Frontal plane ankle position during overground walking was collected at 120 Hz before (pre), after (post), and 4 weeks (f/u) following the intervention. Data were collected using Vicon Nexus 2 (Vicon, Oxford, UK). A repeated measures ANOVA was completed with an a priori alpha level of 0.05 for the dependent variables: inversion, measured in degrees, at heel strike and midstance. A positive mean difference (MD) indicates a less inverted position. **Results:** No significant difference ($p > 0.05$) was seen for inversion position at heel strike (pre-post MD: 0.67° , 95% confidence interval (CI) $(-0.65, 1.99)$, post-f/u MD: -1.10° , 95% CI $(-2.779, 0.56)$, pre-f/u MD: -0.43° , 95% CI $(-1.80, 0.93)$). Similarly, no significant difference ($p > 0.05$) was noted at midstance (pre-post

MD: 0.75° , 95% CI $(-0.69, 2.19)$, post-f/u MD: -0.55° , 95% CI $(-2.18, 1.07)$, pre-f/u MD: 0.20° , 95% CI $(-1.23, 1.63)$). **Conclusions:** While plantar massage is an important intervention to address impairments such as postural control in those with CAI, it does not alter frontal plane foot position during walking in those with CAI. Future research should aim to determine other therapeutic targets which impact walking biomechanics.

Free Communications, Living Your Best Life as an Athletic Trainer: Professional Development and Quality of Life

June 23, 2021, 10:00 AM-11:00 AM

Athletic Trainer Resilience During the COVID-19 Pandemic

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Context: Resilience is the process of adapting in the face of adversity or significant sources of stress. The COVID-19 pandemic created major disruptions in many industries served by athletic trainers in the United States. The initial disruption and subsequent phased reopening have placed athletic trainers under considerable adversity and stress to not only perform their typical job responsibilities, but also to implement safety precautions to minimize exposure and transmission of COVID-19. The purpose of this study was to explore the resilience of athletic trainers across two time points during the ongoing COVID-19 pandemic. **Methods:** We performed a longitudinal study to explore the changes in resiliency scores of athletic trainers during the COVID-19 pandemic. Participants completed the initial assessment during March 2020 when stay-at-home orders were issued. At the end of the initial assessment, 448 individuals expressed interest in completing a follow-up study and were contacted six months later (September 2020). For the purposes of this study, we explored resilience and job status of

athletic trainers across the 6-month follow-up period. In total, 274 individuals (age=32±9y; females=176, 64.2%, males=98, 35.8%; years of experience=9±8y) completed the entirety of the follow-up survey (84% completion rate) to be included in the data analysis. Data were analyzed using descriptive statistics with a paired sample t-test for the brief resilience scale (BRS) scores in March compared to September 2020.

Results: At the initial assessment, participants reported moderate BRS scores (mean=3.7±0.49 points) with 31 participants reporting low resilience, 198 participants reporting moderate resilience, and 45 participants reporting high resilience. At follow-up, participants reported a slightly lower BRS score (mean=3.6±0.6 points) with 27 participants reporting low resilience, 210 participants reporting moderate resilience, and 37 participants reporting high resilience. The paired sample t-test found no statistically significant difference between the initial and follow-up assessments ($p=0.61$, mean difference 0.01 points). Put into the context of the individual athletic trainer over the 6-month observation period, BRS categorization improved for 32 participants, decreased for 28 participants, and remained the same for 214 participants. At follow-up, 20.1% ($n=55$) of participants had no change in their work status, pay, or expectations; 44.5% ($n=122$) worked remotely with no change in work status, pay, or expectations; 20.4% ($n=56$) had their work

time, expectations, or pay reduced; and 14.6% ($n=40$) were on unpaid furlough or had been laid-off at the September 2020 data collection period. **Conclusions:** The results of this analysis suggest that athletic trainers, although facing a multitude of challenging situations related to the COVID-19 pandemic, are maintaining their resilience. However, these data only represent the participants who responded to the follow-up survey. As the pandemic continues, regular follow-ups are needed to see the overall impact of the COVID-19 pandemic on AT resilience

Athletic Trainers' Familiarity With and Perceptions of Athletic Training Scope of Practice

Cabra NL, Pennington TC, Cavallario JM, Eberman LE, Welch Bacon CE: A.T. Still University, Mesa, AZ; University of Texas at San Antonio, San Antonio, TX; United States Olympic and Paralympic Committee, Colorado Springs, CO; Old Dominion University, Norfolk, VA; Indiana State University, Terre Haute, IN

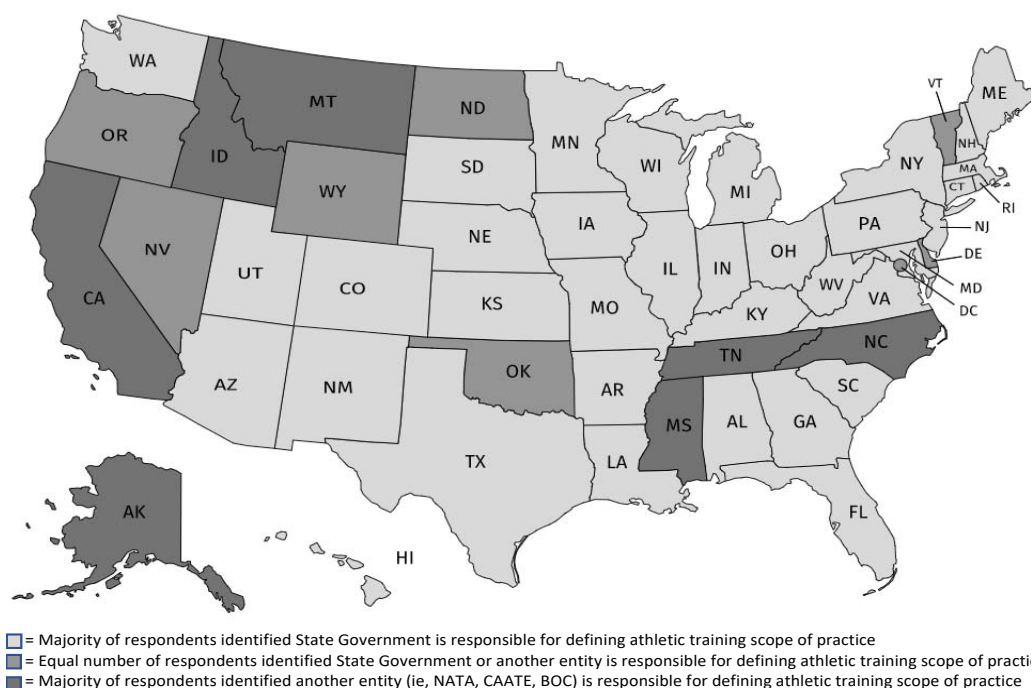
Context: All athletic trainers (ATs) must meet regulatory standards as prescribed by the law prior to enlistment in employment. The United States encompasses various methods of identifying individuals as ATs in the states' practice acts, through a law requiring licensure, certification, or registration. Although state practice acts are similar in nature, the standards and requirements show some variety that can lead to lack of understanding and familiarity with the law and the governing board in the AT's designated state. The purpose of this study was to describe ATs' understanding and perceptions regarding athletic training scope of practice.

Methods: A cross-sectional, validated survey was distributed to 10000 ATs via email. The survey included various questions exploring ATs' understanding of governing bodies that oversee scope of practice as well as perceptions of scope of practice using several question formats. ATs' understanding was measured via separate multiple-choice items, while perceptions were measured on separate, 4-point Likert scales, ranging from (1) strongly disagree to (4) strongly agree. Descriptive statistics were used to report means, standard deviations, frequencies, and percentages. **Results:** 929/10000 (9.29%) ATs representing every practice setting and all 50 states accessed the survey (age=37.9±11.7 years; AT experience=14.1±10.7years). Regarding which entity defines scope of practice for athletic trainers, 29.7% of respondents identified state government, followed by the BOC (22.2%), NATA (15.8%), individual employers (9.9%), the CAATE (9.8%), federal government (8.1%), and the individual AT (2.0%; Figure). 51.7% of respondents agreed (n=309) or strongly agreed (n=104) that their respective state practice act limits the skills they can perform while 37.7% disagreed (n=257) or strongly disagreed (n=44); 5.8% (n=46) of respondents reported their state is not regulated while 4.9% (n=39) reported

they were unfamiliar with the specifics of their state legislation. 46.8% of ATs agreed (n=277) or strongly agreed (n=98) that athletic training practice should be governed by federal legislation rather than individual state practice acts while 31.3% disagreed (n=182) or strongly disagreed (n=69); 22.0% (n=175) were unfamiliar with considerations for federal legislation.

Conclusions: One third of the ATs correctly identified that the scope of practice for athletic training is regulated by their state government, while over half of the respondents incorrectly indicated the federal government, NATA, or the BOC allocated the laws. A majority of the respondents felt their state practice acts limit their skills, which has also been linked to the lack of understanding and familiarity with the practice act origins and standards. These findings shed light on the lack of familiarity with governing bodies that define scope of practice for athletic training. In order to properly advocate for the profession, it is critical ATs have a fundamental understanding of the laws and regulations that promote opportunities to work at their fullest ability according to the law.

Figure. Breakdown of Respondents that Identified State Government or Other Entities Responsible for Defining Athletic Training Scope of Practice



Athletic Trainers' Perceptions of and Experiences With Unlearning in Clinical Practice

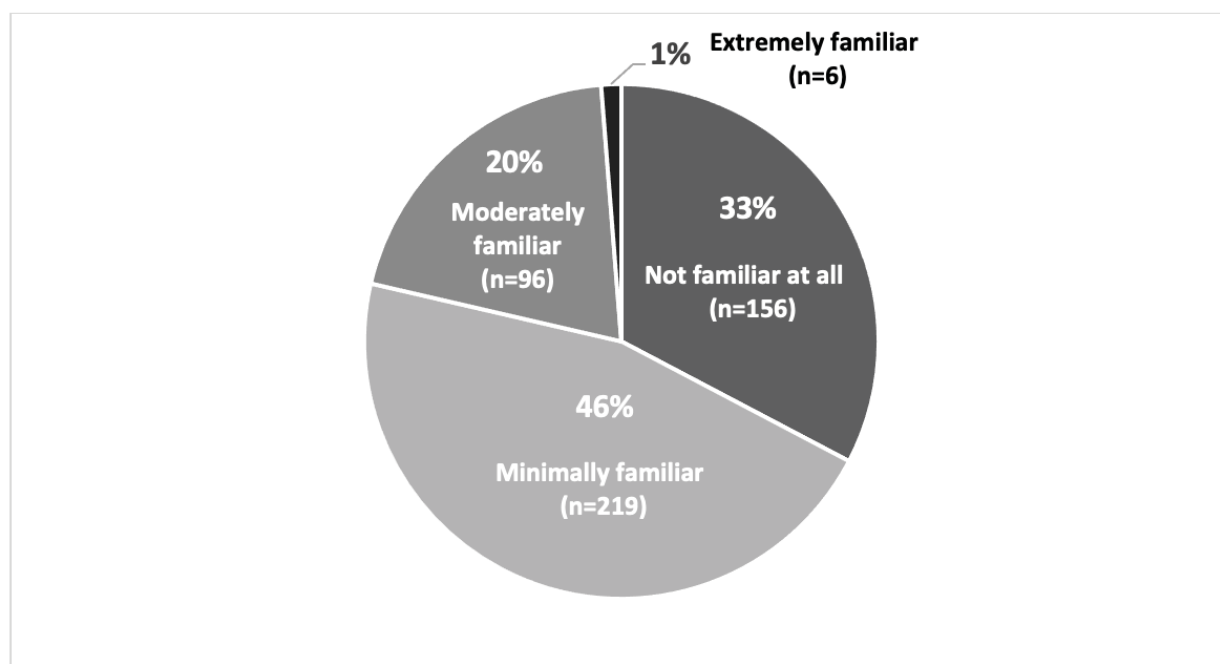
Pike Lacy AM, Cavallario JM, Lam KC, Welch Bacon CE: A.T. Still University, Mesa, AZ, and Old Dominion University, Norfolk, VA

Context: Evidence-based practice is promoted in athletic training to enhance the quality of care provided, yet literature suggests the incorporation of evidence in patient care is limited. While this gap is multi-factorial in nature, one explanation may be the need for unlearning. The concept of unlearning, which involves an intentional process of discarding knowledge or skills that are no longer effective, has been introduced in other healthcare fields, but its role in athletic training remains unknown. Therefore, the purpose of our study was to explore athletic trainers' (ATs') perceptions of and experiences with unlearning in clinical practice. **Methods:** Our study was guided by the consensual qualitative research approach. A Qualtrics survey, composed of eight demographic items and five open-ended questions, was distributed to 6,925 ATs. The survey was accessed by 679 ATs and completed in entirety by 640 (completion rate=94%). Of the 679 ATs who accessed the

survey, 481 identified as a practicing clinician and were included in the analysis. During data analysis, responses regarding ATs' perceived understanding of unlearning were coded as correct or incorrect. Responses from ATs with correct interpretations of unlearning were included in the analysis of open-ended responses. Examples of topics unlearned were coded by athletic training domain. Three members of the research team analyzed the first 30 open-ended responses to develop a consensus codebook. The codebook was confirmed through analysis of the next 30 responses. Two researchers coded the remaining responses and our findings were confirmed by an external auditor. Descriptive statistics were used to report counts and percentages as warranted. **Results:** A majority (79%, n=375) of ATs were minimally or not at all familiar with unlearning (Figure). Approximately 42% (n=120/284; missing=37) of respondents accurately described its meaning. Analysis of the open-ended responses revealed three themes: topics unlearned, barriers to unlearning, and facilitators for unlearning in clinical practice. Topics most frequently unlearned fell within the therapeutic intervention domain (n=72/94; missing=26), followed by the examination, diagnosis, and assessment domain (n=10/94). Respondents described multiple barriers to unlearning including pushback from stakeholders, habitual practice, keeping up with available evidence, and time. Facilitators identified

to promote unlearning centered on education for both ATs and other stakeholders, increased availability of resources/evidence, and support from colleagues and supervisors to carry out the unlearning process. **Conclusions:** Our findings suggest unlearning as a relatively unknown concept among ATs. Continuing education efforts are warranted for ATs and should include strategies to address common barriers related to unlearning. Resources and educational materials to support unlearning may help stakeholders see its value, thus facilitating this process for ATs. Ultimately, increasing ATs' awareness of unlearning may enhance evidence-based practice by increasing the incorporation of evidence in routine practice and promoting contemporary patient care.

Figure. Athletic Training Clinicians' Self-Reported Familiarity with Unlearning



Burnout and Commission of Medical Errors in Secondary School Athletic Trainers

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Context: The physical and financial tolls of medical errors in the United States have been well documented, causing approximately 251,000 deaths per year and costing an estimated \$17.1 billion in 2008. One study suggests that nonlethal medical errors may occur 10 to 20 times more often than lethal errors. Previous research has found a direct association between commission of medical errors and burnout in physicians and surgeons. Smith's Cognitive-Affective Model of Athletic Burnout suggests that emotional exhaustion (EE) and decreased personal accomplishment (PA), two components of burnout, may lead to medical errors in ATs. The purpose of this study was to examine the relationship between burnout and the commission of medical errors in secondary school ATs. We hypothesized that there would be a direct correlation between each burnout component and commission of medical errors in our sample. **Methods:** A cross-sectional study design was utilized in the form of a one-time Qualtrics

survey. A hyperlink to the survey and a brief description of the study were distributed to several social media groups dedicated to and populated by ATs. We also utilized the NATA Research Survey Service. Through these two recruitment methods we received 403 unique and complete responses. Participants were 35.7 ± 11.2 years old and had $12.4 \pm$ years of experience as an AT. Our sample was mostly female ($n=265$, 65.8%) and white ($n=347$, 86.1%), with representation from all NATA districts. We utilized the Maslach Burnout Inventory to assess EE and PA in our sample. A single item derived from previous research was utilized to determine whether participants had committed a medical error in the last month. Participants that reported committing a medical error were further asked how many errors they had committed. A logistic regression model was used to assess the relationship between independent variables (EE, PA) and the dichotomous dependent variable (self-reported medical error in the last month). A Poisson regression model was then utilized to examine the relationship between EE/PA and the number of errors committed among ATs admitting to committing at least one error. **Results:** The logistic regression model showed that PA ($OR=1.06$, 95% $CI=1.02$, 1.10, $p=.005$) and EE ($OR=1.02$, 95% $CI=1.001$, 1.05, $p=.037$) were both directly associated with odds of reporting a medical error (pseudo $R^2=.07$). The Poisson regression

model showed that EE ($B=.02$, 95% $CI=.01$, $.03$, $p=.002$) was directly associated with the number of errors committed (pseudo $R^2=.05$). **Conclusions:** Our findings suggest that a potential relationship between burnout (especially EE) and the commission of medical errors in secondary school ATs may exist. Further efforts should be made to remediate burnout in ATs not only for the sake of the clinicians, but for the sake of the patients they encounter.

Continuing Education Using Infographics Improves the Knowledge and Practice of the Social Determinants of Health

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Context: Secondary school athletic trainers (SSATs) credentialed prior to 2020 may not be aware of healthcare delivery strategies for the social determinants of health (SDOH). Specifically, SSATs have demonstrated the lowest knowledge and practice of the SDOH. Therefore, the purpose of this study was to use infographics as a continuing education method to educate and provide ATs screening recommendations for the SDOH and assess changes in knowledge and practice. **Methods:** We used a randomized controlled trial to compare the outcomes of a SDOH educational intervention on the perceived knowledge (PK) and practice behaviors for ATs in the SS setting. We recruited 6,270 SSATs to participate in the first phase of

the study, which was a cross sectional pre-assessment. The survey asked the participant to define the SDOH and rate their confidence with their response (5-point Likert scale), rate their PK of the SDOH, and report SDOH screening behaviors using a validated yes/yes but/no scale. From the pre-assessment sample (n=482), we identified 258 individuals who were interested in the intervention and randomized them into the control (n=129) and intervention (n=129) groups. The intervention group was sent a different SDOH infographic weekly for 12 weeks that also contained a weekly survey asking the participant's satisfaction with the infographic. The control group did not receive any infographics. After the 12-week intervention, both groups were sent the post-assessment survey. Measures of central tendency were calculated for all items. The definitions were coded by the research team using the CDC definition of the SDOH. We used a Wilcoxon repeated-measures analysis to compare the groups at post-assessment for the PK scores. Finally, we performed a paired samples t-test to compare pre- and post-assessment screening for the 5 behaviors. Significance was set at P<0.05. **Results:** The intervention (n=49; females=41, males=8; age=33±8 y; experience=11±10 y)

and the control (n=64; females=44, males=20; age=35±12 y; experience=11±11 y) group participants were satisfied with the weekly infographics (Table 1). We identified the intervention group improved their ability to correctly define the SDOH (pre-intervention=39/48, 81.3%; post-intervention=32/37, 86.5%) with a 1-point increase in confidence defining the term. We identified a significant improvement in PK at post-intervention (P≤0.001) where the intervention group had a 33.8% change score improvement (mean=3.0±0.9/7) and the control group had a 7.6% change score improvement (mean=4.2±1.3/7). We identified a significant improvement for the intervention group on the SDOH screening behaviors for providing whole-person healthcare (32.7% increase, P=0.008), recognizing the SDOH (45.5% increase, P≤0.001), and incorporating screenings based on the SDOH (33.9% increase, P=0.003). **Conclusions:** Athletic trainers improved their knowledge of the SDOH, as well as their practice in incorporating screenings after engaging in focused professional development using infographics. We suggest ATs explore continuous continuing education to promote behavior change in clinical practice.

Table 1. Overall Weekly Infographic Satisfaction Scores

Question	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Explain the content or concept	2, 0.4%	12, 2.4%	27, 5.3%	269, 53.1%	196, 38.7%
Highlight key information	1, 0.2%	5, 1.0%	40, 7.9%	245, 48.3%	216, 42.6%
Appeal to you in a visual manner	8, 1.6%	42, 8.3%	66, 13.0%	190, 37.5%	201, 39.6%
Meet your athletic training practice needs	3, 0.6%	18, 3.6%	110, 21.7%	224, 44.2%	152, 33.0%
Provide you with suggestions to implement this concept into clinical practice	1, 0.2%	31, 6.1%	78, 15.4%	232, 45.8%	165, 32.5%

Hanging Tough: The Relationship Between Coping Strategies and Increased Workload in Secondary School Athletic Trainers

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Context: The work environment for an athletic trainer (AT) working in a secondary school is typified by heavy workloads and job-related stress. Occupational stress can have negative effects on productivity, absenteeism, employee turnover and quality of life. Research suggests that personal and situational factors can influence the coping process adopted by a person. The approach-avoidance framework suggests that people cope with a stressor by either attending to the stressor (i.e. approach) to reduce it or removing oneself from that stressor (i.e. avoidance). Studies among other healthcare professionals suggest that those using avoidance coping reported higher levels of job stress while those using approach coping had lower stress levels and higher job satisfaction. Research has also suggested that healthcare workers who perceive a greater amount of social support report lower levels of work-related stress. However, the relationship between coping strategies and perceived social support has not been examined in ATs. The purpose of this study was to examine the relationship among

coping strategies, perceived social support and workload in secondary school ATs. **Methods:** A cross-sectional study design was employed. To obtain the sample needed, a recruitment email with a brief description of the study and a hyperlink to a Qualtrics survey were distributed through the NATA Research Survey Service. The recruitment announcement was also placed on several social media groups dedicated to and populated by ATs. Recruitment efforts resulted in the receipt of 392 unique and complete responses. Participants were 35.7 ± 11.1 years old with responses from every NATA district. The sample was mostly Caucasian ($n=340$, 86.7%) and female ($n=258$, 65.8%). A single item asked a participant to report the average number of hours worked each week during a given semester. We utilized the Brief COPE to assess avoidant and approach coping in our sample. The Multidimensional Scale of Perceived Social Support was used to assess perceived social support by each AT. A multivariate linear regression assessed the relationship between independent variables and the self-reported average workload. **Results:** The average workload reported in the sample was 35.5 ± 10.4 hours a week over three semesters (i.e. spring, summer, fall). The regression model showed that avoidant coping ($B=0.34$, 95% CI=0.12, 0.56, $p=.005$) was directly associated with the average number of hours worked (adjusted $R^2=.07$). Approach coping ($B=-0.28$, 95% CI=-0.43, -0.12, $p=.007$) was indirectly associated with the average numbers of hours worked. However, perceived social

support did not display a significant association with any variable of interest. **Conclusions:** Our findings suggest that a relationship between average workload and coping strategies adopted by secondary school ATs may exist. Increased workloads were related to increases in avoidance coping strategies. Further research in this area is needed to determine how coping strategies affect patient care.

Professional Quality of Life: An Examination of Compassion Fatigue and Compassion Satisfaction in Athletic Trainers

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Context: Compassion Fatigue has been identified in many health care professions; however, prevalence in athletic trainers have not been examined. Given the high rate of burnout and excessive demands placed upon those employed in athletic training profession, there is a need to examine the overall professional quality of life to identify compassion imbalances that may affect both patient care and personal well-being.

Methods: A total of 293 (9.8%) clinically active National Athletic Trainers' Association (NATA) members (33.4% male, 66.6% female) with a mean age of 33.08 ± 9.21 years, were randomly selected to complete a demographics questionnaire along with the Professional Quality of Life-21 (ProQOL-21) survey provided via Qualtrics online software. The Professional Quality of Life Scale-21 (ProQOL-21) is a revised version of original Professional Quality of Life Scale (ProQOL-5) measurement tool ($>.80$, Cronbach $\alpha = .90$). This study utilized a cross-sectional, quantitative design. Descriptive statistics were used to determine the prevalence

of the professional quality of life scales including compassion satisfaction and compassion fatigue. A Pearson's Correlation was conducted to examine the relationship between these two factors, as well as between the ProQOL-21 scales and years of clinical experience. **Results:** More than half of the participants (55.3%, $n = 162$) experienced an average level of compassion fatigue, while another 25.6% ($n = 81$) of participants were categorized as experiencing high compassion fatigue. Similarly, half of the participants (53.6%, $n = 157$) experienced average compassion satisfaction. The bivariate correlation analysis indicated a significant, moderate, negative relationship between compassion fatigue and satisfaction, $r = -.377$, $n = 293$, $p = .001$. Another bivariate correlation analysis indicated a significant, weak, negative correlation between compassion fatigue and years of experience in clinically active athletic trainers, $r = -.126$, $n=293$, $p = .032$. **Conclusions:** Athletic Trainers experience average levels of compassion satisfaction while providing patient care; however, compassion fatigue is also prevalent in this profession. The negative relationship between compassion fatigue and years of experience suggest athletic trainers who remain in the profession over time may experience less compassion fatigue. Additional research is warranted to further investigate the relationship of the professional quality of life components in athletic training and examine both prevention and causes of compassion fatigue. The concept

of the Professional Quality of Life serves as an important component of all health care professions. The awareness of this vital, yet understudied aspect of the athletic training profession will allow clinicians to strategize methods to improve and invest in one's professional quality of life. This may lead to improved, quality, compassionate care by athletic trainers, with a balance of emotional well-being for athletic trainers.

Psychological Ownership In Athletic Training

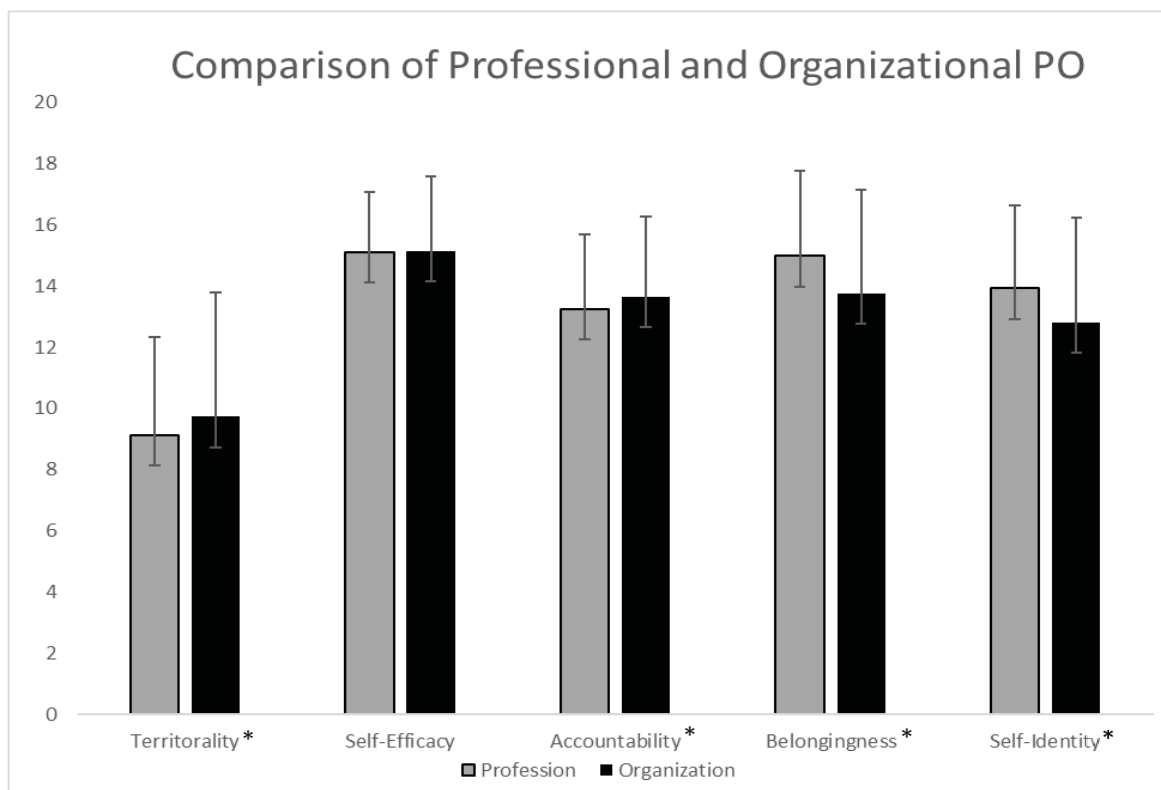
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Context: Psychological ownership (PO), is a state where an individual feels possession over an object (e.g. PO over the organization where one works, PO over the profession one serves). PO incorporates concepts of territoriality and accountability, which are connected to the sense of duty. PO also includes concepts of self-efficacy, belongingness, and self-identity, which connects to an individual's aspirations and accomplishments. PO could provide insight to vitality of the profession. The purpose of this study was to explore athletic trainers' (AT) PO over their employing organization and over the athletic training profession. **Methods:** We used a cross-sectional, web-based survey with demographic questions, the Psychological Ownership Questionnaire (POQ), and the Psychological Ownership in Athletic Training Questionnaire (POQ-AT). The POQ-AT was adapted from the previously validated POQ. Items in the POQ are related to a respondent's "organization." Vernacular changes were made in the POQ-AT

to reflect PO over the "profession," then reviewed by a panel of experts. All items were scored on a 6-point Likert scale (1=Strongly Disagree to 6=Strongly Agree) and calculated for total score and sub-score. The tools demonstrated acceptable internal consistency (POQ Cronbach's $\alpha = .81$; POQ-AT Cronbach's $\alpha = .76$). Parametric t-tests and one-way ANOVAs were calculated to investigate differences in organizational and profession PO between demographic characteristics. **Results:** Emails were distributed to 8,000 NATA members; 887 participants responded (access rate=11.5%) and 623 completed the survey (completion rate=83.7%) (age=33 \pm 9y, experience=10 \pm 8 years; supervisors=195/623, 31.1%). ATs indicated significantly greater ($p < .001$) PO over their profession (66.36 \pm 7.54/96) than over their organizations (65.09 \pm 9.39/96). ATs indicated significantly greater ($p < .001$) belongingness (14.98 \pm 2.78/18) and self-identity (13.91 \pm 2.70/18) with their profession than belongingness (13.76 \pm 3.39/18) and self-identity (12.80 \pm 3.44/18) with their organizations. They indicated significantly less ($p < .001$) territoriality (9.12 \pm 3.22/24) and accountability (13.24 \pm 2.43/18) with their profession than territoriality (9.73 \pm 4.07/24) and accountability (13.65 \pm 2.62/18) with their organizations. Individuals that supervised others indicated

significantly greater POQ (66.94 \pm 8.74/96, $p = .001$) and POQ-AT (67.35 \pm 7.52/96, $p = .026$) than individuals that do not supervise others (POQ=64.24 \pm 9.55/96; POQ-AT=65.91 \pm 7.51/96). ATs with 21+ years of experience indicated significantly greater organizational PO (69.31 \pm 9.69/96) than ATs with 0-5 years of professional experience (64.81 \pm 8.93/96, $p = .015$) and ATs with 6-10 years of professional experience (63.80 \pm 9.81/96, $p = .001$). **Conclusions:** ATs demonstrate greater PO over their profession than their employing organizations. They indicate greater self-identity and belongingness with the AT profession and more territoriality and accountability with their employing organization. This suggests ATs are connecting aspirations and accomplishments with the profession but connecting duty and responsibility to their organizations. However, lower organizational self-identity and belongingness may lead to poor job satisfaction and intent to leave a job or organization, a common problem described in the AT literature. Years of experience and supervisor status may play a role in the level of organizational PO, which may be indicative of the influence of decision-making authority.

Figure: A comparison of athletic trainers' professional and organizational psychological ownership (PO).



* significant at $p < 0.05$

The Lived Clinical Experiences of Expatriate Athletic Trainers

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Context: The international practice setting is gaining popularity for athletic trainers (ATs). However, very little has been investigated about the clinical experiences and challenges this practice setting presents. The purpose of this study was to create a baseline of understanding surrounding AT's lived clinical experiences within the international practice setting.

Methods: We used a consensual qualitative research design and recruited currently credentialed ATs who are practicing with the athletic training skillset outside the United States. The Board of Certification supplied email addresses for recruitment purposes (23 total; 11 females, 12 males; 34 ± 7 years old; 10 ± 6 years credentialed; 6 ± 5 years practicing internationally). International practice regions included Asia (12/23, 52.17%), Europe (7/23, 30.43%), South America, (3/23, 13.04%), and Canada (1/23, 4.35%). Participants completed an electronic informed consent and demographic survey (Qualtrics® Inc., Provo, UT). Based on

previous literature and in consultation with an international sports medicine expert, both interview and survey tools were developed, validated, and piloted. Semi-structured interviews were conducted and transcribed by the lead investigator using teleconferencing software (Zoom, San Jose, CA). Three researchers independently coded transcripts over multiple rounds using a consensual codebook to confirm domains, codes, and data saturation. Member checking, peer reviewing, and multiple researchers were used to triangulate data and enhance trustworthiness. **Results:** Three domains emerged during analysis: (1) Professional and Cultural Adaptations, (2) Healthcare Landscape, and (3) Personal Pathways and Motivators (Figure 1). Participants voiced struggles with self-efficacy in the professional workplace, as well as detailed incongruities of their clinical roles and others' understanding of their skill set as ATs. Clinicians detailed the versatility of ATs' skill set filling clinical gaps within their country's healthcare landscape including emergency, concussion care, and education. Institutional and intraprofessional relationships were greatly expanded on and emphasized personal connections. Participants voiced challenges surrounding resources and adapting scopes of practice to their country's legal systems. Conversations emerged surrounding the importance of cultural competence and clinical advocacy in the workplace. Interprofessional practice and

collaboration were discussed as imperative to clinical practice. Post-professional education and strong internal motivation were commonly expressed along with desires for skills and professional development opportunities. External motivations were additional benefits of the setting. Dual-appointments were regularly found, along with a wide range of work settings within countries. **Conclusions:** International ATs expressed a variety of ways that the AT skill set fits a unique clinical international need. Both interprofessional relationships and intraprofessional practice were crucial to practitioners; relationships were enhanced by strong communication skills, empathy, and cultural competence for all countries of practice. While native clinicians had a consistent lack of knowledge of the AT skill, clinical advocacy, and a strong desire to grow the international practice setting was salient to practitioners.

Figure. Consensual Qualitative Research Domains and Categories



Work-Addiction Risk in Athletic Trainers and Its Relationship to Work-Life Conflict and Burnout

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Context: Individual factors can impact numerous work-life interface outcomes including work-family conflict and burnout. Recently, the concept of work addiction has been investigated as an individual factor that could impact numerous outcomes. While there is a large body of literature investigating work-family conflict and burnout in athletic training, little is known about athletic trainers' risk of developing work-addiction or its potential impact on these outcomes. The purpose of this study was to gather descriptive data on work-addiction risk among athletic trainers and examine the impact work-addiction may have on work-life interface outcomes in athletic training. **Methods:** Our cross-sectional study utilized an online web-based survey. The online questionnaire consisted of four main sections: demographic questions, work-family conflict scale, Copenhagen Burnout inventory, and the Work-Addiction Risk Test. Because all surveys used in the questionnaire were previously validated and have been used among athletic trainer populations, the authors did not edit or shape any of the questions from the

work-family conflict scale, the Copenhagen Burnout inventory, or the Work-Addiction Risk Test. Mann-Whitney U and Kruskal-Wallis tests were run to determine if group differences existed. Simple linear regressions were used to determine if work-addiction risk scores were predictive of burnout and work-family conflict.

Results: Data from 226 ($n = 65$, 28.8% men, $n = 161$, 71.2% women) participants were included in data analysis and represented athletic trainers from all 10 NATA districts and more than 13 employment settings. The average age of participants was 32+9 years and BOC certified for 10+8 years. Athletic trainers experienced moderate levels of Personal (55.0+19.1) and Work-Related (50.0+16.0) burnout and are at medium risk for work-addiction (58.3+11.2). No demographic differences were observed in burnout or work-family conflict scores, but those at greater risk for work-addiction had higher burnout ($p < .001$) and work-family conflict ($p < .001$) scores (Table 1). Women were more at risk for compulsive tendencies than men ($U = 3873$, $p = .018$). Work-addiction risk scores were predictive of both burnout ($F[1, 214] = 39.49$, $p < .001$) and work-family conflict ($F[1, 207] = 19.60$, $p < .001$), though explained a relatively small percentage of variability ($R^2 = .086$ and $.156$ respectively). **Conclusions:** Our results indicate that athletic trainers are at moderate risk for developing work-addiction and women are more likely than men to develop workaholic

tendencies. Data related to women is troubling given the attrition rate of women athletic trainers. Athletic trainers with higher work-addiction risk score categories had higher levels of work-family conflict and burnout. The potential negative impact of burnout on patient care is well supported in the literature and learning that work-addiction risk is predictive of burnout is important to help create individual and workplace strategies.

Table 2. Work-Addiction Risk Classification

	N (%)	Mean WFC Score	Mean Burnout Score
Low-Risk (25-56)	98 (43.4)	33.8 ± 10.0	40.8 ± 16.0
Medium-Risk (57-66)	68 (30.1)	36.4 ± 9.7	47.9 ± 13.5
High-Risk (67-100)	52 (23)	40.5 ± 8.9	54.9 ± 15.6

Descriptive Report of Injuries Sustained by Secondary School Baseball Players Categorized by Level of Community Socioeconomic Status

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Context: Community level factors, such as socioeconomic status (SES), can reveal the impact of different levels of advantage on members of a community. Baseball is a popular sport in the United States, resulting in high schools from affluent to disadvantaged communities supporting secondary school teams. Understanding characteristics of injury in baseball athletes across levels of community disadvantage may inform healthcare access and resource needs. The purpose of this study was to describe the characteristics of injuries sustained by secondary school baseball players by level of community SES. **Methods:** This descriptive epidemiology report of boys' baseball injuries summarizes data from 48 schools within the National Athletic Treatment, Injury, and Outcomes Network Surveillance Program

(NATION-SP). Data were collected during the 2014/2015-2018/2019 school years, with athletic trainers (ATs) reporting injuries and exposures through their respective electronic medical record systems. Community disadvantage was assigned using principal component analysis of community-based variables from the American Community Survey measured at the Zip Code Tabulation Area of the school. Injury data included event type, mechanism of injury, body part injured, diagnosis, and outcome. Frequency counts and proportions and injury rates (IR) per 1,000 athlete-exposures (AEs) were calculated. Injury rate ratios (IRR) were used to examine differential injury rates across levels of community disadvantage. IRRs with associated 95% Confidence Intervals (CIs) excluding 1.0 were considered statistically significant. **Results:** NATION captured 320 baseball injuries across 140,619 total exposures, for an overall injury rate of 2.4/1,000 AEs. Of those, 166 (52.0%; IR=2.3/1,000 AEs) occurred in 24 schools in affluent communities, 50 (15.6%; IR=1.4/1,000 AEs) in 12 schools in average SES communities, and 104 (32.5%; IR=3.3/1,000 AEs) in 12 schools in disadvantaged communities. Injury rates from schools in affluent communities were higher than average (IRR=1.6, 95% CI=1.2,2.3) and lower than disadvantaged (IRR=0.7, 95%

CI=0.5,0.9) communities. Injury rates from schools in disadvantaged communities were higher than average (IRR=2.4, 95% CI=1.7,3.3) communities. Schools in affluent and disadvantaged communities had higher IRs during competition (affluent: n=86, IR=2.8/1,000 AEs, IRR=1.5, 95% CI=1.11,2.05; disadvantaged: n=52, IR=4.3/1,000 AEs, IRR=1.6, 95% CI=1.12,2.41) than practice (affluent: n=80, IR=1.9/1,000 AEs; disadvantaged: n=52, IR=2.7/1,000 AEs) whereas schools in average communities did not (competition: n=20, IR=1.9/1,000 AEs; practice: n=30, IR=1.2/1,000 AEs; IRR=1.6, 95% CI=0.90,2.78). Table 1 presents injury characteristics and time loss outcome from baseball injury according to level of community SES. **Conclusions:** Baseball IRs differed by community SES, with schools in disadvantaged communities reporting the highest IR and average communities reporting the lowest IR. Many similarities exist for baseball injury characteristics and time loss outcomes irrespective of community SES. Examining injury characteristics by community SES provides insight into resource distribution needs in an effort to provide accessible healthcare, such as ATs, to secondary school student-athletes.

Table 1. Mechanism of Injury, Common Body Parts Injured, Common Diagnoses, and Time to Return-to-Play from Baseball Injury According to Level of Community Socioeconomic Status

	Affluent Communities (N=166) Count (%)	Average Communities (N=50) Count (%)	Disadvantaged Communities (N=104) Count (%)
Mechanism of Injury			
Contact	82 (49.4)	27 (54.0)	51 (49.0)
Non-Contact	38 (22.9)	10 (20.0)	21 (20.2)
Overuse	36 (21.7)	11 (22.0)	27 (26.0)
Illness/Other	5 (3.0)	1 (2.0)	3 (2.9)
Not Reported	5 (3.0)	1 (2.0)	2 (1.9)
Body Part Injured			
Head/Face	16 (9.6)	6 (12.0)	5 (4.8)
Shoulder/Clavicle	25 (15.1)	9 (18.0)	18 (17.3)
Hand/Fingers	13 (7.8)	7 (14.0)	14 (13.5)
Thigh	9 (5.4)	2 (4.0)	10 (9.6)
Ankle	29 (17.5)	3 (6.0)	7 (6.7)
Diagnosis			
Sprain/Strain	66 (39.8)	21 (42.0)	37 (35.6)
Contusion	23 (13.9)	3 (6.0)	27 (26.0)
Fracture	13 (7.8)	6 (12.0)	3 (2.9)
Time Loss			
Non-Timeloss	76 (45.8)	25 (50.0)	44 (42.3)
Loss of 1-6 Days	46 (27.7)	7 (14.0)	35 (33.7)
Loss of ≥ 7 Days	43 (25.9)	16 (32.0)	21 (20.2)
Not Reported	1 (0.6)	2 (4.0)	4 (3.8)

The Epidemiology of Injuries in Middle School Baseball Between the 2015/16 and 2018/19 School Years

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Context: Participation in youth baseball has steadily increased over the past two decades, coinciding with an increased incidence of injury. Prior research has reported the injury incidence of high school and collegiate baseball players; however, few studies have investigated baseball-related injury rates unique to the middle school age athletic population. Therefore, the purpose of this study was to examine the epidemiology of injuries among middle school baseball players. **Methods:** Our retrospective descriptive epidemiology study reviewed injury data for nine middle schools as part of the Advancing Healthcare Initiatives for Underserved Students (ACHIEVES) project located in northern Virginia between the 2015/16 and 2018/19 school years. Certified athletic trainers collected injury and athlete exposure (AE) data for all competitions and

practices for the school-sponsored baseball teams. Injuries were classified as non-time loss (NTL; <24 hours participation restriction) and time loss (TL; ≥24 hours participation restriction). Time loss was further categorized: mild (1-6 days), moderate (7-21 days), and severe (>21 days) restriction of activity. An AE was defined as one athlete participating in one school sponsored competition or practice. Injury frequencies and rates (IRs) were calculated. Injury rate ratios (IRR) with 95% confidence intervals (CIs) were used to compare IRs between competition and practice. IRRs with 95% CIs excluding 1.0 were considered statistically significant. **Results:** Overall, 126 injuries were reported (IR=8.75/1000AE; 95% CI: 7.22-10.82) during 14,395 AEs: (competitions=4,116 AEs; practices=10,279 AEs). The proportion of overall injuries by event type was lower for competition (n=33 [26.2%]) than practice (n=93 [73.8%]). There was a greater proportion of NTL injuries (n=78 [61.9%]) than TL injuries (n=47 [37.3%]) with 1 injury having unreported time loss (n=1 [0.8%]). The IR for TL injuries was similar for competitions and practices (3.16 versus 3.31/1000AEs; IRRcompetition/practice= 0.95; 95% CI: 0.00-2.85). Among TL injuries, most were classified as mild (n=41 [87.2%]) while only three injuries (6.4%) were classified as moderate and severe, respectively. The most common TL injuries were contusions (n=14 [29.8%], IR=0.97/1000AE) and strains (n=14 [29.8%] IR=0.97/1000AE), followed by concussions (n=3 [6.4%], IR=0.21/1000AE). The most common mechanisms for TL injuries were direct blow/impact (n=28 [59.6%], IR=1.95/1000AE), inversion (n=5 [10.6%], IR=0.35/1000AE), and overuse (n=4 [8.5%], IR=0.28/1000AE). **Conclusions:** We observed overall and TL injury rates in middle school

baseball athletes were greater than previously reported for high school and collegiate populations. However, the majority of injuries resulted in NTL and occurred during practice as compared to competition, consistent with prior findings in youth athletes. Our findings suggest a need for injury prevention strategies to reduce TL injuries within middle school baseball. Additional surveillance studies are needed to validate our findings as well as investigate injury rates in other sports and settings to better understand injury patterns for middle school athletes.

A Rare Humeral Shaft Fracture During Baseball Pitching

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Background: Upper extremity injuries comprise more than half of all injuries occurring in baseball and pitchers are more susceptible to these injuries in comparison to position players. Injuries sustained by pitchers also tend to be more severe, as 73% of baseball injuries resulting in surgery are sustained by pitchers. Although rare, spontaneous humeral shaft fractures have been reported during baseball pitching and these are generally spiral fractures. This suggests that they arise from the large external rotation torque during late cocking and torsion of the humerus about its long axis. However, we present a unique case of a spontaneous oblique fracture of the humeral shaft during baseball pitching. A 15-year-old male right-handed pitcher was participating in pitching drills for which the distance thrown increased with each consecutive pitch. As he threw to a teammate approximately 30 m away, he felt a “pop” in his right arm during the acceleration phase. He continued with the drill and, upon release of a second pitch from the same distance, experienced an audible “snap” followed immediately by sharp pain. He was unable to continue the drill at that time due to the severity of pain and presented to the athletic trainer while holding the arm against his body. Upon evaluation, the athletic trainer observed immediate swelling and ecchymosis in the upper arm and what appeared to be a Popeye deformity. The patient was tender to palpation along the upper to mid

humerus with significant guarding. Shoulder and elbow range of motion were normal but painful throughout. No numbness or tingling were noted and distal sensation, motor response, and pulses were fully present. The patient’s arm was immobilized with a Sam® splint and sling and he was referred to a physician for further evaluation. Radiographic imaging determined the presence of a midshaft oblique humerus fracture. **Differential Diagnosis:** Distal bicep brachii tear, glenohumeral subluxation, labral tear, rotator cuff tear, ulnar collateral ligament sprain **Intervention & Treatment:** The patient was immobilized for 12 weeks using a coaptation splint and a sling. Following the period of immobilization, he began therapy to improve shoulder mobility, strength and function. Our patient has fully recovered and has returned to sport activity without incident. His current therapy consists of strengthening and functional exercise for reinjury prevention. He was originally managed conservatively with a coaptation splint. These splints are typically used for 7 to 10 days, until more definitive treatment is performed, such as with a functional brace, cast or surgery. Previous studies have found that recovery time following humeral fracture was about 5 weeks shorter following surgical intervention in comparison to conservative management with splinting. Others suggest that functional bracing is recommended over surgery. **Uniqueness:** This case is clinically significant as spontaneous humerus fractures are rare in the adolescent population. Even more rare, spontaneous fractures resulting from a pitch mechanism are typically spiral fractures, whereas our patient suffered an oblique fracture. This suggests an underlying

cause different from the typical external rotation torque and humeral torsion associated with pitching. **Conclusions:** Oblique fractures typically occur from a traumatic angular force such as an external blow or falling on an outstretched hand. Alterations in throwing mechanics may have contributed to our patient’s injury. However, we were unable to find any mention of a spontaneous oblique humerus fracture from pitching or any other activity in the literature. The presence of a spontaneous humeral shaft fracture should be considered when evaluating an adolescent throwing athlete with sudden upper arm pain. Increasing medical knowledge on this injury will help to prevent valuable time lost in terms of executing a proper treatment.

Early Sport Specialization Linked to Upper Extremity Injuries and Throwing Arm Function in Collegiate Baseball Players

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Context: Epidemiologic reports suggest that elbow and shoulder injuries account for 31-37% of all NCAA baseball injuries, and up to 69% of NCAA baseball injuries are non-contact and overuse mechanisms. Early sport specialization, defined as year-round intensive training in a single sport while excluding others, has been associated with a greater risk for musculoskeletal injuries. The purpose of this study was to compare shoulder and elbow injury rates, upper extremity surgery rates, and subjective throwing arm function in college baseball players that were highly, moderately, and lowly specialized in baseball by the age of 13-years. **Methods:** We used a retrospective cohort design. Survey data was collected from participants during mid-season of the 2019 baseball season. Participants (n=129) were all members of a college baseball team (club or varsity) and currently participating in baseball activities. A 3-criteria Sport Specialization questionnaire was used to stratify players into high (n=22, 19.9±1.2 years), moderate (n=38, 19.7±1.4 years), and low (n=69, 19.9±1.2 years)

specialization groups based on the following three criteria at the age of 13-years: (1) training in baseball for more than 8-month of the year, (2) considering baseball more important than other sports, and (3) quitting other sports to focus on baseball. We assigned 1-point for each criterion met, and stratified participants to high (3-points), moderate (2-points), and low (0-1 points) specialization groups. Our primary dependent variables were participants' history of shoulder injury, elbow injury, and upper extremity surgery, as well as scores on the Functional Arm Scale for Throwers (FAST). A shoulder and elbow injury was defined as an injury that required participants to miss ≥2-weeks of baseball activity. Rates of shoulder injury, elbow injury, and upper extremity surgery were compared between specialization groups using Chi-squared tests. FAST scores (median[IQR]) were compared between groups using Kruskal-Wallis tests and post-hoc Mann-Whitney U tests. **Results:** The high specialization group reported greater rates of shoulder injuries (P=.001, high=59.1%, Low=21.7%) and upper extremity surgeries (P=.01, high=27.3%, low=7.2%), and lower FAST scores (P=.03, high=81.3[13.4], low=87.5[15.9]) compared to the low specialization group. The high specialization group also reported greater rates of shoulder injuries (P=.003, high=59.1%, moderate=21.1%) and upper extremity surgeries (P=.02, high=27.3%, moderate=5.3%), and

lower FAST scores (P=.01, high=81.3[13.4], moderate=90.4[18.5]) compared to the moderate specialization group. There were no differences (P=.07) in elbow injury rates between groups (low=31.9%, moderate=13.2%, high=36.4%). **Conclusions:** College baseball players that were highly specialized by age 13-years reported higher rates of shoulder injuries and upper extremity surgeries when compared to players that were moderately and lowly specialized. Highly specialized players also reported worse current subjective throwing arm function than players that were moderate and low specialization by the age of 13-years.

Repair of an Avulsion Fracture of the Rotator Cuff Tendon in a Collegiate Lacrosse Player

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Background: A 22 year old collegiate female lacrosse player was running and tripped, she fell on a forward outstretched hand resulting in $>180^\circ$ of right shoulder flexion (FL). The evaluation post game by the certified athletic trainer revealed a moderate level of pain, no swelling, non-specific anterior shoulder point tenderness and limited AROM in external rotation (ER), FL and abduction (ABD). Flexion and abduction were limited at 45° of AROM. Special test revealed a negative sulcus sign, negative distraction test, but a positive empty can test. No neurological symptoms or previous shoulder injury history. Patient had a right ACL reconstruction surgery 4 years prior. **Differential Diagnosis:** Rotator Cuff (RTC) strain, anterior deltoid strain, labrum tear, acute bursitis, axillary neuropathy, and avulsion of deltoid or RTC. **Intervention & Treatment:** Immediate treatment included ice application and rest for a day. Patient was eager to return to play (RTP) and her signs and symptoms seemed to be improving until the 13th day after injury when her pain increased again. Due to lack of AROM progress and a slight increase in pain, the patient was referred to the team physician. The X-ray revealed an avulsion at the greater tuberosity of the humerus at the insertion of the common RTC tendon. A MRI the next day revealed negative

pathology in the RTC muscle tissue or labrum. The season was cancelled for Coronavirus outbreak and the patient elected conservative care to encourage natural reattachment based on the proximity of the avulsion. Unfortunately, after 3 months of immobilization, a CT scan revealed a lack of healing therefore an open reduction internal fixation (ORIF) surgery occurred 3 months and 2 weeks post-injury. Upon returning home, the patient was placed in a pillow sling for 6 weeks in which she perform pain-free pendulums. She used over the counter medication, TENS, and ice as needed for pain. Upon returning to school at 7 weeks after surgery she began rehabilitation with a physical therapist composed of isometrics, scapular strengthening, and gentle PROM of the shoulder. The PROM revealed ABD (90°), with arm at side ER (40°) and internal rotation (IR) at 65° . At 10 weeks the patient progressed to AROM in FL and ABD with no weights. At 12 weeks the PROM of ER was at 80 degrees. Resistance bands were added to IR, Extension, and ABD with added running. At 14 weeks the patient progressed to PROM of 180° /FL, 90° /ER, D2 with resistance, and weighted FL and ABD. At 18 weeks the patient added stick work (functional skills) without any difficulty. At 20 weeks the patient was allowed to RTP without restrictions. **Uniqueness:** Rotator cuff avulsion fractures are very rare in younger populations and occur mostly in middle-aged adults, impacting 12-14 out of 100,000 people annually¹. This diagnosis is frequently missed if the injury does not involve a dislocation of the glenohumeral joint¹. **Conclusions:** The functionality of the patient immediately

after injury was unexpected, however, certified athletic trainers must trust their physical exam as reported in this case and make the referral to the team physician. This referral allowed a safe RTP without complications after conservative care failed which resulted in no participation for 8 months. At 20 weeks from surgery this patient exhibits full ROM, equal strength bilateral, and functional skill level equal to her previous playing level. Because of misdiagnoses, healthcare personnel need to be aware of various mechanisms of injuries: straight elbow with shoulder flexion and ground contact (as seen in this case), an extreme pull of the external rotators, after abduction and external rotation of the extremity, or after a direct blow to the lateral aspect of the shoulder².

The Acute Effect of Pitching on Range of Motion, Strength, and Muscle Architecture

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and Thomas Jefferson University,
Philadelphia, PA

Context: Acute adaptations of range of motion (ROM) and strength have been found immediately following baseball pitching and ROM deficits have been linked to various upper extremity injuries. However, there is a paucity of research concerning the underlying mechanism responsible for these changes. Adaptations in muscle architecture of the posterior rotator cuff may be responsible for these clinical measure changes. The purpose of this research was to longitudinally assess the acute changes in ROM, strength, and muscle architecture of the infraspinatus and teres minor muscles in baseball pitchers after a simulated baseball game and to examine the relationship between muscle architecture and changes in ROM and strength.

Methods: A repeated-measures design was utilized to examine 10 healthy club baseball pitchers across seven timepoints: pre-pitching,

immediately post-pitching, and each subsequent day for five days after pitching in a simulated game. Subjects threw 60 pitches randomly assigned across three 20-pitch innings with rest between each inning. A digital inclinometer and hand-held dynamometer were used to assess ROM and strength, respectively. Diagnostic ultrasound was used to assess pennation angle and muscle thickness of the infraspinatus and teres minor at rest and at a maximal contraction. Reliability was found to be excellent for all dependent variables. Separate repeated-measures ANOVAs with follow-up paired t-tests were used to examine changes across time. A stepwise multiple regression analysis was performed to identify if muscle architecture measures were predictive of clinical measures.

Results: Internal rotation ROM significantly decreased immediately following pitching and did not return to baseline until four days after pitching (Post: -6.2° , $p<0.001$; Day 1: -8.1° , $p<0.001$; Day 2: -7.2° , $p<0.001$; Day 3: -4.4° , $p=0.001$). Moreover, the resting pennation angle of the superficial and deep portions of the infraspinatus increased immediately after pitching. The superficial portion returned to baseline on day four (Post: 0.6° , $p<0.001$; Day 1: 1.5° , $p<0.001$; Day 2: 1.3° , $p<0.001$; Day 3: 1.0° , $p<0.001$), while

the deep portion returned to baseline on day five (Post: 1.1° , $p=0.012$; Day 1: 1.4° , $p=0.001$; Day 2: 1.2° , $p=0.001$; Day 3: 0.5° , $p=0.004$; Day 4: 0.1° , $p=0.020$). The pennation angle changes of the infraspinatus and thickness of the teres minor were predictive of the loss of internal rotation ROM following pitching ($R^2=0.491$, $p=0.010$).

Conclusions: The pennation angle increase in the infraspinatus at rest may be indicative of increased tension in the muscle, which was found to be the underlying mechanism for the clinical loss of internal rotation ROM. Understanding the underlying mechanism responsible to acute ROM loss following pitching allows clinicians to optimize recovery strategies and prevent the development of chronic deficits that have been shown to increase the risk of injury.

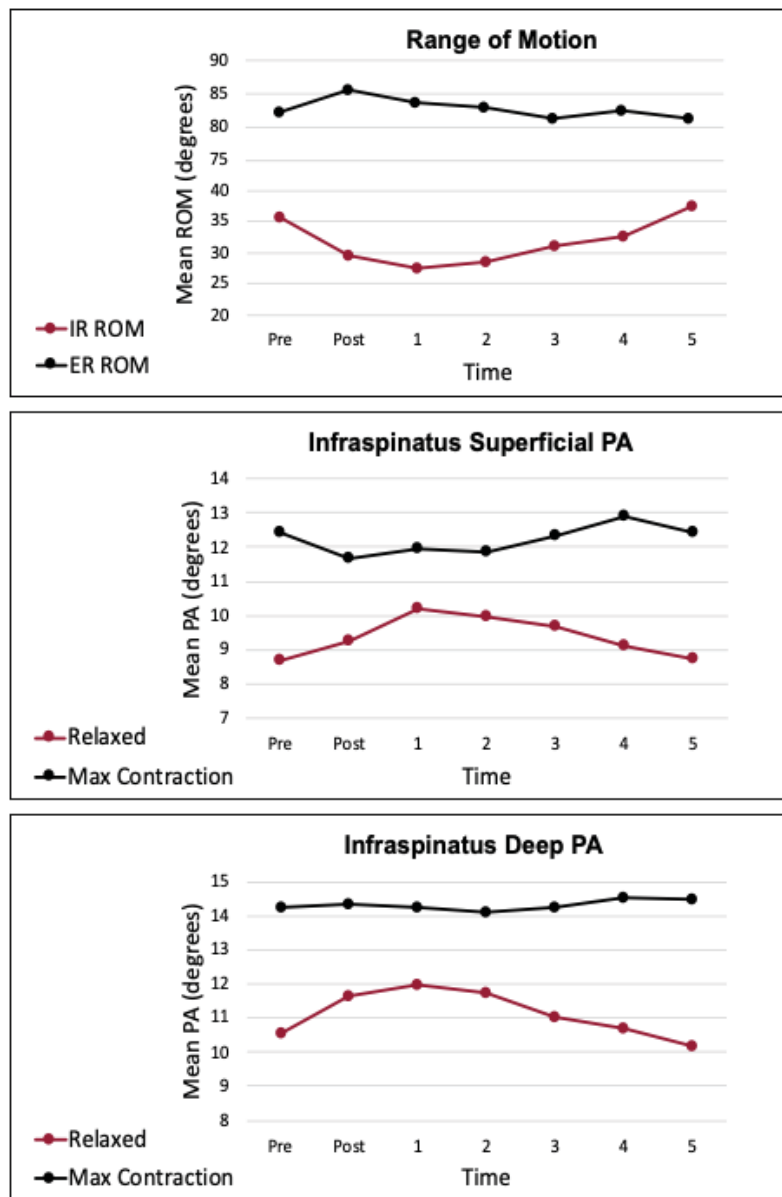


Figure 1. Longitudinal measures of range of motion (ROM) and pennation angle (PA) of the superficial and deep portions infraspinatus at rest and maximal contraction.

IR= internal rotation; ER = external rotation

Effects of Standard and Underweight Baseballs on Thoracolumbar Contralateral Flexion and Ball Velocity in Youth Baseball Pitchers

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Context: The use of underweight baseballs has demonstrated kinematic changes to the upper extremity that produce increases in arm and ball velocities and may reduce injuries in youth baseball players. Increasing the amount of contralateral flexion of the trunk during the pitching motion is associated with greater ball velocity and increased joint loading. It is unknown if using an underweight baseball affects contralateral flexion of the trunk. The purpose of this study was to compare the effects of using a standard baseball and an underweight baseball on thoracolumbar contralateral flexion and ball velocity in youth baseball pitchers during a simulated game. **Methods:** This crossover study design included nine youth baseball players (age: 9.9 ± 1.4 years, height: 143.7 ± 5.8 cm, mass: 34.4 ± 3.2 kg) with prior pitching experience. Participants pitched on two different days separated by at least 72 hours. Through random assignment, each participant pitched with a standard 5oz (142 g) baseball on one day and an underweight 4oz (113 g) baseball on the other day. Participants

were blinded to the ball weight. To simulate a game, participants threw a total of 75 pitches off a turf mound from the stretch position with 15 seconds between pitches and five minutes of rest after every 15 pitches. Kinematic trunk data were captured using inertial measurement units at C7 and L3 vertebrae interfaced with a video camera. Ball velocities (m/s) were recorded with a radar gun. Post analysis of the software and video recordings determined the thoracolumbar contralateral flexion (degrees) at peak glenohumeral external rotation for each pitch. For each participant, the averages for thoracolumbar contralateral flexion and ball velocity were calculated for pitches #6-10 (beginning), #36-40 (middle), and #71-75 (end). The independent variables were ball (standard and underweight) and time (beginning, middle, and end). To analyze the differences in thoracolumbar contralateral flexion and ball velocity, 2x3 factorial ANOVAs were performed ($p < 0.05$). **Results:** There was a significant main effect for ball ($F_{1,8} = 6.927$, $p = 0.03$), in that there was greater thoracolumbar contralateral flexion with the underweight ball ($18.5 \pm 10.4^\circ$) compared to the standard ball ($15.1 \pm 10.4^\circ$). There were no other significant main effects or interactions for thoracolumbar contralateral flexion or ball velocity. **Conclusions:** Using an underweight baseball was found to create more thoracolumbar contralateral flexion in youth baseball pitchers compared to a standard weight baseball. The weight of the baseball did not affect ball velocity

and thoracolumbar contralateral flexion did not change as the simulated game progressed. This information may be useful to clinicians and coaches working with youth baseball pitchers. Future research should investigate the effects of underweight baseballs on the kinetics and kinematics of the upper extremity during a simulated game in this age group.

Neuromuscular Function of the Upper Extremity Musculature in Individuals With a History of Glenohumeral Labral Repair

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Context: Neuromuscular dysfunction in shoulder girdle and upper extremity muscles is commonly observed in individuals with glenohumeral labral repair, yet remains an under-appreciated consequence of joint injury. Postoperative neural impairments from spinal and supraspinal pathways are hypothesized to contribute to the persistent muscle weakness, which may negatively affect shoulder-specific function and perceived quality of life. Although identifying the specific origin of impairment has been theorized to help inform targeted treatment approaches to facilitate muscular recovery, there is limited evidence regarding the origins of muscular impairments in individuals with glenohumeral labral repair. Our objectives were to compare peripheral, spinal and supraspinal measures of neuromuscular function in the upper extremity musculature between individuals with glenohumeral labrum repair and uninjured matched controls. **Methods:** We conducted a cross-sectional study of 16 individuals with a primary, unilateral glenohumeral labral repair

(13M/3F, age: 24.1 ± 5.0 years, time from surgery: 36.7 ± 33.3 months) and 14 uninjured controls (11M/3F, age: 23.8 ± 2.7 years) in a research laboratory. Peak shoulder abduction and wrist flexion maximal voluntary isometric contraction (MVIC) torque (Nm/kg), motoneuron pool excitability of the flexor carpi radialis (Hoffmann reflex [H:M ratio]), corticospinal excitability of the upper trapezius, middle deltoid and flexor carpi radialis (active motor threshold [AMT, %]) were measured bilaterally during one study visit. Dependent and independent t-tests were used to assess between-limb and between-group comparisons, respectively ($p \leq .05$). Cohen's d effect sizes with 95% confidence intervals were used to quantify the magnitude of differences observed. **Results:** Compared to the contralateral limb, shoulder abduction MVIC torque (0.69 ± 0.09 vs. 0.79 ± 0.08 Nm/kg, $p < .001$, $d = -1.16$ [-1.91, -0.41]) and wrist flexion MVIC torque (0.22 ± 0.03 vs. 0.23 ± 0.03 Nm/kg, $p = .02$, $d = -0.38$ [-1.10, 0.34]) were lower, and AMT for the upper trapezius was higher (44.7 ± 2.9 vs. $41.6 \pm 4.4\%$, $p = 0.01$, $d = 0.81$ [0.09, 1.53]) in the involved limb. Compared to the matched control limb, shoulder abduction MVIC torque (0.69 ± 0.09 vs. 0.81 ± 0.10 Nm/kg, $p < .001$, $d = -1.17$ [-1.94, -0.39]) and H:M ratio for the flexor carpi radialis (0.17 ± 0.12 vs. 0.28 ± 0.09 , $p = .01$, $d = -0.99$ [-1.75, -0.23]) were lower, and AMT for the upper trapezius (44.7 ± 2.9 vs. $40.8 \pm 3.4\%$, $p < .001$, $d = 1.23$ [0.44, 2.01]) was higher in the involved limb. **Conclusions:** Individuals with a history of glenohumeral labral repair demonstrated large magnitude deficits in shoulder

abduction strength and corticospinal excitability in the involved limb compared to contralateral, and a reduction in motoneuron pool excitability compared to uninjured controls. These data provide supporting evidence of the presence of neuromuscular impairments following glenohumeral labral repair, suggesting the role of both centrally and peripherally mediated function to activate upper extremity musculature both adjacent and distal to the injured joint. These findings may suggest the need to address such factors in rehabilitation following glenohumeral labral repair.

Evaluation Techniques

June 23, 2021, 2:15-3:15 PM; Moderator: Scott Piland, PhD, ATC

Symptom Provocation During Early-Stage Concussion Rehabilitation: A Randomized Trial of Two Protocols in Professional, Collegiate/University, and Interscholastic Athletes

Register-Mihalik JK, Guskiewicz KM, Marshall SW, McCulloch KL, Mihalik JP, Mrazik M, Murphy I, Naidu D, Ranapurwala SI, Salmon D, Schneider K, Gildner P, Kostogiannes V, McCrea M, Active Rehab Study Consortium Investigators: University of North Carolina at Chapel Hill, Chapel Hill, NC; University of Alberta, Edmonton, AB; New Zealand Rugby, Wellington, New Zealand; Canadian Football League, Toronto, ON; University of Calgary, Calgary, AB; Medical College of Wisconsin, Milwaukee, WI; Elon University, Elon, NC; North Carolina Central University, Durham, NC; Lynchburg University, Lynchburg, VA; Catawba College, Salisbury, NC; York University, Toronto, ON

Context: Post-concussion rehabilitation interventions are an important management strategy for healthcare professionals. Few studies have used randomized clinical trial (RCT) designs to quantify symptom provocation for clinical interventions. This study examined symptom provocation and adverse events (AEs) associated with two concussion rehabilitation intervention strategies among professional, college, and high school athletes participating in diverse sports. **Methods:** This cluster randomized, pragmatic trial was conducted in sports medicine field-based settings. It included 251 concussed athletes (median age=20.7 years; female n=48) from New Zealand professional

rugby (n=31), Canadian professional football (n=52), United States (U.S.)/Canadian colleges (n=128) and U.S. high schools (n=40). The two treatment groups included interventions directed/supervised by site medical personnel (e.g., athletic trainer, athletic therapist, physician): 1) Multidimensional Rehabilitation (MDR): symptom directed exercises from the time participants' symptoms were stable throughout recovery (n=132); and 2) Enhanced Graded Exertion (EGE): international consensus return to sport strategy, and sport specific activities only (n=119). Once asymptomatic, EGE activities were integrated in the MDR group. Participants completed a symptom checklist (22-item) pre- and post-session yielding total symptom severity scores (possible range 0-132). The study outcomes were symptom severity score increases pre- to post-session (proportion with increase), including those exceeding a reliable change (10+ symptom severity score points), and reported AEs. Rehabilitation sessions (# sessions) were the analysis unit. Frequencies, proportions with 95% Confidence Intervals (CI), medians, and Interquartile Ranges (IQRs) were calculated as appropriate for outcomes by treatment group. **Results:** There were 1441 activity-based intervention sessions (MDR=819, EGE=622). MDR participants completed a median of 6 sessions [Interquartile Range (IQR): 5,9] and EGE participants a median of 5 sessions (IQR=4,6). There were 229/1441 (15.9%) sessions resulting in pre-post symptom increases. Symptom increase rates were similar for MDR and EGE arms (MDR: 16.1%, 95% CI:13.6%,18.6%; EGE: 15.6%, 95% CI: 12.8%,18.4%). In total, only 8/1441 (0.6% of sessions) resulted in a pre-post symptom increase beyond a reliable change (10+ severity point increase): 7 during MDR (0.9%) and 1 during EGE (0.2%). Of these 8 significant symptom increases, 7 resolved to within reliable change by the next session. Two study-related AEs (MDR=1, EGE=1)

were reported. MDR AE: symptom spike where a professional sport participant's symptom severity score remained elevated above reliable change at their next session. This participant withdrew from the study but recovered. EGE AE: collegiate athlete reporting to the ED following worsening headache. Neuroimaging was normal. The participant recovered and returned to sport. **Conclusions:** Both MDR and EGE activities resulted in very low rates of symptom increase beyond a reliable change (<1%) and there were only 2 intervention-related AEs reported in the 1441 sessions. These data indicate acceptable safety for these two medically supervised protocols. Results will inform clinical expectations concerning the prevalence of safety-related issues during concussion rehabilitation.

The Association Between Sensation-Seeking Behaviors and Concussion-Related Knowledge, Attitudes, and Perceived Norms Among Collegiate Student-Athletes

Callahan CE, Kay MC, Mihalik JP, Marshall SW, Gildner P, Kerr ZY, Cameron KL, Houston MN, Mrazik M, Register-Mihalik JK: University of North Carolina at Chapel Hill, Chapel Hill, NC; University of Southern Mississippi, Hattiesburg, MS; Keller Army Hospital, West Point, NY; University of Alberta, Edmonton, AB

Context: Athletes are more likely to participate in sensation-seeking behaviors compared to non-athletes. Minimal research exists surrounding the relationship between risky behaviors; personality/behavioral tendencies; and concussion-related knowledge, attitudes, norms, and perceived control over reporting. This study investigated the association between sensation-seeking behaviors and concussion-related knowledge, attitudes, perceived norms, and perceived control among collegiate student-athletes. **Methods:** The study utilized a retrospective cohort of collegiate student-athletes at one institution participating in two parent studies: 1) the National Collegiate Athletic Association-Department of Defense Concussion, Assessment, Research and Education (CARE) Consortium, a longitudinal study assessing concussion effects in United States collegiate student-athletes, and 2) the Behaviors, Attitudes, Norms, and Knowledge (BANK) study, a pre-validated cross-sectional

survey assessing concussion-related perceptions and behaviors. Both studies' preseason, baseline data were collected and merged using a participant link key. Sensation-seeking was collected as part of CARE using the validated Brief Sensation-Seeking Scale, which includes eight items that measure experience seeking, boredom susceptibility, thrill/adventure seeking, and disinhibition. A final score was calculated by averaging all eight answers (possible range=1-5). Dependent variables originated from the BANK study's survey: concussion knowledge (39 yes/no questions, correct scores=1 point, possible range=0-39); attitudes toward concussion (six, 7-point scale items, possible range=7-42); perceived social norms surrounding concussion (seven, 7-point scale items, possible range=7-49); and perceived control over concussion symptom disclosure [single, 7-point scale item, dichotomized to higher (1-5) vs. lower control (6-7)]. Higher scores indicated better outcomes for all (continuous and dichotomized) dependent variables. Separate multivariable linear regression models estimated mean differences (MD) and 95% confidence intervals (CI) for the association between sensation-seeking (1 point increase) and concussion knowledge, attitudes, and perceived norms. A multivariable binomial regression model estimated an adjusted prevalence ratio (PR) and 95%CI for the association between sensation-seeking and perceived control over symptom disclosure. All models adjusted for sex, sport, and concussion history. **Results:** We included 296 student-athletes (51.9% male, 66.4% non-first-year, 79.3% Caucasian, 69.9% contact sport participation, 25.3% with concussion histories) with data from both parent studies. Study variable means and

standard deviations: sensation-seeking 3.1 ± 0.3 , knowledge 33.3 ± 5.3 , attitudes 33.2 ± 7.1 , and perceived norms 44.9 ± 4.4 . Overall, 93.6% reported high control over symptom disclosure. Higher sensation-seeking was significantly associated with less favorable attitudes toward concussion (1 point scale increase, adjusted MD=-1.95; 95%CI=-3.05,-0.85) and less favorable perceived norms surrounding concussion (adjusted MD=-1.40; 95%CI=-2.07,-0.73). No associations were observed between sensation-seeking and knowledge or perceived control. **Conclusions:** Student-athletes with greater sensation-seeking behaviors were more likely to have worse concussion attitudes and perceived norms, despite maintaining knowledge and perceived control consistent to those with less sensation-seeking. For clinicians, this finding is important when identifying individuals at risk for delaying concussion care-seeking. Future research should identify specific sensation-seeking behaviors associated with timely symptom disclosure and interventions to improve such outcomes.

The Association of Sleep Symptoms and Concussion Recovery in Collegiate Athletes

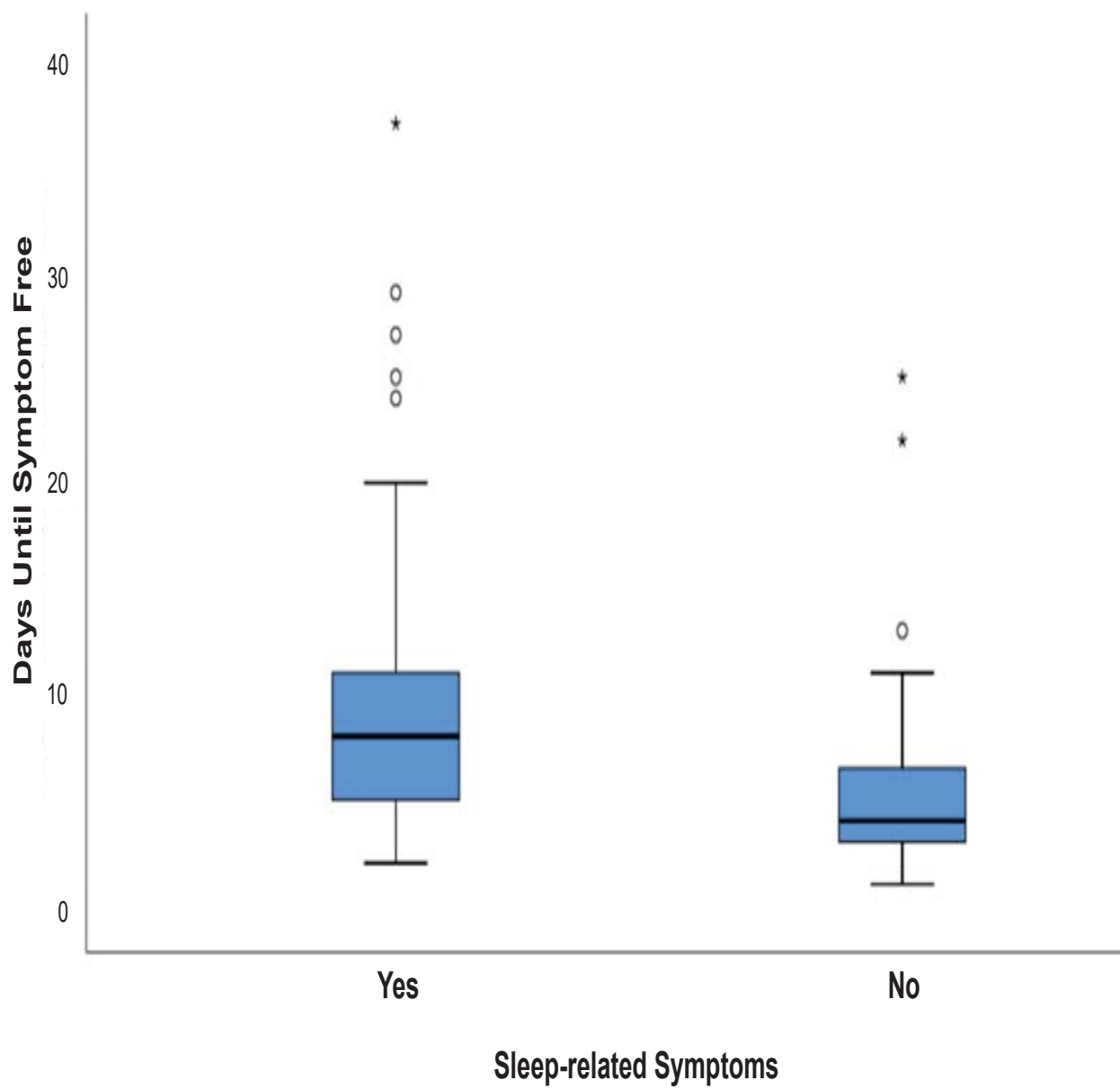
Donahue CC, Resch JE: University of Virginia, Charlottesville, VA

Context: Following a sport concussion (SC), individuals may experience a myriad of symptoms. Disrupted sleep duration and quality is a common complaint of SC and has been identified as a potential modifier of a protracted recovery following injury. However, limited data exists that supports the role of sleep in recovery from SC in collegiate athletes. The primary purpose of our study was to determine if the number of days varied between collegiate athletes with or without sleep-related symptoms following a diagnosed SC. We hypothesized that collegiate athletes who reported sleep-related symptoms would take a greater number of days to report symptom free following their diagnosis compared to athletes who did not. **Methods:** Participants consisted of 108 (20.3 ± 1.3 yrs; 71 male, 37 female) Division 1 collegiate athletes who sustained a SC between the 2016 and 2019 sport seasons. Subjects participated in football ($n=48$), lacrosse ($n=13$), soccer ($n=8$), rowing ($n=7$), cheer/dance ($n=6$), volleyball ($n=5$),

swim/dive ($n=5$), basketball ($n=4$), field hockey ($n=3$), wrestling ($n=3$), baseball ($n=2$), squash ($n=1$), and tennis ($n=1$). Following a diagnosed SC, participants were administered the revised head injury scale (HIS-r) within 72 hours of injury. Participants were classified into groups based on if they reported ($n = 76$ [46 male, 30 female]) or did not report ($n = 32$ [25 male, 7 female]) sleep-related symptoms which included “sleep disturbances” and/or “drowsiness” on the HIS-r. All participants included in our analysis made an unrestricted return to play in alignment with the university concussion protocol following their symptom-free assessment. As days to symptom-free was nonnormally distributed, a Mann-Whitney U test was used to compare the number of days until symptom-free between groups. Analyses were performed with $\alpha=0.05$.

Results: Of the 76 participants who endorsed sleep-related items, 42 reported “drowsiness”, 9 reported “sleep disturbances”, and 25 reported both symptoms. Participants with sleep-related symptoms (Figure 1) took significantly ($z=-3.85$, $p<0.001$, $\eta^2=-0.14$) more days (median [full range]=8.00 [2-37]) to recover with a mean rank of 62.00 when compared to participants who did not endorse sleep-related symptoms (4 [1-25]) who had a mean rank of 36.69.

Conclusions: Our results suggest that individuals who experience sleep-related symptoms in the first 72 hours following a diagnosed SC, may take almost twice as long to report symptom free. Our preliminary evidence highlights the role sleep may play in recovery following SC in collegiate athletes.



Performance on the Concussion Balance Test (COBALT) is Indicative of Time to Recovery in Athletes Following Sports-Related Concussion

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Context: Sports-related concussions (SRCs) are commonly occurring injuries among athletic and recreationally active populations which result in a potential loss of balance function that must resolve before returning to contact or risk activity. It has been suggested that the extent of vestibular impairment is a factor that may influence recovery time. The purpose of this study was to evaluate the effect of vestibular function on recovery following SRC. We hypothesized that subjective and objective measures of vestibular function combined with other known influences of time to recovery would be predictive of recovery time. **Methods:** This retrospective cohort study included patients diagnosed with SRC presenting to a concussion clinic between August of 2016 and July 2017. A total of 32 patient charts were included for analysis (21 males, 15.34 ± 1.47 years, 171.29 ± 8.44 cm, 68.37 ± 15.47 kg). Patients were eligible for inclusion if they were between 14 and 24 years of age, diagnosed with

a SRC, presented to the clinic within 14 days of initial injury, and completed objective vestibular testing. Data were collected via electronic medical records, de-identified, and manually imported into a database. Scores on the Post-Concussion Symptom Scale, Dynamic Visual Acuity Test (DVAT), Gaze Stabilization Test (GST) Concussion Balance Test (COBALT), and other clinical data (days to successful completion of each test and patient demographics including concussion/health history) were used for analysis. Descriptive statistics were calculated for all included variables. Pearson's correlations were used to identify variables related to time to recover. Variables that demonstrated significant relationships with days to recover were entered into a forward linear regression model. Alpha was set a-priori at ≤ 0.05 . **Results:** Patients presented to the clinic for an initial visit an average of 5.97 ± 3.71 days following injury. Thirteen patients had a history of concussion (1 (n=10), 2 or more (n=3)). Average time to recover within the sample was 27.21 ± 11.61 days. Moderate to good relationships were identified between days to recover and DVAT lines lost in the leftward direction (1.17 ± 0.52 ; $r=0.39$, $p=0.04$), COBALT-Condition 8 sway velocity (1.20 ± 0.18 ; $r=0.44$, $p=0.01$), and days to successful completion of the COBALT (14.72 ± 8.35 ; $r=0.63$, $p=0.00$). The regression model determined that participants' predicted time to recover was equal to $-6.49 + 0.77$ (days to COBALT) $+ 18.71$ (COBALT-Condition 8 sway velocity). The overall model was significant ($p<0.001$, $R^2=0.69$). **Conclusions:** Predictors of time to recovery in an adolescent

and young adult athlete sample reporting to the concussion clinic included higher days to successful completion of COBALT and higher average sway velocity on Condition 8, a balance assessment that incorporates vestibulo-ocular reflex cancellation task. Understanding visual and vestibular function during the early part of recovery may provide insight into recovery trajectory and may be used to inform rehabilitation efforts.

The Effects of Concussion on Quantity and Quality of Sleep

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Timmons M, Gilliland A: Marshall
University, Huntington, WV

Context: The reason for this study was to observe how the effects of a concussion change the quantity and quality of sleep in collegiate athletes. There is a lack of research pertaining to this topic, specifically collegiate athletes, and the changes in sleep outcomes during concussion recovery from a concussion. **Methods:** The study design is a convenient cohort in the field involving athletes from two local universities. The participants had to meet the inclusion criteria and sign a consent to be included in the study. There were two groups of participants at each university, one a baseline non-concussed group, and the second was a concussion group. All subjects were male and between the ages of 18-25. For the baseline group, there could be no history of concussion. The concussion group sustained a concussion during the study. Exclusion criteria also included any psychological disorders, sleeping disorders, recent travel through multiple time zones, or taking medications that induced sleep. Participants wore a Readiband™ device for 7-10 or throughout

their concussion recovery. Concussed participants completed a symptom score sheet every day. After 7-10 days or athletes returned-to-play, the device was returned, and a Pittsburgh Sleep Quality Index Questionnaire (PSQIQ) was completed. The sleep parameters and PSQIQ scores were analyzed using non-parametric testing. Independent t-tests analyzed concussed vs. non-concussed sleep outcomes. Independent variables included: sleep quality, sleep quantity, awakenings per hour, total awakenings, wake after sleep onset, sleep efficiency, wake time, and player schedules. Dependent variables included: non-concussed collegiate football players and concussed collegiate football players. Significance was set at the .05 level. **Results:** The t-tests indicated a difference between the total minutes in bed at the initial measurement ($df = 11.839$, $p = .037$) between the concussed (353.29 ± 110.48 minutes) and non-concussed (471.5 ± 125.09 minutes) groups. There was also a difference between the total minutes asleep at the initial measurement ($df = 12.662$, $p = .032$) between the concussed (286.43 ± 86.73) and non-concussed groups (383.7 ± 104.86). The last measurement that indicated a difference was the calculated minutes in bed at the initial measurement ($df = 11.916$, $p = .023$) between the concussed (326.4 ± 97.01) and non-concussed

groups (441.60 ± 110.55). **Conclusions:** The results of this study indicate that concussion affects the quantity of sleep, with concussed athletes spending less time in bed and fewer minutes asleep. Understanding that changes in sleep occur post-concussion, which may delay their recovery time as sleep is important for recovery and performance. This research can formulate new standards of care for athletes through the duration of concussion and recovery.

The Effects of the COVID-19 Pandemic on ImPACT Performance in Collegiate Athletes

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Context: Collegiate athletes competing during the on-going COVID-19 pandemic may be experiencing heightened psychological distress associated with education, athletics, and society. Psychological distress, such as anxiety and depression, may influence baseline performance on computerized neurocognitive tests (CNT). The primary purpose of our study was to compare baseline CNT performance and total symptom burden reported by collegiate athletes prior to and after the COVID-19 pandemic. We hypothesized that collegiate athletes would perform worse on one or more CNT outcome scores and would report a significantly higher total symptom burden during their baseline assessment compared to athletes who were administered the test prior to the pandemic. **Methods:** This retrospective cohort study compared baseline Immediate Post-concussion and Cognitive Test battery (ImPACT) performance of Division I collegiate athletes who completed their assessment preceding the 2019-2020 sport season (Group 1) to athletes who completed the test prior to the 2020-2021 sport season (Group 2). Group 1 consisted of 280 collegiate

athletes (males=162, females=118, 18.74 ± 1.35 y) who were administered ImPACT individually or in pairs in a quiet room (270 sq. ft.) and were seated in a back-to-back position to minimize environmental distractions. Group 2 consisted of 237 collegiate athletes (males=128, females=109, 18.74 ± 1.32 y) who were administered ImPACT individually or in pairs in a quiet room (328 sq. ft.) seated back-to-back. Athletes and their proctor maintained a minimum of six feet between each other during the assessment. Group 2 participants were also screened for COVID-19 related symptoms prior to baseline testing, were signed in for contact tracing purposes, and were required to wear face masks at all times while completing their baseline assessment. Independent samples t-tests were used to compare ImPACT's Verbal (VERBM) and Visual Memory (VISM), Visual Motor Speed (VMS), Reaction Time (RT) neurocognitive outcome scores as well as the Total Symptom Score (TSS). Differences in gender within testing groups was evaluated using a chi-square test. Analyses were performed with $\alpha=0.05$. **Results:** Groups did not differ in terms of age ($t(515)=-0.023$, $p=0.98$) or gender ($\chi^2 = 0.77$, $p=0.38$). For ImPACT composite scores, no statistically significant differences were observed for VERBM ($t(515)=0.30$, $p=0.77$), VISM ($t(515)=1.58$, $p=0.12$), VSM ($t(515)=1.49$, $p=0.14$), or RT ($t(515)=-0.85$, $p=0.40$) or for TSS ($t(515)=-0.80$, $p=0.94$). Means and standard deviations for all ImPACT values are

presented in table 1. **Conclusions:** Overall, ImPACT baseline performance and TSS were not statistically different between collegiate athletes who were administered the test prior to or after the onset of the COVID-19 pandemic. Our data support the clinical utility of baseline ImPACT data collected prior to the 2020-2021 sport season in collegiate athletes.

The Effects of the COVID-19 Pandemic on ImPACT Performance in Collegiate Athletes.

Table 1: ImPACT Composite and Total Symptom Scores

Variable	2019-2020 (Mean \pm SD)	2020-2021 (Mean \pm SD)	P Value
Verbal Memory	89.18 \pm 9.04	88.94 \pm 9.08	0.77
Visual Memory	81.46 \pm 11.01	79.86 \pm 12.02	0.12
Visual Motor Speed	42.59 \pm 6.15	41.80 \pm 5.86	0.14
Reaction Time	0.57 \pm 0.07	0.58 \pm 0.07	0.40
Total Symptom Score	2.18 \pm 4.42	2.22 \pm 4.98	0.94

Frequency and Magnitude of Rotational Impacts in Collegiate Football Players

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Context: The purpose of this study was to investigate the difference of rotational acceleration forces to the head among various football player positions. Helmet and mouthguard accelerometers from Athlete Intelligence were used to track the rotational acceleration caused by impacts to the head during a fall football season. Offensive skilled-position players were expected to have higher frequency and magnitude of rotational impacts in comparison to defensive skilled-position players. **Methods:** The population for this research study consisted of 21 male collegiate football players from various positional groups. Offensive positional players included running backs and wide receivers. Defensive positional players included defensive backs and line backers. The athletes wore accelerometers called CUE sensors in their helmets and Vector mouthguards for the duration of the fall 2019 season. The sensors and mouthguards collected

data from all practices, scrimmages, and games regarding impact location, frequency, magnitude, and acceleration. A one-way ANOVA was used for statistical analysis and the p-value = < .05. **Results:** For the entirety of the fall football season, a total of 7806 impacts were recorded (impact rotational acceleration $M = 169.58$ and $SD = 174.87$). Defensive positional players sustained 3949 impacts ($M = 161.67$, $SD = 77.69$) and offensive positional players sustained 3857 impacts ($M = 177.68$, $SD = 235.73$). Statistical significance was found when comparing rotational acceleration between defensive and offensive players ($p < .001$). A Bonferroni statistical analysis was used to compare rotational acceleration positional groups. Statistical significance was found when comparing defensive backs to wide receivers ($p < .001$), line backers to wide receivers ($p = 0.03$), and running backs to wide receivers ($p = 0.00$). **Conclusions:** The study identified that offensive positional players sustain greater rotation to the head in comparison to defensive positional players. Wide receivers were identified as sustaining the greatest rotation to the head among all of the positional

groups. The data collected from this study is consistent with previous research studies and is consistent with the hypothesis of this research study. While this study helps to further knowledge on rotational impacts in football, more research is needed to determine how it influences injury.

Examining Somatosensory and Neuromuscular Function Throughout Concussion Recovery: A Preliminary Study

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Context: A growing body of research indicates aberrant functional movements are present months after return-to-activity post-concussion. Altered functional movement may indicate dysfunctional somatosensory input and/or motor output, and is theorized to contribute to the heightened musculoskeletal injury risk post-concussion. Somatosensory and neuromuscular impairment have indirectly been examined post-concussion via postural stability and gait assessments, but have not been mechanistically assessed. Therefore, the purpose of our study was to examine somatosensory and neuromuscular function between concussed young adults and healthy matched-controls throughout concussion recovery. We hypothesized concussed individuals would display inhibited somatosensory and neuromuscular function relative to controls. **Methods:** We employed a laboratory-based case-control study with 9 concussed and 9 control participants time-yoked and matched for sex, age, height, mass, and concussion history (66.7% male, age:19.3±1.1 yrs, mass:76.2±13.9kg, height:180.4±12.0cm,

concussion history:0.2±0.6). All participants completed the somatosensory battery acutely (3.7±1.6days post-injury), and 8 concussed and 6 controls completed the neuromuscular assessment when asymptomatic (20.6±20.4days post-injury) due to attrition. All assessments were performed on the dominant limb and are described in the Table. The somatosensory battery comprised of 1) knee absolute joint repositioning error via Biodex joint position sense, 2) plantar pain-pressure threshold via algometry, and 3) plantar touch-sensation threshold via Semmes-Weinstein monofilaments. The neuromuscular assessment utilized the superimposed burst technique to assess quadricep maximal voluntary isometric contraction (MVIC) torque, superimposed burst (SB) torque, and the central activation ratio (CAR; Table). We used Welch's independent t-tests, mean difference 95% confidence intervals (95% CI), and Hedges' g effect sizes to compare somatosensory and neuromuscular outcomes between groups ($\alpha=0.05$). **Results:** Concussed participants required greater pressure to detect touch-sensation (1.9gmm±1.6 vs 0.6gmm±0.7; 95% CI: 0.1, 2.6; $p=0.04$; $g=1.05$) relative to controls acutely. Joint repositioning error (concussed: 8.3°±3.3 vs control: 11.1°±3.9; 95% CI: -6.4, 0.8; $p=0.12$; $g=-0.78$) and plantar pain-pressure thresholds (concussed: 24.3N/cm2±11.2 vs control: 21.5N/cm2±7.7; 95% CI: -6.9, 12.3; $p=0.56$; $g=0.29$) did not differ between groups acutely. The MVIC torque (concussed: 1.0Nm*bw-1±0.4

vs control:0.8Nm*bw-1±0.2; 95% CI: -0.2, 0.5; $p=0.27$; $g=0.60$), SB torque (concussed: 0.4Nm*bw-1±0.2 vs control: 0.3Nm*bw-1±0.2; 95% CI: -0.2, 0.3; $p=0.69$; $g=0.50$), and CAR (concussed: 72.4%±17.9 vs control: 72.9%±11.0; 95% CI: -17.5, 16.5; $p=0.95$; $g=-0.03$) did not differ between groups when asymptomatic. **Conclusions:** Our preliminary findings identified worse plantar touch-sensation among concussed individuals compared to controls with a large effect size, potentially indicating diminished cutaneous mechanoreception acutely post-concussion. Though no other outcomes were significantly different between groups, joint position sense, MVIC, and SB torque displayed medium to large effect sizes which may indicate the concussed group had better joint position sense, greater MVIC recruitment, and SB potential in the absence of statistical differences given our limited sample size. Future research with a larger sample over multiple timepoints is warranted to enhance the clinical interpretation of these findings.

Assessment	Assessment Setup/Parameters	Outcome(s)
Knee joint position sense (JPS)	Blindfolded on Biodex with dominant leg fixed to moment arm. Biodex passively moved lower leg from three starting positions (105°, 30°, 90° knee flexion) to three test position (75°, 60°, 45° knee flexion) blocks at 1°/s, respectively, after being statically placed at the test position for 10s each trial. Three trials per position block (9 trials total). Participant pressed a trigger that marked their current joint angle when they believed their knee was at the specified target position.	The averaged absolute joint repositioning error (°) for all three test positions combined.
Algometry	1cm ² algometer applicator over the dominant foot medial longitudinal arch origin applied at 9N/s for 3 trials. Participant stated "stop" immediately when the pressure was perceived as switching from a pressure to start of pain.	Average pain-pressure threshold (N/cm ²).
Semmes-Weinstein Monofilament	Semmes-Weinstein monofilaments applied to dominant foot's first metatarsal head via standardized "4-2-1" stepping protocol. Participant blinded to filament application and stated "yes" whenever they felt a touch sensation.	Plantar touch sensation –final filament detected (grams).
Neuro-muscular	Computer-controlled knee extension isometric machine and electrical stimulation unit using the superimposed burst technique consisting of a maximal voluntary isometric contraction (MVIC) for 3s. At 2.5s into the MVIC, the remaining dominant leg quadricep muscle fibers were recruited via supramaximal electrical stimulation (10-train, 200µs signals at 200V and 500mA). Participant provided maximal isometric knee extension at a constant, plateaued rate throughout 3s trials.	<i>All outcomes normalized to body weight (Nm*bw⁻¹).</i> <u>MVIC torque:</u> Mean MVIC torque 0.5s prior to electrical stimulation. <u>Superimposed burst (SB) torque:</u> electrically stimulated torque increase over MVIC. <u>Central activation ratio (CAR):</u> $100 * \frac{MVIC}{(MVIC + SIB)}$

Free Communications, Oral Presentations: Tactical Athletes Injury Reporting and Perceptions

June 23, 2021, 3:30-4:30 PM; Moderator: Kenneth Cameron, PhD, MPH, ATC

The Effects of mTBI Lifetime Incidence on Cortical Thickness in Special Operations Force Combat Soldiers
Powell JR, DeLellis SM, Kane SF, Lynch JH, Means GE, Mihalik JP:
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Context: Special Operations Forces (SOF) combat Soldiers frequently sustain blast and blunt neurotrauma. While most military brain injuries are classified as mild traumatic brain injuries (mTBI), repetitive exposure may increase the risk of long-term neurological sequelae. Identifying neurostructural changes associated with increased mTBI lifetime incidence may indicate preliminary neurodegenerative changes, which contribute to poor neurological outcomes. Cortical thickness is a neuroanatomical measure of grey matter integrity. Abnormalities reflect processes including cell-loss due to pathology, drug abuse, and injury. Few studies have described the cortical changes associated with military mTBI. The purpose of this study was to determine the effects of mTBI lifetime incidence on cortical thickness in SOF combat Soldiers. **Methods:** Special Operations Forces combat Soldiers (n=231, age=31.8±3.3 years) consented to this cross-sectional study. Self-reported lifetime mTBI incidence was

collected and grouped into 0, 1-2, and 3+. Neuroimaging was conducted using 3.0-tesla MRI scanners (Siemens MAGNETOM Prisma and Siemens Biograph mMR) at a biomedical research imaging center. Whole-brain T1-weighted 3D anatomical images, acquired with magnetization-prepared rapid gradient echo (voxel size=1.0 mm³, repetition time=2300ms, echo time=2.98ms, flip angle=9°, interval time=900ms), were processed with FreeSurfer 7.1.0 cortical reconstruction and segmentation (recon-all function). Data were resampled to an average template and smoothed with a 10mm full-width half-maximum Gaussian kernel. General linear models were used to investigate group differences (0 vs. 3+ and 1-2 vs. 3+) in cortical thickness. Each hemisphere contains >100,000 vertices, inflating false discovery at the P<0.05 level. Therefore, a vertex-wise cluster-forming threshold of P<0.01 was applied to identify clusters of adjacent vertices that differed between groups. Permutation simulations (1000 iterations) were used to obtain the distribution of the maximum cluster size under the null hypothesis. Clusters with cluster-wise P value (CWP)<0.05 were considered significant. Bonferroni corrections were applied between hemispheres. **Results:** Soldiers with 0 mTBI incidence accounted for 119 participants, 54 had 1 or 2 mTBIs, 59 sustained 3+ mTBIs. While five clusters were initially identified comparing cortical thickness between the 0 and 3+ mTBI groups, no clusters remained significant following the permutation simulations. The

hemisphere, region, surface area, CWP, and 90% confidence intervals (90%CI) for CWPs for these clusters are provided in the Table. All clusters indicated thinner cortex for the 3+ mTBI group. For the 1 or 2 vs. 3+ comparison, no clusters were identified at either hemisphere. **Conclusions:** Only differences between 0 and 3+ mTBI groups were found after whole brain vertex-wise comparisons. While no clusters remained statistically significant following cluster-wise simulation correction for multiple comparison, these analyses are exploratory in nature. Trends indicate inferior frontal and temporal region targets for future research. Understanding the neuroanatomical changes associated with repetitive mTBI exposure, especially in military personnel, may aid clinicians in conducting more targeted assessments for repetitive mTBI exposure.

Table. Clusters identified following whole brain vertex-wise comparisons between the 0 and 3+ mTBI. All clusters indicate regions of thinner cortex for the 3+ mTBI group.

Hemisphere	Region	Surface Area (mm ²)	Cluster-wise P value (CWP)	90% Confidence Intervals for CWP	
				Lower	Upper
Left	Inferior temporal cortex	540.66	0.08	0.06	0.09
Left	Pars opercularis	250.75	0.37	0.35	0.40
Right	Pars opercularis	325.34	0.29	0.27	0.32
Right	Insula	240.13	0.45	0.42	0.47
Right	Superior temporal	234.39	0.46	0.43	0.48

Factors Associated With Musculoskeletal Injury in Military Officers During a Six-Month Officer Training Course

Barrett AS, Ricker EA, Goforth CW, de la Motte SJ: Consortium for Health and Military Performance, Department of Military and Emergency Medicine, F. Edward Hébert School of Medicine, Uniformed Services University, Bethesda, MD; Henry M. Jackson Foundation for the Advancement of Military Medicine; Naval Medical Research Center, Silver Spring, MD

Context: Musculoskeletal injury (MSK-I) is the leading cause of lost duty days in the U.S. military and a threat to military readiness. In particular, MSK-I rates are known to be high during military training. However, little is known about psychosocial factors that may be associated with MSK-I risk in military training environments. The objective of this study is to evaluate relationships among demographic and psychosocial factors and incidence of MSK-I during a 6-month military officer training course. **Methods:** Various surveys were administered at baseline and at the time of training graduation (six months) to assess demographics, MSK-I history, social support, grit, and motivation. Medical encounter data were reviewed for MSK-I during training. A total of 130 females with baseline and post-graduation surveys were matched to 130 males on age and commissioning source. Variables of interest included: Situational Motivation Scale (SIMS) subscale scores (e.g. intrinsic motivation, identified regulation, external regulation,

and amotivation), 8-item Short Grit Scale, 10-item Connor-Davidson Resilience Scale (CD-RISC), and Deployment Risk and Resilience Inventory-2 (DRRI-2) unit, family, and relationship support subscales. Variables deemed statistically significant ($p \leq 0.25$) in univariate analyses were included in multivariate analyses to determine associations with MSK-I during training. Results are reported as adjusted Odds Ratios (aOR) and 95% Confidence Intervals (CI). **Results:** Mean age ($N=260$) was 25 ± 3.2 years. Variables meeting inclusion for multivariate modeling (univariate $p \leq .25$) for MSK-I during training included sex, race, MSK-I within six months prior to training, history of ankle sprain, SIMS, Short Grit Scale, and the DRRI-2. Females were more likely than males to sustain an MSK-I during training (aOR=2.82, 95% CI= 1.51-5.26, $p < 0.001$). Race was collapsed into four categories; White/Caucasian, Black/African American, Hispanic/Latino, Other/Multiracial. Participants identifying as “other” or “multiracial” (aOR 2.7, 95% CI 1.10-6.63, $p=0.03$), those that self-reported an MSK-I six months prior to training (aOR=2.83, 95%CI 1.38-5.82, $p < .01$) or history of ankle sprain (aOR=2.83, 95% CI 1.38-5.82, $p < 0.001$), and those with a greater level of external motivation on the SIMS (aOR=1.25, 95% CI 1.02-1.52, $p=0.03$) were at increased odds of sustaining an MSK-I during training. Specifically, every unit increase on the SIMS external regulation (ER) motivation scale increased the odds of MSK-I 25% during training. **Conclusions:** The odds of sustaining an MSK-I during training appear to be influenced by an increasing ER, independent of race, ankle sprain history, and recent MSK-I. Compared those with lower ER, participants with higher ER may tend to focus more

on rewards or avoiding negative consequences during training, which possibly increases MSK-I risk. Understanding demographic and psychosocial factors that increase odds of future injury during military training is vital for developing risk mitigation and retention strategies. Additionally, health seeking behaviors to properly recover from MSK-Is sustained during training should be encouraged.

Air Force Special Warfare Personnel's Perceptions of Musculoskeletal Injury Reporting

Neitz KL, Hotaling BR, Theiss JL, Cohen BS, Westrick RB: U.S. Army Research Institute of Environmental Medicine, Natick, MA, and Moody Air Force Base, Valdosta, GA

Context: U.S. military Servicemembers (SMs) report 1.6 million musculoskeletal injuries (MSKI) to medical providers each year. Although military personnel seek medical care for a high number of injuries, recent research has revealed that injury concealment occurs in both training and deployed environments resulting in underreporting of MSKIs. Improved understanding of the constructs around MSKI reporting behaviors could have widespread implications for medical readiness and force preservation. Studies using open ended questions and qualitative research methods may provide insight into future injury mitigation strategies. The purpose of this study was to evaluate SMs personal accounts and feelings regarding the Military Health System (MHS) and MSKI reporting behaviors, to understand factors impacting the reporting of injuries among U.S. Air Force Special Warfare personnel. **Methods:** A quasi-qualitative approach was used to analyze

responses to open ended questions about MSKI reporting behavior. This study was part of a larger cross sectional study utilizing survey methodology among USAF Special Warfare personnel stationed at several Army Installations throughout the United States. The open ended questions were intended to facilitate personal insight into reasons SMs do not seek medical care for some MSKIs. **Results:** 119 subjects out of 398 (30%) participated, resulting in 161 total responses. Several themes emerged, including a perception of a flawed MSKI care system, the need for additional sports medicine providers, and favorable opinions of embedded providers. A majority of subjects (N=71, 60%) expressed a desire for change to the current system of MSKI care. A third of responses (N=52, 32%) focused on negative experiences with the MHS. A desire for providers embedded within units, to ensure rapid evaluation and treatment for MSKI, was expressed by 16% of respondents (N=25). **Conclusions:** The use of open ended questions to identify themes regarding injury reporting behaviors of USAF Special Warfare personnel revealed insight into their experiences and perception of MSKI care in the MHS. Future qualitative research may identify opportunities to mitigate barriers to injury reporting, improve our understanding of MSKI challenges, and inform individual and unit readiness strategies.

Dietary Supplement Use in U.S. Service Members During Secondary Training

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Context: Prior studies report that up to 75% of active duty U.S. Service members (SM) regularly use dietary supplements (DS), often with expectations of improved health and/or physical performance despite limited evidence supporting such benefits. Little is known about when SM begin DS use. Given DS use is not permitted during entry level training, secondary training (ST) presents the first opportunity for SM to begin using DS. The purpose of this study is to describe the use of DS in enlisted SM completing ST. **Methods:** Male enlisted U.S. SM (N=274, age=19.6±1.5 yrs.) in either Infantry or Artillery military occupational specialty (MOS) training completed a questionnaire upon ST graduation. Participants answered questions regarding category of DS, frequency and reasons for use, and purchase location; multiple responses per question were allowed. Participants also rated their confidence regarding the statement: “Does the U.S. Government require that all dietary

supplements sold will work as promised?” and rated their confidence regarding DS safety and efficacy. Counts and percentages of responses were evaluated using contingency tables. Pearson Chi-squared tests assessed associations between MOS and DS use. **Results:** Twenty percent (n=54/274) of participants reported at least weekly use of one or more categories of DS during ST; 44% (n=24/54) were Artillery and 56% (n=30/54) were Infantry, which were similar between MOS ($X^2=0.82$, $p=0.37$). Responses to the remaining questions on DS were provided by 40 participants. Participants reported using the following DS categories: individual vitamins/minerals (70%; n=28/40); multivitamins/minerals (60%; n=24/40); protein/amino acids (48%; n=19/40); fish oil (45%; n=18/40); and creatine (3%; n=1/40); 73% (n=29/40) reported using two or more categories of DS. Most use DS to “promote general health” (93%; n=37/40), and for “greater muscle strength” (40%; n=16/40). Participants equally purchased DS both on (70%, n=28/40) and off (63%, n=25/40) their military installation. A majority (65%; n=26/40) reported they were “very confident” or “extremely confident” that DS were safe to consume and 55% (n=22/40) of respondents were “very confident” or “extremely confident” that DS work as claimed. Nearly half (48%, n=19/40) agreed that the U.S. government does not require all DS sold to work as promised, however 45% (n=18/40) were unsure. **Conclusions:** Exploring DS use during ST is the first step in understanding when SM may

begin to use DS in the military. DS use in the current study was relatively low compared to previous research of active duty SM, and therefore, presents an early opportunity to provide education on safe DS use. Furthermore, SM in ST were confident in the safety and efficacy of DS, but were unsure of government regulations. Providing education during ST could address knowledge gaps and/or unsafe DS practices, and help SM avoid health complications or adverse career consequences.

U.S. Army Soldiers Who Do Not Seek Medical Care for Musculoskeletal Injuries Prior to Deployment: Survey Findings From an Infantry Battalion
Mathis KY, Hotelling BR, Adams BG, Smith KA, Westrick RB: U.S. Army Research Institute of Environmental Medicine, Natick, MA

Context: Musculoskeletal injuries (MSKIs) have consistently been recognized as a primary threat to military readiness. This study aims to identify injury reporting behaviors of Active Duty Soldiers preparing to deploy in support of an overseas mission. **Methods:** In this cross-sectional study and observational design, a 55-item survey was distributed in electronic format (NDiV Inc.) to a convenience sample of pre-deploying Army Soldiers from an Infantry battalion. The survey tool included questions regarding symptoms consistent with MSKI, the frequency and type of injuries sustained, if medical treatment was sought, factors that may have influenced injury reporting, and if Soldiers felt that they and their peers are honest when reporting symptoms to medical providers. The surveys were completed in the Soldiers' environments, including outside and inside of work buildings.

There were 137 Soldiers involved in this study. These Soldiers included 123 men and 14 women. The average age of the Soldiers were 24.04 ± 4.66 years. Only descriptive statistics were used in this study. An anonymous survey method was selected to encourage Soldiers to provide honest and accurate responses. The survey was created from Providers and Soldiers with several years of experience in the military. **Results:** In total, 53 out of 137 subjects (38.69%) reported 138 MSKIs within the previous 12 month period (average of 2.60 MSKIs per subject). The majority of injuries were in the lower back (19.57%), and most injuries were gradual onset or chronic (66.67%). The majority of potential MSKIs (60.15%) were not reported to a medical provider. The most common reasons for not reporting injuries were: not wanting to be put on a profile and not wanting to be prevented from participating in training. Few subjects (2.19%) reported having exaggerated symptoms, yet a large number (35.04%) believe that 26-50% of their peers do fake or exaggerate symptoms of MSKI. **Conclusions:** The majority of MSKI symptoms in a cohort of Soldiers pre-deployment were not reported to healthcare providers. These findings are higher than unreported MSKI levels previously found in other military

cohorts (Smith, 2016). From this study we can conclude that strategies to improve Soldiers' willingness to seek medical care for MSKIs are needed for units preparing for deployment. The un-reported injuries in this study are higher than previously reported in other military cohorts; indicating a potential greater likelihood of not disclosing injuries prior to deployment.

Rucksack Palsy in a Military Cadet Soccer Athlete: A Case Report

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Background: Brachial plexus neuropathy common occurs in traumatic events such as those occurring in collision sports. In the military, rucksack palsy is a form of brachial plexus neuropathy that arises from the compression and heavy weight of the cadet's rucksack (back-pack). This type of brachial plexus injury only accounts for a very small percentage of all brachial plexus injuries and is not commonly seen in the general population. We present the case of a non-traumatic brachial plexus injury in a military cadet following a 12-mile hike. An 18-year-old male cadet and collegiate soccer athlete was participating in a twelve-mile ruck as part of summer basic training. At the time of his departure, the patient's rucksack was approximately 25-kg, which was about 9-kg over the typical acceptable weight. The pack was also in poor condition and had a broken waist strap, causing the weight and pressure of his bag to be distributed over his shoulders rather than dispersed through the hips. The patient completed nine miles of the ruck before experiencing severe pain in his right shoulder that radiated down his arm. For the remaining three miles, he

continued to experience severe pain in the right arm however it was now associated with both numbness and paresthesia down the arm. Two days after returning to camp, the cadet's condition did not improve and he reported to the sick hall. He was unable to actively flex or abduct his right arm past ninety degrees. Passive range of motion resulted in a loss of scapular control and scapular winging. The health care providers prescribed rest and referred him to the soccer team's athletic trainer as well as placing the cadet on profile, which removed him from sport participation. He reported to his athletic trainer the following day already showing improvements in shoulder range of motion and strength. **Differential Diagnosis:** Brachial neuropathy, arterial thoracic outlet syndrome, venous thoracic outlet syndrome **Intervention & Treatment:** The athletic trainer initially treated the injury symptomatically before beginning a progressive shoulder and neck strengthening rehabilitation plan with exercises also focused on stabilization and proprioception. Physioballs, Bodyblade® and BOSU® balls were used to assist with scapular positioning and control and glenohumeral proprioception in addition to strengthening. The patient tolerated the strengthening program well and was taken off profile the following day after consultation with the team physician. He slowly returned to soccer related activities as tolerated with specific restrictions on overhead throw-ins, which he was not permitted to perform for one week following his initial return

to participation. Return to full, unrestricted participation occurred approximately one week after the initial injury. He has currently not suffered from any complications or recurrence of his symptoms. His current therapy is focused on reinjury prevention. **Uniqueness:** Brachial plexus neuropathy is a common injury among traumatic events or sports with high contact like football. Rucksack palsy or rucksack syndrome only accounts for a small percentage of those injuries. The incidence of rucksack palsy rises significantly in the military with an estimated number of cases between 29.7 and 53.7 per 100,000 military individuals each year. **Conclusions:** This type of condition is particularly important for health care professionals in the military setting as all cadet-patients are likely to participate in long-distance walking and running activities with heavy packs. Similarly, return to play decisions in this setting may be more complicated as in this case due to the fact that any cadet placed on profile is not permitted to return to their sport until they are removed.

A Qualitative Study of the Perceptions and Expectations Impacting Concussion Care Among Reserve Officer Training Corps (ROTC) Cadets

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Context: Concussions are a paramount concern in military populations given the long- and short-term effects on health and force readiness. Understanding factors that may impact concussion-related care-seeking is essential to improving identification and care in the military environment. This study's purpose was to explore perceptions, factors, and expectations impacting concussion care among reserve officer training corps (ROTC) cadets. **Methods:** The current study utilized a consensual qualitative research tradition/framework based in phenomenology. Twenty-one ROTC cadets (7 males; 14 females;) were interviewed, to reach data saturation. Participants were recruited via convenience sampling. A single, semi-structured in-person interview, transcribed verbatim, accomplished two purposes: 1) address the purpose of the current research question (7 questions) and 2) evaluate a concussion education platform (20 questions). A four-person research team (novice to expert qualitative researchers) individually coded data into themes and categories, and then met to attain consensus

on coding accuracy and comprehensiveness. An internal auditor reviewed results. **Results:** Participant interviews highlighted two key concussion care themes: 1) concussion perceptions and experiences and 2) disclosure support network. Concussion perceptions and experiences included the components of current policies and procedures, military culture, sport culture, and personnel, and each component's role in safety implementation. Participants explained a chain-of-command (COC) in the military where safety decisions were dependent on the context of the situation and the hierarchy of individuals present. Cadets described the assumption of safety decisions being made higher up in the COC. Disclosure support network included roles and responsibilities for concussion. Roles and responsibilities were described as the perceived responsibility and desire to disclose concussive symptoms to trusted individuals including peers, coaches, family, and medical personnel. This theme also included positive vs. negative framing, potential career ramifications, and stigma/pride. Cadets cited the stigma surrounding concussions and the threat injury poses to their status in the military as reasons why they would hesitate to disclose symptoms. In particular, participants described the fear of being perceived as weak if they disclosed an injury. Disclosure support network also included stakes and situational differences between training and missions. Cadets mentioned perceiving training as a lower-stakes scenario than missions and therefore would be more likely to disclose symptoms during training. **Conclusions:** Results suggest that stigma, potential consequences, and the overall military culture may impact a cadet's willingness to disclose concussion-related

symptoms. Cadets described the value of camaraderie and leadership role at each level of the COC that influenced their decisions, making peer and community interactions a key factor in the decision to disclose symptoms. Therefore, with educational interventions, it is important to consider and address education across each level of the COC and the role of military culture, social support, and social perception in a cadet's injury and concussion disclosure decision-making.

Surveillance of Catastrophic Sport and Exercise-Related Injury and Illness Among Middle School, High School, and College Athletes, 2013/14 Through 2018/19

Kucera KL, Register-Mihalik JK, DeLong RN, Stearns RL, Haley CB, Filep EM, Schattenkerk J, Comstock RD, Collins C, Klossner D, Dompier TP, Kerr ZY, Mercer J, Casa DJ, Drezner J, Guskiewicz KM, Marshall SW, Cantu R: National Center for Catastrophic Sport Injury Research, University of North Carolina at Chapel Hill, Chapel Hill, NC; Department of Exercise & Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC; Matthew Gfeller Sport-Related Traumatic Brain Injury Research Center, University of North Carolina at Chapel Hill, Chapel Hill, NC; Korey Stringer Institute, University of Connecticut, Storrs, CT; Center For Sports Cardiology, University of Washington, Seattle, WA; Department of Epidemiology, Colorado School of Public Health, University of Colorado, Denver, CO; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; Sports Medicine, Department of Athletics, University of Maryland, College Park, MD; Lebanon Valley College, Annville, PA; Injury Prevention Research Center, University of North Carolina at Chapel Hill, Chapel Hill, NC; Emerson Hospital, Concord, MA; Boston University, Boston, MA

Context: Surveillance, the first step to understanding the incidence and burden of public health problems, is important in evaluating the effectiveness of preventive measures. Catastrophic sport-related injuries and illnesses among athletes are relatively infrequent events, yet can be physically, emotionally, and economically costly for affected athletes, families,

schools, and communities. The purpose of this analysis was to describe the incidence and characteristics of fatal and non-fatal catastrophic sport and exercise-related injuries and illnesses among United States middle school (MS), high school (HS), and college/university (CU) athletes in organized competitive sports from 7/1/2013 through 6/30/2019. **Methods:** Event details were captured through media searches of publicly available news reports and direct reporting from individuals and national organizations. Characteristics of the athlete, event, and injury were summarized and stratified by severity (fatal versus nonfatal) and event type (traumatic injury versus non-traumatic). Incidence rates per 100,000 athlete-seasons (AS) were reported overall and for fatal events for HS and CU sports with 5 or more events. No denominators are available for MS sports. **Results:** There were 665 catastrophic injuries and illnesses captured over the 6-year period. Of the 665 eligible events, 87.8% (n=584) occurred during sport or exercise and 12.2% were cardiac-related events during at rest or sleep. Of the 584 events during sport or exercise, most occurred in males (87.8%), in high school athletes (72.6%), during official school/team-related athletic activity (91.1%), and were non-fatal (66.8%). Half (50.0%) of events occurred during competition, 30.5% during practice, 9.4% during conditioning/weight training, and 10.1% other. Among the 584 sport or exercise events, traumatic injuries (41.5%), cardiac-related events (45.2%), and heat-related events (10.3%) were most common. Traumatic injury incidence rates in HS and CU were highest in football (2.4 and 6.4 per 100,000 AS, respectively). The highest incidence of non-traumatic exercise-related events in HS and CU occurred in male basketball (1.7 and 13.4 per 100,000 AS) and football (1.1 and 6.9 per 100,000 AS). Fatal events (n=194) were most often cardiac-related (64.4%), head injuries (12.9%), or heat-related (10.8%); most occurred during practice (35.6%), competition (33.0%), or conditioning/weight training (13.4%). The highest fatality rates were in HS and CU football (0.9 and 3.9 per 100,000 AS) and male basketball (0.8 and 3.6 per 100,000 AS). Nonfatal events (n=390) were commonly cardiac-related (35.6%), spinal

cord injuries (29.0%), head injuries (17.2%), or heat-related (10.0%). Most occurred during competition (58.5%), practice (27.9%), conditioning/weight training (7.4%), or scrimmage (2.8%). **Conclusions:** Catastrophic sport-related traumatic injury prevention remains important during competitions and in football in addition to non-traumatic exercise-related events in male basketball. Sudden cardiac arrest and heat illness continue to represent large proportions of fatal and non-fatal sport/exercise-related catastrophic events. Increased attention to emergency preparedness is critical.

Athletic Directors Report of Exertional Heat Illness Policies and Procedures in United States High Schools

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Context: Research has reported low adoption of exertional heat illness (EHI) policies in the high school setting, despite EHI being one of the top three causes of sport-related death. The purpose of this study was to investigate athletic director (AD) knowledge of EHI policies in the high school setting, and the influence of athletic training (AT) services and Title 1 classification on the adoption of these policies. **Methods:** The questionnaire was developed based on the NATA Position Statement: Exertional Heat Illness (2015), validated for content, and distributed via email and social media to ADs in the

United States. A total of n=466 ADs responded, but given the varied distribution methods and the inability to quantify the re-sharing of social media posts, an overall response rate cannot be calculated. Access to AT services was determined by matching AD reported zip code and AT services using the Athletic Training Locations and Services (ATLAS) project. Title 1 schools, those receiving financial assistance to support low-income students, were determined through matching the AD reported zip code with National Center Education Statistics data. If multiple schools were associated with a zip code, AT services and Title 1 classification were classified as "unknown" due to the inability to discern which school had AT access and Title 1 classification. Data analyses include presentation of proportional data for aggregate, AT access, and No AT Access. To identify if associations were present between AT services and Title 1 classification (independent variables) and policy adoption (outcome variable), we performed Chi-Squared Tests of Association (X2) and calculated prevalence ratios (PRs) with 95% confidence intervals (CIs). **Results:** Overall, 77.9% (n=363) of respondents reported adopting an EHI prevention and treatment policy (Table 1). A majority of ADs had access to AT services (61.6%, n=287; No Access=18.9%, n=88; Unknown=19.5%, n=91). ADs with access to AT services were more likely to have a cold-water immersion tub than those without access to AT services (37.4% v 20.8%, X2(1)=4.68, p=0.030, PR=1.80, 95% CI=1.00,

3.21). Non-Title 1 high schools were more likely to have a policy on EHI prevention and treatment compared to those who are classified as a Title 1 school (85.4% v 75.1%, X2(1)=4.28, p=0.038, PR=1.14, 95% CI=1.02, 1.26). No other associations between AT services and Title 1 classification and policy adoption were noted (p>0.05). **Conclusions:** The ADs in this sample report adoption of written policies for most EHI prevention and treatment items, though low reports for the use of wet-bulb globe temperature and rectal thermometer policies are noted. Though ADs may be aware of the EHI policies in their schools, influencing factors such as AT services and Title 1 classification may affect policy adoption.

Table 1. Athletic director responses related to policy and procedure development of exertional heat illness' in US High Schools. Values presented as n (%).

My school has policies and procedures on...	Aggregate	Access to an AT	No Access to an AT
Exertional Heat Illness (prevention and treatment)	363 (77.9)	227 (79.1)	61 (69.3)
My high school's written policy...			
Is based on environmental conditions measured by an on-site Wet-Bulb Globe Thermometer	160 (51.6)	99 (52.4)	24 (46.2)
Is based on environmental conditions that are specific to my region of the country (regionally specific)	227 (73.9)	138 (73.4)	39 (78)
Includes a minimum of 4 levels of modification , including the modification of practice time based on environmental conditions	218 (71.2)	139 (74.3)	34 (66.7)
Includes modification of work:rest ratios based on environmental conditions	228 (75.2)	142 (76.3)	37 (75.5)
Includes modification of protective equipment (if applicable to sport)	243 (80.2)	152 (81.3)	37 (77.1)
Mentions the use of shaded areas for rest breaks	211 (69.2)	128 (68.1)	39 (79.6)
Requires use of rectal temperature for diagnosis and evaluation of exertional heat illness	44 (14.6)	24 (13)	5 (10.2)
Requires a cold-water immersion tub to be on-site (within 5 minutes of each venue)	121 (39.8)	77 (41.2)	13 (26)
Requires a cold-water immersion tub to be set up (including: filled with water, ice chests nearby) during warm weather activities	108 (35.8)	70 (37.4)	10 (20.8)
Requires cooling onsite first, and then transport to the hospital (also known as " cool first, transport second ")	157 (51.8)	98 (52.7)	22 (44)

Access, Engagement, and Experiences With Critical Incident Response Resources

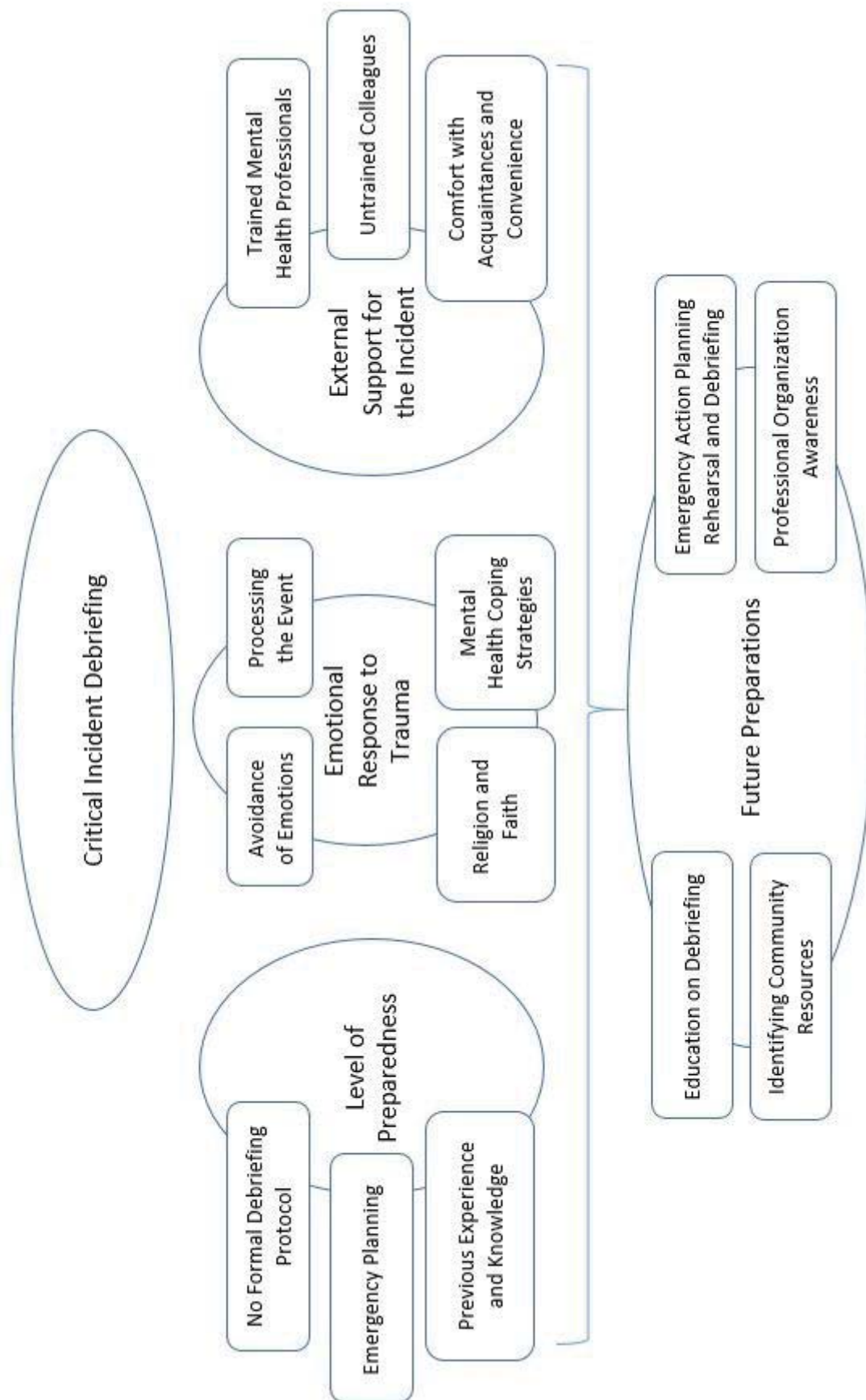
Holmes KL, Granger KC, Neil ER, Eberman LE: Indiana State University, Terre Haute, IN, and Temple University, Philadelphia, PA

Context: A critical incident is defined as experiencing, witnessing, or being confronted with at least one event that involves actual or threatened death, or serious injury of yourself or others. It is an intense, unanticipated event producing serious emotional responses for those encountering the event. Athletic trainers experience critical incidents that can alter their mental status and resources should be available to them to support their overall well-being. The purpose of this study was to identify the accessibility of critical incident response resources for athletic trainers and to explore how they experience their emotional reactions following a critical incident. **Methods:** We used the consensual qualitative research approach with semi-structured interviews focused on access, engagement, and experiences with critical incident response resources. We used a criterion-sampling method to recruit athletic trainers who experienced a critical incident related to clinical practice and used any critical incident response resources in the last year ($n=17$; age = 32 ± 8 ; years of experience = 9 ± 7 ; years in current position = 4 ± 5). Data analysis was conducted using a 3-person team with a multi-phase process to identify the

emerging domains and categories. To establish trustworthiness, we used multi-analyst triangulation and member checking. **Results:** Three domains emerged from the study (Figure): (1) level of preparedness, (2) external support for the incident, and (3) emotional response to trauma. Level of preparedness refers to the participant's preparedness for critical incident management prior to an event. Participants had previous experience and knowledge and emergency planning for healthcare delivery but were not prepared for managing the emotional response following an incident. Participants conveyed they had no formal debriefing training; debriefing is a technique used to help manage physical or physiological symptoms resulting from trauma exposure. However, both the actual situation and the emotional response were often discussed with untrained personnel including friends, family, other athletic trainers or trained mental health professionals through both required and personal referral. Participants noted comfort and convenience with acquaintances when talking about the incident. The participants noted relief when processing the event while focusing on logistical aspects of the incident as a means of debriefing. However, this practice often allowed the participant have avoid emotions surrounding the critical incident. When participants explored their emotional response to trauma, they used personalized mental health coping strategies or religion and faith as a way to address their emotions in conjunction with their external support. **Conclusions:** In preparation for critical incidents, emergency action planning and after

action planning for healthcare delivery and the emotional response are both essential. Many athletic trainers do not have the formal training, but continued education courses, community-based mental health resources, and the promotion of professional organization resources can assist athletic trainers in critical incident management (Figure).

Emergent domains and categories with recommendations for future preparations for athletic trainer's critical incident management.



Stakeholder and Policy Related Factors Associated With Implementation of the NATA-IATF Heat Acclimatization Guidelines

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Context: State mandates of the National Athletic Trainers' Association (NATA) Inter-Association Task Force (IATF) preseason heat acclimatization guidelines are associated with reductions in exertional heat illness (EHI) events in secondary school football. However, the extent of compliance with these guidelines varies, and factors affecting implementation should be identified. This study examined how collaborations with various stakeholders, as well as policy and legislation impact implementation of the NATA-IATF guidelines in secondary school football settings. **Methods:** Semi-structured phone interviews were conducted with 33 secondary school football athletic trainers (ATs) (16 males; 17 females; average age=36±13years) throughout the US who previously participated

in a survey study on compliance with the NATA-IATF guidelines. Interview content focused on factors affecting their high schools' implementation of the NATA-IATF guidelines. Interviews were transcribed verbatim; four progressive analytic stages in the consensual qualitative research tradition were utilized to create a codebook. Study personnel coded each interview; consensus meetings were held to resolve coding discrepancies. **Results:** ATs highlighted the importance of: 1) collaboration with numerous stakeholders and 2) policy and legislation (e.g., best practices, state laws), in successful NATA-IATF guideline implementation. Regarding collaboration, ATs described coaches as being generally supportive, often assisting in recognition and response related to EHI events, but noted instances of pushback. During these instances, support from both athletic and non-athletic administrators (e.g., principals, school board) was important. However, ATs reported little support related to topics such as rectal thermometry. ATs noted referees/officials were typically poor collaborators, but at times helped implement game-specific modifications. Additionally, ATs highlighted the need for collaboration with other healthcare professionals, such as local emergency medical services and other ATs, to ensure optimal patient care. Regarding policy and legislation, ATs noted use of NATA Position Statements as their primary source for initiating policy for their accessibility, clarity, and applicability to various settings. However, ATs noted that EHI best practices have evolved over time, thus requiring such documents to be reviewed and re-evaluated regularly to ensure proper implementation. Further, ATs described NATA-IATF guideline implementation as being helped or hindered dependent on stakeholder motivations for change, and the presence of accountability/enforcement. ATs also suggested that modifications to such guidelines are necessary to address all sports.

Finally, a lack of consistency among standards of care, state-specific mandates, and EMS system protocols proved challenging for many ATs. **Conclusions:** Findings highlight areas of change that may help improve the implementation of NATA-IATF guidelines. There is a need for both continued and improved collaboration among ATs and stakeholders, as well as for better accountability and stricter enforcement of policy and legislation. It is important to consider situational factors that may influence local implementation, such as pre-existing stakeholder relationships, state mandates, accountability/enforcement, and ability to access current EHI-related information.

Proximal Peroneus Longus Degloving Injury in a Women's Soccer Player: Level 4 CASE Study

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Xavier University, Cincinnati, OH

Background: An 18-year-old, women's soccer forward with no relevant lower leg injury history removed herself from preseason practice complaining of pain about her left fibular head. During the on field evaluation she reported feeling a "pull and a pop," around the fibular head while planting her foot to make a cut. She was tender upon palpation about the fibular head and denied tenderness at the lateral malleolus. A bump test was negative for fracture. Dorsiflexion and plantar flexion MMT was a 3/5, while inversion and eversion were not performed due to discomfort. Neurological assessment revealed partial paresthesia along the lower leg associated with the L5 dermatome, all other neurological findings were unremarkable. Due to the localized pain and her neurological symptoms, the patient was referred to the team physician. **Differential Diagnosis:** Proximal peroneal tendon strain, common peroneal or superficial peroneal nerve damage. **Intervention & Treatment:** The next day, the team physician noted: point tenderness at the fibular head; palpable subcutaneous swelling and hematoma along the lateral compartment; severe tenderness at the peroneal longus and brevis muscle belly; severe tenderness distally at the peroneal tendon; and 4+/5 strength in the peroneal muscles. The physician ordered an MRI, which revealed a proximal myotendinous tear. The radiology report indicated a

central myotendinous junction tear with a slight retraction from the proximal muscle belly, also referred as a degloving injury. In addition, there was an intramuscular hematoma in her peroneus longus muscle. The radiologist did not recommend any treatment for the hematoma since it was too small to aspirate. In addition to the MRI, a needle EMG was conducted one month post-injury. The EMG demonstrated decreased left peroneal nerve function below the knee when compared bilaterally, yet still within normal limits. The neurologist was hopeful the nerve function would return due to the mild degree of neural dropout. Due to the rarity of the degloving injury, the team physician recommended conservative treatment for the patient's tendon injury, peroneal neuropathy, and hematoma. The patient was immobilized in a walking boot for 3 weeks, after which she progressed to using the walking boot only for long distances such as walking around campus. At this time, she started to experience hypersensitivity along the sensory distribution of the superficial peroneal nerve. She was instructed to desensitize the area by increasing external stimuli to the lateral lower leg, such as brushing items of various textures across the dermatome. At five weeks post-injury the patient began active and resisted range of motion exercises in the warm whirlpool, which also helped to address her hypersensitivity. By seven weeks post-injury, the patient began part of the team's dynamic warmup during practice, running at 75% maximal effort, and sport specific exercises, such as dribbling and passing. Eleven weeks post injury the patient began participating in noncontact practice, such as full team dynamic warmup and passing

patterns. By week 13 post-injury, the patient was cleared for full participation in soccer practice. **Uniqueness:** The degloving injury of the peroneal tendon has not been reported in the literature, although a proximal rectus femoris tendon degloving has occurred in a football player. However, the rectus femoris degloving was not associated with any neuropathy. It is likely that the soccer player in this case had a congenital malformation at the proximal peroneus longus myotendinous junction that predisposed her to this injury. **Conclusions:** This soccer player suffered a degloving of the proximal myotendinous junction at the peroneus longus tendon, as well as damage to the peroneal nerve. The limitations of neurological diagnostics make it difficult to determine the extent of the nerve damage and the exact injury prognosis. It was important to address this patient's neurological injury.

Acute Traumatic Thyroid Cartilage Fracture in Men's Lacrosse: Level 4 CASE Study
Barrett JL, Siciliano CE: Springfield College, Springfield, MA

Background: A 21-year-old male lacrosse athlete with no significant medical history sustained a direct blow to the anterior neck, from a lacrosse shot, during a game. The athlete immediately complained of pain throughout the anterior neck, pain increased with cervical spine active range of motion. Additional complaints included: trouble “catching his breath”, difficulty swallowing, and feeling tightness in the anterior neck during inhalation and exhalation. The Athletic Trainer’s physical examination identified mild palpable edema along the anterior neck, no palpable deformity of the hyoid, thyroid, or cricoid cartilage. Tenderness was elicited over the thyroid cartilage. Stridor was noted as was dysphonia, hoarseness of voice. The signs of severe injury prompted the AT to seek advanced medical support. **Differential Diagnosis:** Due to the acute direct trauma mechanism, fracture of the thyroid cartilage and/or hyoid bone were suspected. Additionally, a dislocation of hyoid bone was possible as well as a contusion to the anterior neck or a spasm of the sternohyoid, superior omohyoid, thyrohyoid or sternothyroid muscles. **Intervention & Treatment:** The athlete walked to the ambulance, which was on site for the contest, and was provided supplemental oxygen during transport to the emergency department (ED). Within the ED, the Physician suspected a laryngeal cartilage injury. Diagnostic imaging, X-ray, and CT Scan were completed. The CT revealed a closed

fracture of the thyroid cartilage. Surgical intervention was recommended to repair the thyroid cartilage. However, the athlete left the hospital against medical advice and embarked upon a 3-hour car ride to seek care at a surgical facility closer to home. During the ride, the athlete suffered severe respiratory distress. The surgical intervention was completed within 18 hours from injury. The athlete was sedated for 5 days following the surgery. Post-surgical recovery included restrictions of no yelling or whispering, and a limited soft food diet. No physical activity was permitted for 3 weeks after surgery. Voice therapy was completed following initial post-surgery recovery. The athlete made a full recovery and has returned to full athletic activity wearing a throat protector which attaches to the bottom of his face mask when playing lacrosse. **Uniqueness:** The incidence of thyroid cartilage fracture is very low. In an epidemiological report of lacrosse injuries referred to ED’s from 1997-2015, males accounted for 75.5% of injuries, the head and neck accounted for 17.6% of injuries and only 1.5% were treated and admitted to the hospital (Khodaei et al, 2020). Though gender places this athlete in a high-risk category, the incidence of neck injury in lacrosse is low. Suffering from a lacrosse injury requiring hospital admission is rare. Additional epidemiological studies of lacrosse injuries have identified the neck to be involved in 1.1-1.4% of injuries during practice and 1.2-2.2% during games (Kerr et al. 2017; Pierpoint et al. 2019). The current reports do not delineate between injuries of the anterior versus posterior neck. Adding to the uniqueness of this case, the athlete was uniquely fortunate to not experience a catastrophic outcome due to the respiratory distress experienced while traveling by

personal vehicle following diagnosis in the ED. **Conclusions:** The 21-year-old athlete sustained a thyroid cartilage fracture from a lacrosse ball. He exhibited clear signs of serious injury including stridor, difficulty breathing and swallowing, requiring immediate emergent transport to the ED. Though injuries to the anterior neck are rare, athletic trainers must recognize the signs and symptoms necessitating the activation of emergency care. Due to its proximity to the airway, trauma to the thyroid cartilage can be life-threatening. Though this athlete ultimately had a successful outcome, it is not advisable to leave the ED and travel by a personal vehicle following a diagnosed anterior neck fracture.

A Comparison of Change in Body Mass, Urine Color, and Urine Specific Gravity to Determine Hydration Status During College Football Preseason

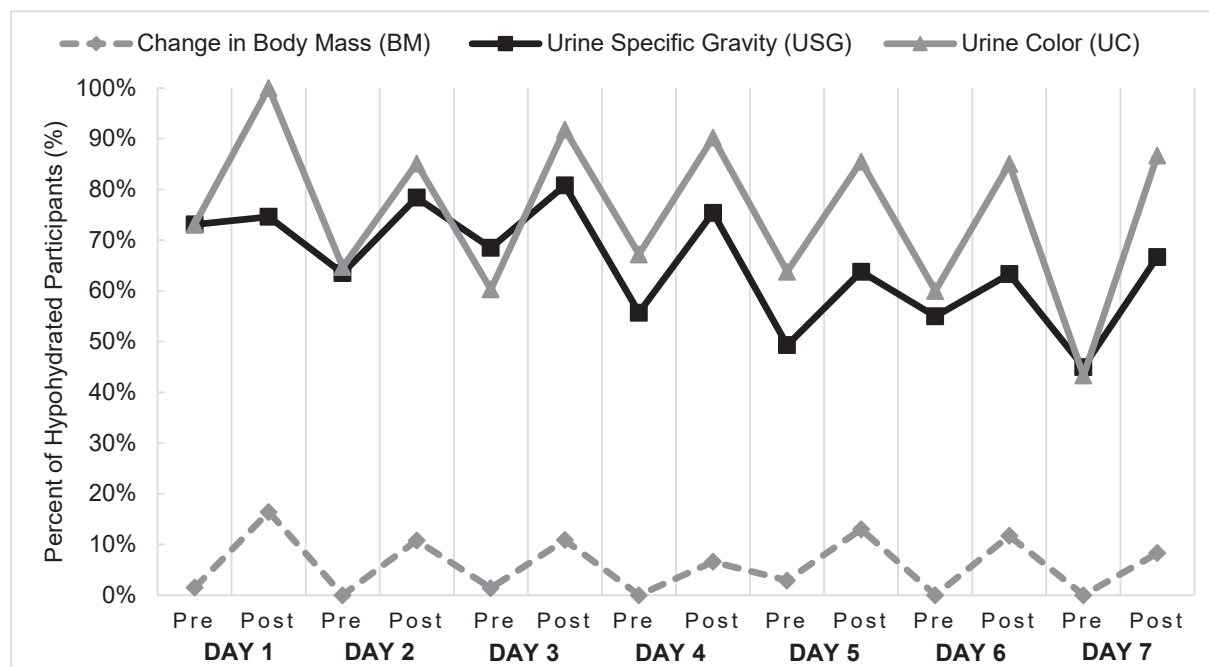
Claiborne TL, Archambeau B, Goetschius JW: Adrian College, Adrian, MI, and James Madison University, Harrisonburg, VA

Context: Dehydration affects athletes' health and performance. Measures of urine specific gravity (USG) can provide an objective, real-time assessment of hydration; however, the clinical feasibility of USG for a large number of patients is limited. Alternative methods of hydration assessment include change in body mass (BM) and urine color (UC). Each of these measures are easily performed in a clinical setting, but may have limitation in accurately assessing hydration. If athletes are not properly hydrated at baseline, it is unclear whether change in BM is a valid assessment of hydration status while UC is subjective. The purpose of this study was to compare the ability of BM and UC to accurately identify patients as hypohydrated or euhydrated when compared to USG.

Methods: A convenience sample of 85 Division III male football athletes (mean age = 18.99 ± 1.21 yrs.) volunteered for this cross-sectional study. For seven consecutive days of pre-season practices, BM, USG and UC were assessed pre and post-practice. Measures of change in BM were performed using our institution's standard clinical procedures while measures of USG and UC were completed for research purposes only. Baseline BM was measured the day prior to the first pre-season practice. Participants were encouraged to hydrate prior to the baseline BM measurement; however, hydration was not confirmed. Athletes were weighed wearing light clothes, and then voided into a clear collection vessel. A digital refractometer determined USG, and UC was graded using a color chart published by the NCAA. USG (cutoff 1.020), UC (cutoff 4), and change in BM compared to baseline (cutoff 3%) were used to categorize athletes as hypohydrated or euhydrated. Using USG as the standard, sensitivity, and specificity were calculated for change in BM and UC to determine clinical usefulness. **Results:** On average, 58.6% of the sample was identified as hypohydrated using USG at pre-practice, 61.8% were identified as hypohydrated using UC and

only 1.7% using change in BM. Similar trends were observed post-practice as well (Figure 1). When using USG as the standard across all time points, change in BM demonstrated low sensitivity (mean = 4.8%) and high specificity (mean = 91.9%) and UC demonstrated high sensitivity (mean = 93.9%) and moderate specificity (mean = 53.7%). **Conclusions:** A concerning finding of this study was that both USG and UC classified the majority of athletes as hypohydrated both pre and post-practice. In contrast, change in BM was not sensitive to hypohydration. Consequently, an average of 95% of hypohydrated athletes were incorrectly identified as euhydrated. The accuracy of change in BM measures may be related to the lack of confirmed hydration at baseline and raises questions whether deviations from recommended standards of practice invalidate change in BM for assessment of hydration.

Figure 1. Percent of Hypohydrated Athletes as Measured by Change in BM, USG and UC over 7 Consecutive Days of Football Pre-Season (Pre and Post-Practice)



Epidemiology of Patients Presenting to Emergency Departments in the United States With Football-Related Injuries, 2006-2019

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Context: Annually, 4.1 million youth and adolescent athletes participate in organized football activities in the U.S. Although organized football participation is associated with relatively high injury rates, little is known about all football-related injuries (eg, organized, playground, pickup) that require an emergency department (ED) visit. Our objective was to describe injury rates and patterns for football-related injuries presenting to EDs from 2006-2019. **Methods:** In October 2020, deidentified patient cases were abstracted from the U.S. Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS), which provides nationally representative data from a probability sample of 100 EDs in the U.S. We used product codes and physician narratives to identify football-related injuries and grouped cases as elementary (5-9 years), middle (10-14 years) and high (15-19 years) school-aged patients. Each case was associated with a weight to provide national estimates. Descriptive statistics were used to summarize counts, percentages, and rates. For incidence rate (IR) calculations, we abstracted population estimates by age group from the U.S. Census Bureau for 2006-2019.

Incidence rates were calculated as the number of cases per 10,000 people. **Results:** During the study period, 146,860 patients reported to NEISS EDs with football-related injuries, with a population-weighted national estimate of 4,619,660. Middle school-aged patients accounted for 52.4% (n=76,920) of injuries followed by high (36.6%, n=53,711) and elementary (11.1%, n=16,229) school-aged patients. Frequently injured body parts were the head (15.5%, n=22,835), finger (12.8%, n=18,833), and knee (9.1%, n=13,296). The most common injury types were sprain/strain (26.3%, n=38,660), fracture (23.8%, n=34,962) and contusions/abrasions (15.9%, n=23,403). The five most frequently reported diagnoses were concussion (8.0%, n=11,819), ankle sprain/strain (6.3%, n=9,267), head injury (6.1%, n=9,024), finger fracture (5.7%, n=8,403), and knee sprain/strain (4.6%, n=6,813). Almost all patients were treated and released (96.0%, n=140,938) but 2.6% (n=3,763) were admitted to the hospital. Between 2006-2019, IR decreased by 34.6%, with the highest IR reported for 2010 (IR=3.9) and 2011 (IR=3.9) and the lowest IR reported for 2018 (IR=2.5) and 2019 (IR=2.6). Incidence rates were 4.7 and 1.5 times higher in the middle school-aged group (IR=5.2) than elementary (IR=1.1) and high (IR=3.5) school-aged groups, respectively. **Conclusions:** Approximately 4.6 million football-related injuries required an ED visit between 2006-2019. However, the number of football-related ED visits and IRs have

generally decreased over time, which may be attributed to a decline in overall football participation or implementation of rule changes. Concussions and head injuries are common reasons for a visit to the ED, and almost all patients were treated and released. Future studies should investigate the role that an athletic trainer can play in further reducing the number of ED visits, particularly patient cases that are generally treated and released.

A Comparison of Subjective and Objective Measures in Adolescents and Young Adults With Lateral Ankle Sprain History

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Context: Lateral ankle sprain (LAS) is a highly prevalent injury that often leads to negative functional outcomes and decreased self-reported scores on patient-reported outcomes (PROs) that assess region-specific and global health-related quality of life. Currently, the overwhelming majority of literature surrounding LAS is predominantly focused on physically active young adults (YA) between the ages of 18 and 35. Previous research has established specific objective outcomes that may contribute to chronic dysfunction in the adolescent population, but the gap that remains is whether the

deficits seen in YA and adolescent populations differ. Therefore, the purpose of this study was to compare weight-bearing dorsiflexion range of motion (DF-ROM), dynamic postural control, and both region-specific and global health-related quality of life PRO scores between adolescents and young adults with a history of LAS. Ultimately, this information may provide a greater understanding of whether these deficits improve or decline across the lifespan. This may encourage ATs to utilize these same constructs in the adolescent population to tailor rehabilitation programs in an attempt to mitigate chronicity often seen following a LAS. **Methods:** A cross-sectional study design was used to compare all primary objective and subjective outcome measures between adolescents (n=13, age: 13.8±1.5 years, height: 166.1±6.5 cm, mass: 61.7±12.2 kg) and YA (n=41, age: 23.2±3.7 years, height: 170.9±10.7 cm, mass: 74.8±15.6 kg) with a history of LAS. Dorsiflexion range of motion (DF-ROM) was assessed by averaging 3 trials of the weight-bearing lunge test (WBLT). Dynamic postural control was assessed utilizing the star-excursion balance test (SEBT). Participants performed 4 practice trials in each direction (anterior, posteromedial,

posterolateral), followed by 3 test trials. The average of 3 trials was calculated and normalized to leg length. Foot and Ankle Disability Index (FADI)-ADL and -Sport subscales were used to assess region-specific health related quality of life. The modified Disablement of the Physically Active (mDPA) scale was used to assess global health-related quality of life. Separate independent samples T-tests were performed to compare each primary outcome measure between age groups. Significance was set at P<0.05. **Results:** There were no significant differences in YA and adolescents between objective and subjective outcomes. All means, standard deviations, and P-values are provided in Table 1. **Conclusions:** Our findings suggest these cost- and time-effective measures that are consistently applied to YA with history of LAS can be applied to adolescents with history of LAS to obtain and track measures throughout the rehabilitation trajectory. Furthermore, these findings provide early support that deficits may originate early in life and persist into young adulthood. Future research should further discern if common deficits seen in isolated age groups are the result of injury history or other confounders not yet identified.

Table 1. Results of participant outcome data: mean (SD)

Outcome	Adolescents (n=13)	Young Adults (n=41)	P-Value
WBLT (cm)	11.8 (2.3)	11.6 (3.3)	0.64
SEBT ANT (cm)	64.9 (8.7)	63.8 (5.4)	0.43
SEBT PM (cm)	81.2 (11.0)	81.2 (8.9)	0.89
SEBT PL (cm)	72.6 (12.2)	73.7 (9.9)	0.89
FADI-ADL	91.3 (12.4)	95.2 (6.2)	0.09
FADI-Sport	88.5 (16.4)	85.2 (14.4)	0.64
mDPA	13.0 (14.8)	9.9 (8.4)	0.24

Abbreviations: ADL = Activities of Daily Living; ANT = Anterior; FADI = Foot and Ankle Disability Index; mDPA = Modified Disablement in the Physically Active; PL = Posterolateral; PM = Posteromedial; SEBT = Star Excursion Balance Test. Note: values are means and values in parentheses are standard deviations.

Pain is a Common Experience in High-School Runners But Does Not Influence Performance or Workload

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Context: Running is popular sport for adolescent athletes, with almost half a million participating in cross-country during 2018-2019. While running has many health benefits, it also has a high rate of injury and pain. Musculoskeletal pain is a significant burden in runners. Up to 86% of adult novice and recreational runners have reported continuing running despite currently experiencing injury or pain. Previous research reporting pain in runners has been limited to a single time point in adults. Therefore, the purpose of our study was to report on pain experienced by high-school cross-country runners over multiple weeks of in-season running and the impact it had on performance. **Methods:** Twenty-four (F=20, M=4, age=15.1±1.0y, running experience=5.9±3.1y) high-school

cross-country runners from two area teams completed a prospective cohort study during the fall 2020 cross-country season. Participants recorded training variables after each running session, including time, distance, session rate of perceived exertion (sRPE; 10-point scale), and pain (11-point scale). If the participant reported pain during a run, location and intensity were selected from a body map. Workload measures were calculated as the products of sRPE with time (timeRPE) and distance (distanceRPE). T-tests compared training run variables between painful and pain-free runs ($p \leq .05$).

Results: Of the 24 high-school cross-country runners, 20 (83.3%) reported lower extremity pain during training/competition at least once during the season. Overall, 872 runs were recorded, of which 117 (13.4%) were reported as painful (average=3.7±1.8). In 60 (51.2%) of the painful runs, runners reported that performance was negatively affected by pain. Single- and multi-site pain were present during 63.2% and 36.8% of runs, respectively. The most common pain locations were shin (21.5%, pain=4.8±1.9), calf (19.8%, pain=4.2±1.6), and knee (19.2%, pain=2.8±1.3). Locations with the highest pain intensities were shins (pain=4.8±1.9), low back (pain=4.4±2.6) and ankles (pain=4.3±1.9). When comparing

runs that were reported pain-free to those reported painful, no differences were found in distance (mean±SD, no pain=7.8±3.4km, pain=7.2±3.4km, $p=.117$), time (no pain=38.8±18.5min, pain=36.9±16.3min, $p=.297$), sRPE (no pain=5.1±2.5, pain=5.1±2.2, $p=.894$), timeRPE (no pain=188.5±113.7, pain=188.4±110.1, $p=.995$), or distanceRPE (38.4±23.0, pain=37.6±22.4, $p=.724$) (Figure 1). **Conclusions:** Most high school cross-country runners experienced pain during in-season training, especially at the legs and knees at a clinically relevant intensity level. However, pain did not influence time, distance, sRPE, or workload. Since cross-country runners have structured training plans, most runners appeared to continue running for a certain amount of time/distance and/or pace, regardless of their pain levels. Presently, it is unclear when pain becomes detrimental to health/performance in this population, but it may be influenced by pain intensity, frequency, and/or location. Further research is needed, especially qualitative research, to determine if/how/when high-school cross-country runners are influenced by pain and when pain becomes detrimental and lead to injuries such as stress fractures and other chronic running-related injuries.

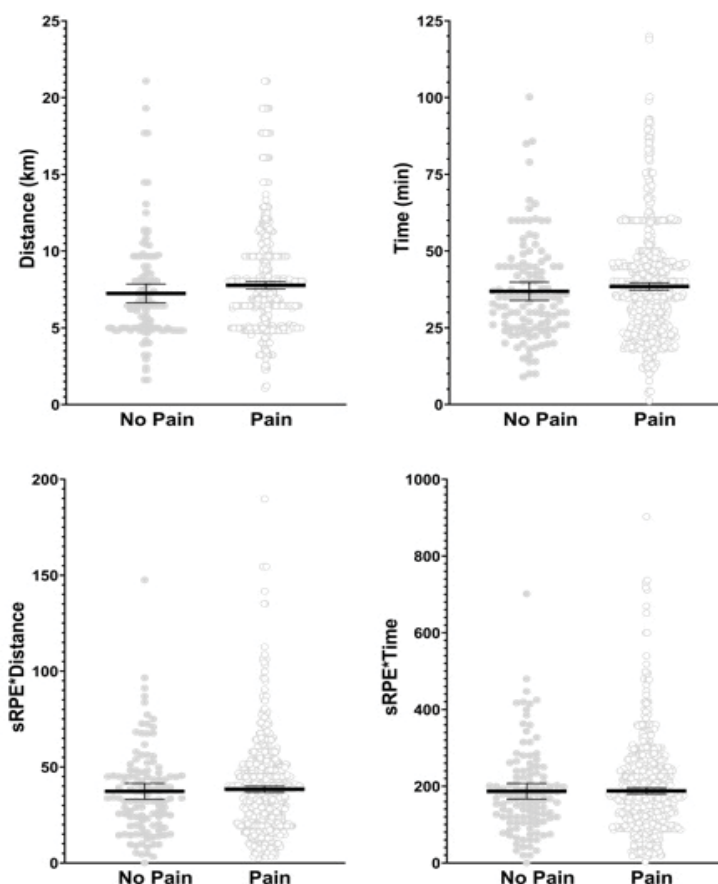


Figure 1: Comparison of mean distance, time, and workload between painful and non-painful runs in high school cross-country runners.

Balance Self-Efficacy Mediates The Relationship Between Injury-Related Fear And Disability In Individuals With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) is associated with various impairments including higher levels of injury-related fear and disablement. In other musculoskeletal conditions, the Fear-Avoidance Model (FAM) postulates that injury-related fear beliefs lead to activity avoidance and further disablement. The FAM has been applied and supported by reported relationships between injury-related fear and disability. Further studies suggest that high levels of self-efficacy may mediate this relationship. Injury-related fear and self-efficacy both appear to contribute to disability in other populations, but these relationships have yet to be explored in those with CAI; therefore, the purpose of this study is to determine if injury-related fear contributes to disability in individuals with CAI, and if self-efficacy mediates this relationship. **Methods:** Thirty-three individuals with CAI (F:18;M:15; 22.8±3.3yrs; 170.2±8.5cm; 78.0 ±13.6kg) participated in a single laboratory session. Injury-related fear and disability were measured with the Tampa Scale of Kinesiophobia (TSK-11) and Disablement in the Physically Active Scale (DPA), respectively.

The Self-Efficacy of Balance Scale (SEBS) was utilized to capture participants' level of confidence in maintaining their balance across a variety of functional tasks. Linear regression modelling was used to analyze the contribution of injury-related fear to disability, and 2 subsequent models were conducted for the mediation analysis. Model 2 was used to investigate the relationship between TSK-11 and SEBS to determine half of the indirect effect. Model 3 entered both TSK-11 and SEBS scores as predictors and DPA scores as the outcome to compute the remaining indirect effects. Significance for regression models was set at $P < .05$ and significance of the indirect effect was assessed using 95% bias-corrected bootstrapped confidence intervals with 5,000 iterations. **Results:** TSK-11 scores explained 22.4%(R²) of the variance in DPA scores ($\beta = 0.50$; $F = 10.23$; $P = .003$) indicating that higher levels of injury-related fear are related to higher levels of disablement. Model 2 found that TSK-11 scores explained 9.2%(R²) of the variance in SEBS scores ($\beta = -0.35$; $F = 4.26$; $P = .047$) indicating that higher levels of injury-related fear are related to lower levels of self-efficacy. Model 3 found that together, TSK-11 and SEBS scores explained 75.3%(R²) of the variance in DPA scores ($F = 49.75$; $P < .001$). The unique contribution of injury-related fear remained with the addition of self-efficacy, but was reduced ($\beta = 0.23$; $P = .020$). Conversely, self-efficacy emerged as a strong predictor ($\beta = -0.77$; $P < .001$). This partial mediation effect was significant as

95%BC CI [0.023-1.140] did not cross zero. **Conclusions:** Injury-related fear was directly related to disability in those with CAI, but this relationship was partially mediated by balance self-efficacy. This suggests when self-efficacy is high, elevated injury-related fear has less of an effect on disability; however, if self-efficacy is low, elevated injury-related fear is more likely to lead to higher disability. Therefore, strategies to address both injury-related fear and balance self-efficacy should be considered in rehabilitation protocols for CAI to help minimize disablement for these individuals.

Differences in Anthropometrics and Patient-Reported Outcomes Based on the Number of Ankle Sprains Sustained

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Context: Ankle sprains are one of the most common musculoskeletal injuries that frequently result in persistent pain and disability. While factors such as body mass and prior injury have been identified as contributors to subsequent injury, the impact of the number of ankle sprains on body morphology and health-related quality of life (HRQL) have yet to be elucidated in this population. Therefore, the purpose of this investigation was to assess the effects of the number of ankle sprains on demographics and health-related quality of life utilizing a large, pooled dataset. **Methods:** A cross-sectional study was performed using data pooled from 14 studies (total n=412) collected by the Chronic Ankle Instability Outcomes Network (COALITION). Participants were categorized

by the frequency of self-reported sprains (1, 2, 3, 4 and ≥ 5 sprains). Demographic data assessed included height, body mass, and body-mass index (BMI). Patient-reported HRQL was assessed using the Foot and Ankle Ability Measure-Activities of Daily Living (FAAM-ADL), FAAM-Sport, and Cumberland Ankle Instability Tool (CAIT). The effects of the number of prior sprains on patient demographics and health-related quality of life were assessed using one-way ANOVAs and post-hoc Tukey's Honest Significant Differences ($p < 0.05$). Cohen's d effect sizes were calculated for all significant findings. **Results:** Significant differences in body mass ($F_{4,402}=3.46$, $p=0.008$) and BMI ($F_{4,402}=2.63$, $p=0.034$) were found based on the number of ankle sprains reported. Specifically, participants who sprained their ankle once ($n=122$) weighed less than those who reported ≥ 5 sprains ($n=96$, $d=0.47$, $p=0.005$, Table 1). Participants who had 1 sprain ($BMI=23.8 \pm 3.6$) had a lower BMI than those who reported 2 sprains ($n=90$, $d=0.41$, $p=0.039$). Significant differences in the FAAM-ADL ($n=294$, $F_{4,289}=6.71$, $p < 0.001$), FAAM-Sport ($n=294$, $F_{4,289}=9.22$, $p < 0.001$) and CAIT ($n=241$, $F_{4,236}=7.39$, $p < 0.001$) were found between ankle sprain frequency. Higher FAAM-ADL scores were present in the single ankle sprain ($n=102$) compared to the 3 ankle sprain group ($n=65$, $d=0.75$, $p < 0.001$). There were higher FAAM-Sport scores in the 1 ankle sprain group ($n=102$) compared to the 2 ($n=58$, $d=0.51$, $p=0.010$), 3 ($n=39$, $d=0.99$, $p < 0.001$), 4 ($n=34$, $d=0.72$, $p=0.021$) and ≥ 5 ($n=61$, $d=0.66$, $p=0.002$) sprain groups. Similarly, for the

CAIT, higher scores were found in the 1 ankle sprain group ($n=50$) compared to the 2 ($n=53$, $d=0.58$, $p=0.023$), 3 ($n=46$, $d=0.85$, $p < 0.001$), 4 ($n=23$, $d=1.04$, $p < 0.001$) and ≥ 5 ($n=69$, $d=0.79$, $p=0.001$) sprain groups. **Conclusions:** Individuals with a history of multiple ankle sprains demonstrated higher body mass and self-reported disability compared to those who have a history of only one sprain, outcomes that are likely interrelated. Due to the potential for long-term morbidity associated with ankle sprains, clinicians need to provide patient education and interventions that promote physical activity, healthy dietary intake, and optimize function as part of comprehensive patient-centered care.

Table 1. Means and standard deviations of the demographic and patient-reported outcomes based on the number of ankle sprains.

Number of sprains	1	2	3	4	≥ 5
Height (cm)	169.5 \pm 8.8	170.4 \pm 10.4	169.3 \pm 8.5	171.0 \pm 8.9	172.1 \pm 10.6
Mass (kg)	68.4 \pm 12.5*	73.6 \pm 13.9	70.9 \pm 14.3	72.4 \pm 13.2	75.0 \pm 15.7*
BMI	23.8 \pm 3.6*	25.4 \pm 4.1*	24.6 \pm 3.9	24.7 \pm 3.6	25.2 \pm 4.1
FAAM-ADL	95.5 \pm 8.5*	90.5 \pm 14.8	84.0 \pm 19.5*	90.5 \pm 8.4	90.7 \pm 9.7
FAAM-Sport	90.0 \pm 16.3*	80.1 \pm 21.7*	71.0 \pm 21.7*	79.0 \pm 14.1*	78.7 \pm 18.0*
CAIT	23.0 \pm 4.7*	19.9 \pm 5.9*	18.3 \pm 4.4*	17.4 \pm 6.0*	19.1 \pm 5.2*

*Indicates statistically significant difference ($p < 0.05$)

Use of a Patient Generated Outcome Measure to Identify Those Symptoms and Activities of Greatest Importance to Collegiate Athletes

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Context: While patient-reported outcome measures(PROMs) have been supported for improving patient-centered care, many were developed for populations seen in outpatient physical therapy settings, and therefore, focus predominantly on activities-of-daily-living(ADLs). Given the highly-active populations with which athletic trainers(ATs) often work, this raises concern regarding the relevance of these measures. For PROMs to benefit both the patient and clinician, encompassed items must be relevant to targeted populations. This cross-sectional study aimed to identify the primary concerns of collegiate-athletes experiencing injury, overall and by phase and region-of-injury, and compare those to the content of PROMs commonly used by ATs. **Methods:** A patient-generated measure(the Measure Your Medical Outcome Profile(MYMOP-2)) was collected from collegiate-athletes experiencing injury(n=149, 74 female). MYMOP-2 responses and items from the Lower Extremity Functional Scale(LEFS), Disabilities of the Arm, Shoulder, and Hand (DASH), and Patient-Reported Outcomes Measurement Information System(PROMIS) Global-10 were linked using established

methodology to International Classification of Functioning, Disability and Health(ICF) taxonomy. Frequency counts were performed to identify the most common MYMOP-generated codes at the second and third levels of the ICF overall, at each phase of injury, and by extremity. Overall and by phase/region, those cumulatively representing 80% of all identified codes were considered the most common concerns/codes and were used for comparisons. Resultant codes from MYMOP-2 responses and the established PROMs were compared via Chi-square one-sample goodness-of-fit tests to test the hypothesis that less than 70% of content was shared between participant-concerns and the established PROMs. **Results:** MYMOP-2 responses generated 594 total codes, with 13 and 23 codes representing the cumulative 80% of second and third level ICF codes, respectively. Participant-generated concerns overall and across all phases/regions were primarily related to sport-participation(16%) and pain(23%). Additional common concerns included running/moving around(8%), sensations related to muscles /movement functions(6%), emotional functions(anxiety, stress, frustration, confidence) (4%), and swelling(2%). Common responses also included items not codable via ICF taxonomy, regardless of region/phase. Common concerns did not differ between phases of injury. Results for shared content between participant-concerns and PROM content are displayed in Table 1. The LEFS presented significant content differences with common participant-generated lower extremity ICF codes at all levels of analysis. The DASH did not have significant content differences with patient-generated upper extremity codes at the second level of analysis.

However, significant content differences were present between the DASH and participant-generated upper extremity codes at the third level. The PROMIS Global-10 presented significant content differences at the second level, but not at the third level of analysis. **Conclusions:** The presence of significant content differences validates perceived barriers held by clinicians regarding a lack of relevance in commonly used PROMs. To overcome these barriers and facilitate the inclusion of the patient-perspective in care, future research must examine the benefits of utilizing population specific and/or patient-generated measures.

Table 1:

Patient-Reported Outcome Measure (PROM)	Percentage of Most Common Concerns		P-value for test for 70% of Common Concerns	Percentage of PROM Content Representing Most Common Concerns (common codes/total codes represented)		P Value for test for 70% of Content
	Addressed (codes addressed/codes not addressed)					
Patient-Reported Outcome Measures Information System Global Health Scale (PROMIS)						
ICF Level 2	46%	(6/13)	0.061*	40%	(6/15)	0.011
ICF Level 3	35%	(8/23)	<0.001	50%	(8/16)	0.081*
Lower Extremity Functional Scale (LEFS)						
ICF Level 2	25%	(3/12)	<0.001	23%	(3/13)	<0.001
ICF Level 3	25%	(5/20)	<0.001	21%	(5/24)	<0.001
Disablement of the Arm, Shoulder, and Hand (DASH)						
ICF Level 2	88%	(7/8)	0.28*	27%	(7/26)	<0.001
ICF Level 3	42%	(5/12)	<0.001	15%	(5/33)	<0.001

*Shared content not significantly different from 70%(p>0.05)

Using the International Classification of Functioning, Disability, and Health to Compare Patient-Generated Concerns With Those Encompassed in Common Sports-Related Patient-Reported Outcome Measures

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Context: The use of Patient-Reported Outcome Measures(PROMs) has been endorsed across medicine as one component of evidence-based practice and patient-centered care. However, the ability of PROMs to represent the patient perspective is dependent on their content accurately addressing patients' primary concerns. The purpose of this study was to compare the primary concerns of injured collegiate-athletes to the symptoms and activities represented in commonly used PROMs. **Methods:** For this cross-sectional study, injured collegiate-athletes (n=149, 74 females) completed a patient-generated outcome measure, the Measure Your Medical Outcome Profile(MYMOP-2). Responses from the MYMOP-2 and PROMs designed for highly-active populations were coded using the World Health Organization's International Classification of Functioning, Disability and Health(ICF) taxonomy. Codes generated from open-ended responses on the

MYMOP-2 were compared to codes generated from commonly used PROMs. Coding was performed independently by 3 investigators to the deepest relevant ICF level. Discrepancies were resolved thru discussion until a consensus was reached. Frequency analyses were used to identify the most common participant-generated codes representing 80% of responses overall and by region. The investigated PROMs included the modified Disablement of the Physically Active Scale(mDPAS), the Functional Arm Scale for Throwers(FAST), the Kerlan-Jobe Orthopaedic Clinic questionnaire(KJOC), the International Knee Documentation Committee Subjective Knee Form(IKDC), the Knee Injury and Osteoarthritis Outcome Score(KOOS), and the Foot and Ankle Ability Measure(FAAM). We hypothesized that the ICF codes generated from these instruments would contain at least 70% of the most commonly occurring ICF codes generated from relevant participant-responses, and that 70% of PROM content would address the most common participant-concerns. Chi-square one-sample goodness-of-fit tests were performed ($p<0.05$) to test the apriori selected 70% thresholds for coding to both second and third levels of the ICF. **Results:** ICF codes generated from the included PROMs are compared to common participant-generated codes in the Table. Although several PROMs (mDPA, FAST, KJOC, IKDC and KOOS) adequately represented the most commonly identified concerns at the second level of the ICF, only the IKDC and KOOS were also representative at the more

specific third level. Additionally, all PROMs, except the IKDC and KJOC, contained a significant amount of unrelated superfluous content. **Conclusions:** Most PROMs designed for highly-active populations had acceptable content representation, addressing the general concerns of injured student-athletes such as pain, or loss of mobility. However, in all measures except the IKDC this representation lacked the specificity addressed in the third level of the ICF where, for example, specific areas of pain or mobility limitations are identified. Furthermore, the majority of PROMs contained significant extraneous content beyond the primary concerns of participants. To account for this lack of both specificity for patient concerns and efficiency, clinicians should consider the use of patient-generated outcome measures to ensure patient-specific concerns are being adequately and efficiently evaluated.

Table: Shared International Classification of Functioning (ICF) Codes Between Participant-Generated Responses and Patient-Reported Outcome Measures(PROMs) Items

Patient-Reported Outcome Measure (PROM)	Percentage of Most Common Concerns Addressed (codes addressed/total most common codes)		P-value for test for 70% of Common Concerns	Percentage of PROM Content Representing Most Common Concerns (common codes/total codes represented)		P Value for test for 70% of Content
modified Disablement of the Physically Active Scale (mDPAS)						
ICF Level 2	62%*	(8/13)	0.506	33%	(8/23)	<0.001
ICF Level 3	43%	(10/23)	0.004	23%	(10/43)	<0.001
Functional Arm Scale for Throwers (FAST)						
ICF Level 2	75%*	(6/8)	0.758	43%	(6/14)	0.027
ICF Level 3	42%	(5/12)	0.006	29%	(5/17)	<0.001
Kerlan-Jobe Orthopaedic Clinic questionnaire (KJOC)						
ICF Level 2	63%*	(5/8)	0.758	45%*	(5/11)	0.076
ICF Level 3	33%	(4/12)	0.006	27%	(4/15)	<0.001
International Knee Documentation Committee Subjective Knee Form (IKDC)						
ICF Level 2	66%*	(8/12)	0.801	53%*	(8/15)	0.159
ICF Level 3	55%*	(11/20)	0.143	52%*	(11/21)	0.078
Knee injury and Osteoarthritis Outcome Score (KOOS)						
ICF Level 2	75%*	(9/12)	0.705	41%	(9/22)	0.003
ICF Level 3	55%*	(11/20)	0.143	28%	(11/39)	<0.001
Foot and Ankle Ability Measure (FAAM)						
ICF Level 2	25%	(3/12)	0.001	21%	(3/14)	<0.001
ICF Level 3	35%	(7/20)	0.001	29%	(7/24)	<0.001

* Shared content is not significantly different from 70% ($p>0.05$)

Change in Physical Activity Level Predicts Knee-Related Quality of Life 6 Months After ACL Reconstruction Kuenze C, Birchmeier T, Triplett A, Collins K, Walaszek M, Shingles M, Wilcox L, Schorfhaar A, Lisee C: Michigan State University, East Lansing, MI

Context: Individuals with ACL reconstruction (ACLR) experience reduced quality of life (QOL) and physical activity (PA) levels that persist after the rehabilitation process. Among healthy individuals, higher levels of PA have been shown to positively influence QOL; however, it remains unclear if change in patient-reported activity level can identify individuals at risk for unacceptable QOL during the terminal phases of rehabilitation. Therefore, the purpose of this study was to determine if change in activity level from pre-surgery to 6-months post-ACLR was associated with unacceptable QOL among a cohort of patients with primary, unilateral ACLR. **Methods:** One hundred eleven individuals who had undergone primary, unilateral ACLR (62 women, 49 men; age=18.8±3.4 years) 6±1 months prior to assessment were included in this secondary analysis of data from a prospective cohort study. Participants completed the Tegner Activity Scale (0= no

activity to 10= national elite) to assess pre-injury (median=9, range= 5-10) and current physical activity level (median=6, range= 2-10). The change from pre-injury to current activity level was calculated. Unacceptable knee-related QOL was defined as a score <87.5 on the Knee Osteoarthritis Outcome Score QOL subscale (KOOS-QOL). Change in physical activity level was used to predict unacceptable KOOS-QOL using logistic regression. Receiver operator characteristic (ROC) curve analysis was used to assess the predictive accuracy of this model and to identify the change in activity level with the best sensitivity and specificity for identification of individuals with unacceptable QOL. We controlled for participant age, sex, and pre-injury activity level. We also calculated odds ratios (OR) and 95% confidence intervals (CI95) to describe the odds of an individual reporting unacceptable KOOS-QOL based on their change in activity level. **Results:** Twenty-one participants reported unacceptable KOOS-QOL and the median decrease in activity level was 2 levels [range= 0-7 levels]. Change in activity level significantly predicted KOOS-QOL ($p<0.001$, $R^2=0.20$) status while controlling for age ($p=0.86$), sex ($p=0.75$), and pre-injury activity level ($p=0.06$). For every 1 level decrease from pre-injury to current activity level, participants had 2.32 (CI95: 1.49-3.63) times greater odds of

reporting unacceptable KOOS-QOL. The area under the curve (AUC) for the ROC curve was 0.81 and a change in activity level >2 levels was identified as the cutoff for identifying individuals unacceptable QOL (Figure 1). **Conclusions:** Reduced activity level 6-months after ACLR is associated with unacceptable KOOS-QOL among individuals rehabilitating from primary, unilateral ACLR. While delayed clearance for unrestricted physical activity (i.e., 9-months post-ACLR) is recommended, the integration of safe, vigorous activities such as intense cardiovascular exercise may promote enhanced QOL among this patient population. Future research should investigate the potential benefits of PA education and promotion as an evidence-based means to enhance QOL throughout the rehabilitation process after ACLR.

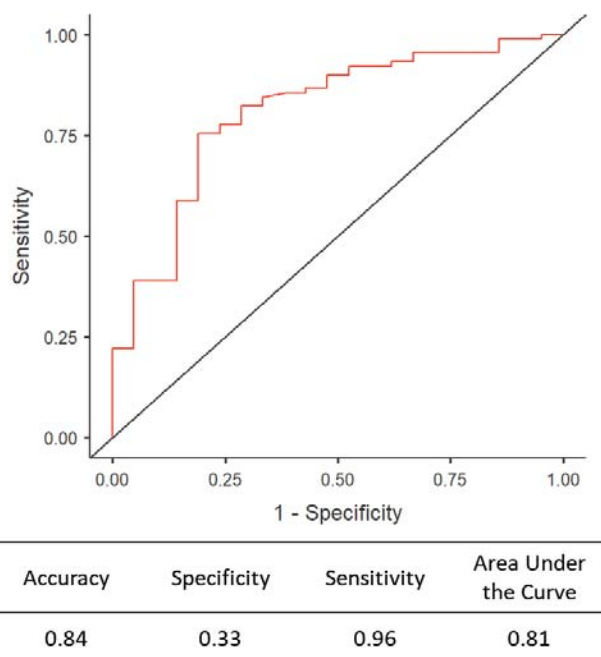


Figure 1. A receiver operator characteristic curve (ROC) depicting the accuracy of our logistic regression model in predicting unacceptable KOOS-QOL status among our study cohort. An area under the curve of >0.80 is considered acceptable for use as a predictive test.

Pain Catastrophizing is Associated With Knee-Related Quality of Life in Individuals With a History of Anterior Cruciate Ligament Reconstruction

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Context: Psychological factors experienced by individuals after anterior cruciate ligament reconstruction (ACLR) may negatively influence knee function and quality of life after injury. Pain catastrophizing, a negative cognitive-affective response to anticipated or actual pain, is a lesser explored psychological factor that has been examined in individuals after ACLR. Pain catastrophizing has been linked to greater pain intensity and poorer rehabilitative outcomes, such as self-reported knee function, which may lead to lifestyle modifications and ultimately influence quality of life. Therefore, the objective of this analysis was to examine the influence of pain catastrophizing on knee-related quality of life in individuals with history of ACLR. **Methods:** A secondary data analysis of a previously published cross-sectional study was completed. Forty participants (24 females; age= 24.3±4.2years, height=169.9±9.1cm, mass=73.2±15.1kg) with history of unilateral ACLR at least 1-year post-operatively (71.03±48.84months) were

included. Participants completed the Pain Catastrophizing Scale (PCS) and the Knee Injury and Osteoarthritis Outcome Score Quality of Life (KOOS-QOL) subscale. The PCS is a dimension specific patient-reported outcome designed to measure an individual's perceptions of their pain experience. The PCS includes three subscales which examine rumination, helplessness, and magnification. The scores range from 0-52, where higher scores indicate greater pain catastrophizing. The KOOS-QOL subscale is used to evaluate self-reported knee function as it relates to quality of life. The subscale score ranges from 0 to 100, where 100 indicates no knee-related quality of life concerns. A multivariate linear regression analysis was used to examine whether pain catastrophizing is associated with knee-related quality of life after ACLR. Age was included as a covariate in the model due to its potential effect on quality of life. **Results:** The average PCS score was 4.1±6.0 and the average KOOS-QOL score was 74.2±17.6. Age and PCS scores explained 22% of the variance observed in KOOS-QOL scores ($r^2=0.22$, $p=0.003$). While controlling for age, every point increase on the PCS was associated with a 1.4 point decrease in KOOS-QOL score ($\beta=-1.42$; Figure 1). **Conclusions:** Individuals with a history of ACLR who exhibit higher levels of pain catastrophizing may experience diminished knee-related quality of life. Poor knee-related quality of life may lead to negative lifestyle modifications, such as

lowered levels of physical activity engagement. Pain catastrophizing is a modifiable outcome that, if addressed appropriately throughout the rehabilitation process, may positively influence knee-related quality of life in this population. Future research should explore interventions to address pain catastrophizing in patients after ACLR and should continue to explore this relationship in the aging post-ACLR population.

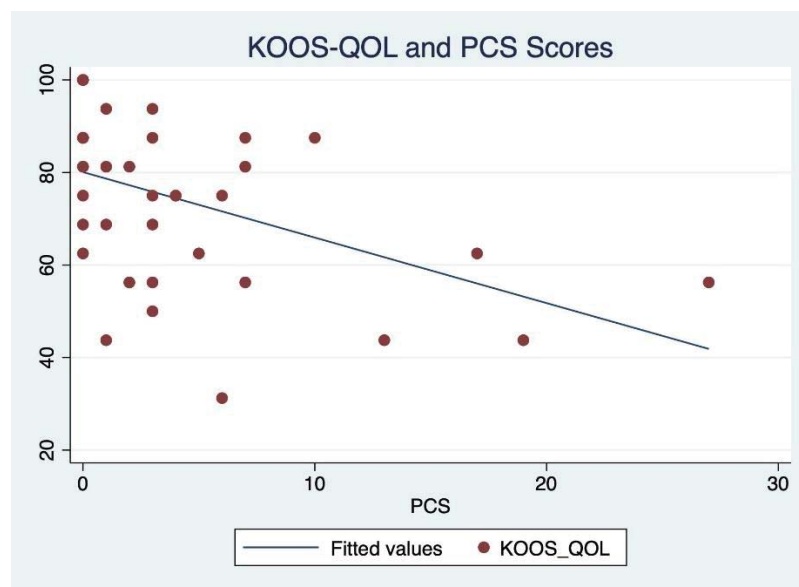


Figure 1. Linear regression between PCS scores and KOOS-QOL scores

Free Communications: Developing the Future Athletic Trainer: Strategies and Issues in Education and Clinical Education

On Demand: June 22-September 30, 2021

Racial and Ethnic Disparities on BOC Exam Performance: 2017-2018 to 2019-2020 Exam Periods

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Context: Racial and ethnic disparities in performance on achievement tests (e.g. SAT/ACT/GRE examinations) remains an issue that highlights the systemic and institutional racism still affecting society; however, it is unknown as to whether similar racial and ethnic disparities on Board of Certification (BOC) exam performance exist. Thus, the purpose of this study was to describe BOC exam performance across racial and ethnic groups during the 2017-2018 to 2019-2020 exam periods. **Methods:** This retrospective, observational study assessed first time and overall pass rates on BOC exam performance during the 2017-2018 to 2019-2020 exam periods. Researchers obtained BOC exam performance data based on race and ethnicity from the Board of Certification on August 31, 2020 for the aforementioned exam periods. The data obtained included the number of overall candidates, first time candidates, overall passing candidates, and first time passing candidates sitting for the selected BOC

exam window based on the candidate-selected race/ethnicity selected during their exam attempt. Descriptive statistics for the 3-year exam window were aggregated based on race and ethnicity and presented as first time and overall pass rates. **Results:** During the 2017-2018 to 2019-2020 BOC exam window, there were 11,808 first time candidates and 13,026 overall candidates; first time and overall BOC exam pass rates were 78.71% (9,294/11,808) and 83.64% (10,895/13,026), respectively. First time pass rates for candidates identifying as non-Hispanic White/Caucasian (81.27% [6623/8149]) were greater than their non-Hispanic Black/African American (58.74% [410/698]), Hispanic (73.28% [639/872]), Multi Ethnic (76.62% [236/308]), Asian/Pacific Islander (76.70% [316/412]), American Indian (74.65% [53/71]), Other (67.72% [86/127]), and Unknown (79.49% [930/1170]). Overall pass rates improved for all races and ethnicities, however, overall passing rates for non-Hispanic White/Caucasian candidates (86.68%) remained higher than non-Hispanic Black/African American (63.32%), Hispanic (77.05%), Multi Ethnic (85.71%), Asian/Pacific Islander (84.00%), American Indian (70.93%), Other (71.14%) and Unknown (83.77%). During the 3-year exam window only one candidate identifying as an Alaskan Native took the BOC exam, which they were successful on the first attempt. **Conclusions:** Performance on the BOC exam during the 2017-2018 to 2019-2020 exam periods highlights racial and ethnic disparities on first time and overall exam

performance; these disparities were most prevalent in candidates identifying as non-Hispanic Black/African American. A collective effort among athletic training education programs, the National Athletic Trainers' Association, BOC, and the Commission on Accreditation of Athletic Training Education is needed to ensure that diversity, equity, and inclusion remains a priority in the recruitment, admission, retention, and credentialing of students pursuing a career in athletic training.

Athletic Training Student Core Competency Professional Behavior Implementation Between Immersive and Non-Immersive Experiences: A Report From the AATE Research Network

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Context: The Commission on Accreditation of Athletic Training Education (CAATE) requires athletic training programs to emphasize the use of professional behaviors that are associated with 5 core competencies: patient-centered care (PCC), interprofessional education and collaborative practice (IPECP), evidence-based practice (EBP), health care informatics (HIT), and quality improvement (QI). Immersive clinical experiences (ICEs) may provide opportunities for professional behavior implementation; however, no research has been conducted examining the implementation of these behaviors in ICEs compared to non-immersive clinical experiences (N-ICEs). Therefore, the purpose of this study was to examine the impact of clinical experience type on student implementation of behaviors associated with 1 or more of the 5 core competencies. **Methods:** This study used a multi-site panel design involving athletic training students from 12 professional, CAATE-accredited programs and required them to log patient encounters for 1.5 academic years (Spring 2018-Spring 2019) in E*Value

(MedHub, Minneapolis, MN). Students were asked to document characteristics of each patient encounter (PE) including whether it occurred at an ICE or N-ICE and whether they engaged in behaviors associated with 1 or more of the 5 core competencies. Composite scores (counts) were calculated to indicate the number of behaviors that were implemented for each core competency during each PE. Differences in professional behavior implementation between ICEs and N-ICEs were assessed using a generalized estimated equation with a negative binomial link for PCC, IPECP, EBP, and HIT behaviors ($p < 0.05$) and a logit link for the QI behavior ($p < 0.05$). **Results:** In 1.5 academic years, a total of 30,630 patient encounters were documented, including 10,999 ICEs and 18,228 N-ICEs. A significant main effect was observed for implementation of behaviors associated with IPECP, EBP, HIT, and QI. For IPECP ($\chi^2(1)=10.607$, $p=0.001$), students in ICEs implemented more behaviors than those in N-ICEs (Mdiff=0.29, 95% CI: 0.12, 0.47, $p=0.001$). For EBP ($\chi^2(1)=10.179$, $p=0.001$), students in ICEs implemented more behaviors than those in N-ICEs (Mdiff=0.09, 95% CI: 0.03, 0.14, $p=0.001$). For HIT ($\chi^2(1)=4.166$, $p=0.041$), students in ICEs implemented more behaviors than those in N-ICEs (Mdiff=0.21, 95% CI: 0.01, 0.42, $p=0.041$). For QI ($\chi^2(1)=10.807$, $p=0.001$), students in N-ICEs implemented the QI behavior more often than those in ICEs (Mdiff=.35, 95% CI: 0.14, 0.56, $p=0.001$). There were no significant differences observed in the implementation of behaviors associated with PCC between ICEs and N-ICEs. **Conclusions:** Students in ICEs implemented significantly more behaviors

associated with EBP, IPECP, and HIT; students in N-ICEs implemented the behavior associated with QI more frequently. Educators should consider the balance of opportunities to implement these behaviors within their clinical education curriculum and set specific objectives related to implementation of these behaviors in both ICEs and N-ICEs. Additionally, athletic training programs should provide training for their preceptors on objectives specific to both ICEs and N-ICEs.

Overview of 2020 Admissions Data Across Post-Baccalaureate Athletic Training Programs

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Context: A descriptive study investigating application and admissions data across professional programs in athletic training at the post-baccalaureate level was conducted. After Fall 2022, accreditation standards require that the entry-level degree in athletic training be at the post-baccalaureate level. The purpose of this study was to describe baseline application and admissions data from post-baccalaureate program during the 2019-2020 application cycle.

Methods: Data was collected using a survey created and piloted by researchers. Program directors for professional programs in athletic training at the post-baccalaureate level were identified through a publicly available list on the Commission on Accreditation of Athletic Training Education (CAATE) website. A recruitment email including consent to participate and a link to the Qualtrics survey was sent to program directors (n=223). Descriptive statistics were performed using SPSS® (v.27) to summarize the demographic, application, and admissions data reported by program directors for the 2019-2020 application cycle. **Results:**

The survey's 38.12% response rate (n=85) from 223 institutions yielded 71 (31.84%) program directors who were able to report data from the 2019-2020 application cycle. Of these, 59.15% (n=42) were public institutions and 40.85% (n=29) were private institutions. Across respondents, 59.15% (n=42) indicated that the program had an admissions pathway other than direct entry at the master's degree level, such as a 3+2 or accelerated program. The cost-to-degree for the program at the post-baccalaureate level as reported by respondents ranged from \$11,000 to \$190,000 with a mean cost-to-degree of \$42,952.38±31,606.29. Program directors (n=62) reported a mean 18.71±7.05 available admissions slots and a mean 17.98±11.95 applications received during the 2019-2020 application cycle. Among programs that successfully enrolled students (n=60), the mean class size was 9.31±5.51, with 79.37% reporting the program had not met its enrollment goal. The overall student enrollment in responding post-baccalaureate programs for 2020 was 16.05±9.86. Among respondents, 61.67% (n=43) reported the institution has offered athletic training as a bachelor's degree. Across the institutions that offered a bachelor's degree, 65.12% (n=28) of respondents reported a change in enrollment goals for the post-baccalaureate program, and 86.05% (n=37) of respondents reported a change in total applications received. Of the program directors who reported a change, 58.14% (n=25) indicated a decrease in applications received and the

mean estimated percent change by program directors was -30.63±39.87. **Conclusions:** Among respondents whose institutions previously offered athletic training at the bachelor's degree, the majority reported a decrease in total applications when compared to the post-baccalaureate program. The mean number of applications received during the 2019-2020 cycle was less than the mean enrollment goal. Nearly 80% of respondents reported not meeting the institution's enrollment goal for the 2020-2021 academic year and the overall mean admitted class size was under 10 students.

Professional Master's Athletic Training Students' Career Influences: A Convergent Mixed-Methods Study
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Context: As athletic training education continues its degree transition, it is essential to understand how professional master's athletic training students' educational experiences influence their perceptions of athletic training and their career intentions after graduation. The purpose of this study was to examine second-year professional master's athletic training students' career intentions and perceptions of athletic training and identify the factors that influenced their perceptions. **Methods:** This study utilized a convergent mixed-methods design. We collected data using online surveys and individual phone interviews. Eighty second-year professional master's students (63 female, 13 male, 4 no response, age: 24.63 ± 2.29) who graduated in 2019 completed the online survey. We then conducted follow-up phone interviews until we reached data saturation, which occurred after 10 interviews. An online survey and semi-structured interview guide were created and validated using a content validity index tool. The validity score for

the survey instrument was 0.98 for relevance and 0.91 for clarity. The validity score for the interview guide was 0.91 for relevance and 0.83 for clarity. We used frequencies and percentages for the quantitative analysis, and a basic, inductive approach for the qualitative analysis. The data from both methodological approaches were blended. Findings are displayed using a qualitative emphasis through higher order themes. We established trustworthiness through triangulation, member checks, memos, and peer debriefing. **Results:** Our survey responses (Table 1) were triangulated by the qualitative findings. Five higher-order themes emerged from the data: 1) Perceptions of the athletic training profession included lack of appreciation and awareness for the profession from others and AT being a rewarding and profession; 2) Perceptions of a career in athletic training included low pay, long hours and inconsistent schedules, and inability to have work-life balance; 3) Factors influencing perceptions included not only one's clinical experiences, but also interactions with athletic trainers, the general public, and other health-care professionals; 4) Career progression identified students having short-term career plans that scaffolded to their long-term career plans, but there was a consistent concern over lack of experience for the career avenues they preferred; 5) Factors influencing career intentions included the clinical experiences and mentorship from athletic trainers and athletic training faculty. **Conclusions:** Students associated the athletic training profession with mostly positive

perceptions, while they associated a career in athletic training with negative perceptions. Only 43.7% percent of survey respondents could commit to a lifetime career in athletic training due to their overall negative view of a career in the profession. Many were considering careers as a physician assistant, physical therapist, and strength and conditioning coach. Our participants' perceptions of athletic training and their career intentions after graduation were primarily influenced by their clinical experiences and the mentorship they received from preceptors and athletic training faculty members.

Table 1. Most Frequently Selected Perceptions of Athletic Training

Perception	N	Percent
Low salary	68	85%
Inconsistent hours/schedules	68	85%
Lack of awareness or appreciation for the profession	65	81.3%
Rewarding Profession	62	77.5%
Dynamic Profession	53	66.3%
Profession people are passionate about and enjoy	52	65%
Team oriented work environment	49	61.3%
Inability to have work-life balance	46	57.5%

Note: The total response percentage is greater than 100% due to respondents' ability to select multiple responses simultaneously.

Athletic Training Program Directors' and Professional Students' Educational Experiences for Delivering Transgender Patient Care

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Context: Literature suggests athletic trainers are not prepared to provide transgender patient care. Research supports the gap could be rectified through enhanced professional preparation. Therefore, this study sought to identify the experiences of program directors (PDs) of professional athletic training programs (ATPs) teaching, and AT students (ATS) learning, about transgender patient care. **Methods:** We used a cross-sectional survey design with PDs (n=365) and ATS (n=3,548) of professional ATPs. The survey was content validated by a panel of experts in lesbian, gay, bisexual, and transgender healthcare needs. The PD survey (14 items) and ATS survey (21 items) asked about the educational experiences specific to transgender patient care with additional items assessing perceived comfort, competence, and barriers in teaching or learning about the topic. Data were collected for 4-weeks and analyzed using descriptive

statistics. **Results:** A total of 74 PDs (age=46±9 y) and 452 ATS (age=23±3 y) responded to the survey. We identified that 50% (n=37/74) of PDs included transgender patient care in their curriculum. These PDs reported that ATS mostly learned about transgender patient care in the classroom (97.3%, n=36) with the most common instructional method being class discussions (77.8%, n=28). Most PDs (87.8%, n=65) thought teaching transgender patient care was important and 58.1% (n=43) felt comfortable doing so, yet only 37.8% (n=28) felt competent in their delivery. Lastly, common barriers PDs identified facing when teaching about transgender patient care were lack of guidance incorporating the topic (55.4%, n=41) and a lack of knowledge regarding transgender healthcare (51.4%, n=38). In the ATS survey, less than half (43.1%, n=195/452) of respondents reported learning about transgender patient care. Most ATS reported learning about transgender patient care during class (84.6%, n=165) as compared to clinical education (26.7%, n=52). Nearly half of participants (42.1%, n=82) reported never interacting or practicing their skills with a transgender patient. The ATS agreed (83.8%, n=379) that considering a patient's gender was important to provide patient-centered care, yet 5.8% (n=26) of ATS did not feel it was important to ask a patient's gender identity. Most ATS agreed (78.3%, n=354) they felt comfortable providing transgender healthcare, but less than half agreed (41.8%, n=189) they were competent. The ATS reported discomfort when asking personal pronouns (61%, n=280) and educating about athletic

participation regulations (50.9%, n=230). Only 23% (n=104) of ATS felt competent in counseling about hormone replacement therapy. Lastly, a lack of guidance for ATS was the most reported (76.8%, n=347) barrier for providing transgender patient care. **Conclusions:** The PDs and ATSs agreed transgender healthcare is an important topic for an ATP, however both groups noted perceived deficiencies linked to a lack of knowledge and guidance. Prior to teaching, we suggest PDs seek professional development on transgender healthcare and creating meaningful clinical and didactic educational experiences.

Athletic Training Student Self-Assessment of Anxiety: Completing Clinical Coursework Amidst the COVID-19 Pandemic

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Springfield College, Springfield, MA

Context: The Center for Disease Control warns that the COVID-19 pandemic may cause feelings of fear and anxiety. Public health precautions such as social distancing, isolation, quarantine, and changes in employment or school status can also be overwhelming and anxiety-producing. Re-entry to employment or school may increase levels of anxiety, particularly for the college student population. For athletic training students (ATS) participation in clinical education may also impact anxiety. In an effort to better understand the anxiety of athletic training students, the primary objective of this study was to examine the self-reported anxiety levels of ATS participating in clinical education experiences amidst the COVID-19 pandemic. The following research questions guided the study: 1) What are the levels of anxiety amongst athletic training students? 2) How do anxiety levels change throughout a clinical education experience? 3) Do variables such as gender, age, number of clinical experiences, or weeks in the clinical experience impact levels of anxiety? **Methods:** This longitudinal study involved 39

students who were enrolled in professional athletic training program clinical coursework. The participants included 23 females and 15 males (age = $20.31 \pm .93$ years). The participants were enrolled in either their fifth ($n=16$), third ($n=13$), or first ($n=9$) clinical experience. One participant took an academic leave of absence from the institution which resulted in a total of 38 participants. Participants completed the validated Generalized Anxiety Disorder 7-item (GAD-7) scale before the beginning of their clinical education experience, then every two weeks over the duration of the experience for a total of seven times over the course of fourteen weeks. The GAD-7 is a seven-item self-assessment used as a screening for generalized anxiety and is rated on a scale from 0-21. Scores of 5, 10, and 15 are cut-off points for mild, moderate, and severe anxiety, respectively. **Results:** Over the initial eight weeks, anxiety levels increased among all students beginning with a mean score of 5.08 ± 5.51 , increasing to 6.67 ± 6.04 . A total of 58% of ATS reported moderate or severe levels of anxiety at one point in time. Third-year students exhibited the highest levels of anxiety, (8.58 ± 7.06) compared to both second year (4.67 ± 5.14) and fourth year (4.62 ± 4.55) students. Male ATS (3.23 ± 3.58) reported less anxiety than their female counterparts (7.90 ± 6.08). **Conclusions:** As athletic training students progressed through a clinical education experience, anxiety levels steadily increased. Additionally,

female and third-year ATS reported more anxiety than their counterparts. Understanding how changes in clinical education and stressors of the pandemic might impact ATS anxiety can provide insight for both educators and preceptors allowing structured and targeted interventions to provide support and guidance.

Clinical Education Coordinators Selection and Deselection Criteria for Clinical Education Experiences

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Temple University, Philadelphia,
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Context: Athletic training students (ATS) have previously identified clinical education as the most important and useful aspect of their professional education when transitioning to practice. However, ATSs have been increasingly frustrated with a lack of engagement, lack of mentorship from preceptors, and lack of diversity within their clinical education experiences. As such, the selection and deselection of clinical sites is critical to creating effective learning experiences. The purpose of our study was to explore how clinical education coordinators (CECs) select and deselect clinical education sites and preceptors for both clinical integration and immersion models. **Methods:** We used a consensual qualitative research design. Semi-structured interviews were conducted until we achieved saturation. We interviewed 13 CECs (age=42±8y, experience in current role=8±8y) from accredited professional masters programs in their position for at least one year with at least one immersive rotation. All interviews were audio recorded and transcribed (Zoom®, San Jose, CA). A 3-person data analysis team used

a multi-phase process to identify the emerging domains and categories. Data trustworthiness was established with member checking, multiple researcher triangulation, and auditing **Results:** Two domains emerged regarding the selection and deselection criteria: 1) accreditation compliance, and 2) strategic choices (Table 1). Accreditation compliance refers to participants deferring to the standards by indicating that clinical education sites must meet the Commission on Accreditation of Athletic Training Education (CAATE) requirements for clinical education. Secondly, participants indicated annual site visits and stakeholder feedback were a large indicator for retaining and/or deselecting preceptors and sites for both immersive and integrative experiences. When it came to the process of deselecting an experience, many programs did not have a specific programmatic policy for deselection, but would deselect a harmful site or preceptor. Generally, participants selected clinical education sites and preceptors out of convenience (geographical location, previous relationships, student led), while also having a convenient curricular structure for clinical immersion. Participants also placed a strong emphasis on the quantity of hours the ATS would obtain as oppose to the quality of the experience. However, many participants did describe how the student's aspirations and diverse learning experiences (site, preceptor, patient population) were a large factor in selecting the sites. Lastly, when choosing a clinical education

experience, it was important for the CECs to select and retain effective preceptors that not only mentored the students, but also allowed the students to practice autonomously. **Conclusions:** For professional masters programs to be successful and sustainable, programs must emerge as novel. Our findings suggest that CECs leverage convenient opportunities that align with accreditation expectations. It is imperative that clinical education offer opportunities that move beyond accreditation minimum standards and focus on high quality experiential learning that leads to autonomous practice and embrace the diversity of the profession.

Table 1. Frequencies of Consensual Qualitative Research Categories

Domains and Categories	Counts	Frequency Label
Accreditation Compliant		
Deferring to the Standards	12/13	Typical
Stakeholder Feedback	12/13	Typical
Programmatic Policy	12/13	Typical
Strategic Choices		
Autonomous Practice	13/13	General
Curricular Structure	12/13	Typical
Convenient Preceptor/Site Selection	10/13	Typical
Quantity over Quality	10/13	Typical
Effective Preceptor Selection/Retention	10/13	Typical
Student Aspirations	10/13	Typical
Diverse Experiences	9/13	Typical
Deselection for Harmful Experiences	8/13	Typical

Identifying Self-Authorship and Developmentally Effective Experiences Among Professional Masters Athletic Training Students

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Milledgeville, GA; Springfield College,
Springfield, MA; University of Con-
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Context: The Commission on Accreditation of Athletic Training (CAATE) will require all accredited athletic training programs (ATP) to transition to professional masters level by 2022, thus, ATP should consider aspects of student development (SD) when designing and implementing innovative curriculums to better suit needs of adult learners. A recommended framework for this approach encourages adult learners to navigate challenges which foster development in the three dimensions of an SD theory called self-authorship: knowing who they are (interpersonal dimension), how they know (cognitive dimension), and how to engage in authentic relationships (intrapersonal dimension). The purpose of this study was to identify what events athletic training students recognize as developmentally effective experiences (DEE), and how meaning-making of those DEE possibly

determine their progress toward self-authorship, which has not yet been explored within athletic training. **Methods:** Design. Qualitative, Grounded Theory. Setting. Eight CAATE accredited athletic training programs housed in NCAA Division 1 universities. Participants. Twelve racially diverse participants (9 female, 3 male; 24 ± 2 years old) participated in the study. Data Collection and Analysis. Participants engaged in a semi-structured video conference interview. Data were analyzed using a grounded theory approach with self-authorship as a lens to situate DEE within the raw data from the interviews. Reaching data saturation, peer review, member checks, and theoretical triangulation were used to establish credibility. **Results:** Participants exhibited meaning making among the three dimensions in two distinct ways: external guidance and movement toward internal guidance due to transformative learning experiences. The categories were further broken down by theme: Responsibility of knowledge on authority, need for step-by-step guidance, and seeking approval marked the themes of external guidance. Building confidence and role identity development marked themes of movement toward internal guidance due to transformative learning experiences. Clinical education was identified as a DEE that supported more complex ways of making meaning. **Conclusions:**

Participants reliant on external guidance required external authorities for their knowledge and learning. Some participants were prompted to begin making meaning at a deeper level through their experiences with clinical education, further identified as a DEE. Educating with self-authorship development in mind through exposures to DEE, such as clinical education experiences, will set the foundation for athletic training students to be constantly evolving practitioners, well on their way to following a life and career journey of their own design, rooted in their individual beliefs and values.

Integration of Interprofessional Education in Athletic Training Clinical Education

Feld SD, Kirby JL, Hankemeier DA, Manspeaker SA: Ball State University, Muncie, IN; Western Carolina University, Cullowhee, NC; Duquesne University, Pittsburgh, PA

Context: As athletic training programs (ATPs) prepare students to enter today's highly collaborative healthcare arena, creating opportunities for them to engage with members of other professions is critical. Interprofessional education (IPE) is the educational process by which individuals from at least two healthcare professions come together to learn with, from, and about each other. Incorporating these types of experiences is mandated by many accrediting bodies. However, little is known about how IPE occurs within the clinical education components of athletic training programs. Therefore, the purpose of our study is to explore how professional, post-baccalaureate ATPs are integrating IPE from a clinical education perspective. **Methods:** We employed a consensual qualitative study design to explore ways in which IPE is integrated into the clinical education component of ATPs. An interview guide was created to assess how

IPE was being implemented in the clinical experiences of students. We conducted semi-structured phone interviews with athletic training faculty members regarding their perspectives on including IPE in their programs. We audio recorded and transcribed each interview verbatim. After achieving data saturation, a team of three experienced qualitative researchers used a consensual qualitative approach to analyze the data. To establish trustworthiness, we included an external auditor to evaluate the themes and associated results. Additionally, we asked participants to complete accuracy member checks. **Results:** Seventeen athletic training faculty members completed interviews. Demographic information can be found in Table 1. Two main themes emerged from this data, Clinical Experiences and Preceptor Involvement, each comprised of subthemes. We built Clinical Experiences on the subthemes of 1) intentional placement, 2) assessment, 3) linking to courses, and 4) organic IPE. We built Preceptor Involvement theme on the subthemes of 1) preceptor development, 2) clear objectives, and 3) active facilitation. **Conclusions:** Integrating IPE into the clinical component of athletic training education is a developing concept as faculty are seeking opportunities to intentionally engage students in collaborative practice during clinical education experiences. However, due to the nature of

clinical education, this is difficult to control or guarantee across sites and at different points in time. Educating preceptors and involving them in the IPE process may help facilitate additional integration of these concepts into clinical education and allow students to put these concepts into practice.

Table 1. Program Faculty Demographic Data

Participant Pseudonym	Age, y	Sex	ATC Experience, y	Faculty Experience, y	Role in Athletic Training Program
Andrew	56	M	35	26	Program Director
Angel	45	F	24	2	CEC
Benjamin	31	M	10	6	CEC
Charlotte	33	F	15	2	CEC
Christine	31	F	11	3	CEC
Fred	45	M	21	17	CEC
Joanne	43	F	22	3	CEC
Leslie	41	F	19	2	CEC
Maria	37	F	11	3	Faculty, non-administrative
Mark	47	M	23	8	CEC
Maureen	44	F	17	3	Faculty, non-administrative
Max	32	M	11	3	CEC
Meg	33	F	12	8	CEC
Mimi	33	F	11	6	CEC
Raoul	43	M	21	11	CEC
Roger	31	M	10	3	CEC
Tom	33	M	11	4	CEC

Abbreviations: ATC, certified athletic trainer; CEC, clinical education coordinator; y, years

Racial Microaggressions During Clinical Education Experiences of Professional Master's Athletic Training Students

Greene ZI, Aronson PA, Bradney DA, Canida RL, Bowman TG: University of Lynchburg, Lynchburg, VA

Context: Racial microaggressions can be comments or actions that subtly, and often unconsciously, or unintentionally expresses a prejudiced attitude toward a member of a marginalized group. Studies have investigated racial microaggressions in other health care professionals however, research on microaggressions in certified athletic trainers and athletic training students is lacking. The purpose of this study was to examine if racial microaggressions exist during clinical education experiences of students in professional Master's athletic training programs. **Methods:** This was a qualitative research study design. We asked program directors of the Commission on Accreditation of Athletic Training Education-accredited professional Master's programs to forward an email with a link to a questionnaire to their second-year students to complete. Participants included 115 second-year master's students 80 female, 33 males, 1 non-binary/third gender, and 1 did not wish to disclose (age=23.67±3.41 years). The questionnaire contained a series of qualitative questions based on the current literature and was validated via peer and expert

review prior to initiation of the study. Data saturation drove recruitment for this study and was met. We used peer review and multiple analyst triangulation to provide credibility and analyzed the data with a phenomenological qualitative approach as we wanted to examine the meaning of human experiences. **Results:** Three themes emerged from data collection: (1) Forms of racial microaggressions athletic training students experience include, but are not limited to, microassaults, microinsults, microinvalidations, and stereotypes. Athletic training students experiencing racial microaggressions are judged based on socioeconomic status, gender expression or identity, sexual orientation, race, ethnicity, nationality, appearance, or religion making students consider whether they are the problem. (2) Athletic training students suffer from a lack of resources available to them when they experience racial microaggressions. Formal reporting mechanisms are lacking for athletic training students to report these actions which cause student anxiety and self coping. (3) Athletic training students go through a period of career reconsideration where they questioned entering the athletic training profession because of feeling uncomfortable and discriminated against. As students questioned continuing with the athletic training profession, they experienced additional anxiety related to career commitment. **Conclusions:** Athletic training students are suffering from racial microaggressions during clinical education. To reduce the number of

racial microaggressions that students face, athletic training education program administrators and preceptors should be educated on racial microaggressions, validate athletic training student emotions, encourage a brave space where students can openly communicate about what is transpiring at clinical sites, safely identify aggressors, and remove students from harmful environments.

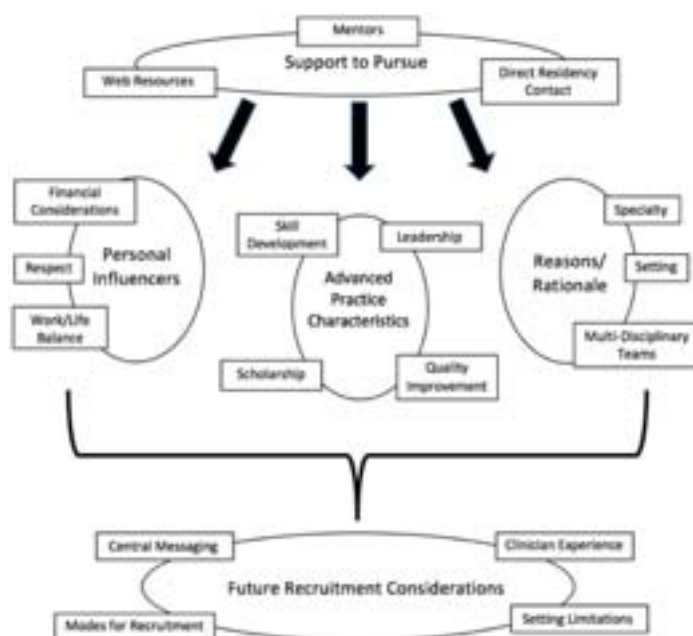
Factors Influencing Athletic Trainers to Pursue Residency Training

Dobrowolski DJ, Welch Bacon CE, Eberman LE: Indiana State University, Terre Haute IN, and A. T. Still University, Mesa, AZ

Context: Athletic training residency programs are designed to provide athletic trainers with learning experiences in a focused area of practice, where the result is specialization. To better understand the pathway to specialization and what motivates an athletic trainer to take that route, we explored factors influencing athletic trainers to pursue residency training. **Methods:** We used a consensual qualitative research design with semi-structured interviews. We identified participants that had interviewed for CAATE-accredited athletic training residencies in the Spring of 2020, but had not yet begun the residency. Twelve athletic trainers (8 females, 4 males; age $26 \pm 3y$; athletic training experience $4 \pm 3y$) participated in the audio-recorded interviews, which were transcribed and deidentified for analysis. We used a three person research team to develop, refine, and apply a consensus codebook of primary domains and themes for analysis. To establish trustworthiness, we used member-checking, multi-analyst triangulation, and external auditing. **Results:** We identified five emergent domains: 1) Support to Pursue, 2) Personal Influencers, 3) Reasons/Rationale, 4) Advanced Practice Characteristics, and 5)

Future Recruitment Considerations (Figure). Web resources, direct residency contacts, and mentors with knowledge of residencies were the primary sources of information provided potential residents with more information about residency programs. Financial considerations, work/life balance, and an increase in respect as a clinician were all personal driving factors that influenced athletic trainers to pursue residencies. Several participants indicated a desire to change to the physician practice setting, where they believed they would be more likely to work in interdisciplinary teams. Participants thought residencies would develop their skills, specifically in the specialty area. They were looking for residencies to improve their advanced practice clinical skills such as algorithmic evaluation techniques, diagnostic imaging, and surgical assist techniques. Participants also described their desire to become a better clinician through clinical scholarship and quality improvement activities. Participants suggested residencies should advertise more using social media and conference presentations to clarify the central message around the purpose of residencies and specialization. **Conclusions:** Athletic trainers that pursued residency programs stated motivating factors that align with programmatic goals and outcomes. Clinicians who pursued residencies were seeking to elevate their clinical practice and develop specialization. Participants discussed a disconnect in knowing enough about residencies before applying and identified more can be done to promote and advertise the

residency pathway for both professional-level students as well as established clinicians. Participants cited organizational websites as being a valuable resource for more information about available programs and positions. While participants who chose to explore the residency pathway aligned with programmatic outcomes, this study suggests residencies can improve recruitment strategies to best match clinicians to the residency that best fits their motivators. Central messaging from professional organizations must clearly articulate residencies are the industry standard for developing specialization.



Multi-Stakeholder Perceptions of Young Professionals' Integration During Role Transition

Thrasher AB, Bowman TG, Kasamatsu TM: Western Carolina University, Cullowhee, NC; University of Lynchburg, VA; California State University Fullerton, CA

Context: The transition to autonomous clinical practice for young professionals (YPs) has been found to be a stressful time. Previous research has investigated transition from the YPs' perspective but no studies with multiple stakeholder groups have been completed. The purpose of this study was to examine the perceptions of YPs' integration during role transition from multiple stakeholder groups. **Methods:** We recruited 17 young professionals in the first 2 years of their first job post certification (9 females, 8 males, age=26±5 years, experience=9.5±5 months), 16 supervisors of YPs (6 females, 10 males, age=52±11 years), and 10 faculty members and 8 preceptors (11 females, 7 males, age=43±10 years) via NATA emails to complete semistructured interviews for our qualitative study. Data saturation drove recruitment and was met. We based the interview guide on current literature and validated it via expert and peer review. We analyzed data using

consensual qualitative research, an inductive approach used to study experiences and attitudes while integrating multiple viewpoints. Multiple analyst triangulation (N=3) was a key component to analysis and maintaining trustworthiness. Member checking as well as peer review of the coding structure and presentation of the results also served as trustworthiness strategies.

Results: We identified 4 themes that defined the integration of YPs during role transition. Integration of YPs was facilitated through role inductance as some responsibilities had to be learned by performing the duties of the position. All stakeholder groups noted the fact that YPs need to perform the roles of autonomous clinical practice in order to successfully transition. Mentoring provided support for YPs as they struggled with navigating job related challenges including difficult clinical decision making, diffusing conflict with stakeholders, and developing clinical skills. YPs struggle to find work life balance as they are new to the profession and feel obligated to exceed expectations from a coverage standpoint rather than focusing on quality of care. Finally, stakeholders suggested a timeline by which YPs become fully integrated into autonomous professional practice and understand all aspects of their role, find identity as ATs, and feel confident in fulfilling their roles that takes anywhere from 6 months to 3 years.

Conclusions: YPs should be afforded clinical

education experiences with appropriate graded autonomy to assist in the development of clinical reasoning skills and confidence. YPs noted the importance of their immersive clinical education experiences to their integration, which also facilitated the development of a mentoring network with past preceptors. Expectations for YPs should be reasonable to allow for adequate work-life balance and integration into the profession without guilt. YPs typically become fully integrated after a period of time that depends on prior learning experiences and support received during their transition to practice.

Multi-Stakeholder Perspectives of Organizational Aspects Affecting Transition to Practice for Newly Credentialed Athletic Trainers

Lyons SM, Thrasher AB, Kasamatsu TM, Bowman TG: Stanford University, Stanford, CA; Western Carolina University, Cullowhee, NC; California State University Fullerton, Fullerton, CA; University of Lynchburg, Lynchburg, VA

Context: Transition to practice (TTP) is a period of growth in which a new athletic trainer (AT) responds to a stressful change and develops confidence and self-efficacy. Employers have an important role in the TTP; however, organizational aspects during the TTP have not been explored from multiple perspectives. The purpose of this study was to explore multiple stakeholders' perceptions of ways for organizations to support new ATs during the transition.

Methods: ATs from three stakeholder groups participated, guided by data saturation: 10 faculty members and 8 preceptors (age=43±10 years, experience=11±12 years), 16 supervisors of newly credentialed ATs (age=52±11 years), and 17 newly certified ATs (age=26±5 years, experience=9.5±5 months). Participants were recruited via purposive sampling through an email blast from the National Athletic Trainers' Association. Participants were interviewed via phone using a semi-structured interview guide. Data were analyzed through consensual

qualitative review, with data coded for common themes and subthemes. Trustworthiness was established via peer review and multi-analyst triangulation. **Results:** Four themes emerged: employer's responsibility, onboarding, support structure, and conflicting priorities. Employers felt they had a responsibility in mentoring new ATs and assisting with socialization into their roles and the profession. Many participants felt employers should share knowledge and experience to ensure new ATs are successful in their role. Successful socialization also leads to employee retention, benefitting the supervisor and organization. Onboarding describes the organizational processes used to orient new ATs to their roles, including formal orientation, mentoring, evaluation, and feedback. In addition to formalized processes, support was also provided to new ATs through informal mentoring, relationships with coworkers, and professional development. Support often extended beyond professional needs and also met personal challenges. Conflicting priorities occurred when there was tension between different aspects of the role. From an employer perspective, a time conflict exists in which employers want to provide more mentoring, but their main priority is patient care and time spent mentoring is time away from their job. Finally, conflicting priorities arise when comparing employees' and employers' expectations of work-life balance. Employers often feel young ATs focus on the "life" portion while young ATs advocate for more balance between expectations and compensation. **Conclusions:** Employers are critical

during the TTP for new ATs. To assist with TTP, employers should provide comprehensive onboarding, formal mentoring, and informal personal and professional support. Employers have a responsibility to assist in the TTP for their new employees; however, challenges may arise when their own clinical requirements limit the time they can spend mentoring new ATs. Organizations should ensure supervisors have adequate support to assist in the TTP for new ATs. Additional dialogue on work-life balance, expectations, and compensation would benefit all ATs and assist in new ATs' TTP.

The Impact of Onboarding During Transition to Practice for Newly Credentialed Athletic Trainers

Walker SE, Thrasher AB, Cavallario JM: Ball State University, Muncie, IN; Western Carolina University, Cullowhee, NC; Old Dominion University, Norfolk, VA

Context: As new athletic trainers (ATs) transition into their roles, some employers provide extensive orientation and onboarding to assist with transition to practice (TTP); however, onboarding practices are inconsistent. There is a lack of research exploring how new ATs perceive the effectiveness of onboarding; therefore, the purpose of this study was to examine how onboarding facilitates TTP. **Methods:** Seventeen newly credentialed, employed ATs who graduated from professional masters' programs participated (11 female, 6 male; 25.6±2.2 years) in this grounded theory study. Participants were recruited via purposive sampling. Each participant was interviewed via phone, using a semi-structured interview guide at approximately 3, 6, 9, and 13-14 months after beginning employment. Data saturation guided the number of participants. Data were analyzed through grounded theory, with data coded for common themes and subthemes. Trustworthiness was established via peer review, member checks, and multi-analyst triangulation. **Results:** Two

themes emerged: facilitating TTP and impact. Onboarding facilitated TTP by helping participants feel supported, understand expectations, and integrate into their role. Participants who had a more robust orientation with continued interaction with a mentor or supervisor to whom they could ask questions, understood their roles faster and felt more comfortable immersing themselves into their roles than those who did not. Participants felt meeting stakeholders (e.g., supervisors, coaches) prior to beginning their role also helped them integrate more effectively into their role. Support from supervisors, peer ATs, coaches, athletic directors, and other stakeholders was reported as the most impactful aspect of onboarding. Participants who had thorough orientation and continued support described quickly gaining confidence and reported lower stress levels throughout their first year because they felt comfortable asking questions and felt validated in their roles. Participants who had regular onboarding meetings with their supervisor and staff meetings with other ATs reported they collaborated with other ATs on patient care decisions, brainstormed ways to solve problems, and felt less isolated. Patient care was a focus for participants who had site-specific information provided prior to fully beginning their roles or who had support from a mentor. In contrast, participants without orientation or support described their time was focused on learning procedures associated with their roles. While the TTP was stressful for all participants,

those who did not have robust orientation and support, more frequently reported feeling stress than participants who had support through the onboarding process. **Conclusions:** Onboarding is vital to the TTP for new ATs and impacts their ATs confidence, role integration, and stress levels. Employers should provide site-specific orientation and ongoing mentoring for new ATs to quickly adapt to their roles and collaborate with other healthcare providers during their first year of employment. Effective onboarding decreases stress and allows new ATs to focus on patient care.

Practice-Based Research Experiences of Doctor of Athletic Training Degree Graduates

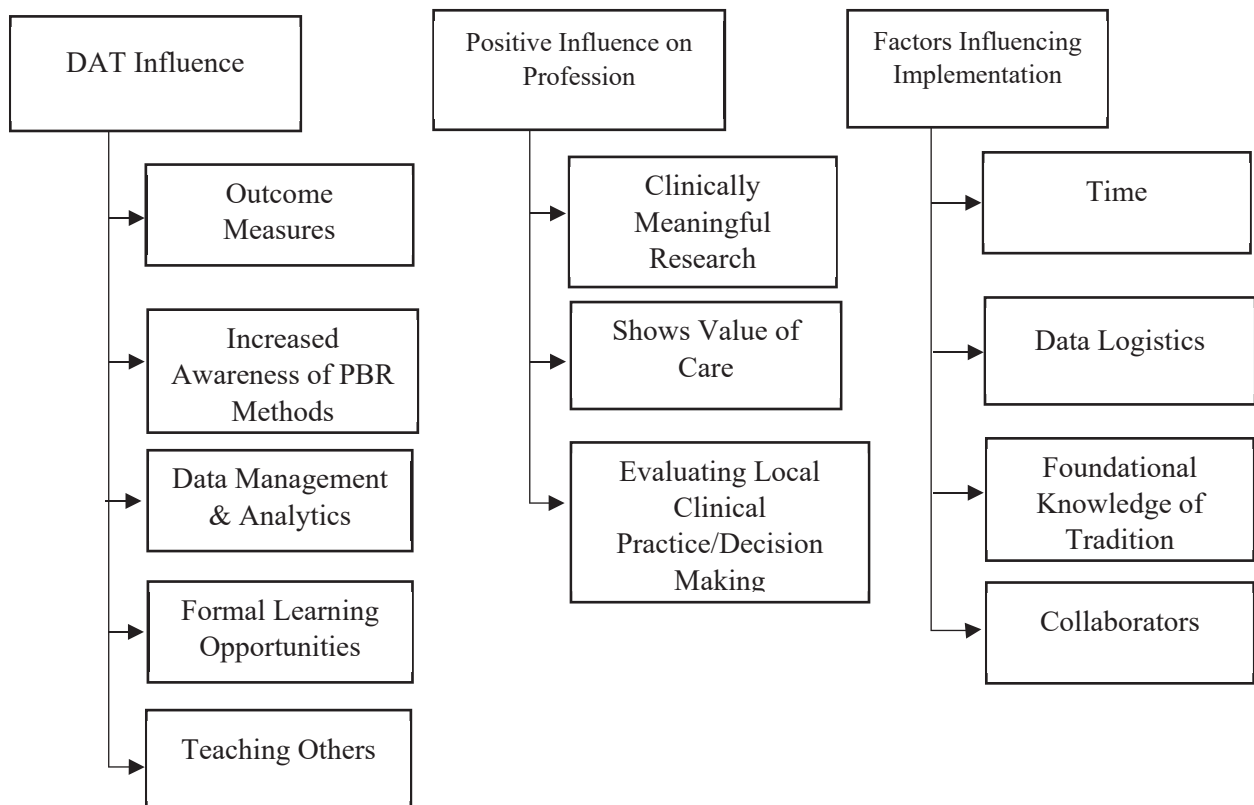
Rivera MJ, Arredondo S, Welch Bacon CE, Games KE, Eberman LE: Indiana State University, Terre Haute, IN, and AT Still University, Mesa, AZ

Context: The Strategic Alliance in the Prioritized Research Agenda has highlighted the need of clinically meaningful data and clinical scholarship in athletic training. Practice-based research (PBR) incorporates the collection of evidence at the point-of-care that evaluates the translation of traditional research into clinical practice, which can be insightful for athletic training. The purpose of our study was to examine Doctor of Athletic Training (DAT) graduates knowledge and use of PBR within clinical practice. **Methods:** We used a consensual qualitative research design to examine the research question. We used criterion sampling to identify graduates of DAT programs who were in their current work place for a minimum of 12 months. Twelve participants completed a semi-structured one-on-one interview, which was audio-recorded and transcribed verbatim (Zoom®, San Jose, CA). A 3-person data analysis team used a multi-phase process to identify emerging themes and to develop a consensus

codebook. Member checking, multiple researcher triangulation, and auditing were used to establish credibility and trustworthiness. **Results:** We identified three emerging domains in DAT graduates' knowledge and use of PBR: 1) DAT influence, 2) value of PBR, 3) and factors influencing implementation (Figure). DAT graduates reported that their DAT gave them the knowledge and skills to execute PBR in their practice. This knowledge and skills included the collection of clinical outcomes, data management and analytics, and strategies to teach others about PBR. Subsequently, the DAT program gave participants increased awareness of PBR methodologies and different formal learning opportunities to implement PBR throughout the program. DAT graduates lauded the value of PBR, whereby clinicians can collect and disseminate clinically meaningful data, demonstrate the value of care, and evaluate local clinical practice. All of which can influence decision making in practice. Lastly, DAT graduates discussed influences on their ability to implement PBR into their clinical practice. Participants identified the amount of time required, foundational knowledge of research, available collaborators, and data logistics can all influence how effectively they can implement PBR. **Conclusions:** DAT graduates perceive that PBR can help produce more clinically meaningful data and allow them to evaluate their own practice. Graduates stated

that their DAT programs positively influenced their knowledge and skills in the execution PBR and gave them meaningful learning opportunities. Regardless of preparation and perceived value, DAT graduates are experiencing factors influencing their ability to integrate PBR into their clinical practice. This finding is consistent with the implementation of many new concepts in athletic training, specifically the measure of patient outcomes. Future research should explore strategies that improve implementation of PBR and collection of clinically relevant data, as well as the role of a DAT graduate in creating partnerships leading to more clinically relevant research.

Figure 1. Domains and Categories



Athletic Training Students' Perceptions of Translating Knowledge From Classroom to Clinical Practice

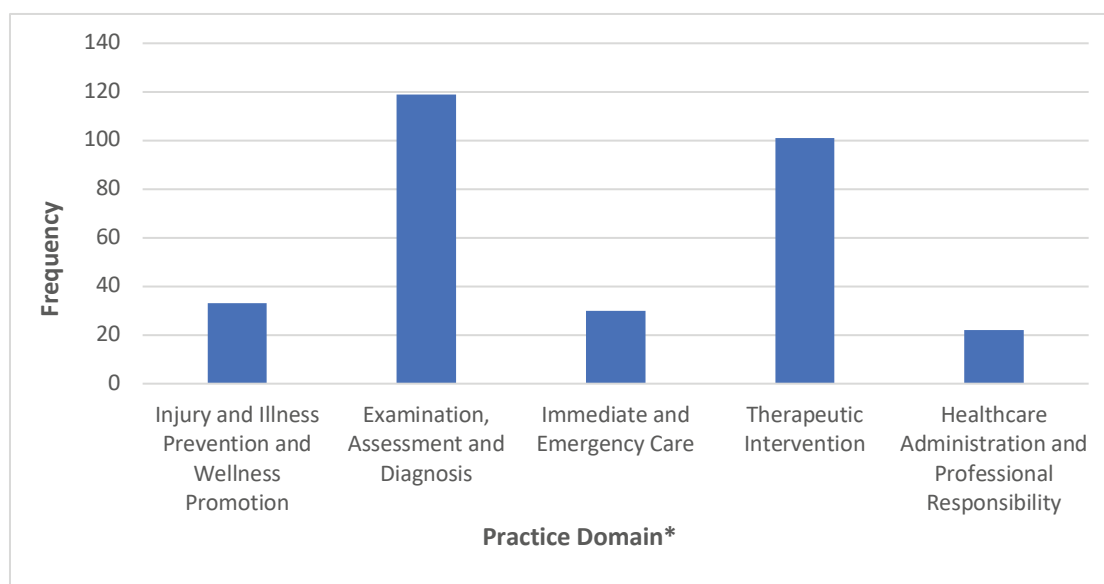
Welch Bacon CE, Pike Lacy AM, Kroskie R, Cavallario JM: A.T. Still University, Mesa, AZ; Erskine College, Due West, SC; Old Dominion University, Norfolk, VA

Context: As future generations of athletic trainers continue to embrace evidence-based practice, it will be important they not only critically appraise available evidence, but effectively translate it into practice to optimize patient outcomes. Knowledge translation is an iterative process that promotes the application of new knowledge by users. However, without a specified focus on knowledge translation strategies in athletic training programs, it is unclear how students translate knowledge gained from the classroom into clinical practice. The purpose of this study was to explore professional athletic training students' perceptions of translating didactically taught knowledge into clinical practice. **Methods:** We used the consensual qualitative research approach to establish a framework of athletic training students' perceptions of, challenges with and strategies to promote translation of classroom knowledge into clinical practice. A Qualtrics survey composed of six open-ended questions was distributed to athletic

training students via the Program Director of CAATE-accredited professional athletic training programs. Three members analyzed the first 20 responses and developed a consensus codebook. The codebook was confirmed through analysis of the next 20 responses. Two members then coded the remaining responses. All analysis procedures were audited by a fourth research team member, including themes and categories that resulted from the analysis. **Results:** Recruitment emails were delivered to 377/385 program directors of professional athletic training programs. The survey was accessed by 255 students and completed by 168 (completion rate = 69.5%). We identified four themes related to students' perceptions of knowledge translation: application of knowledge to clinical practice, challenges prohibiting successful knowledge translation, strategies to promote knowledge translation, and topics translated into clinical practice (Figure). Participants perceived their ability to apply knowledge into practice was contingent on factors such as classroom delivery, clinical practice setting, preceptors, as well as their own self-efficacy. Challenges inhibiting knowledge translation were multifaceted and included variables such as relatability between stakeholders, classroom relevance, limited exposure, and student confidence. Participants discussed several student-, preceptor-, and faculty-driven strategies to promote knowledge translation in ways that would create

greater opportunity for hands-on practice and application of knowledge and skills in real time. **Conclusions:** It is unsurprising that students identified they have translated topics within clinical examination/diagnosis and therapeutic intervention domains more frequently since exposure to patient cases during clinical experiences more often relate to post-injury considerations. Our findings suggest a need to promote synergy between faculty and preceptors regarding didactically taught knowledge and what students are encountering during clinical experiences. The implementation of knowledge translation strategies may help students bridge knowledge-to-practice gaps they currently perceive as challenges inhibiting successful translation of knowledge into the clinical environment. Future research should investigate the influence immersive clinical experiences have on professional athletic training students' opportunities to translate knowledge from all practice domains.

Figure. Frequency of Topics Translated into Clinical Practice by Athletic Training Practice Domain (n=168)



*As identified by the Board of Certification Practice Analysis, 7th Edition

Personality Characteristics, Skills, and Program Preparation That Facilitate or Impede Transition to Practice: Multi-Stakeholder Perspectives

Kasamatsu TM, Bowman TG, Thrasher AB: California State University Fullerton, Fullerton, CA; University of Lynchburg, Lynchburg, VA; Western Carolina University, Cullowhee, NC

Context: Newly credentialed athletic trainers (ATs) experience challenges while transitioning from a supervised student to an autonomous clinician. Previous researchers have explored transition to practice from the perspective of ATs or employers separately. Therefore, the purpose of this study was to investigate the perceptions of multiple stakeholders regarding characteristics of newly credentialed ATs' and their preparation to enter the workforce. **Methods:** We followed the consensual qualitative research tradition while conducting individual, semi-structured interviews using an online video conferencing platform. Interview guides were developed by referencing the literature, were validated through peer review, and were piloted prior to beginning the study. Participants were purposefully recruited through the National Athletic Trainers' Association survey service and social media posts. We interviewed 17 newly credentialed ATs (age = 26 ± 5 years; experience = 9.5 ± 5 months; professional degree: bachelor's = 5, master's = 12), 10 faculty members and 8 preceptors (age = 43 ± 10 years, experience = 11 ± 12 years), and 16 supervisors of newly credentialed ATs (age = 52 ± 11 years). Three researchers confirmed data saturation was met

and analyzed transcripts over multiple rounds following a consensual qualitative research approach to identify themes and sub-themes. To enhance trustworthiness, the inclusion of multiple researchers, member checking, and peer review were used. **Results:** Three themes emerged related to the anticipatory socialization of students and factors that facilitated or impeded newly credentialed ATs' transition to practice. All participants described the benefit of newly credentialed ATs' personal characteristics, such as being moldable, energetic, able to relate to young patients, and eager to enter the profession; however, they were also perceived to lack professionalism and confidence in their abilities. Whereas newly credentialed ATs were purported to have advanced clinical skills and content knowledge (eg, manual therapy, integration of evidence-based medicine), they also commonly struggled with healthcare administration tasks (eg, documentation, policies and procedures) and their communication, conflict management, and clinical decision-making skills. Lastly, participants believed that newly credentialed ATs' professional preparation provided the requisite entry-level knowledge, but that they would benefit from more clinical experience, opportunities to make autonomous clinical decisions within supervision standards, and engagement in a holistic view of the profession. **Conclusions:** Newly credentialed ATs are perceived to be energetic, eager, and academically prepared to enter the workforce. However, underdeveloped professional or interpersonal skills and limited familiarity with healthcare administrative tasks can hinder their transition to practice. Therefore, professional program administrators, faculty, and preceptors should work collaboratively to engage students in all

facets of an AT's job responsibilities, such as communicating with stakeholders and completing administrative paperwork, to better prepare newly credentialed ATs to navigate the workplace. Students should initiate critical conversations with preceptors to improve development in these areas, and newly credentialed ATs should identify mentors to garner support during their transition to practice.

Developing and Assessing Clinical Reasoning in Athletic Training Residency Education

Hofmann DW, Welch Bacon CE, Eberman LE: Indiana State University, Terre Haute IN, and A.T. Still University, Mesa AZ

Context: Athletic training residency programs are emerging rapidly as the industry standard for developing clinical specialists. Clinical reasoning, a central tenet to specialized thinking, requires familiarity with available evidence and the ability to discern between the relevance of that evidence to a particular patient case. It is not clear how residencies are developing and assessing clinical reasoning as residents become specialists. The purpose of this study was to explore current practices and perceptions of clinical reasoning development and assessment in athletic training residency programs. **Methods:** We used qualitative, semi-structured interviews with 7 of 10 CAATE-accredited residency program directors (age=46±9y; years as a program director=5±6y). Interviews were conducted with Zoom Video Conferencing (Zoom®, San Jose, CA) software and audio files were transcribed verbatim, checked for accuracy, deidentified, and member-checked before analysis. We used a 2-person data analysis team and an inductive coding approach. The researchers reviewed the transcripts independently, met to develop a codebook, applied the codes, and conducted internal auditing. Trustworthiness was established

through member-checking, multiple-analyst coding, and auditing. **Results:** Three themes emerged from the study: (1) Defining clinical reasoning, (2) instructional tactics, and (3) assessment tactics (Figure). Program directors defined clinical reasoning as the process of the resident justifying their decision-making or the accuracy the residency demonstrated in diagnosis or in selecting the appropriate treatment plan. When describing clinical instructional tactics, program directors described mentoring is critical to developing specialists, particularly through observation, interactive questioning, and guided practice. Case presentations and rounding were also used as a clinical form of instruction. Didactically, program directors described a combination of lecture, journal club, oral presentations, clinical scholarship, and interactive discussion as methods of instruction. Although few programs used all the techniques, most used several didactic tactics to develop clinical reasoning. Program directors described assessment tactics including measuring specialist development progress through patient and preceptor feedback in structured and unstructured formats. Specifically, program directors referred to the AT Milestones Project as a common tool to evaluate clinical reasoning; however, implementation practices were variable including limited use of the clinical competency committee. Programs also described using self-reflection, knowledge testing, or no mechanisms to measure clinical reasoning. Program directors stated a high reliance on preceptors and clinical mentoring, but also described a singular reliance

on residents to appraise the clinical reasoning capacity of their own preceptors. **Conclusions:** Program directors define clinical reasoning as the rationalization and accuracy of decisions. Although the programs are engaged in effective clinical and didactic approaches to teach reasoning, they rely heavily on the subjectivity of preceptors and residents to assess these outcomes. Residency programs should consider the use of more formal assessments and consensus building through clinical competency committees for a more robust measure of clinical reasoning and resident progression toward specialization.

Pre-Operative Femoral Cartilage Ultrasound Echo-Intensity Associates With Patient-Reported Outcomes at One Year Following Anterior Cruciate Ligament Reconstruction

Harkey MS, Driban JB, Kuenze C, Zhang M, Salzler MJ: Michigan State University, East Lansing, MI; Tufts Medical Center, Boston, MA; Wentworth Institute of Technology, Boston, MA

Context: At 1-year following anterior cruciate ligament injury and reconstruction (ACLR), one-third of patients present with unacceptable symptoms. Therefore, identifying individuals early following ACL injury who are at risk for poor patient-reported outcomes (PROs) following ACLR is crucial to target interventions aimed at improving symptoms and maintaining joint health. Alterations in femoral cartilage are prevalent following ACL injury and are prognostic of poor PROs. However, previous studies have primarily used expensive and inaccessible magnetic resonance imaging techniques, and it is unknown if a clinically accessible cartilage ultrasound technique is prognostic of future poor outcomes. Therefore, the purpose of this study was to determine if pre-operative femoral cartilage ultrasound characteristics (i.e., thickness and echo-intensity) are associated with knee-specific PROs at 1-year following ACLR.

Methods: Orthopaedic patients aged 18-35 years

with a primary unilateral ACL rupture were recruited prior to ACLR in this longitudinal observational study. At a pre-operative hospital visit, patients underwent a bilateral transverse suprapatellar ultrasound assessment with the knee in maximal flexion to image the femoral trochlear cartilage. One reader manually segmented the entire cartilage area. A custom MATLAB program automatically separated the manual cartilage segmentation into standardized medial, lateral, and intercondylar femoral regions and calculated the following in each region: 1) average cartilage thickness; and 2) echo-intensity: average grey-scale pixel value. An interlimb ratio was calculated for cartilage thickness and echo-intensity (>1 = greater value in ACL limb compared to contralateral limb). The following PROs were collected at 1-year following ACLR (lower score = worse outcome for all PROs): 1) International Knee Documentation Committee subjective knee evaluation form (IKDC), 2) Knee Injury and Osteoarthritis Outcome Score (KOOS) Quality of Life (QOL), 3) KOOS Sport, and 4) KOOS Symptoms. Partial correlation analyses were used to determine the association between pre-operative ultrasound measures and 1-year PROs while controlling for the respective pre-operative PRO. **Results:** Thirteen participants (4 female, age=23.0 \pm 4.1 years, mass=75.7 \pm 15.4kg, height=172.9 \pm 11.8cm) with an average time from injury to surgery of 61.9 \pm 67.5 days were included. For medial cartilage echo-intensity, there was a statistically significant positive

association between lesser pre-operative interlimb ratio and worse IKDC ($\rho=0.71$), KOOS QOL ($\rho=0.60$), and KOOS Sport ($\rho=0.58$) at 1-year following ACLR (Table). For medial cartilage average thickness, there was a significant negative association between larger pre-operative interlimb ratio and worse KOOS symptoms at one-year ($r=-0.57$; Table). There were no significant associations for pre-operative lateral and intercondylar average cartilage thickness and echo-intensity (Table). **Conclusions:** This provides preliminary evidence that a clinically feasible ultrasound assessment of the medial femoral trochlear cartilage is prognostic of poor knee function, QOL, and sport-related disability following ACLR. An ultrasound assessment prior to ACLR may identify specific patients that need to be targeted to prevent poor PROs at 1-year post-surgery.

Table. Association between Pre-Operative Ultrasound Measures and 1-Year PROs

Pre-Operative		1-Year Post Anterior Cruciate Ligament Reconstruction			
Ultrasound Measure		Patient Reported Outcomes: r^{\wedge}/ρ^* (95% Confidence Interval)			
Interlimb Ratio		IKDC*	KOOS		
			QOL*	Sport*	Symptoms [^]
Average Thickness	Medial	-0.40 (-0.79, 0.22)	-0.52 (-0.84, 0.08)	-0.41 (-0.80, 0.22)	-0.57 (-0.86, 0.00)
	Lateral	0.28 (-0.35, 0.74)	-0.15 (-0.67, 0.47)	0.09 (-0.51, 0.63)	0.48 (-0.12, 0.83)
	Intercondylar	0.03 (-0.56, 0.59)	-0.13 (-0.66, 0.48)	0.01 (-0.57, 0.58)	0.29 (-0.34, 0.74)
Echo-Intensity	Medial	0.71 (0.22, 0.91)	0.60 (0.03, 0.87)	0.58 (0.01, 0.87)	0.46 (-0.16, 0.82)
	Lateral	0.50 (-0.10, 0.83)	0.05 (-0.54, 0.60)	0.41 (-0.22, 0.80)	0.23 (-0.40, 0.71)
	Intercondylar	0.26 (-0.37, 0.73)	0.02 (-0.56, 0.59)	0.17 (-0.45, 0.68)	0.18 (-0.44, 0.68)

*Spearman Rho Correlation, [^]Pearson Correlation, PRO = patient reported outcome; IKDC = International Knee Documentation Committee; KOOS = Knee Injury and Osteoarthritis Outcome Score; QOL = Quality of Life. **Bold = statistically significant ($p < 0.05$).**

Ultrasound Assessment of Femoral Cartilage Thickness After Anterior Cruciate Ligament Reconstruction: A Longitudinal and Case Control Study

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Context: Anterior cruciate ligament reconstruction (ACLR) is a risk factor for post-traumatic osteoarthritis (PTOA). Diagnostic ultrasound assessments that are valid and reliable have detected thicker femoral cartilage in the involved limb of individuals on average 3 years post-ACLR compared to their contralateral limb and healthy controls. Thickness differences may be due to declines in cartilage health leading to cartilage swelling. However, it is unclear if changes in cartilage thickness occur during recovery post-ACLR. The purpose of this study was to compare femoral cartilage thickness via ultrasound in the involved and contralateral limb from 4- and 6-months post-ACLR and to the dominant limb of healthy controls. **Methods:** Individuals with ACLR (n=20, 50% female, age=21.1±5.7 years) and healthy controls (n=30, 57% female, age=20.8±3.8 years) between 16 and 35 years old participated in this

longitudinal case control study. Participants with history of intra-articular knee injury, lower extremity injury within the past 6 weeks, or arthritic conditions were excluded. Individuals with ACLR were included if they underwent a primary unilateral ACLR 4-months prior to testing. Femoral cartilage ultrasound images were captured in the involved and contralateral limbs of individuals with ACLR at two sessions 4- and 6-months post-surgery and in the dominant limb of healthy controls at a single session. Average femoral cartilage thickness within the medial, intercondylar, and lateral regions were determined using a reliable semi-automated processing technique. Analysis of variance with repeated measures was used to compare average cartilage thickness within all femoral regions between limbs and over time in individuals with ACLR. Independent t-tests were used to compare average cartilage thickness between both limbs of individuals with ACLR to the dominant limb of healthy controls. **Results:** There were no significant differences in age (p=0.60) or body mass index (p=0.23) between the individuals with ACLR and healthy controls. Individuals with ACLR did not demonstrate statistically significant main effects for limb (p-range=0.50-0.92), time (p-range=0.22-0.72), or limb by time interactions (p-range=0.24-0.49) for average cartilage thickness in any femoral region. Average cartilage thickness in all femoral regions were not significantly different between

the involved (p-range=0.36-0.94) and contralateral limbs (p-range=0.19-0.88) of individuals 4- or 6-months post-ACLR compared to healthy controls. However, approximately 40% of individuals with ACLR demonstrated involved limb femoral cartilage thickness increases in at least one region that exceeded minimal detectable change (Figure 1). **Conclusions:** Femoral cartilage thickness is not different between limbs and did not change from 4- to 6-months post-ACLR. However, the group means may not be effective in estimating changes over time after ACLR, as 40% of individuals do experience cartilage thickening over this time period. Future research should explore longer longitudinal follow-ups and if demonstrating early cartilage thickness change is related to later changes in other early PTOA biomarkers.

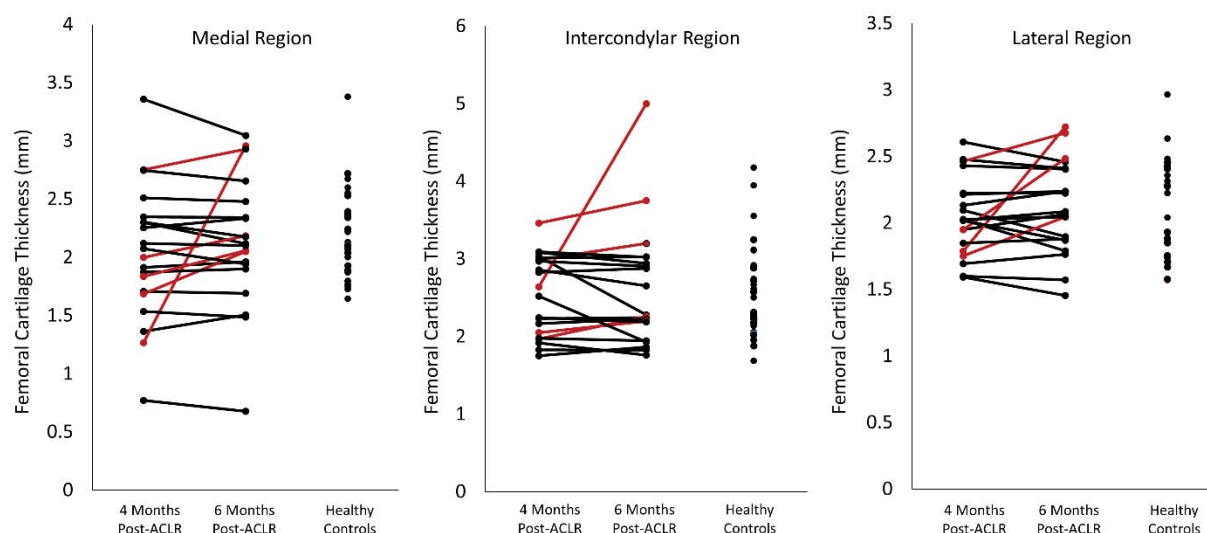


Figure 1. Involved limb and dominant limb femoral cartilage thickness (mm) of medial, intercondylar, and lateral regions in individuals with a history of ACLR and healthy controls. Solid lines represent individual changes in femoral cartilage thickness from 4 to 6 months post-ACLR. Red solid lines represent femoral cartilage thickness changes that exceed minimal detectable change and black solid lines represent femoral cartilage thickness changes that do not exceed minimal detectable change

Ultrasound Measures of Talofibular Interval Length is Different Between Individuals With and Without Chronic Ankle Instability

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Context: Mechanical ankle instability is a residual symptom following an inversion ankle sprain and may contribute to the development of CAI.¹ Traditional clinical assessments of mechanical instability include an anterior drawer and inversion laxity test which can be unreliable and lack sensitivity.² Ultrasonography provides real-time visual inspection of anatomical features allowing for a quantitative approach to assess ankle laxity. The ultrasound measurement of the talofibular interval (TFI) length, the distance between the peak of the lateral malleolus to the peak of the talus, is larger in ankles following an acute sprain compared to uninjured ankles.³ However, it is unknown if the increased TFI is present or can be predictive of individuals with CAI. Understanding the mechanical properties after ankle sprains will assist in developing rehabilitation protocols to prevent chronicity of symptoms. Therefore, the purpose of this study was to assess the TFI in a neutral

position using ultrasound in individuals with and without CAI and determine the ability of the TFI to predict CAI. **Methods:** Twenty adults with CAI (21.45 ± 4.10 years; 169.96 ± 7.54 cm; 81.83 ± 21.97 kg; 15 female) and 20 healthy adults (22.50 ± 1.76 years; 170.30 ± 7.10 cm; 76.58 ± 14.84 kg; 14 female) volunteered for a single session where 3 ultrasound images were taken as they were side-lying with their involved limb on a bolster with $15\text{--}20^\circ$ knee flexion and neutral ankle. A single examiner collected all images while a second examiner measured talofibular intervals using straight-line tool in ImageJ (National Institute of Health, Bethesda, MD), both examiners were blinded to group allocation. Independent t-tests using the average of 3 images compared TFI differences between CAI and healthy. Binary logistic regression was used to determine ability of TFI to predict cases of CAI and healthy. Differences were considered significant if $p \leq 0.05$ and Cohen's d effect sizes were moderate-to-large with confidence intervals that do not cross 0. **Results:** Individuals with CAI had a significantly larger TFI (3.13 ± 0.24 cm) compared to healthy controls (2.31 ± 0.67 cm, $p < 0.001$) with a large effect ($d = 1.22$) and confidence intervals that did not cross 0 (0.55, 1.90). TFI explained a large variance ($R^2 = 0.562$, $p = 0.010$) between groups and successfully predicted 95% of cases with CAI and 71% of healthy individuals. **Conclusions:** Ultrasound measurement of the TFI in a neutral ankle position is larger in individuals with

CAI compared to healthy adults. Although this measurement is highly predictive of presence or absence of CAI, it is not indicative of which mechanical change (fibular or talar position fault, ligamentous laxity, etc) causes the increased TFI length. Clinicians can quantitatively assess the TFI using ultrasound imaging and may be useful in guiding treatment protocols for individuals with CAI. Future research should investigate the associations between TFI length and other mechanical changes after ankles sprains.

Hop Biomechanics Associate With Greater Talar Cartilage Deformation Following a Dynamic Loading Protocol in Those With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) demonstrate changes in talar cartilage composition (i.e. decreased proteoglycan density), an early marker of joint degeneration. As a result, talar cartilage behavior may be altered in response to mechanical loads in this population as cartilage behavior is driven by its composition. Elucidating a link between movement dysfunction and altered cartilage behavior would provide insight regarding potential therapeutic targets to help slow ankle joint degeneration in individuals with CAI. Therefore, the purpose of this study was to identify the relationship between hopping biomechanics and the magnitude of talar cartilage deformation after a standardized dynamic (i.e. hopping) protocol in individuals with CAI. **Methods:** Thirty individuals with CAI (11M, 19F; 20.5±2.2 years, 1.7±0.7m, 75.7±16.2kg) volunteered to participate. Inclusion criteria followed International Ankle Consortium guidelines. After a 60-minute rest, US images of the talar cartilage were acquired immediately before and after a dynamic loading protocol consisting of 60 single leg

forward hops (60cm distance). Talar cartilage images were acquired with the ankle in 140° of plantar flexion, and manually segmented to calculate medial, lateral, and overall average thickness (mm). The percent change relative to the average baseline thickness was used for further analysis. A greater negative percent indicates greater cartilage deformation. Three-dimensional kinematics and kinetics were sampled during single leg hopping at a distance of 60cm away from the center of a force platform. Kinematic variables included initial contact and peak angles of the ankle joint in the sagittal plane. Kinetic variables included the peak vertical ground reaction force (vGRF) and loading rate, which were normalized to body weight. The average of 5 data collection trials was used for further analysis. Pearson correlations were calculated to determine associations between cartilage deformation magnitude and hop biomechanical variables ($p < 0.05$). **Results:** Smaller peak dorsiflexion angles were associated with greater medial cartilage deformation ($r = -0.382$, $p = 0.045$). Greater plantar flexion angles at initial contact were associated with greater overall ($r = -0.376$, $p = 0.048$) and medial cartilage deformation ($r = -0.437$, $p = 0.020$). Greater peak vGRF was associated with greater overall ($r = -0.483$, $p = 0.011$) and medial ($r = -0.440$, $p = 0.019$) cartilage deformation. Also, greater loading rates were associated with greater overall ($r = -0.425$, $p = 0.027$) and lateral ($r = -0.470$, $p = 0.012$) cartilage deformation. **Conclusions:** Our data suggest that a greater

sagittal plane range of motion (i.e. greater peak dorsiflexion) and smaller impact force may be associated with more appropriate cartilage deformation after a dynamic loading protocol. These results suggest that targeting poor ankle biomechanics and loading via rehabilitation strategies may improve how talar cartilage responds to a dynamic load in those with CAI

Short-Term Impact of Volleyball

Workout on Knee Cartilage Thickness

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Context: Repetitive loading may modify knee articular cartilage macrostructure and potentially impact knee cartilage health. While acute structural response of knee articular cartilage from walking and running are widely reported, these structural responses to explosive sporting activities are not well understood. **Objective:** To determine changes in knee femoral condyle cartilage thickness in response to 30 minutes of volleyball-specific activity. **Methods:** Design: Cross-sectional study. Setting: Controlled laboratory. Participants: Twenty-two division I collegiate male volleyball athletes ($1.83 \pm 0.05\text{m}$, $77.0 \pm 10.8\text{kg}$, $19.6 \pm 1.1\text{yrs}$) without current lower extremity injury, previous knee surgery, or serious knee injury history were recruited. Interventions: Participants underwent ultrasound imaging of the medial femoral condyle articular cartilage on both limbs before, immediately after, and one hour after a 30 minute volleyball workout. The 30 minutes volleyball

workout included 7 minutes of dynamic warm-up exercise, 25 repetitions of receiving, 25 repetitions of blocking and 12 repetitions of spiking. **Main Outcome Measures:** Articular cartilage thickness of the middle region of medial femoral condyle was obtained via ultrasound imaging. Two-way repeated measures ANOVA examined the differences in right and left knees femoral condyle cartilage thickness before, immediately, an hour later of 30 minutes volleyball workout. **Results:** There was no significant main effect of limb on knee femoral condyle cartilage thickness ($F(1,21) = 3.127$, $p = .092$). The left knee cartilage thickness was similar with right limb ($1.7 \pm 0.2\text{ mm}$ Vs $1.7 \pm 0.2\text{ mm}$). There was significant main effect of time points on knee femoral condyle cartilage thickness ($F(2,42) = 40.599$, $p < .001$). Post hoc tests using the Bonferroni correction revealed that middle region of knee cartilage thickness increased from pre-workout to immediately post-workout ($1.6 \pm 0.2\text{ mm}$ Vs $1.8 \pm 0.3\text{ mm}$, $p < .001$) and was decreased from immediately post-workout to one hour post-workout ($1.8 \pm 0.3\text{ mm}$ Vs $1.7 \pm 0.2\text{ mm}$, $p \leq .001$). There was no significant difference between pre-workout and an hour post-workout, respectively ($1.6 \pm 0.2\text{ mm}$ Vs $1.7 \pm 0.2\text{ mm}$, $p = 1.000$). There was no interaction between limb and time points on knee cartilage measures ($F(2,42) = 1.684$, $p = .198$). **Conclusions:** After 30 minutes volleyball workout, middle region of knee articular cartilage thickness in apparently healthy knees

was thicker than pre-workout and was recovered an hour later after workout. This work suggests that volleyball workout induced short-term morphologic changes in knee cartilage. Future research focused on how long-term and other high impact activities affect knee cartilage health is needed.

The Effect of Anterior Cruciate Ligament Reconstruction on Circulating Biomarkers of Muscle Hypertrophy and Atrophy
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Context: Patients with an anterior cruciate ligament reconstruction (ACLR) frequently experience quadriceps muscle atrophy. Myostatin and transforming growth factor-beta (TGF-beta) are the biomarkers leading muscle atrophy. On the other hand, insulin-like growth factor-1 (IGF-1) and decorin are considered as the biomarkers inducing muscle hypertrophy. However, the relationships between ACLR and variation of circulating biomarkers is not clear. **Methods:** Cross-sectional research design was used to compare the variation of circulating biomarkers between pre-operative (PRE) and post-operative (PO-1: 48-72hours, PO-2: 7days after surgery) concentration. Research was conducted at a local hospital and university research laboratory. Fourteen patients (4 females, age=30.4 \pm 5.9years, height=170.8 \pm 8.6cm, mass=69.9 \pm 10.8kg) who were scheduled for a unilateral ACLR voluntarily participated. Four ml of venous blood was elected from patient's median cubital vein or cephalic vein into serum separator tube containing clot activator and serum

separator gel. Then the blood in serum separator tube was kept for 30 minutes for solidification and centrifuged at 4000RPM for 15minutes for serum distribution. The concentration of circulating biomarker was analyzed from serum sample in duplicate for each time point. Each biomarker analysis was conducted according to the manufacturer's instructions. Enzyme-Linked Immunosorbent Assay (ELISA) was performed to measure circulating level of myostatin, TGF-beta, IGF-1, and decorin at three time points (PRE, OP-1, OP-2). One-way repeated measure ANOVA was used to compare variation of each circulating biomarkers between time points. Partial eta squared was calculated to assess effect size across time point. **Results:** The hypertrophy inducing factors, IGF-1 (ng/ml) exhibited a significant reduction between three time points (PRE=171.79 \pm 33.55, OP-1=145.29 \pm 26.82, OP-2=143.43 \pm 32.97, F(2,12)=6.24, p=0.006). Pairwise multiple comparisons revealed that PRE IGF-1 level was significantly greater than OP-1 (p=0.02) and OP-2 (p=0.01). Decorin (pg/ml) didn't show a significant differences but exhibited moderated to large effect size (PRE=4251.97 \pm 1395.82, OP-1=3656.89 \pm 1246.92, OP-2=3830.18 \pm 1464.61, F(2,12)=1.64, p=0.218). The atrophy inducing factors, myostatin (ng/ml) (PRE=3.34 \pm 1.83, OP-1=3.63 \pm 2.17, OP-2=5.37 \pm 4.90, F(2,12)=2.47, p=0.104) and TGF-beta (pg/ml) (PRE=7297.86 \pm 2105.00, OP-1=6679.24 \pm 2655.43, OP-2=6473.55 \pm 2293.17, F(2,12)=0.881, p=0.427) didn't show significant differences among three time points.

Conclusions: Hypertrophy inducing factor, IGF-1 significantly reduced in the entire periods. Since hypertrophy inducing factor was decreased, it may indicate that ACLR directly influenced on circulating biomarkers causing alteration of muscle morphology. Therefore, preserving IGF-1 level in the early phase of ACLR rehabilitation may provide a pharmaceutical option to prevent muscle atrophy after an anterior cruciate ligament injury.

Rapid Onset Chondrolysis and Osteoarthritis Following Anterior Cruciate Ligament Reconstruction: Level 4 CASE Study

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Background: A healthy 38-year old female tore her right ACL while skiing and underwent ACL reconstruction with allograft. Post-surgery, she developed severe arthrofibrosis restricting her ROM, and subsequently underwent manipulation under anesthesia(MUA) at 2-months and 10-months post-ACL surgery. She was evaluated in our clinic by an athletic trainer(AT) and orthopedic surgeon 15-months post-ACL surgery with ongoing complaints of pain, loss of motion, and difficulty walking. Her right knee ROM was 0 to 90 degrees, compared with -3 to 135 on the left. Physical examination revealed incision site was well healed, knee had moderate effusion, warm to the touch, tenderness over lateral and medial condyle, and no patellar glide. She was ligamentous stable. **Differential Diagnosis:** Intraarticular infection, arthrofibrosis, chondrolysis, osteoarthritis, reactive synovitis to ACL hardware, rheumatoid arthritis, crystalline arthritis. **Intervention & Treatment:** Radiographs, MRI, and blood cultures were obtained at her initial clinic visit (15-months post-ACL surgery). Radiographs demonstrated ACL hardware intact in anatomical position, and

mild-to-moderate loss of joint space in all 3 compartments (Figure 1). MRI demonstrated moderate-to-high grade chondral thinning throughout weightbearing compartments, diffuse synovitis, and anterior interval arthrofibrosis. Blood work was negative for infection. Patient underwent a round of prophylactic antibiotics which did not alleviate symptoms. The patient subsequently underwent surgery (18-months post-ACL surgery) for removal of ACL hardware and intraarticular biopsies. Biopsies showed signs of inflammation, but were negative for infection, rheumatoid arthritis, or crystalline arthritis. Post-surgery the patient engaged in aggressive physical therapy to regain ROM. She had a steroid injection 1-month later due to ongoing pain, after which she reported additional loss of ROM. A new MRI was obtained at 23-months post-ACL surgery. The MRI revealed tricompartmental grade III to IV cartilage loss, as well as scarring consistent with arthrofibrosis. The patient was diagnosed with chondrolysis. The patient was referred to a joint replacement specialist, where radiographs were obtained demonstrating tricompartmental complete loss of joint space (Figure 1). The patient was diagnosed with end-stage osteoarthritis. Due to ongoing pain and difficulty performing weight bearing ADL she elected to schedule a total knee replacement at age 40. **Uniqueness:** Within 26-months the patient went from a healthy knee to tricompartmental cartilage loss requiring total joint replacement. Rapid onset chondrolysis following an index surgery has been reported in the literature although the clinical incidence is

rare. Most reported cases are at the hip, shoulder, or less commonly the knee. Cases are associated with mechanical (e.g. hardware reaction), chemical (e.g. infection, intraarticular bupivacaine pain pump [bupivacaine is chondrotoxic]) or thermal (e.g. radiofrequency devices) potential etiological factors. However, the etiology of chondrolysis in this case is unknown. The patient had no known predisposing factors, no evidence of infection or hardware reaction, and no intraarticular pain pump use for the ACL surgery (continuous infusion pain pump was used as a regional anesthetic post-MUAs). **Conclusions:** Athletic trainers commonly provide evaluation, rehabilitation, and counseling for patients before and after ACL reconstruction surgery. ACL reconstruction is thought to preserve the knee, decreasing incidence and/or prolonging the time until development of post-traumatic osteoarthritis. In this case, the ACL surgery likely triggered a chain of events that led to rare rapid onset chondrolysis and subsequent osteoarthritis diagnosis. Complaints of pain and loss of ROM are not uncommon post-ACL reconstruction and may be treated with conservative therapy or in persistent cases surgical MUA. However, when these treatments do not resolve symptoms the AT should be aware of differential diagnoses, such as chondrolysis, and have a high index of suspicion if potential etiological factors are present. The AT should promptly refer patients who do not progress normally for orthopedic consult, advanced imaging, and diagnostic studies.

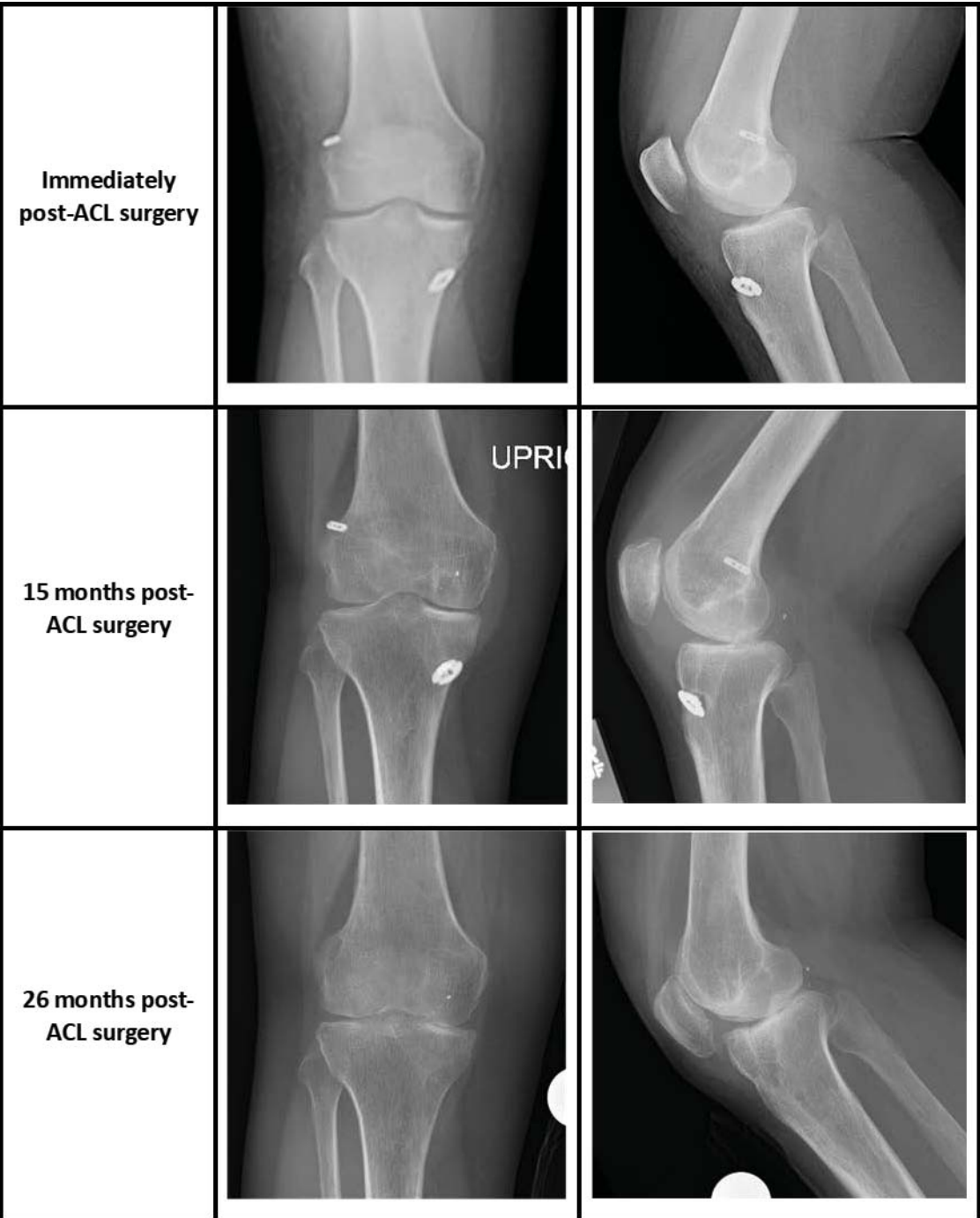


Figure 1. Radiography of the right knee showing rapid onset of degenerative changes.

Quadriceps Muscle Quality Is Associated With Strength But Not Walking Gait Biomechanics Following Anterior Cruciate Ligament Reconstruction

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Context: Diminished quadriceps strength and aberrant gait biomechanics have been linked to post-traumatic knee osteoarthritis following anterior cruciate ligament reconstruction (ACLR). These neuromuscular and biomechanical changes are partially attributable to quadriceps dysfunction due to altered muscle activation. Evidence suggests that the quadriceps undergo morphological changes in the form of atrophy and altered muscle quality due to fatty infiltration following ACL injury and surgical reconstruction (ACLR) that can be detected via B-mode ultrasound. However, the concomitant effect of reduced quadriceps muscle quality (QMQ) on isometric strength and walking biomechanics is poorly understood. Therefore, the purpose of this study was to determine the relationship between QMQ and quadriceps isometric peak torque and gait biomechanics in individuals with ACLR. **Methods:** This laboratory-based, cross-sectional study enrolled 36 individuals (20 F, 16 M; 22 ± 4 years old; BMI

23.7 ± 2.8 kg/m²; 49 ± 35 months since ACLR) at least 6 months removed from unilateral, primary ACLR. Panoramic B-mode ultrasound images of the vastus lateralis (VL) and rectus femoris (RF) were obtained at 50% of the femur length. Images were then analyzed using ImageJ software by outlining the muscle of interest while excluding the surrounding fascia. QMQ was defined as the echo-intensity (EI) of each muscle, with poorer quality represented by higher EI values. Quadriceps peak torque (PT) was averaged from 2 maximal voluntary isometric contraction trials and normalized to body mass. Gait biomechanics were assessed overground at a self-selected speed from which the peak vertical ground reaction force, knee flexion angle, and internal knee extension moment, and knee sagittal plane displacement during the first 50% of stance were determined. Associations between QMQ and strength were assessed via partial Pearson correlation controlling for time since ACLR. Associations between QMQ and gait variables were assessed via partial Pearson correlation controlling for time since ACLR and gait speed. **Results:** Greater EI of the VL (partial $r = -0.514$; $p = 0.002$) and RF (partial $r = -0.544$; $p = 0.001$) were associated with lower PT. There were no significant associations between EI in either muscle group and any gait variables. **Conclusions:** At an average of 4 years removed from ACLR, poorer QMQ was associated with lesser PT, indicating that the composition of the musculature influences maximal force production capacity. However, there were no significant associations between QMQ and gait biomechanics indicating that variability

in QMQ may not be sufficient to account for subtle differences in gait biomechanics due to the submaximal nature of the task. Strength deficits may contribute to decreased physical performance metrics in athletes and increase the risk of secondary injury. Future research is needed to longitudinally evaluate QMQ following ACLR and to determine the concomitant effects on secondary injury risk and long-term knee joint health.

Hamstrings Muscle Morphology After Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-Analysis

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Context: Hamstrings morphology is determinant of muscle function (i.e. strength). Among individuals with ACL reconstruction (ACLR), less cross-sectional area (CSA) and volume in the ACLR limb are associated with muscle weakness, which may contribute to lower rates of return to preinjury activity level and an increased risk for long-term sequelae. To effectively treat muscular impairments, an accurate understanding morphological differences following ACLR is needed. A systematic review and meta-analysis were undertaken to describe hamstrings morphology after ACLR. **Methods:** We searched five databases for studies evaluating the difference between hamstrings size (e.g. volume, CSA, thickness, muscle length) and architecture (e.g. fascicle length, pennation angle, fiber area, fiber type) in individuals with ACLR relative to contralateral and control limbs. Two independent reviewers assessed each study for inclusion and quality. When possible, standardized mean differences (Hedge's g) were calculated with 95% confidence intervals and compared via fixed-effect meta-analysis. **Results:** Twenty-four studies were included

for final review. Eight categories of morphological outcomes were identified, and studies were grouped accordingly: (1) volume, (2) CSA, (3) muscle length, (4) muscle thickness, (5) fascicle length, (6) pennation angle, (7) fiber area, and (8) fiber type. Upon meta-analysis, moderate quality evidence demonstrated lower hamstrings volume in the ACLR limb compared to contralateral ($g = -0.36$, 95% CI $[-0.48, 0.23]$; Figure 1) and control ($g = -0.29$ $[-0.50, -0.08]$) limbs. Additionally, moderate quality evidence demonstrated lower CSA ($g = -0.41$ $[-0.51, -0.31]$), muscle length ($g = -0.74$ $[-1.06, -0.41]$), and thickness ($g = -0.40$ $[-0.66, -0.13]$) in the ACLR limb compared to the contralateral limb. The semitendinosus and gracilis volume ($g = -0.98$ $[-1.22, -0.74]$ and -0.83 $[-1.19, -0.48]$) and CSA ($g = -0.73$ $[-0.90, -0.55]$ and -1.01 $[-1.26, -0.77]$) were most profoundly impacted (e.g. comparisons of biceps femoris and semimembranosus were negligible). Upon systematic review, limited moderate evidence demonstrated the biceps femoris (long head) had shorter fascicle length and greater biceps femoris pennation angle in the ACLR limb compared to the contralateral limb. **Conclusions:** Moderate evidence suggests that individuals with ACLR demonstrate smaller semitendinosus and gracilis CSA and volume, shorter semitendinosus length, and smaller semitendinosus thickness in the ACLR limb compared to contralateral and control limbs. Limited evidence suggests that the ACLR limb biceps femoris long head demonstrates shorter fascicle length and greater pennation angle compared to contralateral and control

limbs. Limited evidence suggests that ST fiber area or fiber type distribution are not different between limbs following ACLR. Collectively, these morphological characteristics align with known clinical impairments (e.g. decreased hamstrings muscle strength), all of which may contribute to poor outcomes seen in this population. The largest of these impairments, semitendinosus and gracilis CSA and volume, may be modifiable via therapeutic exercises that emphasize medial hamstring hypertrophy.

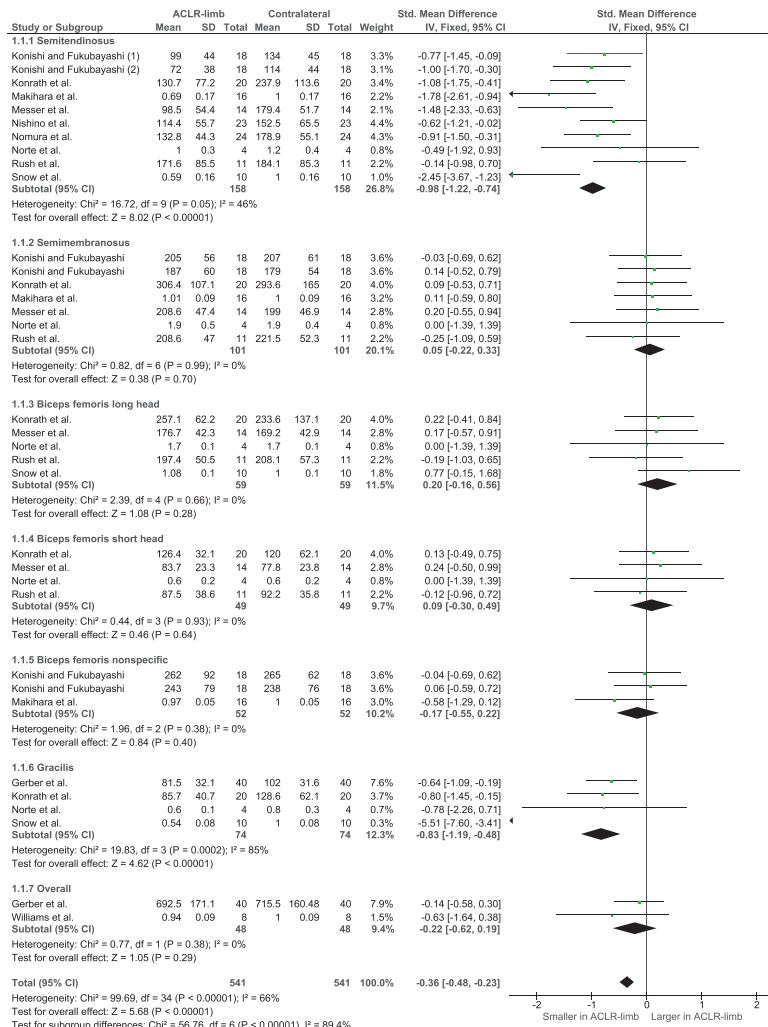


Figure 1: Inter-limb comparison of hamstrings volume. (1) 6 months post-ACLR, (2) 12 months post-ACLR. Abbreviations: *ACLR-limb* Anterior cruciate ligament reconstruction limb, *SD* Standard deviation, *Std.* standard, *CI* confidence interval.

Changes in Knee Joint Loading in Individuals With Anterior Cruciate Ligament Reconstruction Across Times
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Context: Alteration in mechanical loading at the knee joint have been observed at the time of return to sport (RTS) and years after RTS following anterior cruciate ligament reconstruction (ACLR) as potential factors for patellofemoral pain (PFP) and osteoarthritis (PFOA). However, it is unclear how knee joint loading changes across continuum of care. Furthermore, side of dominance that underwent ACLR has not been considered in previous studies. The purpose of this study was to examine the differences in knee joint loading during gait between the surgical (SURG) and non-surgical (Non-SURG) limbs in individuals who injured their dominant limb (ACL-D) or non-dominant limb (ACL-ND) at 12-week post-surgery (12WK) and RTS. **Methods:** Cohort study design was used in the clinical laboratory setting. Thirty-six males (N=16) and females (N=20) between 12-25 years of ages who had undergone

ACLR participated (Age=15.57±1.38yrs; Ht=172.62±9.30cm; mass=74.11±15.92Kg). Eight 3-dimensional cameras and two forceplates collected bilateral kinematics and ground reaction forces while participants walked on 10-meter runway. Peak patellofemoral joint stress (PFJS) in MPa and knee extension moment (KEXTmm) in Nm/(Ht*BW) were assessed during the stance phase of gait. Participants were grouped into ACL-D and ACL-ND. Time-by-limb repeated measures ANOVAs were performed to compare PFJS and KEXTmm between limbs (SURG vs Non-SURG) over time (12W and RTS) in each group. Post-hoc Bonferroni tests were performed with significant interaction ($p \leq 0.05$). **Results:** Means and standard deviations for each dependent variable are presented in Table 1. For KEXTmm, significant limb by time interactions were observed in both ACL-D ($p=0.026$) and ACL-ND ($p=0.017$) groups. For the ACL-D group, both the SURG and Non-SURG KEXTmm significantly improved from 12W to RTS ($p=0.028$ and $p<0.001$, respectively). Additionally, SURG KEXTmm was significantly smaller than Non-SURG KEXTmm at RTS ($p=0.007$). For the ACL-ND group, both the SURG and Non-SURG KEXTmm significantly improved from 12W to RTS ($p<0.001$ and $p=0.049$, respectively). SURG KEXTmm was significantly smaller than Non-SURG KEXTmm at 12W ($p=0.007$). For PFJS, main effect for limb was observed in both groups (ACL-D $p=0.005$; ACL-ND $p=0.012$). While ACL-D group had

greater PFJS in the Non-SURG limb compared to the SURG limb, ACL-ND group had greater PFJS in the SURG limb compared to the Non-SURG limb over time. No other significant differences were observed. **Conclusions:** Side of dominance played a role on KEXTmm and PFJS following ACLR. Although not significant greater KEXTmm in the SURG limb in the ACL-ND may indicate higher risk of PFP and PFOA. In addition, greater PFJS is associated with PFP and PFOA may indicate higher risk in the SURG limb in the ACL-ND and Non-SURG limb in ACL-D. Rehabilitation program should focus on both limbs to prevent consequent patellofemoral joint pathologies. Clinicians should consider which limb was injured when designing rehabilitation programs.

		ACL-D		ACL-ND	
		SURG	Non-SURG	SURG	Non-SURG
PFJS (MPa)	12W	4.76±2.50	8.01±2.83	7.83±3.55	5.57±2.47
	RTS	5.12±1.92	8.69±3.58	8.39±4.78	5.87±2.39
KEXTmm (Nm/[Ht*BW])	12W	-0.023±0.018	-0.009±0.017	-0.010±0.013	-0.031±0.021
	RTS	-0.042±0.017	-0.067±0.023	-0.058±0.022	-0.045±0.016

Table 1. Means and standard deviations of PFJS and KEXTmm at each time point in each group. ACL-D = group that had ACLR on dominant limb, ACL-ND = group that had ACLR on non-dominant limb. SURG = surgical limb, Non-SURG = non-surgical limb, 12W = 12 week post-surgery, RTS = time at return to sport, PFJS = patellofemoral joint stress, and KEXTmm = peak internal knee extension moment.

Inefficient Visual Cortex Activation Is Associated With Postural Control Deficits in Anterior Cruciate Ligament Reconstruction Patients

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Context: Postural control deficits are commonly found in patients with anterior cruciate ligament reconstruction (ACLR), which may alter brain's function. Although visual feedback plays an important role in postural control, it still remains unclear how ACLR impacts neural processing in the visual cortex during postural control tasks. We hypothesized that the ACLR group would have worse overall postural control, but increased electrocortical activation in the visual cortex to compensate postural control deficits compared to healthy individuals.

Methods: This case control study was conducted in a research Laboratory. We examined postural control and electrocortical activation in the visual cortex (Oz) during single-leg stance tasks in ACLR patients and healthy controls. Fifteen unilateral ACLR patients (ACLR: 23.13±3.2yrs, 76.02±17.22kg, 172.55±9.95cm) and 15 healthy controls (CONT: 23.07±3.45yrs, 71.09±11.31kg, 175.68±11.58cm) with no history of knee injury volunteered. All participants performed 40 trials (20s/trial) of single-leg stance under two conditions (VFSP: visual

feedback on stable platform, NVFUP: non-visual feedback on unstable platform) on the affected knee for the ACLR or the matched knee for the CONT. Electrocortical activation in the Oz in theta (4-8Hz) and alpha-2 (10-12Hz) frequency bands during the first 3 seconds of single-leg stance was calculated for event-related synchronization (ERS: % increased power relative to a non-active baseline), while postural control was calculated as the overall stability index (OSI). The OSI and ERS values were compared across groups (ACLR, CONT) and conditions (VFSP, NVFUP) using repeated measure ANOVAs.

Results: A significant group by condition interaction effect for OSI ($p=.034$, $F[1,24]=5.057$) was found. The NVFUP resulted in poorer postural control in both groups (ACLR: $p<.001$, 2.72 ± 0.76 ; CONT: $p<.001$, 2.11 ± 0.53) than the VFSP (ACLR: 0.77 ± 0.15 , CONT: 0.75 ± 0.22), with greater postural control impairment in the ACLR (2.74 ± 0.74) compared to the CONT ($p=.010$, 2.05 ± 0.54) during the NVFUP. There was a significant main condition effect with a greater theta ERS in the Oz during the NVFUP ($p=.042$, $F[1,26]=4.60$, 15.54 ± 24.90) compared to the VFSP (7.25 ± 21.45), as well as a significant main group effect with a greater alpha-2 ERS in the ACLR ($p=.002$, $F[1,24]=11.55$, 8.37 ± 23.28) compared to the CONT (-24.77 ± 15.57) during NVFUP. **Conclusions:** The ACLR group maintained a similar postural control to the CONT group during the VFSP but greater postural control impairment during the NVFSP with increased the visual cortical activation and visual processing. ACLR had higher Oz alpha-2

activation than CONT which indicates lower visual cortex excitability. It may indicate that visual neural processing in ACLR was not efficient enough to compensate for deafferented proprioceptive inputs in order to accommodate for harder postural control. Our findings highlight clinicians the necessity of advanced postural control exercises emphasizing visual neural processing responsible for task complexity to optimize patient outcomes.

Examining the Dynamic Complexity of the Quadriceps Following Anterior Cruciate Ligament Reconstruction

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Context: The anatomical complexity of the quadriceps has traditionally been assessed in a static state after anterior cruciate ligament reconstruction (ACLR). While providing valuable insights, these methodologies fail to examine the intricate changes in the dynamic connective tissue elements (i.e. fascicle length [FL] and pennation angle [PA] behavior) that largely contribute to performance. Hence, it is unclear to what extent the dynamic contractile elements of the quadriceps are altered after ACLR. Thus, the purpose of our research was to determine if alterations in connective tissue behavior are present after ACLR. **Methods:** 18 unilateral ACLR individuals (9m/9f; 21±3yrs; 1.74±0.12m; 71.58±13.31kg; months from surgery: 38±36) and 9 healthy controls (3m/6f;

23±2yrs; 1.67±0.10m; 63.51±10.11kg) participated. Vastus lateralis tissue behavior was recorded bilaterally using high-speed ultrasonography that was synchronized a dynamometer during three maximal isokinetic knee extensions (60°·s⁻¹). FL (cm) and PA (degrees) excursions and fascicle shortening velocity (FSV; cm·s⁻¹), were calculated and analyzed from rest to peak torque. Knee extension strength was also assessed and averaged between the three isokinetic trials and normalized to body mass (Nm·kg⁻¹). Group by limb interactions were assessed using separate two-way analyses of variance. Significant interactions were further evaluated by comparing 95% confidence intervals. **Results:** Significant interactions were present for PA at peak torque (F=7.18; P=0.01), FL excursion (F=4.01; P=0.05), PA excursion (F=10.92; P<0.01), FSV (F=3.87; P=0.05) and strength (F=4.90; P=0.03). Upon post-hoc evaluation, the ACLR limb displayed significant alterations in dynamic contractile behavior compared to all limbs (Table 1; P<0.05) and reduced strength compared to both the contralateral limb and right control limb (P<0.05). No significant interactions were present for resting variables or FL at peak torque (P>0.05). **Conclusions:** Our

data show that those with a history of ACLR have fascicles that are slower and lengthen significantly less. Those with a history of ACLR also operate with lower muscle-fiber pennation angles. Maladaptations in connective tissue behavior are altered in those with a history of ACLR and may be an important underlying factor to explaining the protracted quadriceps dysfunction that is common.

Table 1. Group by Limb Comparison of Connective Tissue Behavior (Mean ± SE (95% CI))

Muscle Mechanics	ACLR		Control	
	Surgical	Contralateral	Right	Left
Pennation angle at peak torque (degrees)	16.20 ± 0.63 (14.93-17.47)	20.70 ± 0.63 (19.43-21.97)	19.49 ± 0.90 (17.69-21.39)	19.84 ± 0.90 (18.05-21.64)
Fascicle length excursion (Δ cm)	19.97 ± 2.50 (14.96-24.98)	27.14 ± 2.50 (22.13-32.16)	33.09 ± 3.53 (26.00-40.18)	28.03 ± 3.53 (20.94-35.12)
Pennation angle excursion (Δ degrees)	4.45 ± 0.46 (3.52-5.37)	7.63 ± 0.46 (6.71-8.56)	8.04 ± 0.65 (6.73-9.34)	7.51 ± 0.65 (6.20-8.81)
Fascicle shortening velocity (cm·s ⁻¹)	44.28 ± 5.56 (33.11-55.45)	63.49 ± 5.56 (52.33-74.66)	67.88 ± 7.86 (52.09-83.68)	60.31 ± 7.86 (44.52-76.11)
Strength (60°·s ⁻¹ , Nm·kg ⁻¹)	1.88 ± 0.09 (1.71-2.06)	2.15 ± 0.09 (1.96-2.32)	2.27 ± 0.12 (2.03-2.52)	2.07 ± 0.12 (1.82-2.32)

Bold values indicate significant difference from surgical limb. Abbreviations: anterior cruciate ligament reconstruction (ACLR)

Individuals With Chronic Ankle Instability Have Lower Motor Cortex Interhemispheric Structural Connectivity Compared to Healthy Controls

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Context: There is growing evidence of CNS adaptation in patients with CAI. Our previous work demonstrates alterations in white matter (WM) microstructure in efferent motor tracts in individuals with CAI. WM microstructure is crucial for the fidelity of transmitted neural information between brain regions. Neural transmission also relies on the number of physical connections between brain regions, or structural connectivity. Interhemispheric structural connectivity between homologous motor regions contributes to motor control, which may provide important insight into the source of aberrant movement patterns in those with CAI. The purpose of this study was to compare the degree of structural connectivity between individuals with and without CAI. **Methods:** Using a case-control design, fifteen volunteers with ($n=8$; Age=30.00 \pm 7.85yrs; Height=168.95 \pm 6.83cm; Mass=81.27 \pm 15.63kg) and without ($n=7$; Age=23.57 \pm 1.27yrs; Height=164.37 \pm 7.99cm; Mass=58.73 \pm 10.63kg) CAI as defined by the International Ankle Consortium guidelines reported to our MRI research

center and underwent neuroimaging of the brain. Neuroimaging data were collected on a Siemens 3T TIM Trio system. Diffusion tensor imaging data were processed and analyzed using Functional MRI of the Brain software library (FSL v5.0.10). Tractography analysis was conducted using FSL's ProbtrackX software. Bilateral lower extremity portions of the homunculus within the motor cortex were isolated for seed and target purposes. ProbtrackX software was used to determine the likely number of connections between the left and right hemisphere, with each hemisphere serving as a seed and target. The number of seed-to-target connections (out of 5,000 streamlines) was determined for each voxel within each seed region. An average number of connections was calculated for all voxels within the seed region. A composite connectivity score (0-2) was generated to determine bilateral structural connectivity strength in each participant. Values closer to zero indicate lower structural connectivity; values closer to 2 indicate higher structural connectivity. Independent t-tests and Cohen's d effect sizes were employed to compare the structural connectivity between CAI and Control groups. Significance was set at $P<0.05$. Moderate effects were considered 0.50-0.80 and strong effects were considered >0.80 . **Results:** The CAI group had significantly higher BMI ($P=0.006$), but this did not present as a significant co-variate on the composite scores ($r=-0.433$; $P=0.107$). The CAI group had significantly lower composite scores (0.255 \pm 0.157) than Controls (0.701 \pm 0.538) ($P=0.042$; $d=1.09$). **Conclusions:** Individuals

with CAI presented with lower interhemispheric structural connectivity between lower extremity portions of the motor cortex. Whether the presence of this difference is the cause or the result of injury has yet to be determined. These findings add to the growing evidence of CNS structural alterations among individuals with CAI, but more work is needed to understand the interplay with observed dampened motor outputs seen in this population. Further, intervention studies should address CNS structural adaptations in those with CAI.

Altered Corticospinal Excitability During Single-Leg Balance Following Acute Ankle Sprain

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Context: There is emerging evidence that altered corticospinal excitability was found in patients with chronic ankle instability during postural control. However, it is unknown whether the neural changes occur following an acute injury. Thus, the purpose of the study was to examine the corticospinal excitability of the fibularis longus (FL) in patients with acute ankle sprains (AAS) during single-leg balance.

Methods: The study design was the case-control study conducted in the laboratory. Fourteen patients with acute lateral ankle sprains (9 female, 5 male; 19.8 ± 2.0 yrs, 171.9 ± 8.2 cm, 69.7 ± 8.2 kg) and 14 uninjured, matched control participants (9 female, 5 male, 20.7 ± 2.3 yrs, 174.17 ± 8.8 cm, 69.5 ± 14.9 kg) volunteered. We used an outcome measure of the motor evoked potential (MEP) to quantify the corticospinal excitability. MEP is a twitch response to Transcranial Magnetic Stimulation (TMS) over the primary motor cortex. We measured MEP of the FL muscle at three different stimulus intensities: 100%, 120%, and 140% of active motor threshold (AMT). AMT was determined as the lowest TMS intensity required to evoke MEPs

exceeding the MEP threshold by using software that runs the maximum-likelihood threshold tracking algorithm. The magnetic stimulation was provided once participants maintain a single-leg balance position with the involved side. Ten trials of MEP at each stimulus intensity were acquired, averaged, and normalized to background FL electromyogram. In addition to MEP testing, we quantified single-leg balance performance with Center-of-Pressure (COP) excursion, collected during 10-sec single leg balance on a force plate. Three trials of COP excursion were recorded, and COP velocity (cm/s) was computed to represent postural control, with a higher value indicating poor balance. We performed separate independent t-tests to determine group differences, with an alpha level set at $P \leq 0.05$ and used Cohen's d effect size and its 95% confidence interval for the group difference's magnitude. **Results:** We found the MEP at AMT100% in patients with AAS was significantly higher than that of uninjured participants: AAS = 18.9 ± 5.5 mv/mv, uninjured = 14.3 ± 4.5 mv/mv, $P = 0.023$, $d = 0.91$. However, there were no group differences for MEP at a higher TMS stimulus intensity: for AMT120%, AAS = 27.8 ± 9.1 mv/mv, uninjured = 24.2 ± 11.7 mv/mv, $P = 0.37$, $d = 0.34$; for AMT140%, AAS = 33.3 ± 10.2 mv/mv, uninjured = 31.3 ± 14.6 mv/mv, $P = 0.30$, $d = 0.16$. As expected, our AAS group had significantly higher COP velocity than that of the uninjured group, indicating impaired postural control: AAS = 3.3 ± 0.9 cm/s, uninjured = 2.6 ± 0.5 cm/s,

$P = 0.03$, $d = 0.92$. **Conclusions:** Our findings are unique in that AAS may alter the corticospinal excitability during single-leg balance. The hyper-excitability in the FL suggests the central nervous system's compensatory mechanism to maintain a single-leg stance for 10 seconds, despite poor postural control due to proprioceptive deficits arising from damaged mechanoreceptors in the injured ankle joint following AAS.

Assessment of Quadriceps Corticomotor and Spinal-Reflexive Excitability in Individuals With a History of Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-Analysis

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Context: Differences in the excitability of motor generating neural pathways have been reported among individuals with ACL reconstruction (ACLR), which are theorized to prevent the restoration of quadriceps strength. There has yet to be a review of the literature investigating differences in spinal-reflexive, corticospinal, and intracortical pathways after ACLR. The aims of our review were to (1) compare quadriceps neural excitability of the involved limb (ACLinv), uninvolved limb (ACLuninv), and uninjured control limbs (CON), and (2) determine the time intervals that such differences occur. **Methods:** We conducted a comprehensive search of studies investigating metrics of quadriceps neural excitability using PubMed, SPORTDiscus, Embase, and Web of Science from their inception until May 2020. Studies were considered if they reported outcomes of spinal-reflexive excitability (Hoffmann Reflex [H-Reflex]), corticospinal excitability (motor threshold [MT]), motor evoked potential (MEP) amplitude, or intracortical excitability (inhibition or

facilitation). Comparisons of interest included ACLinv vs. ACLuninv limb, ACLinv vs. CON limb, and ACLuninv vs. CON limb. Individual studies were dichotomized into early (<2 years) and late (>2 years) phases of recovery based on the range of time from ACLR considering the risk for reinjury is greatest within this period. Sample sizes, means, and standard deviations were extracted for each outcome to calculate standard mean differences (Hedge's *g*) with 95% confidence intervals and heterogeneity ($I^2 < 50\%$ = homogenous) between studies. A 16-point modified Downs and Black checklist was used to assess methodological quality of each study. Where applicable, a meta-analysis was performed using a random-effects model ($p \leq .05$). Strength of evidence was determined using the methodological quality and heterogeneity between studies, and classified as strong, moderate, weak, or inconsistent. **Results:** Fourteen studies were included for review, with methodological quality ranging 11-15. A summary of the results can be found in Figure 1. The ACLinv limb exhibited greater MT compared to CON ($g = 0.60$ [0.24, 0.96], $p = .001$). The ACLuninv limb exhibited greater MT ($g = 0.49$ [0.00, 0.98], $p = .05$) and MEP amplitude ($g = 0.31$ [0.03, 0.59], $p = .04$), but lesser intracortical inhibition ($g = 0.54$ [0.14, 0.93], $p = .008$) compared to CON. During early recovery, the ACLuninv limb exhibited greater MEP amplitude compared to CON ($g = 0.33$ [0.03, 0.63], $p = .03$). During late recovery, the ACLinv limb exhibited greater H-Reflex compared to the ACLuninv

limb ($g = 0.38$ [0.00, 0.77], $p = .05$), and greater MT compared to CON ($g = 0.93$ [-0.01, 1.88], $p = .05$). The ACLuninv limb exhibited greater MT ($g = 0.57$ [0.13, 1.02], $p = .01$) and lesser MEP amplitude ($g = -1.11$ [-2.03, -0.20]; $p = .02$) compared to CON. **Conclusions:** Moderate evidence suggests that bilateral differences in quadriceps neural excitability are present in individuals with ACLR compared to uninjured controls, and occur primarily within the corticospinal tract. These differences appear to be most prominent during later phases of recovery, which may be partially compensated by greater spinal-reflexive excitability. Diminished neural excitability may underlie persistent quadriceps impairments and negatively influence long-term muscle recovery.

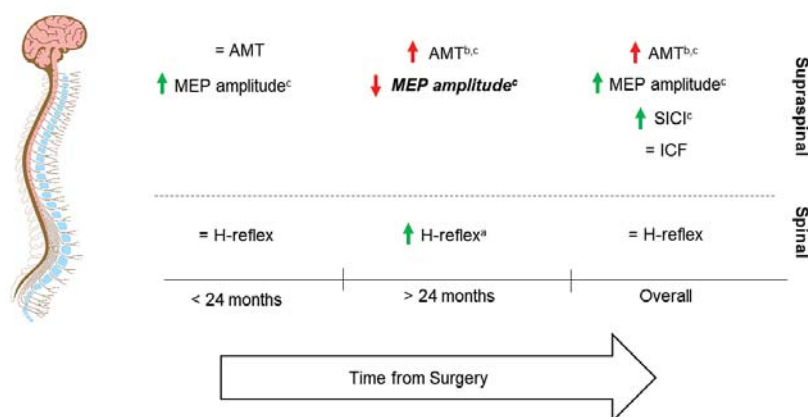


Figure 1. Evidence-based and theoretical course of adaptations in quadriceps neural excitability after ACLR

^a Involved limb different compared to uninvolved limb

^b Involved limb different compared to healthy control limb

^c Uninvolved limb different compared to healthy control limb

Italicized text indicates limited evidence and unable to include in meta-analysis

Bolded text indicates a large magnitude effect size

Red arrow indicated a negative effect

Green arrow indicates a positive effect

Influence of Whole-Body Vibration on Hamstrings Neuromuscular Function in Healthy Individuals

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Context: In those with anterior cruciate ligament reconstruction (ACLR), hamstrings neuromuscular function is a clinical impairment with implications for re-injury. Whole body vibration (WBV) has been shown to improve neuromuscular impairments (e.g. quadriceps EMG amplitude and peak torque [PT]) in both healthy and pathological populations. However, whether WBV influences neuromuscular function of the hamstrings is unknown. Clarifying the effects of WBV on global thigh (i.e. agonist-to-antagonist relationship) neuromuscular function is important for determining its clinical utility. Our purpose was to determine if WBV modified thigh (hamstrings and quadriceps) neuromuscular function characterized by EMG amplitude, antagonist-to-agonist co-activation, and PT in healthy individuals. **Methods:** We utilized a crossover design in a laboratory setting. Twenty individuals (age: 22 ± 1.9 , height: 171.7 ± 10.0 cm, weight: 77.3 ± 11.9 kg, Tegner: 5.7 ± 1.4) without history of lower extremity injury performed WBV and control protocols on separate days in randomized order. Each

protocol consisted of six 1-minute bouts of isometric double limb squatting (hips and knees at 60° flexion). Vertical oscillation WBV parameters were set to: 1mm amplitude, 30 Hz frequency and 1.81 g acceleration. Independent variables were condition (WBV, control) and time (baseline, immediately post, 20-minutes post). All participants completed three knee-flexion and three knee-extension maximal voluntary isometric contractions (MVIC) during each time point. Surface electromyography (EMG) of the semitendinosus (ST), biceps femoris (BF), vastus medialis, and vastus lateralis was recorded during MVICs. Dependent variables were hamstrings and quadriceps EMG amplitude, antagonist-to-agonist co-activation, and PT. We assessed the effect of WBV and time on each outcome measure using a 2x3 ANOVA with Bonferroni post hoc or Friedman's test with Wilcoxon signed rank test post hoc. We used Cohen d effect sizes to evaluate the magnitude of differences. For significant pairwise comparisons, we applied Spearman's rank correlation to explore relationships between baseline values and the magnitude of percent change to determine a responder effect. **Results:** We observed a condition-by-time interaction for ST ($\chi^2(5)=12.38$, $p=.030$) and BF ($\chi^2(5)=21.26$, $p=.001$) EMG amplitudes. Post hoc analyses indicated that hamstrings EMG decreased immediately (ST: $p=.006$, $d=-0.15$ [95% CI: -0.79, 0.49]; BF: $p=.006$, $d=-0.16$ [95% CI: -0.78, 0.46]) and 20-minutes (ST: $p=.001$, $d=-0.16$ [95% CI: -0.79, 0.48]) following WBV

intervention. Higher BF EMG amplitude at baseline associated with a larger magnitude decrease 20 minutes following WBV ($\rho=-0.586$, $p=.008$). **Conclusions:** WBV decreased hamstrings EMG amplitudes immediately (ST and BF) and 20 minutes (ST) following WBV, suggesting that WBV may have a small inhibitory effect on hamstrings muscle activity. In support of this, higher BF amplitude at baseline was associated with the greatest reduction at 20-minutes. These findings may have implications to normalize facilitated lateral hamstrings activity in individuals with ACLR, yet further research is necessary to establish WBV as an appropriate intervention to optimize hamstring neuromuscular outcomes in pathological populations.

The Effects of 72 Hours of Dynamic Ankle Immobilization on Neural Excitability

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Context: Orthopedic injuries have been shown to modify nervous system function, including decreasing neural excitability to stabilizing muscles. The ankle is the most commonly injured joint among the physically active, with injuries often treated with the use of immobilization. Previously, casting models have demonstrated facilitatory effects on neural excitability; however, boot immobilizers (BI) are more commonly used following injuries. Despite its common usage, little is known about the effects of BI use on neural excitability. We aimed to evaluate the effects of 72-hour dynamic ankle immobilization in a BI on corticospinal and reflexive excitability in an uninjured population. **Methods:** A crossover design was implemented using twelve healthy individuals (20.8 ± 1.4 yrs, 1.7 ± 0.1 m, 75.2 ± 9.9 kg). Participants were asked to wear one of two treatments – BI, or

a compression sock (CS) – for three days, with at least a 7-day washout between conditions. Corticospinal excitability was measured using transcranial magnetic stimulation over the primary motor cortex, while reflexive excitability was assessed using the Hoffmann reflex over the sciatic nerve, with outcomes assessed for the tibialis anterior (TA), peroneus longus (PL), and soleus (SOL). Reflexive excitability was determined as the ratio of the maximum reflexive (H) response to maximum direct (M) response. For corticospinal excitability, outcome measures included the resting motor threshold (RMT), the maximum motor evoked potential (MEPMax), and MEP size at 90, 110, and 130% RMT. Differences between times and muscles were assessed with factorial analyses of variance ($\alpha=0.05$). **Results:** A significant condition-by-time interaction was observed for H:M ratio ($F=6.496$; $p=0.031$). Post hoc testing revealed BI significantly decreased H:M ratio with no differences pre-CS and post-CS (Table). The BI did not alter RMT ($F=0.601$; $p=0.468$), MEPMax ($F=0.534$; $p=0.519$), or MEP size at 90%, 110%, and 130% RMT ($F>2.82$; $p>0.608$). **Conclusions:** Our results indicated that BI significantly decreased reflexive excitability, but did not change corticospinal excitability. Based on casting models, we had hypothesized

increased mechanical stiffness would increase excitability; however, we postulate that sensory deprivation from lack of movement served to inhibit reflexive excitability in this population, while not inducing sufficient constraint to alter cortical signaling. Therefore, the loading of the joint that occurs in BI relative to casting may offset some of the neural effects of casting. These data demonstrate the effects of BI on neural excitability among healthy individuals, but future studies are needed to determine effects in injured populations.

Table: H:M Ratio

	Pre-BI	Post-BI	Pre-CS	Post-CS
TA	0.17 ± 0.08	$0.13 \pm 0.07^*$	0.16 ± 0.08	0.15 ± 0.07
PL	0.26 ± 0.16	$0.15 \pm 0.09^*$	0.15 ± 0.07	0.15 ± 0.06
SOL	0.49 ± 0.23	$0.42 \pm 0.19^*$	0.47 ± 0.21	0.47 ± 0.20

Note: * Significantly different from Pre-BI.

The Impact of Differential Knee Laxity on Brain Activation During Knee Joint Loading

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Context: Greater anterior knee laxity (AKL) is an established risk factor of ACL injury. Individuals with greater AKL are known to have decreased ability to stabilize the knee joint during physical movements. In the process of joint stabilization, the brain plays an important role, that of integrating and processing the sensory information arising from peripheral areas. However, the potential impact of greater knee laxity on brain function is not well understood.

Methods: Twenty-seven healthy and physically active female college students without any previous severe lower leg injuries volunteered for this study. Anterior knee laxity was measured to assign participants either a greater knee laxity (GL; N=15) or lower to average laxity group (LL; N=12). Functional magnetic resonance images were obtained during anterior knee joint loading using a 3T MRI scanner. During anterior knee joint loading, a participant went through 30 sec of rest followed by 30 sec of passive

anterior knee joint loading on the left leg for a total of 4 cycles ending with a rest block. Brain image data were analyzed using FSL-FEAT. The motion-related artifacts were removed using ICA-AROMA. The first-level analysis was performed using a cluster-based threshold with z threshold at 3.1 and p threshold at 0.05. Then, the higher level GLM analysis was performed with FLAME 1+2 using an unpaired sample t -test to compare between groups (GL vs. LL). **Results:** There was no significant difference in physical activity level between greater laxity and low to average laxity groups using TEGNER ($p=0.91$) scale. In addition, there was no difference in absolute head motion ($p=0.307$) and relative head motion ($p=0.146$) during anterior knee joint loading tasks. Individuals with greater knee laxity demonstrated significantly diminished cortical activation in the left superior parietal ($p=0.00119$) and right premotor cortex ($p=0.0025$) when compared to the low to average laxity group (Figure 1 A). The greater knee laxity also demonstrated significantly higher activation in the right cerebellum ($p=0.0109$) (Figure 1 B). **Conclusions:** Altered brain activation in individuals with greater knee laxity may indicate possible functional brain reorganization influenced by knee laxity. The superior parietal lobe plays an essential role in maintaining attention to visual and tactile stimuli as well as an internal presentation of the body's state. The premotor cortex plays

a primary function in the planning or programming of voluntary movements. The cerebellum is also involved in the programming and execution of movement. The current findings suggest that individuals with greater knee laxity may have a different perception of their body's internal representation as well as altered strategies in preplanning and preprogramming potential movements when the knee joint is loaded.

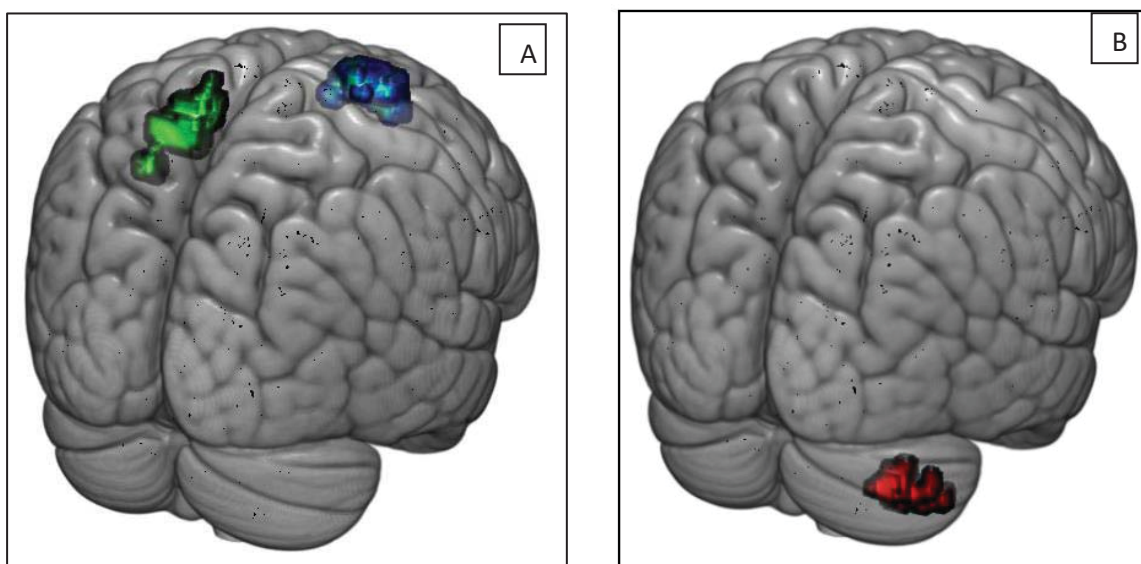


Figure 1 A) Regions with diminished activation in greater AKL individuals; the blue area represents the right premotor cortex, the green area represents the left superior parietal lobe. B) Regions with greater activation in greater AKL individuals; the red area represents the cerebellum

External Focus of Attention Influences Brain Activity Associated With Single Limb Balance Performance

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Context: External focus (EF) of attention consistently improves balance performance in healthy individuals. Consideration of the neuro-modulatory effects of EF may inform its clinical utility in addressing neuroplastic impairments after injuries such as anterior cruciate ligament reconstruction (ACLR). With a growing body of evidence detailing persistent somatosensory integration and motor excitability impairments after ACLR, interventions should consider sensorimotor integration when addressing motor control impairments. Our purpose was to compare electrocortical activity and balance performance between differing attentional foci and determine whether changes in each were associated. **Methods:** We used a cross-sectional design. Healthy individuals ($n=15$, 8 female, age=22.8±4.3 years) performed a bent-knee single-limb balance task on the non-dominant limb under three attentional focus conditions: internal focus (IF), EF-baton, and EF-laser. Electrocortical activity and postural sway were recorded concurrently using electroencephalography (EEG) and a triaxial force plate. EEG signals were decomposed, localized, and

clustered to generate power spectral density in theta and alpha-2 frequency bands. Differences in brain activity were assessed via one-way repeated-measures ANOVA on the absolute EEG power localized in 7 clusters (frontal, central, bilateral motor, bilateral parietal, and occipital). Balance performance was analyzed with center of pressure (COP) sway (e.g. area, distance, velocity) and sample entropy (repeated patterns over time, i.e. degree of variability). Differences in balance outcomes were assessed via one-way repeated-measure ANOVA. Relationships between percent change in brain activity in each cluster and change in balance performance measures were assessed using Spearman's rank correlations. We used Cohen d effect sizes to describe the magnitude of significant differences. Statistical significance was set at $p \leq .05$.

Results: Both EF conditions increased brain activity and improved balance performance compared to IF (Figure 1). EF-laser had the largest effects: increased frontal theta power ($p < .001$, $d = 0.64$), decreased central theta power ($p = .022$, $d = -0.30$), decreased bilateral motor, bilateral parietal, and occipital alpha-2 power ($p < .001$, $d = -1.38$ to -4.27), as well as, shorter overall ($p = .008$, $d = -0.94$) and more variable ($p = .017$, $d = 0.96$) sway. Decreases in non-stance limb (left) motor and parietal power were weakly associated with improved balance performance (left motor: smaller COP area [$p26 = 0.443$, $p = .023$], shorter COP path distance [$p26 = 0.409$, $p = .038$], less variable velocity [$p26 = 0.490$, $p = .011$] and deeper knee flexion angle [$p28 = -0.402$, $p = .034$]; left parietal: less variable velocity [$p26 = 0.395$, $p = .046$] and deeper knee flexion

angle [$p28 = -0.447$, $p = .017$]). **Conclusions:** EF decreased brain activity associated with postural error detection/monitoring (central cluster) and increased motor, somatosensory (parietal cluster), and visual (occipital cluster) processing compared to IF. The type of EF condition resulted in different effects, with the EF-laser condition resulting in the largest improvements in balance performance. Changes in brain activity resulting from EF were independently associated with improved balance performance. Results align with known neurophysiologic impairments (increased cognitive and visual, and decreased motor activity) following ACLR.

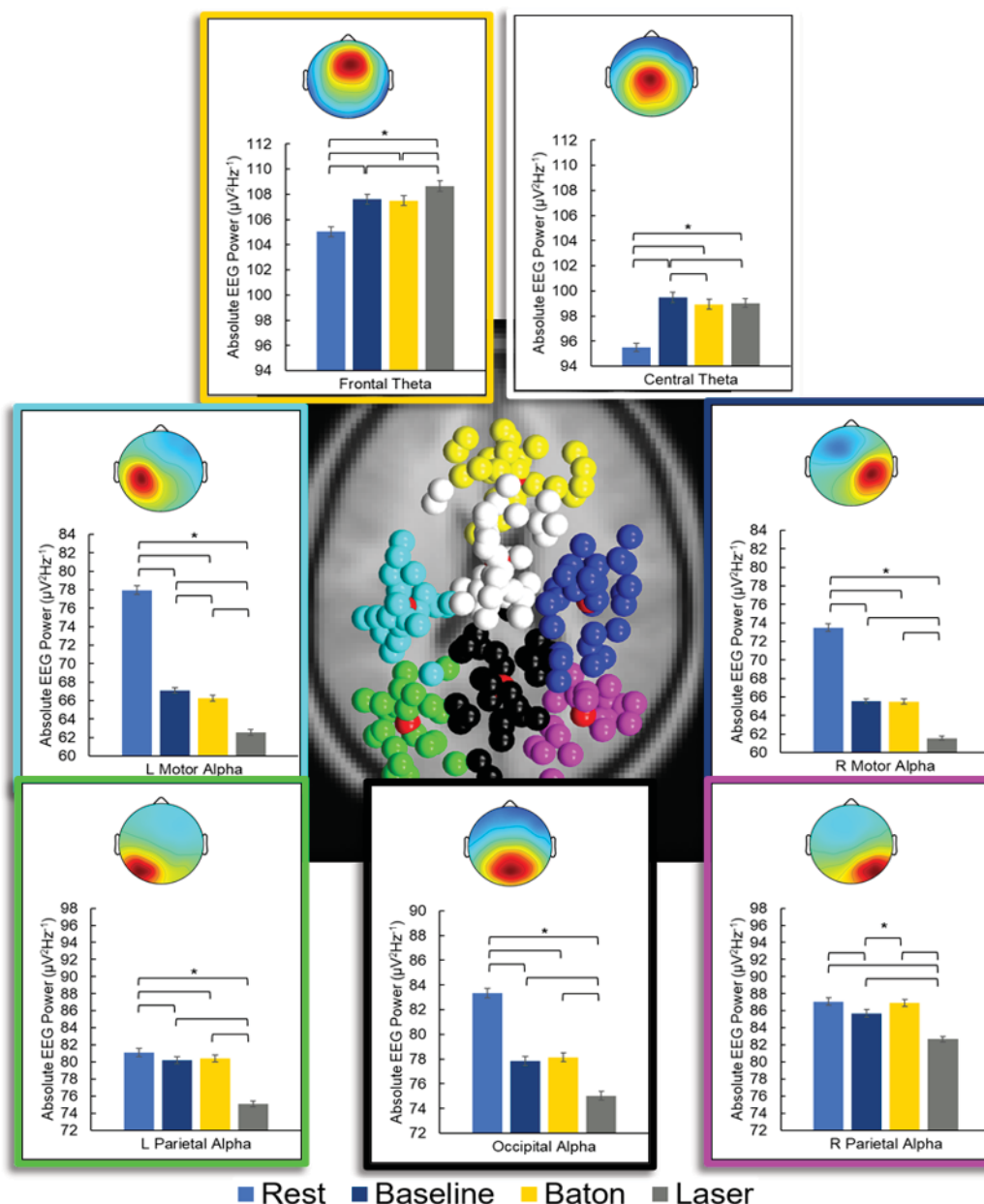


Figure 1. Image: Clusters of independent component EEG sources localized in frontal (yellow), central (white), motor left (cyan), motor right (blue), parietal left (green), parietal right (magenta), and occipital (black) from axial view. Red spheres indicate respective cluster centroids. All other colored spheres indicate a single EEG signal source. Charts: Absolute frequency band power ($\mu V^2/Hz^{-1}$) in all clusters with corresponding scalp maps. Error bars depict standard error of the mean. Statistically significant differences between conditions are indicated by brackets below the asterisk (*) at an alpha level of $p < .05$. Note: the rest condition (light blue bar) was omitted from the text of the abstract.

Countermovement Jump Performance Differences in Females With and Without History of Anterior Cruciate Ligament Construction

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Context: Jump performance and biomechanical alterations exist in individuals who have undergone anterior cruciate ligament reconstruction (ACLR). However, additional knowledge is necessary to understand whether these alterations continue long after ACLR and being cleared to return to activity. The purpose of the study was to investigate the differences in countermovement jump (CMJ) performance in females with and without a history of ACLR. **Methods:** Twenty-seven females with ACLR history (age=19.89±0.89years; mass=63.82±6.18kg; height=1.66±0.061m; duration post-ACLR=44.80±26.65months) and fourteen healthy individuals (age=19.43±0.76years; mass=69.03±12.46kg; height=1.65±0.058m) participated in this case-control study conducted in a research laboratory. After warm-up on stationary bike, the participants performed CMJs. Biomechanical data from averages of five successful CMJ trials were recorded. Independent variables were surgical side (limb dominance for healthy individuals), and group (ACLR, healthy). Dependent variables (DVs) included maximum knee flexion (KF) and hip flexion (HF) before take-off (@Takeoff), maximum KF and HF during landing (@Landing), normalized vertical ground

reaction force (vGRF) during landing, jump height, and landing force symmetry (surgical/dominant side as the numerator). For each DV, a separate group-by-side repeated measures ANOVA was performed. Jump height and landing force symmetry were analyzed across groups using one-way ANOVA. The level of significance was set apriori at $p<0.05$. Post-hoc pairwise comparison with SIDAK adjustment was performed for significant interactions. **Results:** Healthy individuals (dominant= 76.99±10.61°, nondominant= 65.06±12.46°) had greater bilateral differences in KF@Takeoff than ACLR individuals (surgical= 78.32±10.56°, nonsurgical= 74.50±11.84°), but this was not statistically significant. Surgical (dominant) side had greater KF@Takeoff ($p=0.001$). There were significant side ($p=0.001$) and group ($p=0.013$) effects and group-by-side interaction ($p=0.035$) for KF@Landing. ACLR individuals (surgical= 73.34±16.81°, nonsurgical= 70.68±16.69°) had greater KF@Landing than healthy individuals (dominant= 65.05±16.67°, nondominant= 53.58±12.48°), especially on the nonsurgical side. HF@Takeoff between ACLR (surgical= 79.22±13.73°, nonsurgical= 78.89±13.32°) and healthy individuals (dominant= 71.54±12.71°, nondominant= 72.81±11.74°) was not significantly different ($p>0.05$). HF@Landing between ACLR (surgical= 63.17±28.25°, nonsurgical= 63.34±27.20) and healthy individuals (dominant= 47.00±19.95°, nondominant= 48.83±19.29°) did not reach statistical significance ($p>0.05$). Although side and group main effects were not significant ($p>0.05$), group-by-side interaction was significant ($p=0.046$) for vGRF. ACLR individuals demonstrated smaller vGRF (surgical= 1.71±0.44,

nonsurgical= 1.84±0.43) especially on the surgical side than healthy individuals (dominant= 1.98±0.46, nondominant= 1.88±0.42). Jump height was not significantly different between groups (ACLR= 0.348±0.04m, Healthy= 0.349±0.059m, $p=0.912$). Landing force symmetry was significantly higher in healthy (1.07±0.19) than ACLR individuals (0.94±0.16) ($p=0.03$). **Conclusions:** While jump height was not different, females with a history of ACLR seem to jump and land with more exaggerated knee movement to control the force exerted on the body during CMJ. Interestingly, healthy individuals demonstrated bilateral kinematic differences during CMJ. While the importance of proper jump landing techniques post-ACLR is supported in this study, our results may advocate educating appropriate jump landing techniques in healthy individuals for injury prevention.

Neurocognitive Function Influences Dynamic Postural Stability Strategies in Collegiate Athletes

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Context: Lower extremity injuries are common among collegiate athletes. Previous studies have indicated that poorer neurocognitive performance may increase lower extremity injury risk due to alterations in biomechanics. However, it is unclear if poorer neurocognitive function may be associated with altered dynamic postural stability. Exploring this relationship may provide insights into the ability to optimize postural motor commands and further elucidate potential mechanics for injury risk. Therefore, the purpose of this research was to investigate the relationship between neurocognitive performance and dynamic postural stability in collegiate athletes. **Methods:** Forty-five Division-I collegiate soccer and cheer athletes (21 male, 24 females; age: 19.69±1.50; height: 171.12±13.36cm; mass: 67.33±15.93kg) volunteered for this cross-sectional study. During a single session, participants completed four neurocognitive assessments from the NIH Toolbox® (NIHTB) which examined cognitive flexibility, inhibitory control, episodic memory, and processing

speed. A composite score was computed using the fully-corrected scores of each test. From the composite scores, three groups were established to represent high performers (HP; n=16), moderate performers (MP; n=14), and low performers (LP; n=15). Participants also completed a dynamic hop-to-stabilization task. This task involved a forward double-limb jump (40% of the participant's height) over a 30.5cm hurdle with a single-limb landing. Participants were instructed to stabilize as quickly as possible and hold for at least three seconds. Participants completed three successful trials on each limb. Acceleration was recorded during landing through an inertial measurement unit on the participant's low back (L4/5). The root mean squared (RMS) was calculated for the orthogonal planes (mediolateral, anteroposterior, vertical) and the resultant vector for three seconds following landing. Greater RMS values represent greater levels of acceleration. Separate one-way ANOVAs, post-hoc t-tests, and effect sizes (ES) were used to compare groups. The significance level was set at $p \leq 0.05$ for all analyses. **Results:** Significant group effects were identified on the left limb for the vertical ($p=0.047$) and anteroposterior planes ($p=0.005$). Post-hoc tests determined the LP group had significantly higher vertical ($p=0.014$, $ES=-0.82$) and lower anteroposterior RMS values ($p=0.002$, $ES=1.08$) compared to the HP group. Additionally, the MP group had significantly lower anteroposterior ($p=0.021$, $ES=0.84$) RMS values compared to

the HP group. Significant group effects were also identified on the right limb for the vertical plane ($p=0.048$). Post-hoc tests determined the LP group had significantly higher vertical RMS values ($p=0.014$, $ES=-0.87$) compared to the HP group. No other differences were identified (Table 1). **Conclusions:** Neurocognitive performance may influence dynamic postural stability strategies in athletes. Higher neurocognitive performers may use different approaches to perform difficult postural tasks by adopting strategies associated with lower vertical and higher anteroposterior acceleration compared to lower neurocognitive performers. Future studies should determine if the dynamic postural stability strategies exhibited by the LP group contributes to injury risk.

Table 1. Group Means ± Standard Deviations for Inertial Measurement Unit Accelerometer Data

	Low Performers	Moderate Performers	High Performers	Group Main Effect (p)
Left				
aRMS-ML	4.12±0.97	4.48±0.73	4.13±1.47	0.63
aRMS-Vertical	10.65±2.09*	9.62±2.067	8.21±3.48	0.05
aRMS-AP	4.72±2.46*	5.58±1.87*	7.79±3.02	0.005
Right				
aRMS-ML	4.33±1.43	3.88±0.72	3.98±1.30	0.57
aRMS-Vertical	10.63±2.08*	9.27±2.44	8.20±3.22	0.04
aRMS-AP	4.73±2.64*	6.04±2.43	7.27±3.33	0.05

Abbreviations: aRms-medial-lateral (arms-ml); arms-anteroposterior (arms-ap)

* Significantly different from higher performers

Trunk and Lower Extremity Kinematic and Kinetic Characteristics of Good and Poor Movers During a Double-Leg Squat Assessment

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Context: Lower extremity musculoskeletal injuries (MSKI) are endemic amongst female athletes. Double-leg squat (DLS) visual assessments may provide valuable information regarding an athlete's MSKI risk level. However, it has yet to be determined if visually assessed DLS "poor movement quality" agrees with the gold-standard, laboratory-based motion analysis. The purpose of this study was to compare laboratory-based trunk and lower extremity biomechanics between individuals with visually assessed poor and good DLS movement quality. We hypothesized athletes with poor movement quality would display greater

sagittal plane trunk angles and greater frontal plane hip and knee angles and moments; we did not expect to identify any differences in lower extremity sagittal plane biomechanics. **Methods:** We conducted a cross-sectional laboratory study of female collegiate athletes ($n=44$, age= 19.6 ± 1.5 yrs, BMI= 22.5 ± 1.9 kg/m²) who were medically cleared for all physical activity at the time of testing. Participants completed 3 sets of 3 consecutive repetitions of the DLS; the final set was simultaneously recorded by 2-dimensional video cameras (frontal, sagittal, posterior) and a three-dimensional optical motion tracking system (Qualisys, 150Hz) and force platforms (Bertec, 1500Hz). Two-dimensional video data were later scored by a trained clinical athletic trainer via a standardized scoring rubric (Fusionetics LLC). The athletic trainer recorded movement errors if the error was present in the majority of repetitions ($\geq 2/3$). Movement errors were totaled for each participant, and participants were dichotomized as "poor" or "good" movers based on an established cut point (poor movers: ≥ 5 movement errors). Peak sagittal and frontal plane kinematic and kinetic data were averaged across trials for each participant's dominant and non-dominant limbs; kinetic variables were normalized to body weight. Independent samples t-tests compared group means for demographics and trunk, hip, knee, and ankle outcomes ($\alpha \leq 0.05$). **Results:** The overall average DLS score was 5.4 ± 2.4 , with 26 participants classified as poor

movers (7.0 ± 1.7) and 18 participants classified as good movers (3.2 ± 1.2 , $P<0.001$). No demographic differences were observed. The poor mover group displayed less knee flexion ($P=0.049$), greater vertical ground reaction forces ($P=0.047$), greater hip extension moment ($P=0.015$), and greater plantarflexion ($P\leq 0.036$) and ankle eversion moments ($P=0.044$); no additional biomechanical differences were observed (Table). **Conclusions:** Double-leg squat visual assessments can identify biomechanical differences between poor and good movers; however, the observed differences contrasted with our hypotheses. Our comparisons were restricted to sagittal and frontal plane biomechanics as these are what are visually assessed during DLS assessments. Transverse plane biomechanics should also be assessed, but these may be better identified through a single-leg squat. The majority of differences (71.4%) were observed in the non-dominant limb, indicating a potential relationship between movement quality and limb dominance. DLS visual assessments cannot identify all MSKI biomechanical risk factors; thus, clinicians should utilize a variety of assessments to comprehensively assess movement quality.

	Good Movers	Poor Movers	P-value
Trunk & General			
Flexion Angle (°)	30.16 \pm 7.25	34.10 \pm 10.05	0.161
Vertical Ground Reaction Force – Dominant (N/BW)	0.67 \pm 0.08	0.72 \pm 0.12	0.124
Vertical Ground Reaction Force – Non-Dominant (N/BW)*	0.65 \pm 0.09	0.73 \pm 0.14	0.047
Hip			
Flexion Angle – Dominant (°)	118.78 \pm 15.11	118.20 \pm 7.97	0.871
Flexion Angle – Non-Dominant (°)	117.53 \pm 14.58	117.14 \pm 10.54	0.920
Abduction Angle – Dominant (°)	14.91 \pm 4.65	16.05 \pm 5.04	0.458
Abduction Angle – Non-Dominant (°)	11.75 \pm 7.59	12.14 \pm 5.24	0.845
Extension Moment – Dominant (Nm/BW)*	1.12 \pm 0.20	1.34 \pm 0.30	0.015
Extension Moment – Non-Dominant (Nm/BW)*	1.12 \pm 0.18	1.35 \pm 0.35	0.015
Adduction Moment – Dominant (Nm/BW)	0.20 \pm 0.09	0.20 \pm 0.11	0.930
Adduction Moment – Non-Dominant (Nm/BW)	0.33 \pm 0.13	0.34 \pm 0.15	0.908
Knee			
Flexion Angle – Dominant (°)	106.18 \pm 16.47	98.64 \pm 10.46	0.070
Flexion Angle – Non-Dominant (°)*	106.96 \pm 16.32	98.40 \pm 11.78	0.049
Valgus Angle – Dominant (°)	6.08 \pm 4.07	5.30 \pm 3.50	0.499
Valgus Angle – Non-Dominant (°)	5.93 \pm 2.76	5.79 \pm 3.49	0.884
Extension Moment – Dominant (Nm/BW)	1.01 \pm 0.29	1.07 \pm 0.32	0.502
Extension Moment – Non-Dominant (Nm/BW)	1.04 \pm 0.32	1.12 \pm 0.35	0.438
Varus Moment – Dominant (Nm/BW)	0.07 \pm 0.06	0.08 \pm 0.08	0.613
Varus Moment – Non-Dominant (Nm/BW)	0.01 \pm 0.07	0.01 \pm 0.06	0.923
Ankle			
Dorsiflexion Angle – Dominant (°)	19.18 \pm 3.07	18.75 \pm 2.96	0.643
Dorsiflexion Angle – Non-Dominant (°)	17.99 \pm 3.14	18.52 \pm 3.14	0.582
Inversion Angle – Dominant (°)	18.69 \pm 7.59	17.34 \pm 8.45	0.590
Inversion Angle – Non-Dominant (°)	23.12 \pm 6.71	19.27 \pm 8.47	0.115
Plantarflexion Moment – Dominant (Nm/BW)*	0.39 \pm 0.12	0.51 \pm 0.22	0.036
Plantarflexion Moment – Non-Dominant (Nm/BW)*	0.36 \pm 0.14	0.50 \pm 0.19	0.011
Eversion Moment – Dominant (Nm/BW)	0.02 \pm 0.03	0.02 \pm 0.03	0.697
Eversion Moment – Non-Dominant (Nm/BW)*	0.07 \pm 0.04	0.11 \pm 0.06	0.044

*Indicates between group difference

Balance Differences on the Star Excursion Balance Test and the Dynamic Leap and Balance Test in Healthy and Patellofemoral Pain Individuals

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Context: Dynamic balance is important while performing movements of everyday activity such as walking, squatting, stair ascent and descent. Knee pain has shown to affect dynamic balance in individuals with Patellofemoral Pain (PFP). The Star Excursion Balance Test (SEBT) is a common clinical tool to evaluate dynamic balance. However, the base of support is static during the SEBT, and deficits on this task have been attributed to decreased ankle range of motion rather than poor balance. The Dynamic Leap and Balance Test (DLBT) is a novel dynamic balance test where the base of support is serially changing. The objective of this study was to compare the SEBT and DLBT in healthy and PFP individuals. If group differences were identified, the secondary aim was to identify the clinical measures in the lower extremity that predicted balance differences in order to direct potential interventions.

Methods: This was a cross-sectional, matched case-comparison design laboratory study. 36 PFP (age=20.53±3.75 years, mass=69.42±13.05 kg, height=171.13±12.28 cm) and 36 healthy (age=20.44±3.13 years, mass=64.81±11.36 kg, height=169.28±9.11cm) participants volunteered. The primary outcome measures were results of three trials of SEBT and DLBT. SEBT reach distances in each direction (anterior, posteromedial, posterolateral) were averaged and normalized to leg length (%MAXD). DLBT trials were averaged based on time (in seconds) to complete the task and overall errors. Primary outcome measures were analyzed with independent t-tests to compare the balance metrics between the healthy and PFP groups with Cohen's d effect sizes with 95% confidence intervals (CI) to compare the magnitude of difference. Secondary outcome measures were patient reported pain and function, alignment/range of motion (ROM)/torque of the hip, knee, foot, and ankle, and ultrasound imaging (USI) of the IFMs and were assessed using a Pearson r correlation to determine which measures most strongly correlated with DLBT time within the PFP group. **Results:** There were no differences in %MAXD SEBT between PFP and healthy groups (all directions $P>.05$). The PFP group took significantly longer to complete the DLBT (PFP: 50.31±8.27s, Healthy: 42.98±6.01s, $P<.001$) and committed significantly more errors (PFP: 5.98±4.11, Healthy: 3.06±2.69, $P=.001$) than

the healthy group, with strong effect sizes that do not cross zero (DLBT time: $d=1.22$, 95% CI: (0.72, 1.72), DLBT errors: $d=1.09$, 95% CI: (0.59, 1.59)). Mass, hip external rotation range of motion (ROM), hip flexion strength, and abductor hallucis cross-sectional area described 50.4% of the variance in DLBT time in individuals with PFP (Table 1). **Conclusions:** DLBT should be evaluated in individuals with PFP to determine dynamic balance. If deficits are identified, evaluation of the mass, hip external rotation ROM, hip flexion strength, and size of the abductor hallucis muscle may help guide clinical intervention.

Table 1. Dynamic Leap and Balance Test Step-Wise Regression Results

DLBT	β	P Value	ΔR^2	Final Model
Body Mass (kg)	.073	<.001	.212	$R^2 = .504$ $P < .001$
Hip ER ROM (°)	-.350	<.001	.175	
Hip Flexion Torque (Nm/kg)	11.42	.005	.081	
AH CSA (mm ² /kg)	-30.35	.017	.096	

ER: External Rotation. ROM: Range of Motion. AH: Abductor Hallucis. CSA: Cross-Sectional Area

Single-Leg Hop Anthropometric Threshold is More Sensitive Than a Limb Symmetry Threshold Following a Lower Extremity Injury

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Context: Functional testing with limb symmetry comparison is common clinical practice for determining return to sport (RTS) readiness. Without baseline measures, reliance on improving limb symmetry index (LSI) is emphasized despite LSI potentially overestimating performance. Evaluating performance based on anthropometric thresholds may provide an alternative metric and negate overestimating function when baseline data is unavailable. Therefore, the purpose of this study was to compare frequency counts of athletes meeting LSI and/or height-based thresholds for the single-leg hop for distance (SLHFD) at baseline and RTS, and determine which threshold was more sensitive to functional performance recovery post-injury.

Methods: Ninety-two adolescent athletes completed the SLHFD at baseline (pre-season) and at the time of RTS. Thirty-four (22 males, 12 females, 16.2±1.1 years, 161.4±9.3 cm, 70.2±26.9 kg) sustained knee/thigh injuries and 58 (37 males, 21 females 15.8±1.18 years, 174.4±9.7

cm, 78.8±15.3 kg) sustained ankle/foot injuries and missed at least three days of sports participation. Each participant performed three trials of the SLHFD per leg, and the maximum distance across trials was used for analysis. A successful trial required maintaining balance upon landing for at least two seconds. Athletes meeting baseline and RTS thresholds of 90% LSI and 90% of height were totaled. Chi-Square tests for knee/thigh and ankle/foot were used to determine if there was a relationship between groups of athletes meeting either LSI or height thresholds at baseline and/or RTS timepoints. Additionally, Chi-Square tests for knee/thigh and ankle/foot were used to determine if there was a relationship over time for athletes meeting either threshold. Alpha level was set at 0.05.

Results: At baseline, more athletes met LSI (91%) than height-based (65%) thresholds ($X^2=6.92$; $p=0.01$) for knee/thigh injuries. At RTS, fewer athletes met the height threshold (LSI 79%, height 38%, $X^2=11.9$; $p<0.01$). At baseline for ankle/foot injuries, there was no difference between groups (LSI 79%, height 74%; $p=0.51$); however, at RTS, 34% of athletes met the height-based threshold and 62% met LSI ($X^2=8.84$; $p<0.01$). When comparing between baseline and RTS, fewer athletes met the height-based threshold (62% knee/thigh $X^2=4.77$; $p=0.03$; 66% ankle/foot $X^2=18.38$; $p<0.01$) than LSI, with 20% of athletes sustaining knee/

thigh and 37% ankle/foot injuries unable to meet LSI thresholds ($p=0.17$, $p=0.06$, respectively). **Conclusions:** LSI may overestimate function following injury when deficits still exist, whereas performance-based normalized metrics may provide a more stringent criterion for functional performance. These data support the need for both baseline metrics and possibly normalized anthropometric standards instead of relying on LSI to determine RTS decisions.

Effects of Virtual Reality on Postural Stability During a Dynamic Transition Task

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Context: Static assessments are most used clinically to assess postural stability, however, dynamic tasks to assess postural stability may be more applicable to the athletic setting. Virtual reality (VR) may be a viable tool to help assess postural stability while performing a dynamic task as VR allows for the direct manipulation of the environment. Therefore, the purpose of this study was to determine the effects of a VR sport perturbation on postural stability compared to traditional methods of perturbation. **Methods:** A cross-sectional study was performed to evaluate different postural stability perturbations. Sixteen healthy NCAA football Division I athletes aged 18-23 years with no history of injury within 12 months and at least 1 full fall season of collegiate athletics were enrolled (19.56 ± 1.36 years, 187.40 ± 9.0 cm, 106.45 ± 18.35 kg, Tegner 9.88 ± 0.34). Individuals completed a double-leg to single-leg stance task under the following conditions: eyes-open, eyes-closed, sport video, and VR. For the transition task the participant

was instructed to transition their weight to one leg from two as quickly as possible. The eyes-open task was delivered via a PowerPoint presentation with arrows indicating direction. The eyes-closed task was delivered audibly. For the VR and sport video conditions, the participant was instructed to “avoid” an incoming football player by transitioning from a double-leg to single-leg stance away from a player appearing from behind a practice dummy. The VR condition used an Oculus GO headset (Menlo Park, CA) with a pre-recorded task was also used and played on a laptop computer for the sport video task. A repeated measures ANOVA was conducted for the dependent variable time to new stability (seconds [s]) for condition (eyes-open, eyes-closed, sport video, and VR). Alpha was set at $\alpha < 0.05$. **Results:** The overall repeated measures ANOVA was significant for condition ($F=4.59$, $p=0.02$, $\eta^2=0.51$). Time to new stability was significantly slower in eyes-closed compared to eyes-open (eyes-closed: 8.99 ± 2.77 s and eyes-open: 6.01 ± 2.44 s, $p=0.02$) and sport video (eyes-closed: 8.99 ± 2.77 s and sport video: 6.33 ± 3.06 s, $p=.02$). For VR, time to new stability was significantly slower than eyes-open (VR: 8.84 ± 3.06 s and eyes-open: 6.01 ± 2.44 s, $p=0.02$) and sport video (VR: 8.84 ± 3.06 s and sport video: 6.33 ± 3.06 s, $p=.03$). However, there was no significant difference between VR and eyes-closed conditions (mean difference= 0.155 s,

$p=1.0$). **Conclusions:** VR and eyes-closed conditions took significantly longer to achieve stability after transition to single leg than eyes-open or sport video. Traditional methods to challenge postural stability include varied static stances, catching/throwing objects, and closing eyes. However, traditional methods have been shown to not restore postural stability adequately. In the VR environment, there is an immersive real-world scenario that can simulate a variety of sport specific training scenarios. These scenarios can provide a similar postural perturbation as eyes-closed but be more clinically applicable and facilitates sport specific postural stability.

Movement Errors Improve Between Age Groups in Children

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Context: Lower extremity injury incidence increases in children throughout adolescence. Previous research suggests that movement-based risk factors for injury also change across development. Understanding specific movement errors prevalent among children of different ages can guide injury prevention strategies. The purpose of this study was to evaluate differences in specific movement errors, using the Landing Error Scoring System (LESS), between elementary and middle school children by genders. **Methods:** A multi-site, cross sectional study design was used for this investigation. Participants were recruited to complete a single test session from schools and youth sport

organizations across the country. All participants (n=557, males=289, females=268) and their parent/legal guardian provided informed assent and consent, respectively. Gender and age were reported on a questionnaire completed by parents/legal guardians. Participants were grouped into 3 categories based on their age during data collection (elementary school: 6-10years; middle school: 11-13years) All participants performed 3 trials of a standardized jump-landing task. Participants stood on a box 30 cm high, jumped forward a distance of half of their body height, and upon landing immediately performed a maximal vertical jump. All landings were analyzed using LESS via an automated movement assessment software (PhysiMax Technologies Ltd, Tel Aviv, Israel). The LESS is a valid and reliable measure of movement control and predicts reduced risk of ACL injury in youth athlete. Errors were deemed present if the participant exhibited the specific movement error during >1 of their jump-landing trials. Of the 17 errors used to calculate the LESS, only errors that were observed in >20% of the population

were analyzed. Chi-square tests were used to analyze the differences in the proportion of individuals displaying a specific movement error between age groups. Analyses were performed separately for males and females given the well-documented gender differences in movement control. **Results:** Specific LESS errors are summarized in Table 1. Lateral trunk flexion at IC, medial knee position at IC, knee flexion displacement and trunk flexion displacement errors were more common in ES children than MS children for males and females. Stance width narrow and maximum medial knee displacement errors were more common in ES versus MS among males only. External foot rotation errors were more common in MS females than ES females. **Conclusions:** Most movement errors are more common in ES children over MS children. Injury prevention programs should aim to address specific errors occurring in that age group. Overall, as children age, their movement skills appear better in both males and females suggesting injury risk may be related to poor development of motor control.

Table 1. LESS Error Results from Chi-Square

LESS Error	Gender	P-Value (Cramer's V)	Elementary School % with Error	Middle School % with Error
Lateral Trunk Flexion IC	Males	<0.001* (0.280)	63.3%	34.4%
	Females	<0.001* (0.297)	58.8%	28.9%
Medial Knee Position IC	Males	<0.001* (0.362)	61.8%	25.2%
	Females	<0.001* (0.413)	75.8%	33.6%
Stance Width Narrow IC	Males	0.047* (0.123)	90.2%	81.1%
External Rotation Foot Position	Females	0.009* (0.175)	22.4%	39.3%
Knee Flexion Displacement	Males	<0.001* (0.244)	32.5%	12.3%
	Females	<0.001* (0.272)	36.9%	13.5%
Trunk Flexion Displacement	Males	<0.011* (0.163)	67.4%	50.7%
	Females	<0.001* (0.251)	78.0%	53.1%
Max Medial Knee Position	Males	<0.001* (0.266)	88.7%	64.6%
* Significant Chi-Square				

Relationships Between Lumbopelvic Function and Patient-Reported Outcomes in Individuals With Chronic Ankle Instability

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Context: CAI is associated with perceived sensory impairments represented via patient-reported outcomes (PROs) such as decreased perceived ankle function and balance self-efficacy, and high levels of injury-related fear. Deficits in the sensory-perceptual function in those with CAI might contribute to reduced postural control ability which is assessed by the clinician. However, the relationship between impaired PROs and clinician-oriented outcomes have yet to be explored for individuals with CAI. Specifically, hip and trunk neuromuscular impairments have been considered as critical factors that can cause decreased postural stability and malpositioning of the lower extremity in those with CAI. Identifying the relevance between reduced lumbopelvic function and impaired sensory-perceptual outcomes might direct clinicians to novel methods of improving perceived ankle function as well as postural control ability for CAI patients. Therefore, the aim of this study was to examine the relationship between tests of lumbopelvic function and PROs that assess self-reported function, balance self-efficacy, kinesiophobia, and fear avoidance

beliefs in individuals with CAI. **Methods:** We recruited 33 individuals with CAI (F:18, M:15, 22.8 ± 3.4 yrs, 169.8 ± 8.4 cm, 77.4 ± 13.4 kg) to conduct a single laboratory session. We assessed participants' transversus abdominis and lumbar multifidus muscle contractility using diagnostic ultrasound; lumbopelvic stability via the unilateral hip bridge, trunk flexion endurance, Biering-Sorensen, and side plank tests; and isometric hip extension, abduction, and external rotation strength via hand-held dynamometry. We assessed participants' ankle function using both subscales of the Foot and Ankle Ability Measure (FAAM-ADL and FAAM-Sport), injury-related fear via the Tampa Scale of Kinesiophobia-11 and Fear-Avoidance Beliefs Questionnaire, and balance self-efficacy via the Self-Efficacy of Balance Scale. Pearson product moment correlations were used to identify the relationship between lumbopelvic function and patient-reported outcome scores. Separate backward linear regression analyses assessed the degree of each PRO score variance explained by the tests of lumbopelvic function. Alpha was set a priori at $P < 0.05$. **Results:** Regression analyses demonstrated that the side plank test was the lone final predictor of FAAM-ADL scores ($r = .451$, $R^2 = 0.20$, $P < 0.01$). Furthermore, hip abduction strength was the lone final predictor of SEBS scores ($r = .540$, $R^2 = 0.29$, $P < 0.01$). No other significant relationships between lumbopelvic function and patient-oriented outcomes were identified. **Conclusions:** Our data

suggests that deficits in lumbopelvic function are related to low levels of perceived ankle function and balance self-efficacy in individuals with CAI. If lumbopelvic function contributes to impaired sensory-perceptual function, it may also contribute to reduced postural control performance in individuals with CAI. Therefore, patients may benefit from rehabilitation that includes a concentration on lumbopelvic function, as it may help address reduced patient-perceived function as well as postural impairments in individuals with CAI.

Running Gait Biomechanics in Females With Chronic Ankle Instability and Ankle Sprain Copers

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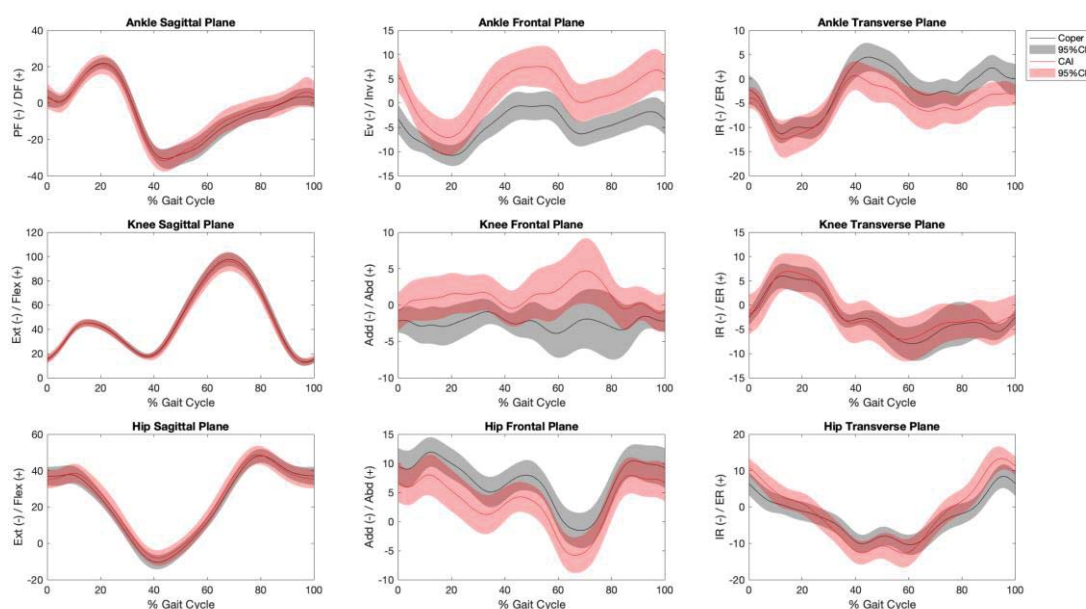
Context: Running is a common form of exercise and is utilized during many types of athletic activities. In active individuals, lateral ankle sprains are the most common musculoskeletal injury. Some individuals will fully recover and are called copers, however, about 40% develop chronic ankle instability (CAI). Individuals with CAI have been demonstrated to walk with a more inverted foot position in comparison to ankle sprain copers and healthy controls, yet, little is known about running gait mechanics in individuals with CAI. The purpose of this study was to simultaneously analyze running gait kinematics, kinetics, and surface electromyography (sEMG) between ankle sprain copers and individuals with CAI. **Methods:** Twenty-six (13 CAI, 13 Coper) recreationally active females

participated in this study (CAI: age = 20.7 ± 2.8 , mass = 66.5 ± 13.7 kg, height = 167.3 ± 8.1 cm, # ankle sprains = 3.3 ± 1.2 , time since last sprain = 18.2 ± 57.3 months; Coper: age = 20 ± 0.8 , mass = 62.3 ± 8.1 kg, height = 166.3 ± 4.5 cm, # ankle sprains = 1.3 ± 0.6 , time since last ankle sprain = 52.2 ± 25.3 months). Participants ran shod on an instrumented treadmill at 2.68 m/s following a 10-minute walking warm-up. Three-dimensional kinematics and kinetics were simultaneously recorded for the ankle, knee, and hip joints. sEMG amplitude was measured for the fibularis longus, tibialis anterior, medial gastrocnemius, and gluteus medius muscles. Ten consecutive strides from the beginning of the trial were analyzed for the test limb using statistical parametric mapping (SPM). Independent SPM t-tests were used to compare group differences between the CAI and coper groups. The level of significance was set a priori as $p < 0.05$.

Results: The CAI group had significantly more ankle inversion during 0-6%, 42-53%, and 96-100% of the running stride cycle compared to the coper group (figure 1). At initial contact (0%), the CAI group was in an inverted ankle position ($5.9^\circ \pm 6.8^\circ$) and the coper group was in an everted ankle position ($-3.2^\circ \pm 5.5^\circ$; $p = 0.01$, $d = 1.5$). There were no significant differences identified for any other measures of kinematics, kinetics, or sEMG amplitude. **Conclusions:** At initial contact and during the loading phase (0-6%), the CAI group displayed an inverted ankle

position while the coper group was in an everted foot position. Additionally, the CAI group was more inverted during the loading phase, after toe-off, and during the late swing phase. Increased ankle inversion during the swing phase leading into the loading phase is concerning because the ankle is in an open packed position and inversion is a primary mechanism of injury for sustaining a lateral ankle sprain. Clinicians should be aware of this potentially risky ankle position and develop strategies such as gait training programs to improve the ankle position during running for females with CAI.

Figure 1. Three-dimensional kinematics of the ankle, knee, and hip for copers and CAI participants.



Hamstrings Stiffness and Strength Associate With Hamstrings-to-Quadriceps Co-Activation During Jump Landing Tasks

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Context: Hamstrings stiffness, strength and hamstrings-to-quadriceps (H:Q) co-activation are associated with joint stability during dynamic tasks, such as jump landing. Previous research has yet to describe the relationships between hamstring stiffness and strength with H:Q co-activation during jump landing tasks. Our primary objective was to investigate the relationships between hamstrings stiffness and strength with H:Q co-activation during the preparation and execution of single-limb (SL) and double-limb (DL) landing tasks. Our secondary objective was to compare H:Q-co-activation between the medial and lateral compartments during each task. We hypothesized that individuals with lesser hamstring strength and stiffness would exhibit greater H:Q-co-activation and that lateral compartment co-activation would be greater than the medial compartment in preparation for landing. **Methods:** We conducted a descriptive laboratory study in a university laboratory. Thirteen physically active males and females (11 males, 22.5±2.0 years, 180.4±7.2

cm, 79.5±10.8 kg) participated in two study visits separated by 3 days. Hamstring stiffness and strength served as explanatory variables for H:Q-co-activation ratios (medial, lateral, and composite). Musculotendinous hamstrings stiffness was assessed in the dominant limb using the damped frequency oscillatory technique as previously described. Participants laid prone on a stationary isokinetic dynamometer, and were instructed to maintain 30° of hip and knee flexion, while resisting cuff weights secured to the distal shank (equal to 30% of maximal voluntary isometric contraction [MVIC]) and a downward manual perturbation delivered to the calcaneus. An inertial measurement unit (IMU) was placed on the plantar calcaneus overlying a custom ankle-foot orthosis to determine the downward acceleration of the shank following perturbation, and used to calculate stiffness. During the second visit, participants completed the SL and DL landing tasks. Mean EMG amplitudes of the vastus lateralis and medialis, biceps femoris, and semitendinosus were measured during each task and normalized to the MVIC EMG amplitudes collected earlier in the visit. Normalized EMG was used to calculate H:Q-co-activation ratios 250ms pre- and post-initial ground contact. Correlation coefficients (r or ρ) were calculated to determine the associations between hamstrings stiffness/strength and co-activation ratios. Dependent t-tests with Cohen's d effect sizes (95% CI) were used to determine the magnitude of differences in co-activation between the lateral and medial compartments. **Results:** Greater hamstrings stiffness (ρ=.566, p=.044) and strength (r=.600, p=.030) were associated

with greater lateral compartment co-activation during the pre-landing phase of a SL and DL landing task, respectively. Co-activation was greater in the lateral compartment compared to medial compartment post-initial ground contact of a DL landing task (medial: 0.20±0.12 vs. lateral: 0.42±0.26; d=1.09 [0.24,1.94]; p=.004). **Conclusions:** Greater hamstrings stiffness and strength may influence lateral compartment co-activation during the preparation of SL and DL landing tasks. Improving hamstring strength and stiffness through injury prevention programs may increase knee joint stability during landings.

Free Communications: Restoring Function in ACL-R Patients

On Demand: June 22-September 30, 2021

Anterior Cruciate Ligament Repair Using the InternalBrace™ Ligament Augmentation Technique

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Background: ACL injuries account for up to 64% of athletic knee injuries, resulting in 120,000–200,000 ACL reconstructions (ACLRs) performed annually. Although ACL injuries are regarded as a particular concern for female athletes, recent data shows that football has the largest number of ACL injuries and the highest competition-related ACL injury rate. The purpose of ACLR is to restore the native ACL footprint on both the tibial and femoral sides of the knee and to recreate the natural functional knee kinematics. During ACLR, a new ligament is reconstructed using grafts such as hamstring tendon (HT), bone-patellar tendon-bone (BPTB), or quadriceps tendon (QT) to reconstitute the anatomy and function of the native ACL. However, over the past decade there has been a renewed interest in surgical repair to treat ACL injuries. Benefits of repair include preservation of the native ACL's nerve endings and blood supply, which are essential for healing and for knee proprioception and kinematics. The purpose of this case report is to showcase an innovative surgical repair technique used to manage an interscholastic athlete following a second ACL injury. A 16-year-old male football athlete complained of left knee pain after being tackled while carrying the ball. This was the patient's first game following a left ACLR using a BPTB autograft twelve months prior. The athletic trainer's initial evaluation was inconclusive, as there was significant hamstring guarding during valgus stress, Lachman's and anterior drawer testing. The patient received cryotherapy

treatment and was sent home non-weight-bearing with crutches and a knee immobilizer. The patient was referred to an orthopedic physician who diagnosed him with a complete tear of the ACL following MRI. **Differential Diagnosis:** Anterior cruciate ligament injury, meniscus tear **Intervention & Treatment:** Pre-surgical intervention included cryotherapy, electrical stimulation (ES) and lower extremity strengthening for two months. After consultation with the patient and his family, the physician decided to repair the ACL and to use an InternalBrace™ ligament augmentation (IBLA). The patient was able to achieve full weight-bearing within the first week postoperatively. Post-operative rehabilitation included protective bracing, cryotherapy, ES, passive and active motion, and strengthening, balance and proprioception exercises. The patient completed the rehabilitation protocol without incident and with very positive outcomes. He has made a full return to participation however football competition has yet to resume as a result of the COVID-19 pandemic. His current therapy is focused on reinjury prevention. **Uniqueness:** The addition of an internal brace to the ACL repair technique is thought of as a means to protect the ligament during early ROM and functional rehabilitation. Clinical outcomes of pain, function, and quality of life for patients who underwent ACL repair with IBLA suggest less pain and improved function. Additionally, lower failure rates have recently been observed in patients with IBLA repair in comparison to those without IBLA (7.4% vs 13.8%). While we did not make comparisons to patients managed with ACLR, our patient made a full recovery and has returned to full participation. **Conclusions:** Augmentation of an ACL repair with an internal brace is an evolving surgical option. It consists of passing a nonabsorbable braided suture, placed on a fixation device,

through the proximal end of the torn ACL. The construct is passed through the drilled tibial, through the ACL stump and femoral tunnel and pulled up onto the lateral surface of the femur where it is fixated to the cortex utilizing a femoral button loaded with high-strength suture tape. In clinical studies investigating ACL repair with IBLA, the majority of patients have demonstrated functional stability with near-normal knee function, excellent patient satisfaction and return to previous levels of competition.

Biomechanical Underloading During Gait is Linked to Less Physical Activity in Individuals With Anterior Cruciate Ligament Reconstruction

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Context: Biomechanical underloading during gait, defined as lesser peak vertical ground reaction force (vGRF) in the first 50% of stance, is associated with deleterious PTOA-related joint tissue changes following anterior cruciate ligament reconstruction (ACLR). Additionally, ACLR patients demonstrate fewer daily steps and engage in lesser daily moderate to vigorous physical activity (MVPA) compared to uninjured controls, suggesting that individuals with an ACLR exhibit behaviors that habitually underload lower extremity joint tissues. It remains unknown if individuals who demonstrate biomechanical underloading during gait will also exhibit greater behavioral underloading (i.e. fewer steps and lesser MVPA). It is critical to determine the link between biomechanical underloading during gait and behavioral underloading (i.e. cumulative loading), as a relationship between these factors may indicate the need for a comprehensive rehabilitative strategy that includes both gait retraining and physical activity

promotion on order to normalize overall joint loading post-ACLR. Therefore, the purpose of this study was to determine the association between peak vGRF during gait and daily steps and MVPA in a cross-section of individuals who were all between 6 and 12 months post-ACLR. We hypothesized that individuals with lesser peak vGRF would exhibit fewer daily steps and lesser time spent in MVPA. **Methods:** Thirty-six participants (50% Female, age=21.6±4.7 years, BMI=24.4±2.8 kg/m², months since surgery=8.1±1.6) were included in this cross-sectional study. All participants walked at their preferred walking speed over two force plates embedded in a 6m walkway and peak vGRF was extracted from the first 50% of stance. Daily walking was assessed using a triaxial accelerometer worn at the right hip. Participants were instructed to wear the accelerometer during all waking hours aside from water activities for 7 days and data were considered valid if the accelerometer was worn for ≥ 10 hours/day for ≥ 4 days. Daily steps and time spent in MVPA were calculated based on ActiLife's step-counting proprietary algorithm and Freedson VM 2011 cut-points, respectively. Multiple stepwise linear regression analyses were used to estimate the unique associations (change in R² [ΔR^2]) between peak vGRF, daily steps and MVPA after first controlling for age, sex, months post-ACLR, and total wear time as these covariates may influence biomechanical and behavioral loading. **Results:** After controlling for covariates, participants with lesser vGRF during the first 50% of stance demonstrated fewer daily

steps ($\Delta R^2=0.14$, $p=0.02$) and lesser time spent in MVPA ($\Delta R^2=0.25$, $p=0.001$). **Conclusions:** These data suggest that a proportion of individuals exhibit both biomechanical and behavioral underloading following ACLR and future work is needed to understand the underlying mechanisms linking these two types of underloading. These data also suggest the need to develop a comprehensive strategy including gait retraining and physical activity promotion for normalization of joint tissue loading following ACLR.

**Disagreement in Pass Rates Among
Different Components of Return to
Sports Test Batteries After ACLR**

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Context: Patients with ACL reconstruction (ACLR) are at considerable risk for re-injury following return to activity. Batteries of objective tests are often used to make data-informed return to activity decisions. Many test batteries use measures of bilateral symmetry from isolated strength tests and functional tests. Clinicians may have difficulty in determining which criteria to follow if there is disagreement in outcomes from two test types. Therefore, the purpose of this study was to (1) compare pass rates between isokinetic strength tests and single leg hopping tests (2) compare disagreeing pass rates among men and women and (3) compare disagreeing pass rates in those with higher activity levels versus those with lower activity levels. **Methods:** A total of 190 participants (90 males, 100 females) on average 7.2±1.25 months post primary, unilateral, and uncomplicated ACLR (22.6±9.13 years, 172.5±9.76 cm, 74.6±17.98 kg). Participants completed a comprehensive

testing battery as a part of a larger-scale point-of-care longitudinal research study. For this study, we evaluated quadriceps strength using peak torque during isokinetic knee extension at 90°/s and maximum jump distance during a single leg hop to calculate limb symmetry index (LSI = (ACLR / contralateral side)/100). We operationally defined “pass” as 90% LSI or above for each test. We compared pass rates between the isokinetic strength tests and single leg hop and then compared the proportion of disagreeing outcomes by sex (male vs female) and activity level (Tegner activity level ≥7 vs <7)) using chi square tests. Test results were considered statistically significant if the p-value was ≤ 0.05. **Results:** Pass rates were non-uniformly distributed between strength and hop testing (X²=11.47 p=0.001, Table 1). Only 9.5% (18/190) of the sample passed both strength and hop test criteria and 50% (95/190) percent of the sample failed both tests. Disagreement between strength and hop test pass results occurred in 40.5% (77/190) of the patients. Specifically, 4 patients passed strength testing and failed hop testing whereas 73 patients failed strength testing and passed hop testing. Among these 73 patients, a greater portion reported higher activity levels than lower activity levels before their injury, (X²=6.02 p=0.014) however there was no difference among men and women. **Conclusions:** Non-uniformity in pass rates among different test types may challenge

clinicians when making decisions regarding rehabilitation progress and timing for safe return to unrestricted physical activity. ACLR Patients with higher activity levels (defined by Tegner activity level) are more likely to be involved in competitive athletics and may be more capable of compensatory movements to pass hop testing in the presence of failed strength testing. Sport participation may expose this population to higher risk of re-injury, giving the rate of disagreement among tests notable importance during clinical decision making.

Table 1: The number of Pass or Failure for Strength and Hop Tests with sub-analyses by Sex and Activity Level.

	Single Leg Hop for Distance		
Isokinetic Extension at 90°/s	Pass Hop Tests	Fail Hop Tests	Total
Pass Strength Tests	18 10m, 8f 16 Tegner ≥7	4 1m, 3f 3 Tegner ≥7	22 11 m, 11f 19 Tegner ≥7
Fail Strength tests	73 35m, 38f 67 Tegner ≥7†	95 44m, 51f 77 Tegner ≥7	168 79m, 89f 144 Tegner ≥7
Total	91 45m, 46 f 83 Tegner ≥7**	99 45 m, 54f 80 Tegner ≥7	190* 90m, 100f 163 Tegner ≥7

*Significant relationship between strength test pass rates and hop test pass rates

**Significant relationship between Activity level among those who failed strength tests but passed hop tests

Single Stage Revision ACL Reconstruction With Quadriceps Tendon Autograft, Lateral Meniscus Transplant, and Osteochondral Allograft Transplantation in a 27-Year-Old Male: Level 3 Case Study
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Background: This is a level 3 case study of a 27-year-old active male presenting to clinic with 6 prior left knee surgeries and electing to have ACL revision reconstructions, meniscus allograft transplant, and osteochondral allograft transplant on the left knee. This case is unique as all three major surgical procedures were done in a single stage fashion. Previous studies have examined patient outcomes when combining two of the three procedures used in this case in a single stage fashion but little is known about outcomes when combining all three. **Patient:** A 27-year-old active male initially presented to clinic with complaints of left knee pain, instability, catching, locking, and swelling with increased activities. His extensive left knee surgical history included a primary ACL reconstruction with allograft and 3 subsequent revision ACL reconstructions, the first with hamstring autograft, and the following two with allografts. Furthermore, he underwent two other procedures including an arthroscopic chondroplasty with loose body removal, and most recently, a closing wedge tibial tubercle osteotomy, chondroplasty and an unknown cartilage allograft to the central trochlea. On examination, he presented with hyperlaxity, a trace joint effusion, symmetrical ROM with

crepitus and popping, positive Lachman's and McMurray's test. X-rays showed mild arthritic change in the lateral and medial compartments. His MRI confirmed a distal ACL graft tear, absent lateral meniscus, and the grade IV chondral defect in the trochlear groove. CT scan revealed widening of ACL tibial and femoral tunnels to 14x14mm and 13x12mm, respectively. Long standing hip to ankle x-ray revealed the weight-bearing line falling in the middle third of the left knee. Final diagnosis was left knee ACL graft tear, absent lateral meniscus, and acute cartilage defect in the femoral trochlear groove.

Intervention & Treatment: Given his complex surgical history, a single staged revision ACL reconstruction with a quadriceps tendon autograft, meniscal allograft transplant, and osteochondral allograft transplant to the trochlear groove was elected. Previous studies have demonstrated that meniscus allograft transplant is most successful when conducted on a stable knee. To achieve a ligamentous stable knee, a revision ACL reconstruction was done prior to the placement of the meniscal allograft, in a single stage procedure. Studies do show this has been done as a concomitant procedure.

Outcomes or Other Comparisons: At the time of this study the patient was approximately 11 weeks post op and the patient is progressing as expected in relation to physician instructed therapy. He remains ligamentous stable with mild effusion and increasing ROM and strength. The patient is currently transitioning from a double leg strengthening to a single leg strengthening protocol. Unfortunately, there are no comparable studies that have looked at the combination of all three surgeries in a single stage approach.

Conclusions: This case presents a challenging situation as three major procedures were

performed during surgery in a single stage fashion. To date, there are no case studies that have had a similar single stage approach including these three procedures. However, there are studies that have investigated two of the three procedures at once with successful and similar outcomes in an active population. **Clinical Bottom Line:** A thorough history must be taken and include a patient's surgical history. Patient history plays an important role in decision making and discussing surgical management. In addition, it is important for the physician to take into consideration the benefits and success rates of specific surgeries versus the risks and failure rates which will allow better counseling of the patient and patient expectations.

The Influence of Self-Reported Function on Lower Extremity Energy Absorption in ACL Reconstructed Individuals

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Context: Measurements of self-reported function (SRF) following anterior cruciate ligament reconstruction (ACLR) are useful to understand individuals' perceptions of their knee function and quality of life. Previous research has reported SRF in conjunction with physical task measures; however, SRF has not been compared to joint loading using energy absorption (EA) and energy absorption contribution (EAC). The purpose was to examine if energy absorption during various physical performance tasks within ACLR subjects and between ACLR and controls was influenced by SRF. We hypothesized that ACLR participants with lower SRF would display altered energy absorption patterns compared to ACLR participants with high SRF. The secondary hypothesis was that ACLR individuals with similar SRF as control participants would continue to exhibit altered loading pattern differences across all tasks. **Methods:** Twenty ACLR participants (11 females, 9 males; Age = 21.9±2; Years since ACLR = 5.2±2.5) were compared to 20 age, sex,

limb and activity-matched healthy controls (11 females, 9 males; Age = 22.2±1.9) in an observational case control laboratory-based study. Lower extremity biomechanical data was collected during a single leg squat (SLS), the first 50-150ms of a single-leg hop (Hop50, Hop100, Hop150), and gait. EA and EAC were calculated at the knee, hip and ankle joints during eccentric loading of all tasks. EAC was calculated from all joints and expressed as a percentage out of 100%. SRF was evaluated using the Knee Injury and Osteoarthritis Outcome Score (KOOS) and International Knee Documentation Committee (IKDC) subjective forms. Participants were classified as either high (ACL-high; CON-high) or low (ACL-low; CON-low) relative to established cut-off scores for each scale. Linear mixed effects models and Tukey post hoc tests were performed to determine an interaction between groups, tasks and self-reported function ($\alpha \leq 0.05$). **Results:** A significant three-way interaction was found between group, task and SRF for various EA and EAC outcomes. Significant differences between SRF cut-offs for ACLRs and controls were found across various tasks. For example, controls with a high SRF score on the KOOS Stiffness scale showed greater knee EAC (%) during Hop100 than ACLR with high SRF on the stiffness scale ($\Delta = 17.5$, $p < 0.001$; Figure 1). This finding was also similar between groups with low SRF on the stiffness scale ($\Delta = 56.5$, $p < 0.001$; Figure 1). Also, within group comparisons revealed that

for the KOOS Stiffness scale, high SRF ACLR participants used greater knee EAC during the Hop100 task than low SRF ACLR participants ($\Delta = 29.0$, $p < 0.001$; Figure 1). **Conclusions:** ACLR participants with lower SRF used joint loading strategies that limited knee loading and emphasized hip and ankle compensations. When compared to control groups with similar SRF scores, ACLR participants still consistently demonstrated altered loading strategies with more ankle and/or hip contribution in an effort to underload the knee.

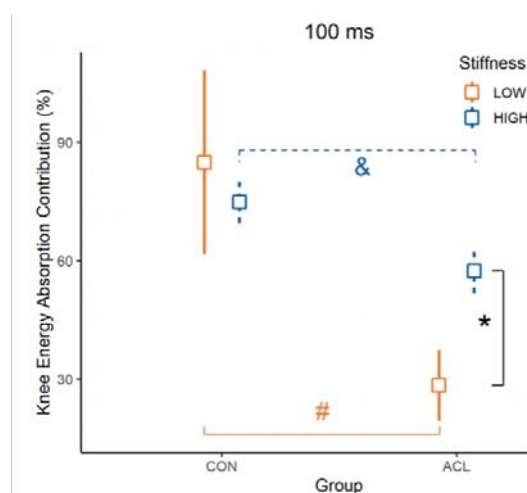


Figure 1. Statistically significant difference ($p < 0.05$) in knee energy absorption contribution (EAC) between High SRF ACL vs. Low SRF ACL groups*, High SRF ACL vs. High SRF Control[&], and Low SRF ACL vs. Low SRF Control[#] groups during the Hop100 task (100ms after initial contact). (SRF = self-reported function as measured by the Knee Osteoarthritis Outcome Score (KOOS) Stiffness scale).

Unique Cause of Anterior Knee: Level 3 CASE Study

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Background: The pathologies presented in this level 3 CASE study each have rare characteristics in the specific population, injury mechanism and occurrence. The patient presented with three combined pathologies resulting in a unique surgical intervention. In literature, subchondral cysts are most found in males between third and sixth decades of life in the epiphysis of long bones. This patient's gender, young age and location of the cyst, presents as a rare injury. Patella stress injuries account for 1% of all fractures. The unique aspect of this patient's patellar stress injury is the lack of a relationship caused by the patella tendon. Lastly, the unique aspect of fat pad impingement lesion is the mechanism of injury. Since these lesions usually develop secondary to ACL or meniscus injury the lack of these primary pathologies makes the lesion unique. Overall, the combination of these three pathologies creates an exceptional presentation in one patient. **Patient:** A healthy 17-year-old female basketball and tennis player presented to the clinic with insidious onset of right anterior knee pain which had not responded to conservative treatment. Upon evaluation, the patient presented with joint effusion, limited tibiofemoral extension, and mild patellofemoral, tibial tubercle, and patella tendon tenderness. Patella grind and patella clunk stress tests were positive. Diagnostic imaging included radiographs, MRI,

and CT scan. These scans showed mild tibial tuberosity- trochlear groove (TT-TG) distance of 22 mm, stress reaction of the inferomedial patellar facet, and an inferolateral subchondral cyst with overlying chondral fissuring of the patella. Although patella alta was noted, there was no causation between patellar alignment, the patellar tendon and subsequent injuries. She was diagnosed with inferolateral subchondral cyst, anteromedial patellar stress reaction with an associated stress fracture, and fat pad impingement lesion. **Intervention & Treatment:** Initial conservative treatment included an immobilizer brace locked at 0° of extension and non-weight-bearing. She was directed to take calcium and vitamin D to promote bone healing. The purpose of this initial treatment was to relieve stress on the patella to provide optimal healing conditions for the stress injury. After 3 weeks without relief of symptoms, the patient chose surgical intervention. Procedures performed included, extensive synovectomy of the right knee with debridement of the infrapatellar fat pad impingement lesion, patella open reduction internal fixation, and inferolateral patellar cyst decompression with marrow stimulation. Post-operative rehabilitation concentrated on pain modulation, improving range of motion and lower extremity strengthening. Literature does not report a standard of care with measured outcomes for any of these pathologies. **Outcomes or Other Comparisons:** Due to the unique diagnosis of anterior knee pain, this case study shows the importance of further investigation when conservative treatment fails. The lack of prior cases with this combination of pathologies does not allow for comparison to prior cases. However, individual cases of each pathology show good

outcomes post-operatively. The patient is expected to return to full athletic activity which is determined by incorporation of the stress injury repair and rehabilitation progress. **Conclusions:** The main challenge of this case was the rarity of the pathologies. There are many causes of anterior knee pain in young athletes including patella tendon pathologies. Due to the lack of literature for each of these pathologies, diagnosing and treating this patient was difficult. The main recommendation for healthcare providers is to pursue further diagnostic evaluation including imaging when conservative treatment fails. **Clinical Bottom Line:** The importance of this case study is to show that rare pathologies may be a common complaint by young active patient populations. Anterior knee pain requires thorough evaluation to create the proper diagnosis and treatment plan.

Predicting ACL Reinjury From Return to Activity Assessments at 6-Months Post-Surgery: A Prospective Cohort Study

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Context: Return to activity (RTA) assessments are commonly administered following ACL-Reconstruction (ACLR) to manage post-operative progressions back to activity. To date, there is little knowledge on the clinical utility of these assessments to predict patient outcomes such as secondary ACL injury once returned to activity. The purpose of this study was to identify what measures of patient function at 6-months post-ACLR best predict return to activity and secondary ACL injury at a minimum of 2-years following ACLR. **Methods:** This was a prospective cohort study with all assessments performed in a laboratory setting. A total of 234 patients with primary ACLR completed functional assessments at approximately 6-months following ACLR. Assessments consisted of patient reported outcomes (Knee Osteoarthritis Outcome Score(KOOS)-Sports), isokinetic knee extensor strength(90°/sec), and single-leg hopping(m). A total of 192 patients

(104 Female, 21.2±9.2 years, 6.73±1.4 months post-ACLR) completed a follow-up ≥2-years post-ACLR (Follow-up:82%). All reinjury analyses were performed on patients that successfully RTA (n=155, Figure 1). The proportion of sex and graft type was assessed between the side of the second ACL injury (ACLR graft or Contralateral ACL). Logistic regression was used to assess the ability of functional measures at 6-months to predict RTA and ACL reinjury, controlling for patient sex, age, and pre-injury activity level. Regression analyses predicting reinjury were also performed on the cohort stratified on the median time to RTA (8-months). P-values ≤.05 were considered statistically significant. **Results:** Of the 192 patients, 155 returned to prior levels of physical activity (80%). Higher measures of the KOOS-sport ($\beta=.038$, $P=.023$), knee extension symmetry ($\beta=.022$, $P=.045$), and triple-hop symmetry ($\beta=.027$, $P=.046$) increased the probability of RTA. Within the patients who did RTA (n=155), a total of 44 (28%) individuals had a subsequent ACL injury; graft: n=24 (15.5%), contralateral ACL: n=20 (12.9%)(Figure 1). A greater proportion of females had a secondary injury to their contralateral ACL (15/24, 63%) whereas a greater proportion of males reinjured their ipsilateral ACL graft (15/20, 75%, $P=.017$). There were no differences between graft types in the proportion of reinjury ($P=.71$) or the side

of reinjury ($P=.23$). Greater knee extension symmetry at 6-months increased the probability of reinjury ($\beta=.016$, $P=.048$). In patients who RTA before 8-months, every 1% increase in quadriceps strength symmetry at 6-months increased the risk of reinjury by 2.1% ($\beta=.021$, $P=.05$). In patients who RTA after 8-months, every month that RTA was delayed reduced the risk of reinjury by 28.4% ($\beta=-.284$, $P=.042$). **Conclusions:** Patients with more symmetric quadriceps strength at 6-months post-ACLR were more likely to experience a second ACL injury, especially in those who returned to activity earlier than 8-months after the index surgery. A greater proportion of males had a secondary rupture to their ACLR graft, whereas more females ruptured their contralateral ACL.

Figure 1:

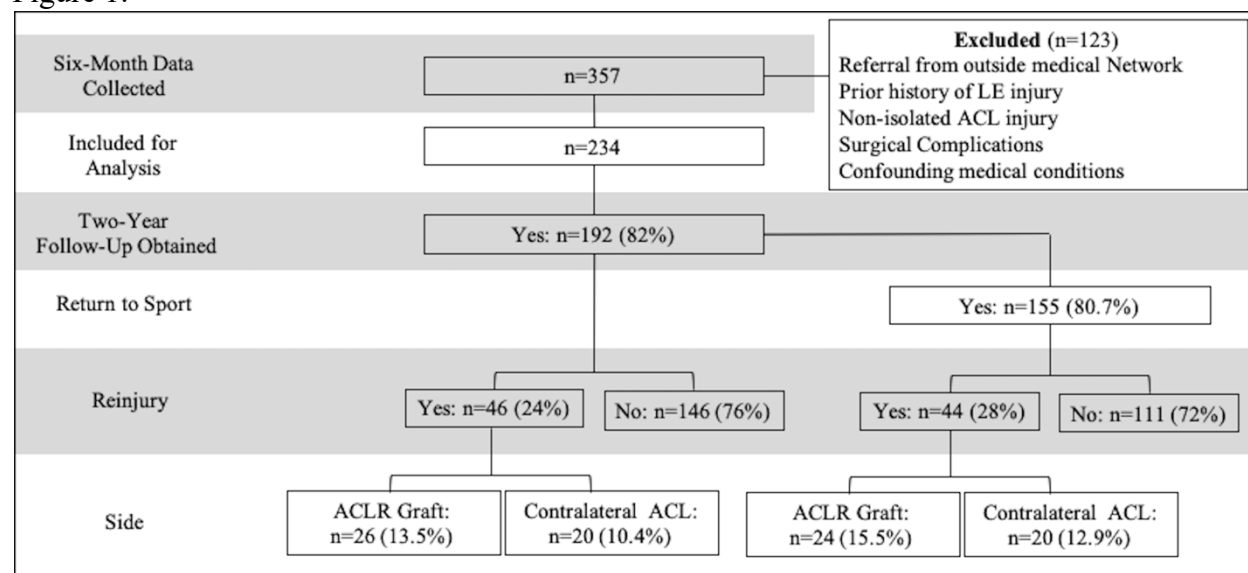


Figure 1: Flow chart of study participants.

Single Leg Hop Performance in Individuals With Anterior Cruciate Ligament Reconstruction: Should We Consider the Journey Rather Than the Outcome?

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Context: The single leg hop (SLH) for distance is the most used test to assess functional performance among individuals recovering anterior cruciate ligament reconstruction (ACLR). In recent years, the SLH has received criticism for overestimating function as assessed by conventional limb symmetry criteria. Many individuals with ACLR “pass” the SLH, despite presenting with an array of muscular deficits, suggesting they generate alternative compensatory movement patterns to accomplish the task. Our objective was to compare lower extremity kinematics and kinetics between individuals with ACLR and matched controls to characterize the development of movement patterns used to perform a SLH for distance. We hypothesized the ACLR limb would adopt a hip-dominant strategy compared to the contralateral and matched control limbs. **Methods:** Sixteen individuals with primary, unilateral ACLR (9 female, 20.3±2.1 years, 39.5±33.1 months from surgery) and 18 uninjured matched controls (8 female, 22.3±2.5 years) participated in this cross-sectional study conducted in a research laboratory. Participants performed three maximal effort SLH for

distance on each limb from an embedded force plate and must have maintained balance to be considered successful. SLH distance was expressed relative to body height and the contralateral limb (limb symmetry). Three-dimensional motion capture was used in conjunction with force plate data to calculate lower extremity kinematics (range of motion [ROM], peak angles) and kinetics (internal moments, powers) for the hip, knee, and ankle during the take-off phase of the SLH. Propulsive and vertical ground reaction forces were also calculated. Dependent and independent t-tests were used to compare outcomes between-limbs and between-groups. Mean differences and Cohen’s d effects sizes were calculated with 95% confidence intervals. **Results:** SLH distance (ACLR=0.73±0.12 vs. control=0.72±0.14, p=.917) and symmetry (ACLR=0.92±0.13 vs. control=1.00±0.13, p=.108) did not differ between groups. The ACLR limb demonstrated lesser peak knee flexion (-3.6° [-7.4,0.2], d=-0.7 [-1.4,0.0], p=.018), knee extension power (-1.2W/kg*m [-2.6,0.3], d=-0.6 [-1.2,0.1], p=.008), and peak dorsiflexion (-2.1° [-4.9,0.7], d=-0.5 [-1.2,0.2], p=.030) compared to the contralateral limb. The ACLR limb demonstrated lesser knee extension moment compared to controls (-0.2Nm/kg*m [-0.4,-0.0], d=-0.8 [-1.5,-0.1], p=.03). The contralateral limb demonstrated greater knee frontal plane ROM (2.7° [0.2,5.2], d=0.8 [0.1,1.5], p=.032) and plantarflexion power (0.7W/kg*m [0.1,1.5], d=0.7 [0.0,1.4], p=.048) compared to controls. **Conclusions:** Individuals with ACLR achieved comparable SLH distance compared

to controls despite demonstrating a large magnitude deficit in the ability to generate quadriceps torque during take-off. Moreover, adequate symmetry was achieved, despite producing less knee flexion, quadriceps power, and ankle dorsiflexion. Although a clear pattern of compensatory movement was not identified at the hip or ankle, these data indicate that individuals with ACLR accomplish the SLH different than uninjured individuals. These findings suggest that conventional criteria used to assess hop performance may fail to identify meaningful impairments in the development of the movement.

Single-Leg Triple Hop Propulsion Strategies in Females With and Without a History of ACL Reconstruction

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Context: The single-leg triple hop (SLTH) is a widely used return-to-sport test following ACL reconstruction (ACLR) because it is thought to provide insight into the restoration of quadriceps strength. However, recent research suggests that SLTH performance may overestimate an individual's quadriceps strength in the ACLR limb, and that compensatory movement strategies may be employed that propel the individual to similar hop distances bilaterally while masking underlying quadriceps dysfunction. Quantifying total support moment impulse (TSM) and relative joint contributions of the triple extensors (i.e., hip, knee and ankle extensors/plantarflexors) could identify potential compensatory strategies employed during SLTH propulsion. However, it is unclear whether individuals following ACLR exhibit similar propulsion strategies compared to individuals without ACLR in a SLTH. Therefore,

the purpose of this study was to compare SLTH propulsion strategies in females with and without a history of ACLR. **Methods:** Thirty-eight females (ACLR=19, 19.2±1.8 years-old, 164.1±7.0 cm, 63.8±7.6 kg, time after surgery: 20.1±9.5 months; Control=19, 21.1±3.3 years-old, 167.3±7.3 cm, 67.3±9.3 kg) were included in this analysis. Participants completed three SLTHs on both limbs. Kinematics and kinetics of the reconstructed limb for ACLR females and the non-dominant limb of control females were assessed during the initial propulsion phase (i.e., peak knee flexion through toe-off) using an optical motion capture system interfaced with a single force plate. Net internal joint impulses of each extensor were quantified by integrating the area under the moment-time curve during SLTH propulsion. TSM was quantified by summing these values across joints and relative joint contributions to TSM are expressed as a percentage of the TSM. Average total hop distance, limb symmetry index (LSI), and TSM were assessed between groups using independent t-tests and a mixed-model ANOVA was used to assess potential influences of prior ACLR, lower extremity joint, and their interaction on the magnitude of relative joint contributions to the TSM ($\alpha \leq 0.05$). **Results:** There were no significant between group differences in total hop distance (ACLR: 2.19±0.34 body-heights, Control: 2.23±0.40 body-heights, $p=0.721$), LSI (ACLR:

96.21±6.32%, Control: 98.82±5.31%, $p=0.189$) or TSM impulse (ACLR: 45.92±10.08 N-m-s, Control: 48.06±9.08 N-m-s, $p=0.506$). Results from the mixed-model ANOVA found joint contributions to TSM did not differ between groups ($p=0.409$) nor was there a significant interaction between prior ACLR and joint identified ($p=0.528$). Irrespective of group, the ankle was the largest contributor to TSM ($p<0.001$) (Figure 1). **Conclusions:** ACLR females demonstrate similar performance and propulsion strategies to females without a history of ACLR in a SLTH. Regardless of previous injury status, SLTH propulsion is predominantly driven by the ankle plantarflexors and the demand on the knee extensors is likely insufficient to identify potential underlying quadriceps dysfunction following ACLR. Therefore, clinicians should interpret SLTH performance with caution as it may not be a good indicator for quadriceps strength following ACLR.

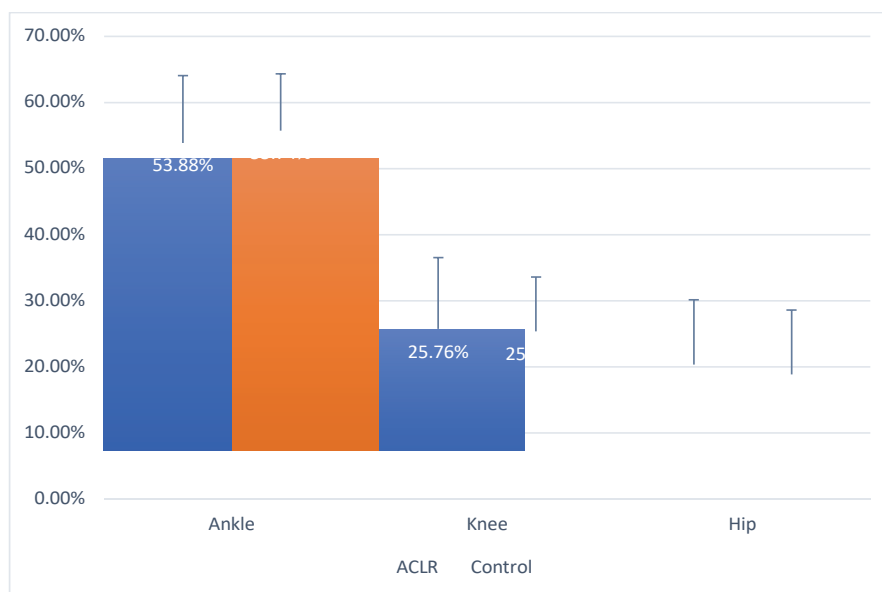


Figure 1. Results from the 2 (ACLR and Control) x 3 (Ankle, Knee, and Hip) Mixed-Model ANOVA. Significant joint main effects were identified from the ANOVA table. Post-hoc testing with a Bonferroni correction following the identification of a significant joint main effect indicated that the ankle plantarflexors contributed significantly more to the total support moment than the knee and hip extensors during single-leg triple hop propulsion ($p<0.001$).

Trunk and Lower Extremity Biomechanics During Two Single-Leg Landing Tasks in Individuals With Anterior Cruciate Ligament Reconstruction

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Context: Altered biomechanics during jump landing are commonly exhibited by individuals with ACL reconstruction (ACLR). Single-leg landing tasks, such as the single-leg drop (SLD), are often used to assess functional recovery and inform return-to-play decisions for these individuals. However, the ability to assess abnormal movement patterns in the frontal plane with the SLD may be limited. The single-leg cross drop (SLCD) was proposed to provide lateral perturbation to challenge frontal plane motion and highlight the effect of lateral trunk flexion in landing mechanics. The SLCD may serve as a more sensitive indicator of multiplanar functional recovery. Our purpose was to compare trunk and lower extremity biomechanics in individuals with ACLR during the SLD and SLCD. We hypothesized the SLCD would elicit landing biomechanics associated with injury risk to a greater extent than the SLD. **Methods:** Nine individuals with history of primary unilateral ACLR (6 females; 19.6±2.1 years) and nine uninjured controls (3 females; 22.0±1.8 years) participated in this cross-sectional, laboratory study. Three-dimensional motion analysis was

used to assess landing biomechanics during the SLD and SLCD. For the SLD, participants jumped and landed on the same limb. For the SLCD, participants jumped from one limb, crossed over medially in flight, and landed on the other limb. Kinematic and kinetic data were calculated during the landing phase of each task (initial contact to 500ms post-initial contact) and extracted at the point of peak knee flexion. Variables of interest included sagittal and frontal plane trunk, hip, and knee angles and internal moments, and vertical ground reaction force (vGRF). Three trials were performed on each limb and were compared between limbs and groups (ACLR, control). Dependent t-tests evaluated differences between tasks in the ACLR group and independent t-tests evaluated differences between ACLR limbs and matched control limbs ($\alpha \leq .05$). **Results:** The ACLR limb exhibited reduced peak knee flexion during the SLCD compared to SLD (SLD: $-56.9 \pm 10.4^\circ$, SLCD: $-52.3 \pm 10.6^\circ$, $p = .024$). The ACLR limb exhibited greater hip adduction angles, less ipsilateral trunk lean, less knee extension moment, and lower vGRF compared to the contralateral limb in the SLCD (Table 1). For the SLD, the ACLR limb exhibited lower knee flexion angles only (Table 1). The ACLR limb exhibited lower knee extension moments during the SLD (ACLR: 0.92 ± 0.21 Nm/kg*m vs. Control: 1.15 ± 0.22 Nm/kg*m, $p = .038$) and SLCD (ACLR: 0.96 ± 0.19 Nm/kg*m vs. Control: 1.35 ± 0.36 Nm/kg*m, $p = .012$) compared to matched controls. **Conclusions:** Challenging individuals with ACLR using

landing tasks that include multiplanar movements reveal altered landing biomechanics. Compared to the SLD, the SLCD elicited additional movement patterns affiliated with risk factors for ACL injury, such as stiff landings and dynamic knee valgus (hip adduction). Clinicians should consider using multiple landing tasks when evaluating functional recovery to ensure they are challenging multiplanar movement.

Table 1. Results for within-task, between-limb differences for ACL Reconstruction group

Variables at Peak Knee Flexion	Single-Leg Drop			Single-Leg Cross Drop		
	Involved	Uninvolved	p-value	Involved	Uninvolved	p-value
Joint Angle, deg						
Hip Flexion	59.2±9.6	63.0±15.0	.211	60.8±13.1	59.1±15.8	.468
Hip Adduction	4.1±3.5	-0.24±6.4	.140	5.8±3.4	-0.14±6.2	.014 ^a
Knee Flexion	-56.1±10.5	-61.91±13.2	.010 ^a	-52.3±10.6	-55.7±12.6	.068
Knee Abduction	-4.5±6.1	-7.1±4.9	.357	-2.9±6.8	-6.2±4.0	.259
Trunk Flexion	-28.6±8.7	-28.7±10.8	.971	-28.5±12.3	-26.5±12.4	.091
Trunk Lateral Flexion	4.7±5.0	5.5±3.3	.781	3.9±4.3	8.8±3.3	.044 ^a
Joint Moment, Nm/kg*m						
Hip Extension	-0.62±0.31	-0.63±0.30	.923	-0.59±0.32	-0.57±0.38	.729
Hip Abduction	-0.51±0.22	-0.54±0.27	.854	-0.44±0.26	-0.53±0.3	.513
Knee Extension	-0.92±0.21	1.1±0.29	.085	0.96±0.19	1.3±0.22	.002 ^a
Knee Adduction	-0.24±0.10	-0.17±0.21	.945	-0.04±0.20	-0.03±0.16	.915
Vertical ground reaction force, N	1.45±0.43	1.47±0.32	.901	1.5±0.32	1.6±0.31	.031 ^a

^aSignificant outcomes

The Epidemiology of Injuries in Middle School Wrestling Between the 2015/16 and 2019/20 School Years

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Context: Wrestling is a physically demanding and high intensity contact sport. Previous research has described wrestling injuries at the collegiate and high school levels; however, limited data exists at the middle school level. Therefore, the purpose of this study was to describe the epidemiology of injuries sustained by middle school age wrestlers in a large metropolitan school division. **Methods:** A retrospective descriptive epidemiology study of middle school wrestling injuries was conducted as part of the Advancing Healthcare Initiatives for Underserved Students (ACHIEVES) project. Data was examined from competitive wrestling seasons at nine (2015/16 to 2018/19) and 16 (2019/20) middle schools, respectively. Certified athletic trainers collected injury and athlete exposure (AE) data during practice and competition for all school-sponsored sports. Injuries were classified as non-time loss

(NTL, <24 hours restriction of participation) or time loss (TL \geq 24 hours restriction of participation). Time loss injuries were further categorized as mild (1-6 days), moderate (7-21 days) and severe (>21 days) based on participation restriction. An AE was defined as one athlete participating in one school-sponsored practice or competition. Injury frequencies and rates (IRs) were calculated. Injury rate ratios (IRR) with 95% confidence intervals (CI) were then calculated to compare IRs between practice and competition. IRRs with 95% CIs that did not include the value of 1.0 were considered statistically significant. **Results:** Overall, 1432 injuries were reported (IR = 37.39/1000 AE, 95% CI: 35.46-39.33) for 38,297 AEs. The TL injury rate was similar in competition and practice (12.27 vs. 14.10/1000 AE, IRRcompetition/practice = 0.87, 95% CI: 0.00-2.11). The vast majority of TL injuries (n = 524), were mild, (n = 435 [83.0%]) and fewer injuries were moderate (n = 57 [10.9%]) and severe (n = 32 [6.1%]). The most common TL injuries were strains (n = 122 [23.3%], IR = 3.19/1000 AE, 95% CI: 2.90-3.47), contusions (n = 114 [21.8%], IR = 2.98/1000 AE, 95% CI: 2.70-3.26), general medical conditions (n = 71 [13.5%], IR = 1.85/1000 AE, 95% CI: 1.42-2.29) and concussions (n = 40 [7.6%] IR = 1.04/1000 AE, 95% CI: 0.88-1.21). The most common mechanisms for all TL injuries were direct blow/impact (n = 239 [45.6%], IR = 6.24/1000 AE, 95% CI: 5.84-6.64), general medical/ not applicable (n=70 [13.3%], IR=1.83/1000AE, 95% CI:1.76-1.90), overuse (n = 22 [4.2%], IR=0.57/1000 AE, 95% CI: 0.45-0.70). **Conclusions:** Our study suggests that middle school wrestlers have a higher overall injury rate than previously

reported among middle school, high school, and collegiate wrestlers. Additionally, our findings were inconsistent with prior research regarding injury rates for TL injuries observed in practice than competition. These findings indicate that further research is needed to better understand practice related injury risk factors and inform risk reduction strategies among middle school age wrestlers.

Associations Between Injury and Sport Specialization Behaviors in Youth Basketball

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Context: Basketball is the most popular youth team sport in the United States, and there has been media interest in how sport specialization affects the health of National Basketball Association (NBA) players. Sport specialization is increasingly common in youth sports, including basketball. However, sport specialization research in youth basketball players has been limited. The purpose of this paper was to examine the association of various sport specialization behaviors with injury history by surveying a nationally representative sample of parents of youth basketball athletes. **Methods:** Eight-hundred and five parents (female N=353, 43.9%; age: 39.9±7.1 years old) of youth basketball players (female N=241, 29.9%; age: 12.9±2.5 years old) were recruited via Qualtrics Research Panels to complete an online questionnaire. Participants were a parent of a child between 8-18 years-old who participated in organized youth basketball. Participants were recruited to be nationally-representative with regards to race/ethnicity (White/Caucasian 62.7%; Hispanic/Latino of any race 15.3%; African-American/Black 13.3%; Asian 4.6%;

2+ races 2.9%; Other 1.2%). The questionnaire was adapted from previous research and consisted of three sections: 1) parent/child demographics, 2) child basketball participation in the previous year (e.g. months of basketball participation, sport specialization status, receiving private coaching, traveling at least once a month for basketball competitions, participation on multiple sport teams at the same time) and 3) child basketball-related injury history in the previous year. Child sport specialization status (low, moderate, high) was determined using a validated 3-point specialization scale. Injury history was defined as a child suffering an injury while playing basketball during the previous 12 months that caused the child to miss time from basketball and seek medical care. Adjusted odds ratios (AORs) with 95% confidence intervals (95%CI) were calculated using multivariate logistic regression for the associations between variables of interest and injury history, adjusting for covariates. **Results:** Child demographics and sport participation characteristics are in Table 1. Highly specialized athletes were more likely than low specialization athletes to have a basketball-related injury in the previous year (AOR [95%CI]: 2.47 [1.25-4.88], p=.009). The odds of a basketball-related injury in the previous year were twice as likely among athletes who played on a basketball team at the same time as another sport team compared to those who did not (AOR [95%CI]: 1.98 [1.30-3.01], p=.001). The odds of an injury in the previous year were three times greater among athletes who received private coaching compared to

those who did not (AOR [95%CI]: 2.91 [1.97-4.31], p<.001). **Conclusions:** Specialization in basketball, along with several other behaviors that have become typical of modern youth sport participation, were associated with basketball-related injury history. Recently developed guidelines for safe youth sport participation, such as the NBA and USA Basketball recommendations, should be widely disseminated to encourage safe basketball participation.

TABLE 1. Child Demographics and Sport Participation Characteristics (N=805).

Variable	N (%), Mean (SD), or Median [IQR]
Child Age	12.9 (2.5)
Child Sex	
Male	564 (70.1%)
Female	241 (29.9%)
Months/Year of Organized Basketball	6 [4-10]
Hours/Week of Organized Basketball	12 [8-20]
Specialization	
Low	255 (31.7%)
Moderate	361 (44.8%)
High	189 (23.5%)
In past 12 months, child participated on organized basketball team and other organized sport team at same time?	
Yes	356 (44.2%)
No	449 (55.8%)
Travel overnight regularly for basketball competitions (at least once a month)	
Yes	423 (52.5%)
No	382 (47.5%)
Receive Private Coaching Outside of Team	
Yes	375 (46.6%)
No	430 (53.4%)
Basketball-Related Injury in Previous Year	
Yes	204 (25.3%)
No	601 (74.7%)

Descriptive Epidemiology of Acute and Overuse, Time-Loss and Non-Time-Loss Lateral Ankle Sprains and Healthcare Utilization in Collegiate Student-Athletes

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Context: While lateral ankle sprains (LAS) are a common injury, there is little information on what proportion are non-time-loss (NTL) and what healthcare utilization results from NTL sprains. The purpose was to describe the epidemiology of acute and overuse LAS, stratified by time-loss (TL) and NTL, and to characterize associated athletic training services (ATS) and physician encounters (PE) in collegiate student-athletes. **Methods:** This descriptive epidemiology study utilized electronic medical records from all Pac-12 Conference institutions that were migrated to the Health Analytics Program. De-identified LAS injuries were collected from all sports at each member institution from August 2018-March 2020, representing 123 men's and 143 women's teams for 532 team-seasons. LAS were identified by location (ankle), injury type (ligament sprain/tear or instability), and specific Orchard Sports Injury Classification System code (OSICS-10). Data underwent quality assurance procedures, and

LAS injury, ATS, and PE frequencies were calculated. For a subset of 9 men's and 8 women's selected sports, representing 309 team-seasons, mean number of sprains and mean ATS per team per season and per player per season were calculated. Study methods were approved by the local institutional review board and the Pac-12 Student-Athlete Health & Well-Being Initiative.

Results: In the overall sample, a total of 927 LAS were captured, of which 540 were acute-TL, 370 were acute-NTL, 5 were overuse-TL, and 12 were overuse-NTL. Over half the LAS were in men (528; 57%). The majority of LAS occurred in-season for both men (n=282, 53%) and women (n=191, 48%). The percentage of NTL injuries in acute LAS was $\geq 40\%$ for 15 of 29 teams. In subset analysis, football and men's basketball had the highest mean number of sprains per team per season for acute-TL and -NTL (Table 1). Men's and women's basketball had the highest mean number of sprains per player per season. There were 9443 ATS associated, and 282 PE, of which 75% and 70%, respectively, were for acute-TL LAS. Football had the highest mean number of ATS per team per season for acute-TL and acute-NTL (Table 1) but men's and women's basketball had the highest mean number of ATS per player per season.

Conclusions: There were few overuse LAS, but acute-NTL LAS comprised 41% of this sample. Rates for LAS and ATS varied considerably by sport and gender, with women's sports over-represented in acute-NTL injuries. Healthcare utilization for acute-NTL injuries was less than

acute-TL, but represented 22% of ATS and 28% of PE for all LAS. NTL LAS constitute an important proportion of LAS injuries in collegiate student-athletes, and their treatment account for substantial resources, including athletic trainer and physician time. Capturing both TL and NTL ankle injuries allows better estimates of injury rates and treatment resources needed to maintain student-athlete health.

Table 1. Acute Lateral Ankle Sprain and Athletic Training Services in Selected Collegiate Sports

Sport	Acute Lateral Ankle Sprains		Mean No. Sprains per Team per Season		Athletic Training Services Provided		Mean No. ATS per Team per Season	
	TL	NTL	TL	NTL	TL	NTL	TL	NTL
Basketball (M)	66	61	2.75	2.54	746	257	31.1	10.7
Basketball (W)	50	43	2.08	1.79	1542	235	64.3	9.8
Cross Country (M)	2	3	0.11	0.17	7	12	0.4	0.7
Cross Country (W)	4	7	0.17	0.29	26	45	1.1	1.9
Football (M)	132	109	5.50	4.54	1573	623	65.5	26.0
Gymnastics (M)	4	1	1.00	0.25	4	0	1.0	0.0
Gymnastics (W)	13	7	0.81	0.44	149	111	9.3	6.9
Lacrosse (W)	15	12	1.25	1.00	190	72	15.8	6.0
Soccer (M)	15	6	1.50	0.60	98	16	9.8	1.6
Soccer (W)	38	25	1.58	1.04	705	342	29.4	14.3
Tennis (M)	14	3	0.78	0.17	218	7	12.1	0.4
Tennis (W)	13	11	0.59	0.50	104	50	4.7	2.3
Track&Field (M)	19	7	0.95	0.35	150	24	7.5	1.2
Track&Field (W)	21	17	0.88	0.71	216	97	9.0	4.0
Volleyball (M)	10	3	1.67	0.50	116	1	19.3	0.2
VB/Beach VB (W)	20	16	0.48	0.38	340	28	8.1	0.7
Wrestling (M)	15	4	2.50	0.67	110	18	18.3	3.0

TL: Time-Loss; NTL: Non-Time-Loss; ATS: Athletic Training Services; M: Men's; W: Women's;

Descriptive Epidemiology of Lower Extremity Acute and Overuse, Time-Loss and Non-Time-Loss Injuries in Collegiate Student-Athletes

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Context: More accurate and comprehensive data related to acute and overuse athletic injuries, stratified by time-loss (TL) and non-time-loss (NTL), are needed to provide a complete picture of injury burden and clinician workload. The purpose was to describe the epidemiology of acute and overuse lower extremity injuries, stratified by TL and NTL, in collegiate student-athletes in running, cutting, and jumping sports. **Methods:** This descriptive epidemiology study utilized the Health Analytics Program of migrated electronic medical records from all Pac-12 Conference institutions. De-identified injuries were collected from men's and women's basketball, soccer, volleyball, cross country, men's football, and women's field hockey and beach volleyball at each member institution sponsoring those sports from August 2018-March 2020. This represented 82 men's and 130 women's teams for 212 team-seasons.

Injuries were identified by mechanism (acute or overuse), time-lost (TL or NTL), location (lower extremity), and injury type (any musculoskeletal). Quality assurance procedures were completed and injury frequencies were calculated. Additionally, mean number of injuries per team per season and per player per season were calculated. The local institutional review board and the Pac-12 Student-Athlete Health & Well-Being Initiative reviewed and approved study methods. **Results:** A total of 5192 injuries were captured. The majority were acute (n=4235, 81.6%) and of those, most (n=2874, 67.9%) were in males. Overuse injuries (n=957, 18.4%) were more common in females (n=506, 9.7%). NTL injuries represented 45% of the sample (n=2340) and of those, most (n=1376, 58.8%) were in males. TL injuries were primarily acute (n=2390, 46.0%) and occurred more frequently in males (n=1725, 33.2%). Overuse-TL and -NTL had similar frequencies across genders and ranged from 4.3 to 5.2% (Table 1). Football had the highest means for injuries per team per season for acute and overuse for both TL and NTL, followed by men's and women's basketball and soccer in acute-TL or -NTL, depending on the category (Table 1), but in overuse-TL and -NTL injuries, those spots switched to men's and women's cross country and women's field hockey. Mean injuries per player per season varied by sport across categories (Table

1). **Conclusions:** NTL injuries represented almost half (45%) of the sample. While overuse injuries were less frequently documented, they did demonstrate parity across genders for both TL and NTL when reported per team per season or per player per season. Both overuse and NTL injuries appear to vary by sport and gender and may influence injury treatment burden for student-athletes and clinicians. Including a mechanism of acute versus overuse, stratified by TL and NTL, provides a more comprehensive picture of injury burden and clinician workload as a first step to informing decisions supporting strategic clinician staffing and data-driven overuse injury prevention programs.

Table 1. Lower Extremity Acute and Overuse Injuries, Stratified by Time-Loss and Non-Time-Loss for Collegiate Student-Athletes

	Acute Injuries		Mean No. Acute Injuries per team per season		Mean No. Acute Injuries per player per season		Overuse Injuries		Mean No. Overuse Injuries per team per season		Mean No. Overuse Injuries per player per season	
	TL	NTL	TL	NTL	TL	NTL	TL	NTL	TL	NTL	TL	NTL
Sport												
Basketball (M)	214	274	8.9	11.4	0.6	0.7	43	31	1.8	1.3	0.1	0.1
Basketball (W)	160	284	6.7	11.8	0.5	0.9	45	46	1.9	1.9	0.1	0.1
Cross Country (M)	30	24	1.7	1.3	0.1	0.1	47	36	2.6	2.0	0.2	0.1
Cross Country (W)	35	48	1.5	2.0	0.1	0.1	96	37	4.0	1.5	0.2	0.1
Field Hockey (W)	13	30	3.3	7.5	0.1	0.3	10	13	2.5	3.3	0.1	0.1
Football (M)	1273	736	53.0	30.7	0.5	0.3	100	114	4.2	4.8	0.0	0.0
Lacrosse (W)	65	56	5.4	4.7	0.2	0.1	25	37	2.1	3.1	0.1	0.1
Soccer (M)	136	79	13.6	7.9	0.5	0.3	21	19	2.1	1.9	0.1	0.1
Soccer (W)	289	165	12.0	6.9	0.4	0.3	34	63	1.4	2.6	0.1	0.1
Volleyball (M)	34	29	5.7	4.8	0.3	0.2	7	11	1.2	1.8	0.1	0.1
VB/Beach VB (W)	103	113	2.5	2.7	0.1	0.2	28	74	0.7	1.7	0.0	0.1

TL: Time-Loss; NTL: Non-Time-Loss; M: Men's; W: Women's; VB: Volleyball

The Relationships Between Early Sports Specialization, Overuse Injuries, and Health-Related Quality of Life in Throwing Athletes

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Context: Early sport specialization (ESS) is a concern in many sports, including baseball and softball, due to its association with increased rate of overuse injury. Sport-related injury is also associated with a decrease in health-related quality of life (HRQOL). To date, there is little research on whether prior upper extremity (UE) overuse injuries and ESS affect collegiate baseball and softball athletes' HRQOL. The purpose of this study was to identify the relationships between ESS, self-reported UE overuse injury history, and HRQOL in collegiate baseball and softball athletes. **Methods:** This cross-sectional, survey-based study recruited baseball and softball athletes rostered for full participation on a junior/community college or college/university sanctioned team. Athletic trainers were recruited for a convenience sampling design in which they sent the study invitation with the survey link to eligible athletes at their institution. The survey was developed by investigators, underwent content validation, and captured sport participation, UE overuse injury history, sport specialization pathway (early/late/none), and

HRQOL. The Disablement of the Physically Active Scale (DPAS) and Functional Arm Scale for Throwers (FAST) scores (DPAS: 0-64 points; FAST: 0-100 points) measured HRQOL, with higher scores indicating greater levels of dysfunction/decreased HRQOL. Spearman's correlations were calculated to estimate the strength of association between: 1) ESS and self-reported UE overuse injury history (yes/no), 2) self-reported UE overuse injury history and HRQOL (FAST and DPAS scores), and 3) sport specialization and HRQOL. An alpha level of .05 was used for all analyses. Strength of correlations were identified as no relationship-very weak if $r_s=0-.25$, weak if $r_s=.25-.50$, moderate if $r_s=.50-.75$, and strong if $r_s=.75-1.00$.

Results: For athletes who accessed the survey, there was a 76% completion rate ($n=94/123$) with 29 partial responses. Respondents were 19 ± 1.0 years old (male: 52/123, 42.3%; female: 36/123, 29.2%, undisclosed: 25/123, 28.5%), competed at a junior/community college (78.9%, $n=90/114$), and represented both baseball (55.3%; $n=63/114$) and softball athletes (44.7%; $n=51/114$). Correlations are presented in Table 1. Results indicate: 1) weak negative correlations between ESS and self-reported UE overuse injury history, 2) presence of self-reported UE overuse injury history had a weak relationship with diminished HRQOL, and 3) a weak positive correlation between ESS and HRQOL. **Conclusions:** This study concludes that ESS in baseball and softball athletes may

not be related to a history of UE overuse injuries, nor related to current HRQOL. However, findings indicate that prior UE overuse injury is associated with lower HRQOL. Clinicians should be aware of how prior UE overuse injury impacts a patient's HRQOL not only at the time of injury, but even after returning to full participation. ESS should be explored further to better understand its influence on injury and HRQOL.

Table 1. Spearman Rho Correlation Summaries for all Respondents

	Injury History	DPAS Total	FAST Total	Specialization
Injury History	1			
DPAS Total	-.325*	1		
FAST Total	-.373*	.551*	1	
Specialization	-.125	.066	.122	1

DPAS- Disablement of the Physically Active patient reported outcome measure, FAST- Functional Arm Scale for Throwers patient reported outcome. *Significant at the .01 level (2-tailed)

Injury and Treatment Characteristics of Sport-Specific Injuries From 2013-2020: A Report From the Athletic Training Practice-Based Research Network

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Context: An understanding of injury and treatment characteristics may help inform medical staffing and coverage decisions. While epidemiological studies can describe injuries that occur during sport participation, few investigations have described the treatment of sport-related injuries by athletic trainers at the point-of-care, with the last large-scale sport-specific dataset from 2013. Our objective was to describe injury and treatment characteristics of sport-specific injuries reported within the Athletic Training Practice-Based Research Network (AT-PBRN) from 2013-2020. **Methods:** We retrospectively analyzed patient records from the AT-PBRN. Records were created by 368 athletic trainers (years certified=6.5±7.2, years employed at site=3.1±5.1) practicing in 317 athletic training clinics (high school=252, college=40, other=25) across 34 states between 2013-2020. For quality assurance purposes, data were abstracted from the AT-PBRN's electronic medical record following processes used for previous investigations. We used summary statistics (frequency, percentages, median, interquartile ranges [IQR]) to describe injury (sex, sport, diagnosis [ICD-10 code]) and treatment characteristics. Treatment characteristics included the type (Current Procedural Terminology code),

amount (number of visits), and duration (days between intake and last documented visit) of care. **Results:** A total of 26,162 sport-related injuries (male=14,934) were documented during the study period. Male football (25.6%, n=6,695), female basketball (8.5%, n=2,225), female soccer (8.1%, n=2,131), male basketball (7.1%, n=1,864), and female volleyball (6.5%, n=1,702) reported the most injuries. Concussion (ICD-10=S06.0X0XA; 12.2%, n=3,186), ankle sprain/strain (ICD-10=S93.409A; 10.8%, n=2,814), hip and groin sprain/strain (ICD-10=S73.109A; 7.4%, n=1,927), distal thigh sprain/strain (ICD-10=S83.90XA; 3.6%, n=945), and knee pain (ICD-10=M25.569; 3.2%, n=835) were the top five diagnoses documented. A total of 162,025 services were recorded with male football (22.2%, n=35,961), female basketball (9.2%, n=14,834), female soccer (8.8%, n=14,262), female volleyball (7.1%, n=11,505), and male basketball (6.8%, n=11,075) accounting for the highest number of services. Common services included hot/cold packs (21.4%, n=34,598), therapeutic exercise (18.4%, n=29,879), athletic trainer re-evaluation (12.4%, n=20,081), therapeutic activities (11.4%, n=18,421), and athletic trainer evaluation (8.1%, n=13,092). Across all injuries, patients received care over a median of 5 visits (IRQ=1-8) across a median of 9 days (IRQ=1-28). The sports associated with the highest number of visits were male gymnastics (median=19, IQR=14-42), female gymnastics (median=7, IQR=3-21), and male lacrosse (median=7, IQR=3-17). These sports were also associated with the longest duration of care: male gymnastics (median=66 days, IQR=39.5-81.5), female gymnastics (median=16 days, IQR=2-30), and male lacrosse (median=16 days, IQR=3-29).

Conclusions: Football, basketball, soccer, and volleyball accounted for the highest number of injuries and highest number of services. Although gymnastics and lacrosse accounted for a lower number of injuries, these sports were associated with more visits and longer duration of care. Future investigations should determine how treatment characteristics can be used to best inform medical staffing and coverage decisions.

Injury History Profile of Hip Impingement in NCAA Sports: 2009/10-2019/20

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Context: Hip impingement, often referred to as femoroacetabular impingement, is a motion-related clinical disorder of the hip that causes abutment between the acetabulum and proximal femur. Physical examination tests provide good levels of sensitivity, but poor specificity, making patient history a critical diagnostic element of the clinical exam. A record of prior injury is an essential component of patient history that aids in identifying compensations that may have predisposed the athlete to their current injury and in assessing the risk of recurrence. This study aims to explore the injury history of collegiate athletes during their collegiate career. We hypothesize that prevalence of prior hip/groin injuries will be higher than all other injuries among athletes with hip impingement injuries. **Methods:** Injury and exposure data

captured within the National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISP) during the 2009/10-2019/20 academic years were examined. Certified Athletic Trainers (ATs) at participating institutions contributed data via clinical reports recorded within their Electronic Medical Record systems. Hip impingement diagnoses were based on clinician diagnoses; no diagnostic criteria were provided. Hip impingement injury rate per 100,000 athlete-exposures (AEs) were estimated. History of prior injury was examined (body parts, specific diagnoses), and summary statistics (frequencies, percentages) were used to identify patterns in injuries sustained during competitive collegiate careers among athletes with hip impingements. **Results:** A total of 222 hip impingements were reported from 14,825,362 AEs during the study period (Rate=1.4 per 100,000 AEs); the sample comprised of 217 athletes. Among all hip impingements, 212 (95%) were new injuries, and 10 (5%) were recurrent. Moreover, 145 (65%) hip impingements were reported in male athletes; 77 (35%) were reported among female athletes. Approximately half (n=115; 52%) of all athletes with hip impingements reported it as their first injury; 51 athletes (23%) reported

it as their second injury; 15 athletes (7%) reported it as their third injury; 18 athletes (8%) reported it as their fourth injury; 6 athletes (3%) reported it as their fifth injury; and 8 athletes (4%) reported it as their sixth injury during their collegiate careers. Among athletes for whom hip impingement was not a first injury, most prior injuries were to the hip/groin (37%), ankle (30%), and knee (28%). The most common prior injuries were partial or complete tears of the Lateral Ligament Complex (ankle) (16%), Medial Collateral Ligament (10%), and Adductor (10%). **Conclusions:** The injury history profile of hip impingement in NCAA athletes across 10 years primarily comprised of hip/groin, knee, and ankle injuries. This work will assist ATs in their assessment of suspected hip impingement in their athletes by illustrating the injury history profile preceding a hip impingement. Future studies should aim to describe the risk of hip impingement associated with types of hip/groin, knee, and ankle injuries.

Proportion Of Injuries By Body Part Preceding A Hip Impingement Diagnosis

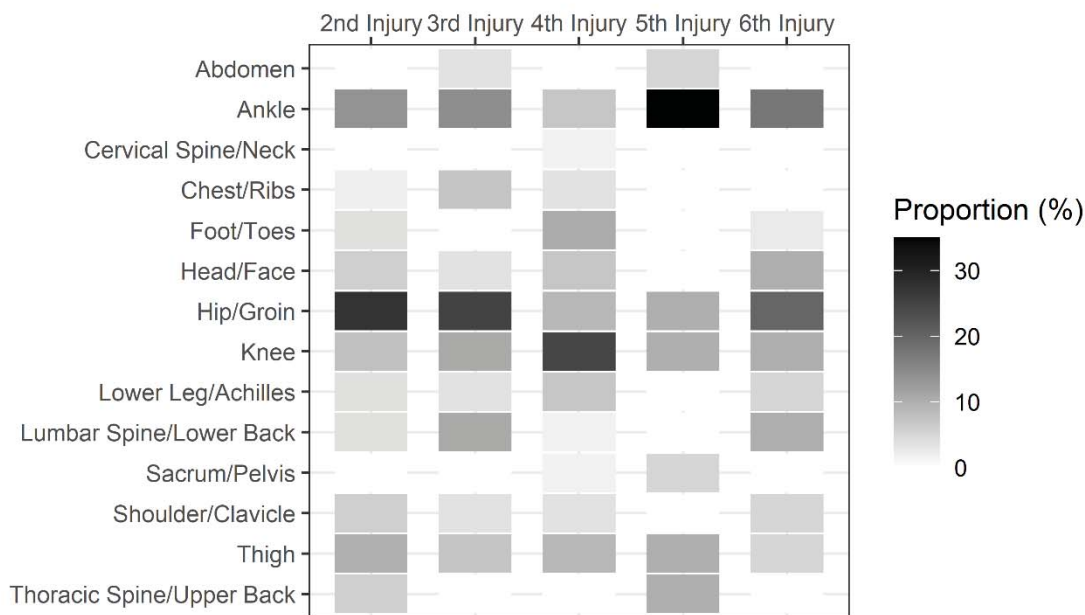


Figure 1. Prevalence of injured body parts prior to the diagnosis of a hip impingement (Hip Impg.) injury among collegiate athletes during the 2009/10-2019/20 academic years. (i.e., among athletes whose second injury was a hip impingement, the most commonly injured body part was the hip/groin.)

Attitudes Towards Injury Prevention Program Participation Differ Based on Sport

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Context: Injury Prevention Programs (IPP) are effective at reducing lower extremity injuries within athletic populations, but there is a lack of adoption and adherence. There is a potential that attitudes towards IPPs differ based on type of sports participation and implementation strategies may need to be individualized by sport. Therefore, the purpose of this study was to determine if attitudes towards IPPs differ based on sports within collegiate athletes.

Methods: The study design was cross-sectional where the participants completed scales on one occasion using pen and paper. Eleven women's basketball athletes (Age: 19.73±1.49 years, Height: 179.88±8.79cm, Mass: 77.02±11.88), thirty-seven women's lacrosse athletes (Age: 19.24±1.35years, Height: 170.55±7.24cm, Mass: 67.45±5.96 kg), and eleven women's volleyball athletes (Age: 19.67±1.41years, Height: 174.70±5.93cm, Mass: 70.86±10.78kg) volunteered to participate in this study. Participants were recruited at team meetings where surveys were distributed. Participants completed a survey packet

containing a cover letter, demographic questionnaire, and the Theory of Planned behavior Scale (TPBS). The cover letter described how participation in the study was voluntary and anonymous as well as the benefits and risks of participating in the study. Consent was implied if the participants chose to complete the scales. The demographic questionnaire assessed age, height, weight, sport, previous history of injury, and previous exposure to IPPs. The TPBS consisted of 22 items and 5 subscales (perceived benefits, perceived barriers, social norms, social influence, intention to participate) that measured attitudes towards participation in IPPs. The response options ranged along a 7-point Likert scale from strongly agree to strongly disagree. The independent variable was sport (basketball, lacrosse, volleyball) and the dependent variable was attitudes towards IPPs measured through the TPBS. Total scores and associated median and interquartile ranges were calculated for each subscale and used for analyses. A Kruskal-Wallis test was used to assess differences in attitudes between the three groups. Mann-Whitney tests were then performed to determine where those differences specifically occurred. Non-parametric effect size (ES) was calculated using z/\sqrt{n} where "z" was the z score and "n" was the number of participants.

Results: There was a statistically significant difference between groups in the TPBS barriers,

social norms, and intention subscales (Table 1). Lacrosse athletes had greater intention to participate ($P=.01$, $ES=-0.35$), perceived significantly less barriers ($P=.01$, $ES=-0.35$), and greater social norms ($P=0.002$, $ES=-0.45$) than basketball athletes. Additionally, lacrosse had greater intention to participate when compared to volleyball athletes ($P=0.04$, $ES=-0.30$). There were no additional statistically significant differences ($P>0.05$). **Conclusions:** Lacrosse players had attitudes towards IPPs that were more consistent with an increased likelihood to participate and had the most intention to participate. There is a need to improve attitudes towards IPPs within women's volleyball and basketball collegiate athletes. Future research should investigate effective interventions to improve attitudes and adherence rates.

Table 1. Differences in Attitudes Towards Injury Prevention Programs Based on Sport

Variable	Volleyball	Basketball	Lacrosse	P-Value
TPBS Benefits	11.00 (6.00)	10.00 (8.00)	13.00 (4.50)	0.38
TPBS Barriers*	2.00 (5.00)	1.00 (1.00)	-1.00 (4.00)	0.05
TPBS Social Norms*	12.00 (6.00)	8.00 (4.00)	12.00 (3.5)	0.01
TPBS Social Influence	9.00 (4.00)	9.00 (6.00)	9.00 (1.50)	0.32
TPBS Intention^*	7.00 (8.00)	7.00 (8.00)	11.00 (5.50)	0.01

TPBS=Theory of Planned Behavior Scale

^= statistically significant difference between volleyball and lacrosse

*= statistically significant difference between basketball and lacrosse

The Association of High School Sport Participation and Injury History in Collegiate Club Sport Athletes

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Context: Research has demonstrated an association between adolescent sport specialization (high school age) and sport related injuries. Some postulate that the repetitive loads and training volume in high school may affect future injury risk. This association between adolescent sport specialization and injuries has been demonstrated in some professional sports athletes. Currently, there is no data demonstrating the link between adolescent sport specialization and club collegiate athletes. The purpose of this study was to determine the association between adolescent sport specialization levels and injuries sustained during collegiate club sporting events. **Methods:** Cross-sectional study. An anonymous survey was administered to 412 club collegiate sport athletes (Female=245, 59%; age=20.1±2.0) from September 2019-May 2020. The survey included sport specialization classification via commonly used 3-point scale (Low, Moderate, High), multisport participation (single vs multisport), for each high school year (9th-12th), high school sports participation, and injuries sustained during their collegiate club

sport career. The number of years an individual was highly specialized in high school was then calculated. Individuals who participated in the same sport in high school and college were considered an athlete who was continuing their high school sport into college. An injury must have occurred during sport activity and could be classified as arising from a contact, non-contact, or overuse mechanism that required the individual to seek treatment or diagnosis from an athletic trainer or physician. Injuries were classified into overuse and acute (noncontact and contact) for the upper and lower extremity (UE and LE respectively). Chi-square analyses were used to compare years being classified as a highly specialized athlete, multisport status, and continuing high school sport into college with any, overuse, and acute injuries. **Results:** Approximately 49% of collegiate club athletes were classified as highly specialized during their high school careers. Single sport participation in high school was not associated with reported LE or UE overuse or acute club sport injuries in college ($p>0.1$). Similarly, number of years being classified as highly specialized in high school sports was not associated with club sport injuries ($p>0.1$). However, individuals who played a different collegiate club sport than their high school sports were more likely to report a LE acute injury compared to athletes who played the same collegiate and high school sport (20% vs 8%, $X^2=8.6$ $p=0.003$). **Conclusions:** Adolescent sport specialization

was not associated with reported injuries during club sporting events in club sport athletes, despite many these athletes being classified as highly specialized at some point in their high school career. Collegiate club sport athletic trainers should be aware that incoming students who are exploring a new sport may be at risk for LE acute injuries.

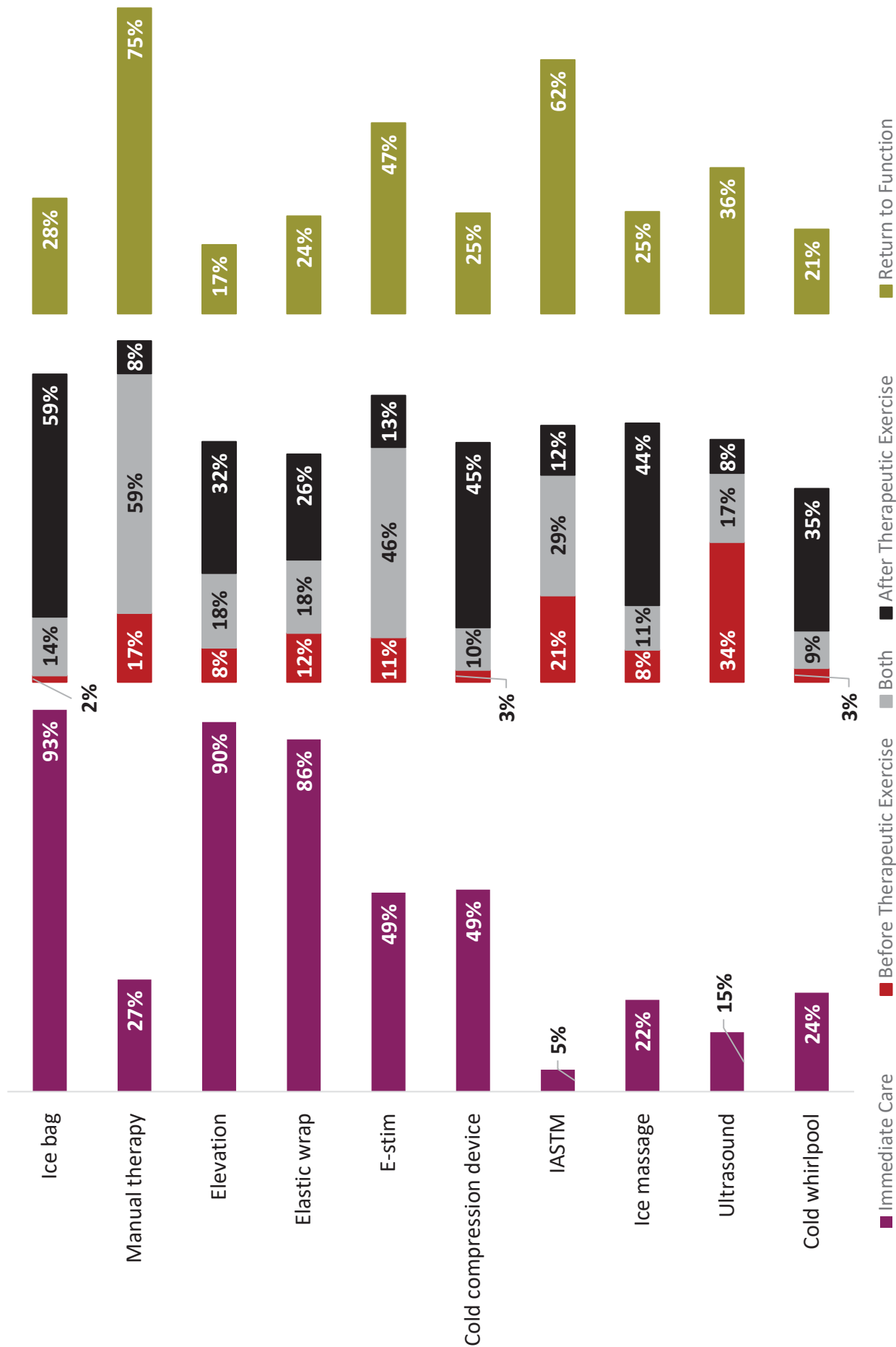
Current Practices in Acute Musculoskeletal Injury Care: A National Survey of Athletic Trainers
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Context: Caring for acute musculoskeletal injuries is an important part of the practice of athletic training (AT). A wide variety of physical agents are available to be used in the treatment of these injuries. This represents a potential source of undesirable variability in treatment protocols between practitioners, but this has not been demonstrated in the literature. This abstract expands on previously presented preliminary data. **Methods:** We used an online cross-sectional, questionnaire to ask ATs to indicate if they used specific physical agents to treat acute musculoskeletal injuries in a particular phase of recovery. They were then asked to select and rank reasons for using or not using some common physical agents. The questionnaire was reviewed by 5 external content experts over 2 rounds of reviews for face and content validity. We emailed the 32,618 ATs who indicated interest in being contacted to participate in research through the BOC and additionally recruited via snowball sampling over social media. Only BOC

certified ATs whose current practice includes acute care of musculoskeletal injuries were eligible to respond **Results:** We received 1109 valid responses from ATs in all 50 states, who had been certified between <1 and 51 years (mean = 12.4±11.1), representing all major practice settings with 45% practicing in the high school setting and 38% practicing in the collegiate setting. The percentage of ATs reporting using the ten most frequently used physical agents over the course of an injury are reported in the figure. In order of frequency The most common forms of manual therapy ATs reported to use are: instrument assisted soft tissue mobilization, massage, joint mobilization, active release therapy, cupping, muscle energy technique, proprioceptive neuromuscular facilitation, and trigger point therapy. The most frequent/highly rated rationale for using cryotherapy in all phases of care was to reduce pain. The rationale most frequently chosen/highly rated for not using cryotherapy, compression, or elevation in the acute care of musculoskeletal injuries was that there are more effective treatment options available. **Conclusions:** This study greatly expands our previous work in this area, with nearly 10 times the number of respondents. The findings have meaningful implications about current practice and are helpful in forming additional questions

we are now exploring in an additional project. We note the considerable variability in physical agent use by ATs in the treatment of acute musculoskeletal injuries. Excessive variability in care represents inefficiencies and opportunities to improve patient outcomes. We suspect that this variability also represents a lack of clarity of best practices in the scientific literature.

Percentage of Athletic Trainers Reporting Using Various Physical Agents in the Treatment of Acute Orthopedic Injuries by Phase of Recovery



History of Sport-Related Concussion Negatively Influences Knee Self-Efficacy in Individuals With a History of ACL Reconstruction

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Context: Knee self-efficacy is associated with poor self-reported knee function and decreased physical activity in patients after anterior cruciate ligament reconstruction (ACLR). Limited research has explored other contextual factors that may influence psychological responses in patients after ACLR, such as history of sport-related concussion (SRC). After sustaining a SRC, individuals may experience alterations in mental status, including increased negative emotions. However, we do not know how SRC history may influence knee self-efficacy in individuals with a history of ACLR. Therefore, the purpose of this study was to examine the effect of a history of SRC on knee self-efficacy among individuals with a history of ACLR. We hypothesized that individuals with history of ACLR and SRC would demonstrate worse knee self-efficacy when compared to individuals with history of ACLR without history of SRC. **Methods:** This study was a secondary data analysis from a previously published study. Forty participants (24 female, mean age = 24.3 ± 4.1 years; height = 169.9 ± 9.1 cm; weight = 73.2 ± 15.1

kg) ≥ 1 -year post unilateral ACLR were separated by previous history of SRC (No SRC N=29, SRC N=11). History of SRC was self-reported by the participant (Yes/No). The Knee Self-Efficacy Scale for Physical Activity (KSES-PA) is a 6-item questionnaire that assesses the patient's confidence to complete functional tasks (e.g. squatting). The Physical Activity subscale is scored on a scale of 0 to 10 with higher scores representing higher knee self-efficacy. To examine between group differences, Mann-Whitney U tests were performed as the data were not normally distributed. Hedge's g effect sizes (ES) and 95% confidence intervals (95%CI) were used to examine clinically meaningful group differences. ES were interpreted as small (0.01-0.20), medium (0.21-0.50), and large (>0.5). A priori p-value was set to $p \leq 0.05$. **Results:** Medians and IQRs for the KSES-PA were calculated. There was a statistically significant difference between groups in the KSES-PA ($p=0.03$). Individuals with a history of ACLR and SRC demonstrated worse knee self-efficacy (7.5 [5.3]) when compared to individuals with history of ACLR without SRC history (8.1 [6.1]). While a large ES was present (Hedge's g = 0.62), it must be interpreted with caution as the 95%CI did cross 0 (95%CI = (-0.08-1.34)). **Conclusions:** In this sample, post-ACLR participants that had a history of SRC had decreased knee self-efficacy compared to those without a history of SRC. Athletic Trainers should monitor knee self-efficacy deficits in the post-ACLR population and recognize the influence

of cumulative injury history on these outcomes. While SRC appears to have an additive effect to knee self-efficacy in post-ACLR participants, the influence of other injuries requires further investigation. The use of psychological interventions, such as goal setting, may improve knee self-efficacy in this population and can be easily implemented by Athletic Trainers.

Collegiate Beach Volleyball Athlete Diagnosed Concussion Turns to Three Level Cervical Disc Herniation

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Background: : Level 4 CASE report presents a 19 year-old female collegiate beach volleyball athlete with no previous history of cervical injury. In early March of 2020, athlete collided with a teammate when she dove for the ball while playing beach volleyball at an away game. Athlete sought out medical attention after incident at a sports medicine institute in her hometown and was diagnosed with a concussion and told to rest. Symptoms continued and the athlete sought medical attention again two-months following initial injury and was diagnosed with cervicgia or “whiplash”. She was given naproxen and a home exercise plan. Due to continued symptoms, athlete sought out and completed 30 physical therapy visits but continued to have pain. During physical therapy, athlete completed therapeutic exercises, neuromuscular rehabilitation, manual therapy, and patient education. Athlete was cleared to return to sport. Upon returning back to the university, athlete was evaluated by the athletic trainer. Due to her continued symptoms, she was referred to the team chiropractor for further evaluation. **Differential Diagnosis:** Concussion, cervicgia or “whiplash”, or disc pathology. **Intervention & Treatment:** Physician evaluation noted acute pain in posterior neck and shoulders bilaterally and painful AROM and PROM of cervical spine. Athlete presented decreased cervical spine muscle flexibility, joint mobility of cervical spine, and bilateral rotator cuff strength. MRI scans of the cervical region were ordered. MRI scans

revealed (1) C3-C4 right paracentral herniated nucleus pulposus (2.5 mm) with caudal subligamentous extension (3 mm) and associated annular fissure effacing the thecal sac, (2) C6-7 right paracentral herniated nucleus pulposus (2 mm) with cephalad subligamentous extension (1.5 mm) and associated annular fissure, effacing the thecal sac, (3) mild straightening/reversal of the normal cervical lordosis, (4) neural foraminal stenosis due to diffuse bulge of the annulus fibrosis, right, C3-4, (5) C5-6 diffuse bulge of the annulus fibrosis with a central and right paracentral annular fissure. Athlete now receives chiropractic treatments once a week including spinal decompression traction used to open cervical vertebral segments. Therapeutic exercises, neuromuscular rehabilitation, and modalities to decrease pain are performed during daily rehabilitation with athletic trainer. Athlete is prohibited from overhead lifting, hitting and live play activities. She continues to have migraine headaches. **Uniqueness:** While three level cervical disc herniations are not uncommon, this athlete’s case was. Most herniations in the cervical region occur from an impact or stress to the region. The athlete’s mechanism of injury was an impact with another athlete. Disc herniation are common cause of neck and back pain in athletes due to constant pressure placed on the spine and concurrent microtraumas that are unable to heal. A MRI should have been ordered in the first place to rule out any other injury. When the chiropractor assessed the MRI with the athlete and presented the damage, she had no idea how severe her neck pain was. MRI stated C3-C7 right paracentral herniated nucleus pulposus. C3-C4 and C5-C7 are effacing the thecal sac, which is causing muscle guarding. Chiropractor’s treatment was to relax the muscles around the disc’s to allow for the spinal realignment. Manipulative therapy is an alternative treatment

instead of surgery. **Conclusions:** This case highlighted the diagnosis and treatment of an athlete suffering from three level cervical disc herniations. This case further highlighted how a diagnosis can be misinterpreted without further evaluation. As the athlete’s treatment, care, and rehabilitation continue we will discover if the athlete will experience progression with this current treatment.

Returning to the Higher Education Classroom Following Concussion

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Context: Athletic trainers working in the collegiate setting state that the Return To Learn (RTL) process is a challenge for concussed student-athletes due to a lack of communication between stakeholders, patients feeling anxious over needing accommodations, and difficulty receiving reasonable accommodations for patients. Multiple stakeholders exist in the collegiate setting, which can complicate communication and streamlined care during the RTL process. Our purpose was to determine perceptions of academic support professionals regarding the RTL process for concussed National Collegiate Athletic Association (NCAA) student-athletes. **Methods:** We recruited 22 staff members at higher education institutions who manage student accommodations (age=47±13 years, experience=10±9 years) to participate in a qualitative research study by completing an online questionnaire composed of demographics and open-ended questions related to academic support professionals' perceptions and knowledge of the RTL process. Data saturation drove recruitment and was met. The online questionnaire was based on the current RTL literature and the content was validated via expert

and peer review. We analyzed the data using a general inductive approach in order to develop themes from the experiences and views of our participants. Peer review of the coding structure and presentation of the results and multiple analyst triangulation served as trustworthiness strategies. **Results:** We identified 5 themes that defined academic support professionals' perceptions of RTL following concussion in collegiate student-athletes. Policy is purposefully vague because concussion is an individualized injury requiring an individualized plan of care. Collaboration both facilitates and hinders RTL. Multiple stakeholders, including physicians, academic support professionals, faculty, coaches, athletic directors, and especially athletic trainers (ATs) need to effectively communicate to execute appropriate accommodations. Participants noted ATs are key components to appropriate care and explained it is difficult to keep everyone abreast while also protecting patient confidentiality. Some stakeholders who are not healthcare professionals are provided medical information that is protected and unnecessary to execute accommodations. Professional development on concussion for stakeholders is needed, as many fail to understand the need for accommodations. Finally, NCAA guidelines are not well communicated outside of the athletic department as most of our participants did not know if a policy existed for RTL. **Conclusions:** Policy regarding RTL should be clear but flexible to provide individualized plans for care and recovery. Despite participants' reported difficulties with interprofessional communication among stakeholders, ATs are recognized as key healthcare professionals in the RTL process and

communication between academic support staff and ATs is critical. Professional development regarding RTL and concussion management should be provided to all stakeholders and include information about role expectations, interprofessional collaboration, the Health Insurance Portability and Accountability Act, and policy from the NCAA Sports Medicine Handbook.

The Influence of Timing of Reporting and Clinic Presentation on Concussion Recovery Outcomes: A Systematic Review and Meta-Analysis

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Context: Determining the influence of modifiable factors on recovery following concussion is important in providing post-injury education and anticipatory guidance to patients. One modifiable risk factor is the timing of concussion reporting and presentation to a medical provider. Thus, the purpose of this systematic review was to assess clinical outcomes and recovery time among athletes who immediately report concussion symptoms or present earlier to medical care compared to those with delayed reporting or care-seeking behaviors. Specifically, we aimed to address the following clinical questions (CQ): 1) Among patients who sustained a concussion, does immediate reporting of the concussion result in a faster recovery compared to patients who delayed reporting their concussion? and 2) Do patients who present later to concussion specialty care have a longer recovery compared to patients who present earlier following their concussion? **Methods:** This systematic review was completed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Searches of PubMed, Ovid Medline, SPORTDiscus, and Cochrane Central Register of Controlled

Trials were conducted. The search terms used were Sport AND Concussion AND Recovery, Concussion AND Delayed AND Report, Continued play AND Concussion. Studies included an investigation of immediate versus delayed reporting or early versus late presentation following a concussion, were published in the past ten years, English language, and were level 4 evidence or higher. The quality of a study was assessed using the Newcastle-Ottawa Scale for cohort studies. Studies for both clinical questions were analyzed using a narrative, qualitative synthesis. Random-effects meta-analysis models were used for recovery time and symptoms, and standardized mean differences are reported, with 95% confidence intervals. Heterogeneity was assessed using an I² statistic, the percentage of variability attributable to study heterogeneity. An alpha of 0.05 was used as the criterion for statistical significance. **Results:** Twelve studies were included. Patients who continued play or delayed reporting their concussion had significantly longer recovery times [standardized mean difference= 0.36 days (95% CI: 0.662, 0.066)] than those who immediately reported or were removed from play (p=0.017). Expressed in raw scores, those who immediately reported recovered 5.4 days (95% CI: -10.14, -0.75) faster than delayed reporters. Comparable results were found for post-concussion symptom scores (p=0.034) with immediate reporters demonstrating lower symptom severity scores. Our qualitative synthesis found patients who presented earlier to a concussion specialist tended to recover faster than those who presented later. Quality of studies was

fair-good for selection and outcome and poor for comparability. **Conclusions:** Patients who delayed reporting or continued play had longer recovery times compared to their immediately-reporting peers. Providers should ask patients approximately how long they continued to play or waited to report their injury and also focus educational efforts on encouraging immediate reporting of concussion.

Undergraduate Students' Experience Returning to Academics After Concussion

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Context: Current literature supporting the concussion return-to-learn (RTL) progression lacks empirical support and is thus anecdotal and consensus driven. Previous work has focused on primary and secondary education student populations with recommendations for a multidisciplinary team approach coordinated administratively through a central office. Oftentimes, college students must navigate their own recovery and advocate for their academic needs autonomously due to the limited interactions between medical and academic staff. Therefore, the purpose of this study was to unveil novel themes regarding student perceptions of their RTL experiences after sustaining a concussion in the university setting which have yet to be considered in current RTL literature. **Methods:** Fifteen non-varsity sport participants (10 females, 5 males; mean age = 21.00 ± 1.00 years; mean time since concussion = 1.33 ± 0.82 years) representing 14 different academic majors were enrolled in this study. All participants were either current undergraduate students ($n=11$) or recent graduates ($n=4$) of a university in southeastern Michigan, had sustained a concussion within the last three years while enrolled at the university, and spoke English fluently. Following consent, participants completed a 10-question semi-structured interview lasting approximately

40 minutes over BlueJeans video-conferencing software (San Jose, CA, USA), which was voice recorded and transcribed (Otter.ai. Los Altos, CA, USA). Participants described their general concussion experiences, symptom duration, and their progression back to extracurricular, physical, and academic activities. Additional queries included their interactions with medical staff and instructional faculty, specific academic modifications, and suggestions for future university-wide administrative policies for other students recovering from concussions. The research team reviewed each transcription and verified accuracy via voice recordings. A codebook was developed by the principal investigator to identify developing themes across the interviews. **Results:** Study participants identified three primary emergent topics: pressure to self-advocate in large classroom settings, limited knowledge of academic resources available on campus for students recovering from concussion, and persistent symptoms beyond the timeline allotted for their accommodations. Students highlighted the additional stress and anxiety as they experienced as they attempted to return to their pre-injury academic performance at a highly competitive university. Most students reported significant difficulty while managing technological demands of their coursework regardless of major. Specific instances include communicating with professors via email or attempting to complete online assignments, which is particularly relevant today with the transition to online learning due to the SARS-CoV-2 pandemic. **Conclusions:** This study indicates collegiate students recovering from concussion may feel increased pressure to perform at high

academic standards, as well as difficulty working with coursework-specific technology. These themes suggest a need for a graduated RTL progression rather than implementation of specific academic modifications. Further research is critical to developing a robust, data-driven RTL policy that will improve communication among medical personnel, university students, and academic staff.

Association Between Symptom Clusters at Initiation of a Return to Activity Protocol and Time to Return to Unrestricted Activity After Concussion in United States Service Academy Cadets

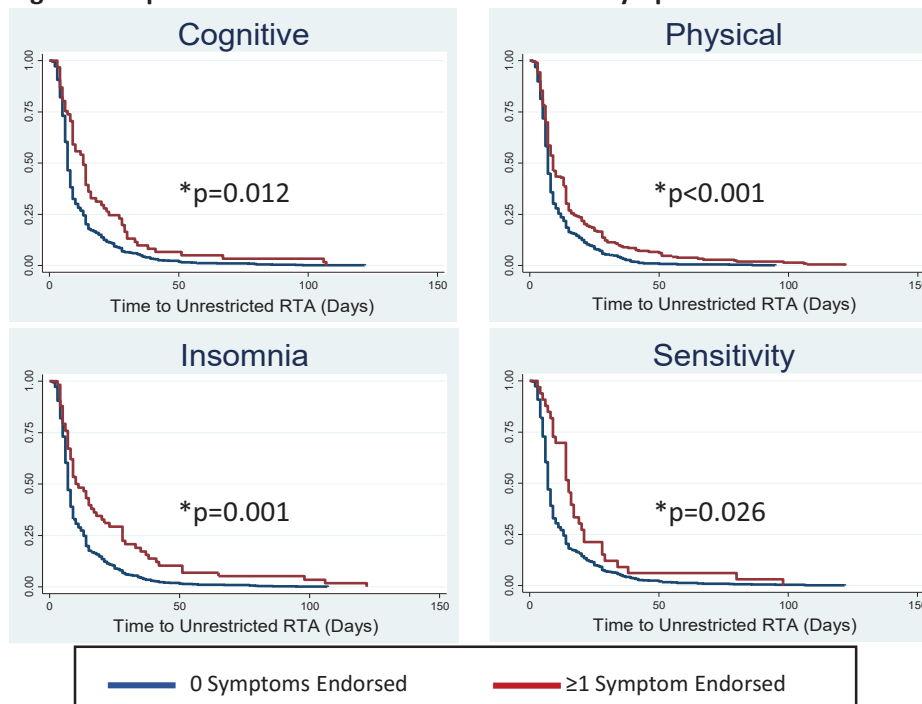
Aderman MJ, Brett BL, Ross JD, Malvasi SR, McGinty G, Jackson J, Estevez C, Brodeur R, Svoboda SJ, McCrear M, Broglio SP, McAllister T, Pasquina PF, Cameron KL, Houston MN: Keller Army Hospital, West Point, NY; Medical College of Wisconsin, Milwaukee, WI; United States Air Force Academy, Colorado Springs, CO; United States Coast Guard Academy, New London, CT; University of Michigan, Ann Arbor, MI; Indiana University School of Medicine, Indianapolis, IN; Walter Reed National Military Medical Center, Bethesda, MD

Context: Self-reported symptom checklists are used to aid in concussion evaluation and management. While higher symptom endorsement at the initiation of a graduated return-to-activity protocol (GRTA) has been associated with prolonged GRTA protocol duration, it is unclear how specific symptom clusters influence recovery duration. The purpose of this study was to describe symptom cluster endorsement at the initiation of a GRTA protocol and to examine the association between symptom cluster

endorsement at the initiation of a GRTA protocol and return-to-activity time in cadets recovering from a concussion. **Methods:** A prospective cohort study was conducted among cadets enrolled in the Concussion Assessment, Research and Education (CARE) Consortium at three U.S. Service Academies. Participants completed the Sport Concussion Assessment Tool Symptom Evaluation post-concussion upon initiation of a GRTA protocol. The symptoms endorsed were grouped into six previously identified clusters (cognitive, emotional, insomnia, physical, sensitivity, ungrouped). Participants were classified as endorsing or not endorsing each symptom cluster, regardless of symptom severity. The primary outcome of interest was time from initiation of a GRTA protocol to unrestricted return-to-activity. Frequencies were calculated to describe symptom cluster endorsement. Kaplan-Meier survival estimates were calculated for all six symptom clusters (endorsed vs not endorsed) to estimate time to return-to-activity. Univariate and multivariable Cox proportional hazards regression models were used to estimate the association between each symptom cluster and time to return-to-activity ($\alpha < 0.05$). Site, sex, varsity status, and concussion history were accounted for in the multivariable models. Hazard ratios (HR) and 95% confidence intervals (95%CI) were calculated. **Results:** During the study period, 821 cadets (36% Female; 19.1 ± 1.4 y) sustained a concussion and completed the GRTA visit. Upon initiation of the GRTA protocol, 546 cadets (35% Female) were asymptomatic, endorsing

zero symptoms. In the symptomatic group (37% female), physical symptoms (83.0%) were the most commonly observed cluster followed by the cognitive (26.9%), insomnia (25.1%), ungrouped (16.0%), sensitivity (13.5%), and emotional (8.7%) clusters. Significant Kaplan-Meier survival estimates for time to return-to-activity by group are presented by symptom cluster in Figure 1. Univariate results revealed a significant association between endorsing cognitive (HR=0.63, 95%CI=0.48-0.82), physical (HR=0.68, 95%CI=0.58-0.80), insomnia (HR=0.57, 95%CI=0.43-0.75) and sensitivity (HR=0.59, 95%CI=0.41-0.83) symptom clusters and return-to-activity time. The emotional (HR=0.73, 95% CI=0.47-1.14, $p=0.168$) and ungrouped (HR=0.75, 95%CI=0.54-1.03, $p=0.075$) symptom clusters were not significantly associated with return-to-activity time. In the multivariable models endorsing cognitive (HR=0.66, 95%CI=0.48-0.91, $p=0.012$), physical (HR=0.72, 95%CI=0.60-0.86, $p<0.001$), insomnia (HR=0.56, 95%CI=0.40-0.78, $p=0.001$), and sensitivity (HR=0.62, 95%CI=0.40-0.94, $p=0.026$) clusters maintained a significant association with return-to-activity time. **Conclusions:** Participants endorsing cognitive, physical, insomnia, or sensitivity symptom clusters at the initiation of GRTA protocol took 28-44% longer to return-to-activity after controlling for site, sex, varsity status, and concussion history. Endorsing emotional or ungrouped symptom clusters was not associated with return-to-activity time.

Figure 1. Kaplan-Meier Survival Estimates for SCAT Symptom Clusters



Concussion Incidence in NCAA Sports: 2014/15-2018/19

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Context: Sport-related concussions (SRCs) continue to be a major concern among athletes of all ages. Athletic Trainers (ATs) frequently manage concussions as part of clinical practice in the collegiate setting. While previous epidemiological studies have been helpful in identifying the concussion burden among National Collegiate Athletic Association (NCAA) athletes, routine examinations of concussion incidence in this population are needed to identify emerging patterns, appraise concussion prevention and management policies. We hypothesize that concussion incidence will be highest in collision sports,

and in women's sports compared to men's sports (in sex-comparable sports). **Methods:** Injury and exposure data captured within the NCAA Injury Surveillance Program (ISP) during the 2014/15-2018/19 academic years were examined. ATs at participating institutions contributed data via their Electronic Medical Record (EMR) systems. Concussion rates (stratified by sport and event type) per 10,000 athlete-exposures (AEs) were estimated, and concussion patterns were examined by injury mechanism (player contact, surface contact, apparatus contact, other) and history (new, recurrent). Differential injury rates across event types (competitions, practices) and sex (male, female for sex-comparable sports) were assessed using Injury Rate Ratios (IRRs); IRRs with 95% Confidence Intervals (CIs) excluding 1.00 were deemed significant. **Results:** A total of 3,497 concussions were reported from 8,462,964 AEs during the study period (Rate=4.13 per 10,000 AEs). Among men's sports, overall concussion rates were highest in ice hockey (7.35 per 10,000 AEs), football (6.99), and wrestling (6.44; Table 1). Among women's sports, highest overall concussion rates were observed in soccer (7.15 per 10,000 AEs), ice hockey (6.98), and gymnastics (6.68). Most concussions in men's sports were attributed to player contact (77.0%), whereas a comparable

proportion of concussions in women's sports were attributed to player (37.3%) and apparatus (ball, bat, stick, etc.) contact (39.0%). A similar proportion of men's (6.3%) and women's (5.5%) concussions were recurrent injuries. Competition concussion rates were higher than practice rates in both men's (IRR=4.56; 95% CI=4.20, 4.95) and women's (IRR=4.31; 95% CI=3.85, 4.82) sports. Among sex-comparable sports, concussion rates were higher in women's basketball (IRR=1.57; 95% CI=1.28, 1.92), and soccer (IRR=1.61; 95% CI=1.33, 1.96) as compared with the respective men's sports. **Conclusions:** Highest concussion rates were observed in men's ice hockey and women's soccer. Concussion rates in men's football and wrestling, as well in women's ice hockey and gymnastics were also notably high. The proportion of concussions attributable to apparatus contact in women's sports warrants further attention and potential intervention. Relative to men's basketball and soccer, factors contributing to higher concussion incidence in women's basketball and soccer need further examination, and tailored injury prevention may be warranted to ease the concussion burden in these sports. Incidence estimates and concussion distributions presented here may be used to inform point-of-care concussion assessments in AT clinical practice.

Table 1. Concussion Counts and Rates in Men's and Women's NCAA Sports: 2014/15-2018/19

	Overall count; Rate per 10,000 AEs (95% CI)	Competition count; Rate per 10,000 AEs (95% CI)	Practice count; Rate per 10,000 AEs (95% CI)
Men's sports			
Football	1301; 6.99 (6.61, 7.37)	594; 28.54 (26.24, 30.83)	707; 4.28 (3.96, 4.60)
Wrestling	123; 6.44 (5.31, 7.58)	49; 2.25 (16.02, 28.48)	74; 4.38 (3.38, 5.38)
Baseball	54; 0.95 (0.70, 1.20)	40; 1.55 (1.07, 2.03)	14; 0.45 (0.21, 0.69)
Basketball	160; 3.35 (2.83, 3.86)	59; 5.28 (3.93, 6.62)	101; 2.76 (2.22, 3.29)
Cross Country	2; 0.22 (0.00, 0.53)	1; 1.42 (0.00, 4.20)	1; 0.12 (0.00, 0.35)
Ice Hockey	320; 7.35 (6.55, 8.16)	263; 23.36 (20.54, 26.18)	57; 1.77 (1.31, 2.23)
Lacrosse	149; 3.90 (3.28, 4.53)	68; 10.28 (7.84, 12.72)	81; 2.57 (2.01, 3.12)
Soccer	147; 4.43 (3.72, 5.15)	98; 12.18 (9.77, 14.59)	49; 1.95 (1.40, 2.50)
Swim & Dive	8; 0.37 (0.11, 0.62)	2; 0.88 (0.00, 2.09)	6; 0.31 (0.06, 0.55)
Tennis	7; 1.23 (0.32, 2.14)	4; 3.01 (0.06, 5.95)	3; 0.69 (0.00, 1.47)
Track & Field	15; 0.33 (0.16, 0.50)	8; 1.19 (0.36, 2.01)	7; 0.18 (0.05, 0.31)
Total	2286; 4.51 (4.33, 4.70)	1186; 12.24 (11.54, 12.93)	1100; 2.68 (2.53, 2.84)
Women's sports			
Field Hockey	67; 5.38 (4.09, 6.66)	36; 12.50 (8.42, 16.59)	31; 3.23 (2.10, 4.37)
Gymnastics	49; 6.68 (4.81, 8.55)	9; 12.65 (4.39, 20.92)	40; 6.04 (4.17, 7.91)
Softball	103; 2.67 (2.15, 3.18)	57; 3.51 (2.60, 4.42)	46; 2.06 (1.46, 2.65)
Basketball	223; 5.25 (4.56, 5.94)	101; 9.67 (7.79, 11.56)	122; 3.81 (3.13, 4.48)
Cross Country	0; 0.00 (0.00, 0.00)	0; 0.00 (0.00, 0.00)	0; 0.00 (0.00, 0.00)
Ice Hockey	109; 6.98 (5.67, 8.29)	72; 16.18 (12.45, 19.92)	37; 3.31 (2.25, 4.38)
Lacrosse	103; 3.58 (2.89, 4.27)	51; 9.29 (6.74, 11.84)	52; 2.23 (1.63, 2.84)
Soccer	325; 7.15 (6.38, 7.93)	208; 18.53 (16.01, 21.05)	117; 3.42 (2.80, 4.04)
Swim & Dive	42; 1.25 (0.87, 1.62)	5; 1.67 (0.21, 3.14)	37; 1.21 (0.82, 1.59)
Tennis	7; 0.96 (0.25, 1.68)	5; 2.83 (0.35, 5.31)	2; 0.36 (0.00, 0.87)
Track & Field	11; 0.18 (0.07, 0.28)	2; 0.25 (0.00, 0.60)	9; 0.17 (0.06, 0.27)
Volleyball	172; 4.93 (4.19, 5.67)	65; 6.05 (4.58, 7.52)	107; 4.43 (3.59, 5.27)
Total	1211; 3.57 (3.37, 3.77)	611; 8.06 (7.42, 8.70)	600; 2.27 (2.09, 2.46)

Returning After Concussion in Collegiate Student-Athletes: The Academic Experience

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Context: Collegiate student-athletes recovering from a concussion have both academic and athletic responsibilities. However, the academic return is understudied, especially in the collegiate setting. Therefore, the purpose was to describe collegiate athletes' academic return from concussion, compare recovery time outcomes between student-athletes receiving academic accommodations (yes/no), and compare the use of academic accommodations between socio-demographic variables. **Methods:** Ivy League and Big Ten student-athletes who sustained a diagnosed concussion ($n = 3,142$) from 2013-2020 were identified, consented, and enrolled by athletic trainers into the Ivy League-BIG Epidemiology of Concussion prospective cohort study. Athletic trainers monitored athletes' recovery outcomes (symptom resolution, return-to-full academics); time was calculated as days between SRC and the recovery outcome. Demographic information, characteristics of the concussion, and recovery outcome dates were entered into the online database. Athletic trainers recorded (yes/no) if student-athletes received academic accommodations going back to full academics. Frequencies and percentages presented categorical variables. Kaplan-Meier survival curves assessed the time, in days, to symptom resolution and return-to-academics, truncated at 100 days. Peto tests analyzed equivalence of the median (interquartile range[IQR]) days for each outcome stratified by

academic accommodations (yes/no). Logistic regression models estimated odd ratios (OR) and 95% confidence intervals (CI) of receiving academic accommodations between sex, class year, and previous concussion history. Chi-square tests compared the use of academic accommodations by school within conferences and by male and female sports; statistical significance was set at $p \leq 0.05$. **Results:** Sixty-eight percent ($n=2,143/3,142$; female: 45.1%, $n=966$, male: 54.9%, $n=1,177$) of all concussion cases had complete data recorded for academic accommodations. Half ($n=1,067/2,143$) of student-athletes with a concussion received academic accommodations while returning back to academics (female: 55.0%, $n=531/966$; male: 45.5%; $536/1,177$; previous concussion history: 52.6%, $n=529/1,005$). The median time to symptom resolution was 8 [IQR:4-15] days, and return-to-academics was 7 [IQR:3-15] days. Student-athletes with academic accommodations had a median of 6 days longer symptom resolution time ($p < .001$), and took 5 days longer to return to academics than those without ($p < .001$). The odds of receiving academic accommodations was lower for males vs. females (OR: 0.68, 95%CI:0.58-0.82, $p \leq .001$) and greater for previous concussion history vs. without (OR: 1.26, 95%CI:1.06-1.50, $p \leq .01$). There were proportional differences between-school student-athletes receiving academic accommodations within Ivy League schools ($X^2(7)=28.32$, $p \leq .001$) and BIG schools ($X^2(6)=158.23$, $p \leq .001$). There were proportional differences between student-athletes receiving academic accommodations within female sports ($X^2(23)=36.7$, $p=.04$), but not male sports ($X^2(25)=30.61$, $p=.20$). **Conclusions:** Half of student-athletes received academic accommodations while returning to

academics following concussion, however the proportions varied by school and female sports. Additionally, student-athletes with academic accommodations displayed longer recovery outcomes than those without. Athletic trainers should consider academic difficulties throughout concussion recovery, and concussion management teams should incorporate return-to-academics into concussion management protocols in the college setting.

Altered Postural Control in Dysfunctional Breathers With a History of Lateral Ankle Sprain

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Context: Altered diaphragm contractility has been linked to lateral ankle sprain, potentially leading to dysfunctional breathing mechanics. The diaphragm contributes significantly to postural stability through controlling intra-abdominal pressure. Our previous work demonstrates associations between diaphragm function and postural control in individuals with lateral ankle sprain. An influence of dysfunctional breathing mechanics on postural control in youth athletes with a previous history of lateral ankle sprain is currently unknown. A screen of breathing mechanics following lateral ankle sprain may provide important insight into the source of aberrant postural control patterns in youth athletes with lateral ankle sprain. The purpose of this study was to compare postural control between youth athletes, who have a history of lateral ankle sprain, with and without dysfunctional breathing mechanics. **Methods:** Using a cross-sectional design, 57 youth athletes (M:42, F:15; Age=16.64±0.62yrs; Height=168.40±8.06cm; Mass=64.85±10.09kg) with a previous history of lateral ankle sprain underwent a breathing patterns screening and a postural control

assessment. Breathing patterns was assessed using the Hi-Lo breathing test in the standing position. The Hi-Lo test was scored based on the presence or absence of abdominal excursion, lateral rib cage expansion, superior rib cage migration, and shoulder elevation. The Hi-Lo test scores were utilized to categorize breathing patterns as dysfunctional breathers or diaphragmatic breathers. Postural control was assessed with the SEBT in the anterior (SEBT-A), posteromedial (SEBT-PM), and posterolateral (SEBT-PL) reaching directions. Three trials of each SEBT direction were averaged and normalized as a percentage of stance leg length (%). Mann-Whitney tests were employed to compare the SEBT scores between the dysfunctional breathing and diaphragmatic breathing groups. Significance was set at $P<0.05$. **Results:** Forty-one athletes with a history of lateral ankle sprain were classified as dysfunctional breathers (Age=16.56±0.62yrs, Height=168.10±8.01cm; Mass=65.61±11.01kg). The diaphragmatic breathing group included 16 athletes with a history of lateral ankle sprain (Age=16.81±0.63yrs, Height=169.03±7.11cm; Mass=63.48±7.85kg). The dysfunctional breathing group had significantly lower SEBT-PM and SEBT-PL scores compared to the diaphragmatic breathing group (SEBT-PM: dysfunctional=82.91±8.07%, diaphragmatic=91.31±11.19%, $P=0.012$, SEBT-PL: dysfunctional=88.77±9.21%, diaphragmatic=93.38±15.39%, $P=0.039$). There were no differences in SEBT-A between the dysfunctional (67.59±6.04%) and diaphragmatic

(69.85±5.02%) groups ($P=0.189$). **Conclusions:** Dysfunctional breathers with a previous history of lateral ankle sprain had a significantly lower dynamic postural control level compared to diaphragmatic breathers with a history of lateral ankle sprain. Data from the current study indicate that screening breathing patterns may be an important step towards the development of effective intervention strategies to restore proper postural control in youth athlete with lateral ankle sprain. Future intervention research should address altered breathing mechanics in youth athletes with lateral ankle sprain.

Clinical Evaluation Findings in Patients Diagnosed With Deltoid Ligament Ankle Sprains: A Report From the Athletic Training Practice-Based Research Network

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Context: The deltoid ligament resists eversion and rotary forces through multiple superficial and deep ligaments that support the medial ankle. Since isolated deltoid ligament injuries are uncommon, details about their clinical presentation is limited. The purpose was to describe the clinical presentation and initial management of patients diagnosed with deltoid ligament ankle sprains by athletic trainers (ATs). **Methods:** This is a retrospective analysis of de-identified electronic medical records. Evaluation forms with a recorded deltoid sprain (ICD-10 diagnostic code: S93.429A) between October 2009-April 2020 were analyzed. Patient records were created by 133 ATs (female=69, years certified=6.4±7.3, years employed at site=2.9±5.0) practicing in 52 athletic training clinics (high school=40, college=11, other=1) across 19 states during the study period. Summary statistics (frequencies, percentages, 95% CI) were calculated to describe clinical findings (sex, age, sport, mechanism of injury [MOI], severity, effusion, edema, pain, ROM, special tests) and initial plan (participation status, care). **Results:** ATs diagnosed 105 deltoid sprains (n=11

missing data) within 3.2±4.1 days (95% CI=4.4-5.2) of injury, with most sustained in males (n=62/105, 59.0%) and athletes aged 16.4±4.3 (95% CI=15.6-17.3) years. Common sports played by patients with deltoid sprains were football (n=29/94, 30.9%), basketball (n=28/94, 29.8%), and soccer (n=15/94, 16%). The most common MOIs were twisting (n=35/94, 37.2%) and contact (n=28/94, 29.8%), and most occurred during in-season games (n=44/105, 46.8%) and practices (n=31/94, 33.0%). Most deltoid sprains were classified as mild (1st degree) severity (n=59/94, 62.7%) with mild or no edema and effusion (n=85/96, 85.5%; n=90/96, 93.4%, respectively). Patients reported pain as 4.8±1.1 (95 CI=4.4-5.2) on a 10-point scale and described their pain as sharp (n=54/94, 57.4%) and achy (n=21/94, 22.3%). Active and passive ROM was normal (n=49/96, 51.0%; n=54/96, 56.3%, respectively) or with mild limitation (n=29/96, 30.2%; n=18/96, 18.8%, respectively). On average, ATs recorded 3.6±1.7 (range: 1-7) special tests for deltoid sprains, with anterior drawer (n=74/105, 70.5%; positive=19, negative=51, inconclusive=4), talar tilt-eversion (n=74/105, 70.5%; positive=54, negative=18, inconclusive=2), talar tilt-inversion (n=57/105, 54.3%; positive=23, negative=33, inconclusive=1), squeeze (n=46/105, 43.8%, positive=3, negative=39, inconclusive=4), and bump (n=45/105, 42.9%; positive=3, negative=40, inconclusive=2) tests documented most frequently. Most athletes were removed from participation (n=48/94, 51.1%) while a proportion were able to participate without restrictions (n=22/94,

23.4%). The initial management by ATs was to deliver treatment (n=22/40, 55.0%) or refer to a physician (n=16/40, 40.0%). **Conclusions:** Deltoid sprains occurred most often in males, during football and basketball, due to a twisting MOI, resulted in moderate pain levels, and minimal effusion, edema, and ROM loss. ATs used varied special tests, with the talar tilt producing the highest number of positive results. The infrequent occurrence of deltoid sprains and difficulty to rule in/out the condition using special tests indicates a thorough clinical evaluation is needed to make diagnosis and management decisions.

Talar Cartilage Deformation and Spatiotemporal Gait Patterns in Individuals With and Without Chronic Ankle Instability

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Context: Research has demonstrated decreased proteoglycan density and a loss in collagen fiber organization in individuals with CAI; two biomarkers of early post-traumatic osteoarthritis. Alterations in compositional structure can reduce the ability of cartilage to absorb forces, causing increased cartilage deformation during physical activity. Therefore, the altered biomechanics associated with CAI may influence the amount of cartilage deformation that occurs while walking. Thus, we aimed to compare cartilage deformation of the talus between those with and without CAI. Secondly, we examined the association between spatiotemporal gait patterns and cartilage deformation.

Methods: Forty-eight college-aged adults volunteered to participate in this case-control laboratory study. Previously established inclusion criteria by the International Ankle Consortium was followed to identify participants with self-reported CAI ($n=24$; age= 23.3 ± 3.9 years; height= 166.5 ± 10.1 cm; mass= 69.5 ± 11.9 kg) and un-injured controls ($n=24$; age= 24.3 ± 2.9 years; height= 167.5 ± 6.9 cm; mass= 64.4 ± 9.7 kg). After sitting for 30 minutes, talar cartilage was

assessed with participants seated with 90° of hip and knee flexion. An 8-to-13 MHz linear-array ultrasound transducer placed transversely in line with the medial and lateral malleoli of the ankle captured three images of talar cartilage before and after a standardized exercise protocol consisting of 30 single and double-limb squats, 2-minute single-limb balance and 10 single-leg drops from a 40cm height box. Talar cartilage area was manually outlined using imaging software. Deformation was calculated as the difference between the average post- and pre-exercise area, divided by the pre-exercise area, multiplied by 100. Spatiotemporal gait was assessed from five self-selected trials using an instrumented walkway with data sampled at 120 Hz. Spatiotemporal variables (speed, cadence, stride length, stance, single-limb support and double-limb support) of the involved limb were extracted. Gait speed and cadence were normalized using non-dimensional procedures to minimize the effect of body size by dividing each variable by $\sqrt{9.81\text{m/s}^2} / \text{height}$. Stride length was normalized to each participants height (%Height). Temporal variables were normalized to the percent of gait cycle (%GC). Separate Independent T-tests assessed between-group differences for all primary outcomes. Separate Pearson Product moment correlations examined the relationship between cartilage deformation and spatiotemporal gait variables. Statistical significance was set a priori $p < 0.05$. **Results:** Participants with CAI had greater talar cartilage deformation ($-17.31 \pm 6.7\%$) compared to un-injured controls ($-12.6 \pm 7.5\%$; $P=0.034$). No group differences were identified for any spatiotemporal gait

measure ($P=0.745$ to $P=0.993$). Non-significant weak partial correlations were observed between talar cartilage deformation and all spatiotemporal gait parameters ($P=0.115$ to $P=0.662$).

Conclusions: The increased cartilage deformation after a standardized exercise protocol observed in the CAI group may be attributed to compromised structural integrity of the articular cartilage previously shown and may contribute to the increased risk of post-traumatic osteoarthritis. Furthermore, spatiotemporal gait patterns do not appear to influence the amount of cartilage deformation in response to standard loading protocol.

Predicting Recovery From Midportion Achilles Tendinopathy: More Than Just Symptomatology

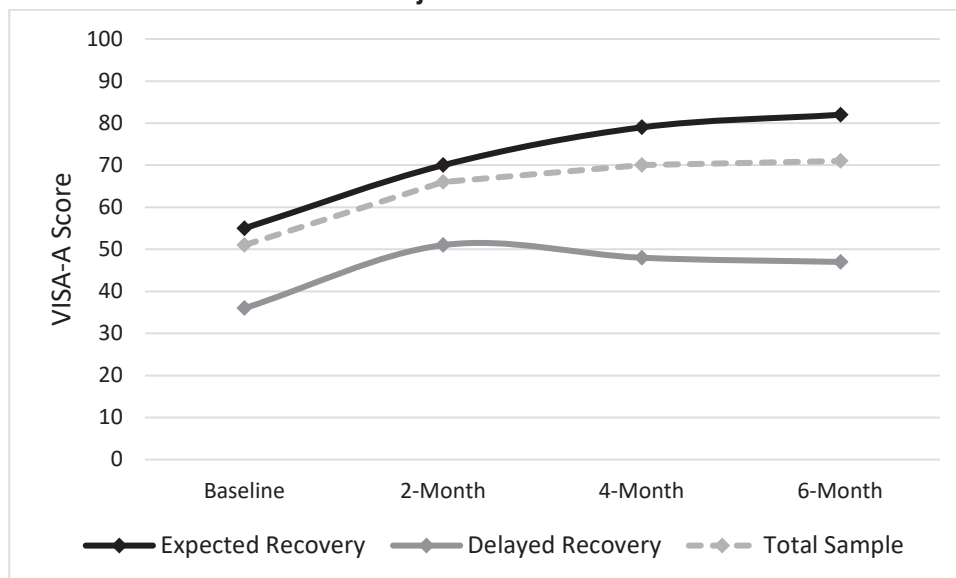
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Context: Achilles tendinopathy affects a wide variety of athletes and non-athletes with an incidence rate of 2.35 per 1000 in the general population (21-60 years). It remains unknown what patient characteristics are beneficial or potential hurdles to recovery. The purpose of this study was to identify indicators of delayed recovery from Achilles tendinopathy over 6 months following exercise therapy. **Methods:** Data were collected from 90 subjects (45 M, age (mean±SD) 48±12 years, Body mass index (BMI) 28.4±6.2kg/m²) with midportion Achilles tendinopathy as part of a larger clinical trial. Subjects were evaluated in a research facility at Baseline, 2-, 4-, and 6-months while all receiving standardized exercise therapy. Subjects were evaluated with questionnaires, a clinical exam, and functional test battery. Latent growth mixture modeling was used to iteratively model the number of trajectories of symptomatic recovery over time using subject's Victorian Institute of Sport-Achilles (VISA-A) scores. VISA-A is valid and reliable for measuring symptoms

with activity (0-100) with a reported MCID of 13 points and score >80 indicating symptomatic recovery. Mann-Whitney U tests were performed post-hoc to compare differences in baseline measures between trajectories including demographics, Physical Activity Scale (PAS), Foot and Ankle Outcomes Survey-Quality of Life subscale (FAOS-QoL), Tampa Scale of Kinesiophobia (TSK-17), tendon morphology (Achilles tendon thickness and cross-sectional area (CSA)) using diagnostic ultrasound, and a functional test battery (countermovement jump (CMJ), drop countermovement jump (Drop CMJ), heel-rise endurance test) Treatment compliance was defined as completing heel-rise exercises at least twice per week for the initial 4 weeks and compared between groups. **Results:** Two distinct latent trajectory classes (expected recovery (n=69) and delayed recovery (n=21)) were identified (FIGURE 1). Subjects in the delayed recovery group had higher BMI (32.2±5.9 vs 27.1±5.8 kg/m², P>.001), shorter symptom duration (median[IQR] 4.0[6.5] vs 19.7[35.1] months, P=.004), lower VISA-A scores (36±17 vs 55±15, P<.001), greater tendon thickness (0.29±0.20 vs 0.21±0.16cm, P=.01) and CSA (1.17±0.49 vs 0.85±0.37 cm², P=.008), lower FAOS-QoL (33±19 vs 44±16, P=.04) and had poorer lower extremity function (CMJ height

3.92±2.76 vs 7.24±3.7cm, P<.001; Drop CMJ height 4.0±3.7 vs 6.7±3.9cm, P=.01; heel-rise repetitions 18±12 vs 25±10, P=.04 and heel-rise work 1159±758 vs 1758 ±793J, P=.003) compared to expected recovery group at baseline. There were no significant differences in sex, age, PAS, TSK-17, pain with hopping at baseline and no difference in treatment compliance between the two groups. **Conclusions:** This study demonstrates that unobserved heterogeneity between baseline patient characteristics can affect symptomatic recovery including high BMI, altered tendon morphology, poor quality of life, and impaired lower extremity function.

FIGURE 1. Two Latent Growth Trajectories of VISA-A Scores Over 6 Months



Intra- and Inter-Rater Reliability of Novice Clinician Users of Diagnostic Ultrasound to Assess Anterior Talofibular Ankle Ligament Length
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Context: The gold-standard for diagnosing most ankle injuries is a thorough physical exam. Augmenting the exam with portable diagnostic ultrasound (DUS) may provide a more accurate diagnosis of ankle injuries through point-of-care imaging. At present, the use of diagnostic ultrasound in athletic training is minimal. If diagnostic approaches are to be improved, the reliability of athletic trainers evaluating ankle structures with diagnostic ultrasound must first be established. The purpose of this study was to assess the reliability of novice clinician ultrasound users' ability to assess anterior talofibular ankle ligament (ATFL) length. **Methods:** This cross-sectional study assessed the reliability of seven athletic training clinicians (Age=30.0±4.7 years, clinical experience=7.9±4.3 years) who were novice diagnostic ultrasound users. Participants measured the length of the ATFL in both neutral and an inverted position

on 11 individuals participants (Age=24.0±2.7, Mass=69.9±24.4kg, Height=173.0±10.2 cm) from 16 healthy ankles. Two separate data collections occurred, each separated by at least one week. Intraclass correlation coefficients (ICC (2,k)), Chronbach's alpha and standard error of the measurement (SEM) were used to assess the test-retest and intra-rater reliability of clinicians to assess the ATFL. **Results:** Clinicians demonstrated poor to moderate reliability in ankle neutral (ICC=0.53±0.19) and inversion (ICC=0.51±0.22) (Table 1). However, individual clinicians demonstrated increased reliability between the two data collection periods (ICC Neutral Day 1=0.46±0.20, ICC Day 2=0.51±0.13, ICC Inversion Day 1=0.24±0.19, Day 2=0.04±0.24) (Table 1). SEM values demonstrated that reliability was worse across days (Neutral=0.53±0.19, Inversion=0.51±0.22). Clinicians overall had lower SEM numbers in neutral compared to those in inversion. **Conclusions:** We observed poor reliability across clinician raters for all days except Neutral Day 2, which increased to moderate levels for all clinicians. These improvements may be attributed to a training effect that occurred as the clinicians became more familiar with the testing protocol and with the device. We feel this suggests a critical role

for continued DUS practice and training. As a whole, clinicians demonstrated good-excellent intra-rater reliability. On an individual level, results varied drastically with some clinicians more consistent than others. This may have significant implications on how clinicians integrate DUS at the point of care. Clinicians seeking to integrate diagnostic ultrasound into clinical practice should proceed with caution and rely on expert clinicians and those with significant experience to accurately utilize these devices.

Table 1. Summary inter-rater reliability statistics for the clinicians

		ICC*	p	95% CI	Cronbach's Alpha	Mean Ligament Length (cm)	SD Ligament Length	SEM
Neutral	Day 1	0.463	0.041	-0.082, 0.785	0.463	1.611	0.199	0.381
	Day 2	0.510	0.002	0.190, 0.732	0.510	1.682	0.183	0.392
Inversion	Day 1	0.244	0.137	-0.249, 0.587	0.244	1.8599	0.194	0.466
	Day 2	0.367	0.100	-0.275, 0.747	0.367	1.863	0.240	0.502

Note: ICC: interrater correlation coefficient, SD: standard deviation, SEM: standard error of measure

Dynamic Balance Performance Is Not Associated With Self-Reported Function In Young-Adults With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) has been associated with numerous impairments in disease-oriented and patient-oriented outcome measures of function. Impairments in dynamic balance have been observed in patients with CAI using disease-oriented outcomes such as the star excursion balance test (SEBT), while impairments in self-reported ankle function have been observed using patient-oriented outcomes such as the Foot and Ankle Ability Measure (FAAM) Sport and Activities of Daily Living (ADL). As patient-centered healthcare providers, it is important to understand the relationships between disease-oriented and patient-oriented outcomes in clinical populations. The purpose of this study was to examine associations between dynamic balance performance and self-reported ankle function in young-adults with a history of CAI. **Methods:** Our study used a cross-sectional design and all data was collected in a laboratory setting during a single visit. Our sample included forty-five ($n=45$) young-adults with a history of CAI as defined by the criteria outlined by the International Ankle Consortium (age: 20.9 ± 2.3 years, BMI: 25.6 ± 4.3 , IdFAI: 20.6 ± 4.7 , Sprains: 4.5 ± 2.9). We

assessed participant's current self-reported ankle function using the FAAM Sport and ADL questionnaires. We assessed participants dynamic balance using SEBT reach distances (cm) in the anterior, posteromedial, and posterolateral directions. Participants balanced on their CAI limb with hands on their hips and reached with their contralateral limb as far as possible in each direction along a tape measure secured to the floor. Participants completed four practice trials followed by three test trials for each reach direction. The average of the three test trials, normalized by height (cm), was used for analyses. We examined associations between the FAAM Sport and SEBT reaches and between the FAAM ADL and SEBT reaches using Pearson's (r) and Spearman's (ρ) correlation coefficients, respectively. **Results:** Average FAAM Sport was 78.3 ± 12.6 and average was FAAM ADL was 90.5 ± 6.3 . Average normalized SEBT reach distances during the anterior, posteromedial, and posterolateral directions were 0.39 ± 0.05 , 0.46 ± 0.04 , and 0.42 ± 0.05 , respectively. FAAM Sport was not associated with SEBT reaches in the anterior ($r=0.05$, $P=0.75$), posteromedial ($r=0.11$, $P=0.46$), or posterolateral ($r=0.09$, $P=0.54$) directions. FAAM ADL was not associated with SEBT reaches in the anterior ($p=0.15$, $P=0.32$), posteromedial ($p=0.10$, $P=0.52$), or posterolateral ($p=0.10$, $P=0.50$) directions. **Conclusions:** We observed no association between dynamic balance and self-reported ankle function in our sample of young-adults with CAI. Despite the

common observance of impairments in both dynamic balance and self-reported function in individuals with CAI, our findings suggest that these outcomes may be assessing independent aspects of patient function. It is importance that clinicians incorporate both disease-oriented and patient-oriented outcomes into their plan of care to appropriately assess patient function.

Amounts and Sources of Parental Stress Are Highly Variable Following Pediatric Concussion

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Context: Many parents of children with moderate and severe traumatic brain injury (TBI) report extreme levels of stress following their child's injury. One study found that following pediatric mild TBI, 10% of parents score in the 99th percentile for total stress and these scores remained almost unchanged a year following injury. However, parental stress responses following pediatric concussion, the mildest form of TBI, have not yet been studied. Therefore, the objective of our study was to determine the amount and sources of stress that parents experience following their child's concussion. **Methods:** Forty-nine concussed children (13.8 ± 2.3 years, nfemales=27) and a parent (nfemales=40) were recruited from a specialty concussion clinic. Parents rated their stress using the Perceived Stress Scales (PSS) at the child's initial clinic visit. PSS scores were categorized as low (0-13), moderate (14-26), or severe (27-40). A subset of parents (n=12) completed an eleven-question, semi-structured

interview at a follow-up clinic visit (median: 26 days post-concussion, interquartile range: 19-39 days). Interview questions focused on the parent's perceived stress levels following their child's injury and the parent's interpretation of sources contributing to their stress. Descriptive statistics are provided for the quantitative data and thematic analysis was used to interpret the interview data. **Results:** For the quantitative data, twenty-eight parents (57.2%) reported low perceived stress, compared to 18 with moderate stress (36.7%) and 3 with severe stress (6.1%). Mean parental stress was 13.58 ± 7.96 and responses were wide ranging, encompassing over 75% of the scale's range (Parent Scores: 1-32, Total Range: 0-40). Specific to the qualitative data, parents described sources of stress related to (1) their personal concussion knowledge (knowledge), (2) the child's injury and dysfunction (medical), (3) the child's return to school and sport (activity), (4) caring for their injured child (caregiving), and (5) personal stressors unrelated to the child's injury (personal). Overall, the child's post-concussion dysfunction and the uncertainty of recovery were the primary source of stress identified by parents (n=9, 75%), followed by post-injury academic performance (n=2, 17%) and the emotional toll of caring for their injured child (n=1, 8%). **Conclusions:** Parental

stress following pediatric concussion is highly variable. Most parents reported low levels of distress, but some parents reported severe perceived stress following their child's concussion. Parents described that their stress stemmed from medical, activity, caregiving, knowledge, and personal factors, with medical factors related to the child's dysfunction post-concussion being the most significant source of parental stress. Future studies should investigate interventions to reduce stress for parents experiencing severe parental stress following their child's concussion.

Attitudes of Headgear Safety Among NCAA Women's Lacrosse Stakeholders

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Context: Athletic trainers are key in understanding and treating sports related concussions (SRCs). As headgear may play a role in both the likelihood and severity of SRC, it is important to understand the culture among stakeholders likely to influence headgear usage. It was expected that differences would exist between players, coaches, and officials in women's lacrosse regarding attitudes toward headgear use.

Methods: An online multi-item cross-sectional survey of women's lacrosse players ($n=70$), coaches ($n=11$ male, $n=59$ female), and officials ($n=9$ male, $n=21$ female) at NCAA Division I and III levels was conducted via Qualtrics. Recruitment occurred through targeted emails, posts on relevant lacrosse social media sites and other listservs of target group members, and the distribution of informational flyers at lacrosse conferences. The survey captured demographic information and attitudes toward headgear use and safety (Chronbach's $\alpha = .514$). We also validated the survey via peer and expert review prior to participant recruitment. Data

were analyzed using stepwise multiple regression to predict attitudes toward headgear use from stakeholder group (player, coach, official), prior concussion history, headgear aesthetics, and prior headgear use. Additional predictive analysis was conducted for players only and included intention to report concussions. Chi-squares were used to assess the relationship between prior headgear use and intention to report concussions among players. A point-biserial correlation was used to determine the relationship between intention to report concussions and future headgear use. **Results:** Among all stakeholders, attitudes toward headgear use were significantly predicted by headgear aesthetics, concussion history, and prior headgear use, $F(3,61)=31.4$, $p<0.001$, $R^2=.61$. Among players, attitudes toward headgear use were significantly predicted by aesthetics and intention to report concussions, $F(2,57)=38.0$, $p<0.001$, $R^2=.57$. Among players, future headgear use was significantly predicted by previous use and intention to report, $F(2,58)=114.9$, $p<.001$, $R^2=.80$. There was a significant relationship between future headgear use and previous headgear use, $\chi^2(1,n=94)=70.5$, $p<.001$ with those having a previous history of use being over 200 times (OR:253, CI95:39.7,1610.8) more likely to wear headgear in the future. There was a negative relationship between intention to report and future headgear use, $rpb=-.85$, $n=79$, $p<.001$. **Conclusions:** Attitudes of headgear use were significantly predicted most consistently by prior use and aesthetics. Interestingly, prior concussion history did not predict future headgear use among athletes, suggesting that athletes are not inclined to adapt the intervention due to

personal injury experiences. If headgear implementation is the intent of lacrosse stakeholders, early headgear exposure, as well as headgear aesthetics, will contribute toward athlete compliance; however, headgear use is not desired by all stakeholders. Future research should focus on how implementing headgear in women's lacrosse may improve safety allowing medical professionals and other stakeholders evidence to inform decisions.

Basilar-Type Migraines with Coma in an Adolescent Female Basketball Player A Case Study

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Background: A 15-year-old female high school basketball player with a history of ADHD, migraines, and 2 concussions reported to the athletic training facility with concussion like symptoms. The patient reported a migraine and requested to rest in the athletic training facility. After 15 minutes she was unable to be aroused by the athletic trainer. She presented with a heart rate of 88 bpm, shaking, normal breathing, and visible eye movement. The athletic trainer contacted her mother, who denied EMS transportation. Prior to concussions last year she occasionally reported dizziness, blurred vision, dilated pupils, and headache during high intensity workouts. Following her first concussion, she began to have similar episodes of sleep-like coma, from which she was unable to be aroused. The episodes last for 30 minutes to two hours and she typically gradually regains consciousness. This was her first episode in 8 months. Episodes were not disclosed on her pre-participation exam. **Differential Diagnosis:** Based on the history and evaluation, possible diagnoses for this case include: narcolepsy, epilepsy, postural orthostatic tachycardia syndrome (POTS), basilar artery migraines with coma, and familial hemiplegic migraine. **Intervention & Treatment:** The patient was transported and admitted for 3 days of dihydroergotamine (DHE) migraine protocol. She was found to have a wandering atrial pacemaker, but it was

a side effect of the DHE. MRI results revealed no abnormalities, and she was released with no restrictions. For one month the patient reported no-recurring symptoms and participated in all basketball related activities. Approximately one-month after the first episode, the patient experienced another episode. During this event, she was given IV fluids and scheduled for an EEG. The EEG revealed a slight abnormality and the patient was prescribed Lamotrigine for possible epilepsy. Two-weeks after sustaining a second concussion, she had another episode that lasted 75 minutes after which another EEG and sleep study were ordered. The EEG returned normal, and the sleep test was not completed. After the fourth episode, the third EEG was clear and her physician referred her for cognitive behavioral therapy to treat migraines and she wore a halter monitor for 48 hours. The results of the halter monitor indicated no abnormalities. She was diagnosed with basilar-type migraine with coma. Her current treatment is focused on managing migraines through medication, fluid intake, proper diet and sleep habits. After each episode during the basketball season she was taken through a gradual return to play progression similar to a concussion return to play. To date, these recommendations, tracked through a daily log, have resolved the episodes primarily. The patient is constantly monitored by athletic trainer before and during practice. **Uniqueness:** This case is unique because the patient's migraines cause episodes of coma. The multiple EEGs, MRI, and cardiac testing showed no abnormalities, which caused the inability to confirm a diagnosis. There have been two previous cases in the literature, both described as basilar migraines with coma in adolescent patients, leading to this diagnosis. Although this patient had migraines before both concussions, the

coma-like episodes began after the first concussion, suggesting exacerbation of symptoms after injury. This patient also has diagnosed ADHD, which predisposes her for increased symptoms after concussion. **Conclusions:** This case involves an adolescent female patient that experienced episodes of coma after two concussion injuries. Her previous medical history of ADHD and migraines may have exacerbated her concussion symptoms. This case emphasizes the importance of knowing previous medical history for patients who experience concussion. Even though this case is rare, this may occur in other patients with similar histories. Furthermore, more research on this condition is needed to better understand how to treat it.

Collegiate Athletes' Anxiety-Related Concussion Perceptions

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Context: While previous literature has focused heavily on concussion knowledge and reporting, few studies have explored how collegiate athletes feel about this injury. In order to bring further awareness to the patient experience, the aim of this study was to determine anxiety-related concussion perceptions of collegiate athletes and investigate factors that may be associated with increased anxiety in this population. **Methods:** We conducted a cross-sectional survey study of National Collegiate Athletic Association athletes (n=482; mean age=19.7±1.4 years) from 7 institutions. Our convenience sample of males (n=303) and females (n=179) participated in a variety of NCAA sports (e.g., football, soccer, ice hockey, golf, tennis, rowing). Participants voluntarily completed the 10-15 minute survey in athletic training clinics or classrooms during team meetings, before or after practices, or during musculoskeletal injury treatment. The outcome of interest, anxiety-related concussion perceptions, was assessed using the Perceptions of Concussion Inventory for Athletes (PCI-A) anxiety score (maximum score=20). The 21-item PCI-A also assessed beliefs related to long-term effects, treatment effectiveness,

symptom variability, personal control, and injury comprehension. The questionnaire captured personal and sport demographics, self-reported diagnosed concussion history (Yes/No), mental health history (Yes/No), concussion knowledge (maximum score=49), and sources of concussion information acquisition (Yes/No; i.e., sports news, social media, movies/books). The survey was validated by 3 context experts and pilot tested on 10 undergraduate students. We calculated the mean±SD of the PCI-A anxiety score and response frequencies of individual perception item (i.e., anxious, fearful, upset, or worried). Variables associated with higher anxiety-related concussion perception were identified using univariable logistic regressions and a backward stepwise multiple regression. Statistical significance was set a priori at .05. **Results:** Collegiate athletes displayed moderate anxiety-related concussion perceptions (12.8±3.2, range 4-20). The majority of participants reported that concussions are upsetting to them (60.7%), with a sizable proportion being worried (46.7%), fearful (40.7%), and anxious (25.0%) about sustaining a concussion. The following variables from the univariable logistic regressions met the inclusion criteria for the multivariable regression: female sex, concussion knowledge, PCI-A long-term effects, PCI-A personal control, and PCI-A symptom variability. See Table 1 for all univariable logistic regression results. In the multivariable regression, higher perception that concussions have long-term effects (OR=2.72; 95% CI=1.79-4.12, P<.001), greater beliefs of internal control to influence concussion outcomes (OR=1.78; 95% CI=1.15-2.75, P=.01), and female sex (OR=1.77; CI=1.15-2.71, P=.009) were associated with higher anxiety-related

concussion perceptions (R² =0.07; P<.001). **Conclusions:** The results of our study suggested that anxiety about concussions is prevalent in collegiate athletes. Addressing these perceptions at the individual-level may be critical for improving emotions related to concussion. This may be particularly important for female athletes. We recommend that education include evidence-based information regarding the current state of knowledge surrounding the potential long-term health consequences of concussion and highlight the treatability of this injury.

Table 1. Univariable Logistic Regression Results Predicting Higher Anxiety-related Concussion Perceptions

	OR	95% CI	R ²	P
Female Sex	1.78	1.22-2.61	0.01	.003**
Depression/Anxiety History	1.14	0.56-2.35	0.00	.71
Diagnosed Concussion History	1.09	0.73-1.64	0.00	.66
Concussion Knowledge	1.49	1.01-2.20	0.01	.04**
PCI-A Effects	2.78	1.88-4.11	0.04	<.001**
PCI-A Clarity	1.01	0.70-1.47	0.00	.95
PCI-A Treatment	1.33	0.91-1.93	0.00	.14
PCI-A Symptom Variability	1.38	0.95-1.99	0.00	.09*
PCI-A Control	1.99	1.33-2.96	0.02	<.001**
Movies/Books	1.28	0.88-1.88	0.00	.20
Social Media	1.25	0.85-1.83	0.00	.26
Sports News	1.25	0.85-1.85	0.00	.25

* if P<0.1; entered into multivariable logistic regression model

**significant at P<.05

Concussion Knowledge and Attitudes in University Students Studying Physical Education and Health Sciences

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Context: Little research has examined concussion knowledge and attitudes in students intending to enter professions working with athletes including teaching and coaching, as well as the health care professions, such as athletic training or physical therapy. The purpose of this study was twofold: 1) to determine concussion knowledge and 2) attitudes toward concussions in physical education and health sciences university students. Taken into account were personal concussion history and planned professional goals. **Methods:** Participants were chosen as a sample of convenience from one state-sponsored university in the Pacific Northwest. The survey was administered electronically via email. One hundred thirty-six students responded to the survey (response rate = 17.8%). The one-time survey included demographic information, the Rosenbaum Concussion Knowledge and Attitude Survey –Student Version (RoCKAS-ST), which included three sections of knowledge questions, and the Attitudes and Beliefs

Towards Concussion survey, which consists of ten closed statements about concussion beliefs and willingness to play through concussive injury. Both survey instruments were previously tested for validity and reliability. Surveys were sent to academic departments and forwarded to students. Reminders were sent out at weeks two, four, and six of data collection. Data were tabulated using Qualtrics. **Results:** Means, standard deviation, percentage, and frequencies were calculated for demographic information, concussion knowledge, and attitude results. Mean knowledge score was 17.17 ± 2.04 out of a score of 20. Mean attitudes score was 42.34 ± 6.29 of out of a score of 50. A one-way ANOVA was performed to compare groups. No significant differences were found between participants planning careers in health care professions or those planning careers in teaching and coaching. Concussion history was not a factor. **Conclusions:** Planned profession and concussion history did not influence concussion knowledge or attitudes. Both groups showed high concussion knowledge and conservative attitudes toward concussions. While knowledge and conservative attitudes toward concussion by teachers and coaches may be beneficial in the outcome of a concussed athlete's care, it must be emphasized that only trained health care professionals are in positions to make a final decision in regards to care.

Concussion Knowledge of Parents of Youth Athletes

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Context: Parents are a primary source for health care decisions for children, which may be influenced by their health literacy. In youth sport, on-site health care providers are rarely present, therefore, parents are responsible for identifying and making appropriate immediate care decisions regarding concussions. Previous studies have found parents have acceptable concussion knowledge, but there are mixed results regarding internal and external variables that promote higher levels of understanding. This investigation sought to identify factors associated with increased concussion knowledge in parents of youth contact sport athletes. **Methods:** This cross-sectional study included 466 parents of youth football, soccer, ice hockey, and lacrosse athletes between the ages of 8 and 14 years. Participants were recruited at youth sport practices and competitions in Pennsylvania and Michigan. After consent was obtained, participants voluntarily completed a 10-15 minute paper and pencil survey that assessed concussion knowledge. Concussion knowledge was measured with a previously established 47-item instrument with a resultant Cronbach alpha of

.74 in the parent sample. The assessment included sign and symptom recognition and general questions about anatomy, loss of consciousness, and potential consequences of premature return to play and multiple concussions. Additionally, personal and family demographic, sport, and diagnosed concussion history information was captured. Univariate and multivariable linear regressions were used to determine if concussion knowledge was associated with parent age (mean age=44.1±6.6 years), sex (60.3% women), state (62.8% Pennsylvania), highest level of education (43.4% bachelor's degree, 24.7% master's degree, 19.1% some college, 9.4% terminal degree, 3.4% high school/GED), medical occupation (14.9% yes), spouse medical occupation (10.7% yes), previous sport participation (81.7% yes), previous high-risk concussion sport participation (65.2% yes), current or previous coaching experience (45.4% yes), concussion education (37.7% yes), diagnosed concussion history (11.4% yes), and diagnosed concussion history of child(ren) (17.5% yes). Statistical significance was set a priori at .05. **Results:** Parents had a mean concussion knowledge score of 39.3±4.6 out of a possible 47 points. Univariate analyses results can be found in Table 1. The multivariable model found that having a medical occupation ($P=.04$) and being older in age ($P=.03$) were associated with higher concussion knowledge scores. The final model accounted for 1.8% of variance in parent concussion knowledge ($R^2=.018$; Estimate=35.88;

SE=1.58; 95% CI=32.77-38.99). **Conclusions:** Parents correctly answered 83.6% of concussion knowledge items on average. While having a medical occupation and being older in age were significantly associated with greater concussion knowledge, the clinical relevance of these findings is small given that the final model accounted for less than 2.0% of variance. Additionally, more concussion awareness resources for parents are needed at the youth sport level as approximately only 4 in 10 parents reported receiving concussion education previously. Future research should consider social determinants of health to assess a more diverse sample.

Table 1. Univariate Tests for Factors Influencing Parent Concussion Knowledge

Factor	Sample Difference	Standard Error	P
State ^a	1.02	.45	.02 *
Male ^a	-.44	.44	.33
Medical occupation ^a	1.37	.60	.03 *
Spouse medical occupation ^a	-1.33	.98	.18
Sport participation ^a	-.12	.57	.84
High risk sport participation ^a	.03	.51	.94
Coaching experience ^a	.29	.44	.51
Any child concussion history ^a	.62	.57	.28
Previous diagnosed concussion education ^a	.48	.45	.28
Parent diagnosed concussion history ^a	-.03	.70	.97
Highest level of education ^b	-	-	.02 *
	Estimate	Standard Error	P
Age ^c	.07	.03	.04 *

^a Binomial (yes/no) variables compared with independent samples t-test.

^b Highest education compared with one-way ANOVA.

^c Age tested with simple linear regression.

*Significant univariate variables added used in multiple linear regression.

Concussion Modifiers Associated With Prolonged Recovery of Sport Concussion

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Context: Previous studies have investigated specific modifiers that may influence recovery from a sport concussion (SC) in collegiate athletes. However, the evidence supporting each of these factors in their association with recovery from SC remains inconclusive. The purpose of this study is to investigate the prevalence of evidence-based modifiers associated with prolonged recovery in collegiate athletes who reported symptom free within or beyond 10 days of a diagnosed SC. **Methods:** Participants included 165 Division I collegiate athletes (110 males, 55 females) with an average age of 20.1±0.19 years who were diagnosed with a SC by a certified athletic trainer or physician. Following their diagnosis, participants were monitored until they reported symptom free. Participants were then divided into typical (< 10 days) or prolonged recovery (> 11 days) groups based on the number of days they reported concussion-related symptoms. Each participant's ImPACT™ report was then reviewed for gender,

age, and years of collegiate sport experience. Self-reported use of antidepressants, psychostimulants, previously diagnosed learning disorders, ADHD, psychiatric conditions, and treatment for headaches or migraines were recorded. Concussion history and associated loss of consciousness and/or amnesia were also considered in our analyses. Independent t-tests were used to compare group age and years of collegiate sport experience. Chi squared (χ^2) tests were used to compare the proportion of individuals in each group who identified with one or more of the aforementioned modifiers. Analyses were performed with $\alpha=0.05$. **Results:** No differences were observed between groups based on age ($t(163)=1.85$, $p=0.95$, $d=0.30$), years of experience at the collegiate level of sport ($t(163)=0.7$, $p=0.44$, $d=0.13$) or group composition based on gender ($\chi^2(1)=0.14$, $p=0.71$, $V=0.71$). On average, the typical and prolonged recovery groups reported symptoms for 5.9±2.37, and 23.4±28.04 days, respectively. A significantly greater ($\chi^2(1)=4.048$, $p=0.04$, $V=0.16$) proportion of participants in the prolonged recovery group (1.9% [2/106]) compared to the typical recovery group (8.5% [5/59]) reported a learning disorder. No additional significant differences were observed between groups for any other modifier (Figure 1). **Conclusions:** Our results suggest that despite the presence of one or more evidence-based modifiers that associate with a

prolonged recovery from SC, an equitable proportion of collegiate athletes recovered within or beyond ten days of their diagnosed injury with the exception of a previously diagnosed learning disorder. Our data further support that collegiate athletes, regardless of previously existing conditions, should be treated on an individual basis as previously identified factors may not indicate that a prolonged recovery will occur.

Examining the Association Between the Brief Sensation Seeking Scale and Head Impact Exposure in Collegiate Football Players

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Context: The Brief Sensation Seeking Scale (BSSS) is a self-reported measure of risk-taking behavior and has been associated with demographic and sport-related characteristics in athletes. To date, risk-taking behavior and objective head impact exposure in football players has not been examined. Therefore, the purpose of this investigation was to examine the association between head impact exposure and risk-taking behavior in collegiate football players. **Methods:** A prospective cohort design was used to examine the association between head impact exposure over the course of a football season and baseline risk taking behavior. A total of 229 male Division I collegiate football players (19.1±1.3y, 186.2±14.3cm, 104.4±19.8kg) were recruited from four universities through the Concussion Assessment, Research, and Education (CARE) Consortium. All CARE participants complete the BSSS at baseline. The BSSS is an eight-item survey. Each item is rated

on a five-point Likert scale. Four subscales exist within the BSSS labeled ‘experience seeking’, ‘boredom susceptibility’, ‘thrill and adventure seeking’, and ‘disinhibition’. Each participants’ helmet was equipped with the helmet-based Head Impact Telemetry (HIT) System (Riddell SRS, Riddell, Rosemont, IL, USA) sensor which captures head impact accelerations using six single-axis accelerometers. The HIT System has the ability to compute peak linear and rotational accelerations for each head impact exceeding a 9.6g threshold. Each participant wore the HIT System equipped helmet for practices and games. Descriptive statistics were calculated to summarize all variables. Means are reported as mean±standard deviation and medians are reported as median (Interquartile Range). Spearman’s rho correlations were used to examine the relationship between season head impact exposure metrics [number of head impacts, risk weighted exposure (RWE), head injury criterion (HIC), median peak liner acceleration (PLA), and median peak rotational acceleration (PRA)] and BSSS total score (Score Range=8-40) and subscale scores (Score Range=2-10). Correlations were interpreted as very weak (0.00-0.19), weak (0.20-0.39), moderate (0.40-0.59), strong (0.60-0.79), and very strong (0.80-1.00). Significance was set at $p \leq 0.05$ for all analyses. **Results:** During the study period, 126,273 head impacts (Median=445.00 [214.00-736.00]) were recorded. RWE for all players was 0.95 (0.30-2.02). Median HIC score was 4.60 (3.60-5.80). Median PLA was 20.30g (18.90-22.10g) and median PRA was 947.82rad/s² (891.75-1016.79rad/s²). Spearman rho correlation coefficients and p-values are reported in

Table 1. Very weak non-significant correlations existed between all head impact exposure metrics and BSSS total score (24.49±5.33), experience seeking (6.27±1.78), boredom susceptibility (6.27±1.61), thrill and adventure seeking (6.09±1.96), and disinhibition (5.86±1.66) subscales. **Conclusions:** Among all players, very weak non-significant correlations existed across all variables for all head impact exposure metrics and BSSS and subscale scores. The results of this examination demonstrate that risk-taking behaviors, as measured by the BSSS, have no correlation to head impact exposure metrics in Division I collegiate football players.

Table 1. Spearman Rho Correlations between Head Impact Exposure Metrics & Risk-Taking Behavior

	Number of Head Impacts		Risk Weighted Exposure		Head Injury Criteria		Peak Linear Acceleration		Peak Rotational Acceleration	
	<i>r_s</i>	<i>p</i>	<i>r_s</i>	<i>p</i>	<i>r_s</i>	<i>p</i>	<i>r_s</i>	<i>p</i>	<i>r_s</i>	<i>p</i>
BSSS-Total	0.004	0.956	0.054	0.417	-0.025	0.704	0.016	0.816	-0.053	0.429
Experience Seeking	0.058	0.383	0.054	0.414	0.031	0.640	0.010	0.883	-0.022	0.741
Boredom Susceptibility	-0.004	0.958	0.056	0.400	-0.092	0.164	-0.023	0.734	-0.045	0.500
Thrill & Adventure Seeking	-0.009	0.894	0.028	0.679	0.013	0.848	0.021	0.751	-0.035	0.603
Disinhibition	-0.060	0.366	0.027	0.684	-0.062	0.350	0.064	0.339	-0.058	0.382

Factors Associated With Increased Concussion Knowledge in Youth Athletes

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Context: Injury recognition and immediate removal from activity are key elements of on-field concussion care recommendations. These responsibilities commonly fall to athletes, parents, and coaches at the youth sport level due to the lack of on-site sports medicine resources. Previous studies have investigated the level of concussion knowledge of youth athletes, but few have considered multiple factors across the socioecological model that may influence knowledge. The aim of this study was to investigate factors associated with increased concussion knowledge in youth athletes. **Methods:** This was a cross-sectional survey study of 390 youth contact sport athletes ages 8-14 (mean age=11.05±1.80 years; 66.4% boys; 26.5% ice hockey, 26.3% soccer, 24.9% lacrosse, 26.3% soccer, 22.4% football) from Pennsylvania (62.8%) and Michigan (37.2%). Consent, assent, and paper and pencil surveys were collected at youth sport practices and competitions. The youth athlete survey included demographics and a previously used 47-item concussion knowledge assessment that included sign and

symptom recognition and a series of general concussion questions. The survey was reviewed by a child reading psychologist to ensure it was at an appropriate reading level and research assistants were available to provide clarification during survey completion if needed. A parent survey was also used to capture parent concussion education, parent concussion knowledge, and participant, sibling, and parent diagnosed concussion history. Univariate analyses informed multivariable linear regressions to identify if age, state, sport (sport by sex; 7 options), multi-sport participation (74.5% yes), concussion education (88.8% yes), concussion history (7.1% yes), sibling concussion history (8.4% yes), parent concussion history (11.5% yes), parent concussion education (35.8% yes), or parent concussion knowledge (mean=39.3±4.6 out of 47) were significantly associated with higher youth athlete concussion knowledge. Statistical significance was set a priori at .05. **Results:** Youth athletes had a mean concussion knowledge score of 35.0±5.7 out of 47. See Table 1 for univariate analyses results that informed the multivariable model. Never receiving concussion education ($P<.001$), a history of diagnosed concussion(s) ($P=.01$), sport type (relative to girls' ice hockey, $P<.001$), older age ($P<.001$), and parent concussion knowledge ($P=.04$) all accounted for significant variance in youth athlete concussion knowledge. The final model accounted for 17.6% of variance in youth athlete concussion knowledge ($R^2=.176$;

Estimate=25.40; SE=3.21; 95% CI=19.08-31.72). **Conclusions:** Youth athletes in this study correctly answered only 74.5% of concussion knowledge items on average. There were a variety of factors that contributed to youth athlete concussion knowledge; however, an important modifiable factor was previous concussion education of the youth athlete. Present findings suggest that concussion education may be essential to improving concussion knowledge of youth athletes, thus warranting further study into effective concussion awareness programs for this population.

Table 1. Univariate Tests for Factors Influencing Youth Athlete Concussion Knowledge

Factor	Sample Difference	Standard Error	P
State ^a	.43	.57	.46
Sport ^b	-	-	.02*
Multi-sport participation ^a	.57	.63	.37
Diagnosed concussion history ^a	4.14	.77	<.001*
Sibling diagnosed concussion history ^a	1.91	1.03	.07
Parent concussion education ^a	.35	.58	.55
Parent concussion history ^a	.24	.88	.93
Never educated about concussion ^a	-4.40	.85	<.001*
	Estimate	Standard Error	P
Age ^c	.73	.73	<.001*
Parent concussion knowledge score ^c	.19	.19	.003*

^a Binomial (yes/no) variables compared with independent samples t-test.

^b Sport compared with one-way ANOVA.

^c Age and parent concussion knowledge score tested with simple linear regression.

*Significant univariate factors variables added used in multiple linear regression.

Lived Experiences of Student-Athletes Following Multiple Concussions: A Qualitative Exploration

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Context: Research suggests a link between multiple concussions and long-term negative behavioral, emotional, and cognitive outcomes. However, there is insufficient evidence to understand the link between these outcomes and concussions from the student-athletes' perspective. This population is unique in that participants are not only identified as athletes, but also as students. The purpose of this study is to understand the meanings and lived experiences that multiple concussions have in the lives of student-athletes. **Methods:** This study employed an interpretive phenomenological approach (IPA). Participants included current and former student-athletes. Participants were recruited from a Division I Midwest University. Participants were included if they had suffered >1 diagnosed concussion during their athletic career and could speak and understand the English language. Perspectives of participants were obtained through semi-structured interviews utilizing an interview guide developed from the literature. All interviews were transcribed verbatim. To understand the lived

experiences of student-athletes suffering from multiple concussions, a data analysis approach that encourages reflection and interpretation was used. This analysis, termed horizontalization, is a 6-step methodological approach, ending with thematic development. Themes were distributed to participants for their feedback as a means of validating the findings. **Results:** There were a total of 13 student-athletes that participated in the study. They reported an average of 3 diagnosed concussions (range 2-6). Table 1 provides demographics for all participants, with pseudonyms to protect their identity. A total of 6 themes emerged from the data: 1) Persistent symptoms, 2) Positive and negative experiences with academic accommodations, 2) Lack of medical coverage led to self-diagnoses and improper care, 4) Loss of identity as an athlete, 5) Positive and negative impact(s) on social relationships, and 6) Concussions are viewed differently from other sports-related injuries. Surprisingly, many participants reported persistent symptoms, including difficulty concentrating, memory deficits, sensitivity to light, irritability, and depression. Several participants had positive experiences with academic accommodations but many reported that they were not provided any accommodations/cognitive rest following their diagnoses and struggled academically. Furthermore, while many student-athletes stated they had a supportive social network, many participants also noted they

were viewed as a liability by coaches and teammates. **Conclusions:** This study demonstrated that student-athletes that have suffered multiple concussions continue to exhibit persistent cognitive and behavioral symptoms, despite having returned to sport. In addition to the loss of athletic identity experienced by many of the participants, persistent symptoms appear to impact academics and social relationships. Results indicate the need for further education and return-to-learn programs. Further research is needed to determine the prevalence and severity of self-report symptoms in student-athletes with a history of multiple concussions.

Table 1-Participant Demographics

Name	Sport(s)	# of Diagnosed Concussions	Most recent Diagnosed Concussion
"Olivia"	Basketball/Soccer	3	4 years
"Emily"	Rugby	3	5 days
"Jacob"	Rugby	2	2 months
"Sarah"	Cheerleading	3	3 weeks
"Brittany"	Soccer	3	2 years
"Michael"	Ice Hockey	3	3 years
"Rebecca"	Cheerleading	5	2 weeks
"Vanessa"	Soccer	5	18 months
"Caitlin"	Basketball/Rugby	2	4 months
"Amanda"	Snowboarding	2	1 month
"Renee"	Basketball/Soccer	6	18 months
"Daisy"	Ice Hockey	2	4 years
"Grace"	Ice Hockey	2	3 years

You're the Expert! Collegiate Coaches' Perceptions of the Athletic Trainer's Role Regarding Concussion

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Context: Athletic trainers (AT) are often the first qualified healthcare provider to assess a sports-related concussion (SRC). However, recent literature shows that ATs can face several barriers when managing SRC, including pressure or skepticism from coaches. For example, recent studies suggest that coaches believe return-to-play protocols are too long or that SRC are managed too conservatively by healthcare professionals. Gaining a better understanding of coaches' perceptions about SRC and the role of the AT in SRC care may help ATs more effectively overcome these barriers. **Methods:** Qualitative study. Participants were recruited from a larger study of NCAA coaches. Twelve individual interviews were conducted via teleconferencing with NCAA collegiate coaches (6 male, 6 female) of sports with high-concussion rates using a convenience sampling procedure. Participants represented all three NCAA divisions (e.g. I, II, and III) and a variety of men's and women's sports including football, men's and women's lacrosse, ice hockey, basketball, soccer, and

women's field hockey. A semi-structured interview was used to explore coaches' perceptions and attitudes towards concussion policy and management on their team and campus, as well as general attitudes towards concussion. Once data saturation was reached, recruitment ceased and interviews were transcribed and coded by two independent coders using a phenomenological approach. Trustworthiness of the data was achieved through triangulation, including independent coding, and member checks. **Results:** Several themes emerged, including "reliance and deference to AT," "diagnostic challenges and perceived questionable validity," and "education is obtained from expert organization and ATs." The overarching perception described by coaches shows a belief that when a concussion management decision needs to be made, it is the AT who is the trained content expert and qualified to make such decisions. However, coaches also seemed to be skeptical about the validity of current concussion diagnostic tools and the RTP protocol. Additionally, coaches stated that most of the concussion education is provided to teams by the AT or sports medicine department. **Conclusions:** While coaches agree that SRC management decisions should be made by an AT, they also question the validity of available diagnostic tests being used by ATs to assess for SRC and desired more definitive tests. This doubt may be attributed to a lack of understanding about the properties of these tests and how results are integrated with clinical judgement.

This lack of understanding may lead to difficulty accepting SRC management decisions and the perception of overly conservative management. Since ATs are trusted experts on their teams, ATs should consider including more in-depth information regarding the SRC diagnostic and return-to-play decision making process into concussion education, which may improve coaches' knowledge in this area and decrease pressure placed on ATs by coaches to return athletes to play prematurely.

On-field Characteristics That Influence Head Impact Magnitude in Youth Tackle Football

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Context: Youth football athletes have the greatest participation rate in football compared to high school, college, and professional levels. Football accounts for 50% of all sports-related concussions in team sports with youth athletes having the highest concussion incidence. The research points to the importance of identifying ways to decrease repetitive blows to the head. However, most football head impact related research has focused on high school, collegiate, or professional athletes, leaving out a potentially vulnerable population, youth athletes. It is unknown if collision characteristics such as mechanism, preparedness, head direction, struck versus striking activity, stance, play type, closing distance, penalty, and quarter have similar influences on head impact magnitudes in youth football athletes where mitigation efforts might be the most potent. The purpose of this study was to determine the effect of video-verified collision characteristics on head impact magnitudes in male youth tackle football athletes. **Methods:** A prospective cohort design was used for this study. Participants ($n=23$, age= 10.9 ± 0.3 yrs, height= 150.0 ± 8.3 cm, mass= 41.6 ± 8.4 kg) wore Triax Sim-G sensors throughout the Fall 2019 season. The sensors recorded the magnitude

and frequency of head impacts over 14g. Linear (g) and rotational acceleration (rads/s²) determined impact magnitudes. Ten filmed games were used to identify nine different collision characteristics that served as the independent variables: mechanism, preparedness, head direction, struck versus striking activity, stance, play type, closing distance, penalty, and quarter. The camera and Triax system were date- and time-synchronized before each game. Random-effects general linear models and Cohen's d effect sizes were used to examine differences in log-transformed peak linear (PLA; g) and rotational (PRA; rad/s²) accelerations across characteristics. The α value was set to $P=0.05$ a priori. **Results:** The 10 games produced 533 total video-verified impacts and 23.2 ± 7.2 impacts per athlete. PLA (p range: 0.107-0.923) and PRA (p range: 0.057-0.768) did not differ across characteristics. Struck players ($3,370$ rads/s², 95%CI= $2,986$ - $3,808$) had a small effect for higher PRA compared to striking players ($3,037$ rads/s², 95%CI= $2,713$ - $3,404$, $d=0.251$), but negligible effect for simultaneous struck-striking players ($3,340$ rad/s², 95%CI= $2,945$ - $3,792$, $d=0.018$). Fourth quarter impacts ($3,490$ rads/s², 95%CI= $3,083$ - $3,951$) had a small effect for higher PRA compared to first ($2,945$ rads/s², 95%CI= $2,596$ - $3,337$, $d=0.404$), second ($3,196$ rads/s², 95%CI= $2,832$ - $3,604$, $d=0.219$) and third quarters ($3,241$ rads/s², 95%CI= $2,841$ - $3,699$, $d=0.144$). **Conclusions:** Youth tackle football characteristics did not significantly affect head impact magnitudes during games.

Previous rule changes and the enforcement of safe tackling techniques in youth football may have contributed to no differences in impact magnitudes across collision characteristics in the present study. Youth athletes may also have relatively slower collision speeds and less body mass compared to high school, college, or professional football which may be critical factors for future research to consider. Thus, more research is needed to explore additional factors that could be modified to increase sport safety in general rather than mitigating impact mechanism.

Epidemiology of Emergency Medical Services Activations for Sport-Related Injuries

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Context: Research examining emergency medical services (EMS) activations for sport-related injuries has been limited regarding the populations examined, inclusion criteria, and location. The management of sport-related injuries by EMS providers has also not been examined. The purpose of this study was to describe EMS activations for sport-related injuries from a national sample and describe their management by EMS. **Methods:** Data were obtained from the National EMS Information System database for the years 2017 and 2018. Sport-related injuries were identified using specific International Classification of Diseases, 10th Revision, Clinical Modification codes for cause of injury and incident location type. 9-1-1 responses for patients aged 3-99 years were included. Descriptive variables included patient characteristics (e.g. age, gender), incident location, complaint reported by dispatch, chief complaint organ system and anatomic

location, primary symptom, provider's primary impression, service level, and procedures performed. Frequencies and proportions were calculated for all descriptive variables. Missing values were excluded from analyses. **Results:** There were 71,322 sport-related injuries identified, accounting for 0.2% of all EMS activations during the study period. Amongst EMS activations for sport-related injuries, the average patient age was 36.6±22.9 years and most patients were male (58.1%, n=41132). Traumatic injury was the most common complaint reported by dispatch (22.5%, n=16064), followed by falls (12.4%, n=8850) and sick person (11.1%, n=7935). The most common incident location types were "gymnasium" (36.7%, n=26196) and "sports and athletics area" (27.8%, n=19821). Over 55% of injuries noted falls (n=14944) as the cause of injury. The anatomic location most often reported as the patient's chief complaint was "global/general" (46.9%, n=24075). "Global/general" was also the most common organ system affected (38.9%, n=20543). Unspecified pain was the prevalent primary symptom (14.6%, n=9642), followed by syncope and collapse (6.1%, n=3963). On average, 1.4 procedures were performed per EMS activation, with the most frequent procedure being catheterization of the vein (n=25449). Most EMS activations for sport-related injuries received an advanced level of care (n=25885, 85.5%). **Conclusions:** Sport-related injuries account for a small proportion of all EMS activations. Patients of all ages were represented in this sample, indicating EMS utilization for

sport-related injuries affects a wide variety of people in formal and informal sport settings. General/global chief complaints are likely indicative of sport-related injuries affecting multiple anatomic locations and organ systems. An age-appropriate pain assessment should be performed during all patient assessments. Most sport-related injuries receive an advanced level of care and have procedures performed, indicating EMS activation was likely necessary. These findings highlight the need for coaches and administrators hosting athletic events to consider having trained on-site medical personnel to develop an emergency action plan, provide immediate care for an injury, and facilitate the EMS response (e.g., communication with dispatch, direction to the scene, assistance with care).

Prevalence of Dysfunctional Breathing Patterns in Youth Female Athletes

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Context: There is growing evidence of associations between altered breathing patterns and numerous musculoskeletal and psychological conditions, and restoring optimal breathing patterns has been recommended through breathing exercises implemented during rehabilitation of musculoskeletal conditions such as low back pain. Diaphragmatic breathing has been recognized as optimal breathing mechanics and a significant contributing factor to improved spinal stability, improved posture, and improved functional performance. Individuals with dysfunctional breathing typically display reduced abdominal excursion, lateral rib cage expansion, and superior rib cage migration. In recent years, increased research has focused on altered breathing patterns among athletes. A significant gap exists in the prevalence of dysfunctional diaphragmatic breathing patterns in youth female athletes. As youth athletes with dysfunctional breathing may be at increased risk of a musculoskeletal injury, a screen of breathing mechanics may aid in identifying targets to prevent an injury. The purpose of this study was

to examine the prevalence of dysfunctional and diaphragmatic breathing patterns in youth female athletes. **Methods:** Using a cross-sectional design, 1160 youth female athletes (Age=15.05±2.46yrs; Height=159.06±7.61cm; Mass=51.86±8.49kg) were screened. Breathing mechanics was assessed using the Hi-Lo breathing test in the standing position. Scores of the Hi-Lo test were determined based on the presence or absence of abdominal excursion, lateral rib cage expansion, superior rib cage migration, and shoulder elevation. The Hi-Lo test scores were utilized to categorize breathing patterns as 1) thoracic-dominant (absence of visible abdominal excursion and visible lateral rib expansion and/or presence of visible superior rib cage migration), 2) abdominal-dominant (presence of abdominal excursion, absence of superior rib cage migration, and absence of lateral rib expansion), as well as 3) diaphragmatic breathing patterns (presence of abdominal expansion and lateral rib expansion and absence of superior rib cage migration). Participants with thoracic-and abdominal-dominant breathing patterns were classified as a dysfunctional breather. Data were analyzed for frequencies and descriptive statistics. **Results:** The prevalence of thoracic dominant-breathers was 73.79% (n=856, Age=15.16±2.51yrs, Height=158.77±8.01cm; Mass=51.97±8.79kg). Among 1160 participants, 183 of those were classified as abdominal-dominant breathers (15.78%, Age=15.77±2.49yrs, Height=159.66±7.34cm; Mass=52.63±8.26kg). Youth female athletes with diaphragmatic breathing patterns accounted for 10.43% of all participants in our sample (Age=16.14±2.56yrs,

Height=158.48±6.08cm; Mass=52.82±7.24kg).

Conclusions: In youth female athletes, dysfunctional breathing patterns (89.57%) were more prevalent than diaphragmatic breathing pattern (10.43%). Dysfunctional breathing patterns have been related to numerous health conditions and poor performance. Our data indicate that screening breathing patterns may be an important step towards the development of effective prevention strategies for musculoskeletal injuries. Future research is needed to investigate if breathing pattern screening tools can demonstrate risk of musculoskeletal injuries.

High School Sport Specialization and Young Adult Physical Literacy and Physical Activity
 McKay CM, Hoch JM, Gadd N, Hoch MC, Dlugonski D: University of Kentucky, Lexington, KY

Context: Nearly 8 million high school-aged youth in the United States participate in sports. Youth sport participants are more likely to report regular vigorous physical activity participation than those who do not participate in sports. Youth sports also provide opportunities for children to learn fundamental movements skills, potentially having an effect on physical literacy levels. Physical literacy is defined as “the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life”. While the benefits of sport participation are many, the increased likelihood of school-aged youth to specialize is not always universally beneficial. In addition to increased injury risk, youth sport specialization may be associated with young adult physical literacy and physical activity. Therefore, the aims of this study were to compare young adult physical literacy and self-reported physical activity by high school sport specialization status and to examine the relationship between self-reported physical activity and physical literacy. **Methods:** A

cross-sectional design was used to survey current levels of physical literacy and subjective physical activity along with determining the retrospective recall of high school sport specialization status. A total of 181 participants (79% women; 88% white) aged 18-25 (average 22.2±2.1 years) who participated in high school athletics and did not have a current injury or any physical activity limitations were recruited. Participants completed the demographics and injury history questionnaire, the sport specialization assessment, the PlaySelf physical literacy assessment, and Godin Leisure-Time Exercise Questionnaire through web-based surveys. The independent variable was high school sport specialization level (no, low, moderate and high specialization). The dependent variables were scores on the PlaySelf and self-reported physical activity. We conducted two one-way ANOVAs to examine differences in physical literacy and physical activity by youth sport specialization groups. If a significant ANOVA ($p<0.05$), Tukey’s post hoc analyses were performed to compare between groups. Pearson correlations examined the relationship between physical literacy and physical activity. **Results:** The means and standard deviations for physical literacy and physical activity across each sport specialization group can be found in Table 1. There was no statistically significant difference between sport specialization status groups for physical literacy ($p=0.485$) or MVPA ($p=0.359$).

There was a statistically significant relationship between physical literacy and physical activity ($r=0.35$, $p<.001$). **Conclusions:** Young adult physical literacy and physical activity levels were similar regardless of high school sport specialization status. Thus, it does not seem that youth sport specialization is related to the development of young adult physical literacy. In addition, young adult physical literacy scores were positively associated with self-reported physical activity. Future research should continue to examine the development of physical literacy as a way to promote physical activity across the lifespan.

Table 1. Mean (standard deviation) values of physical activity and physical literacy by specialization status

Specialization Status	Physical Literacy	Physical Activity
No Specialization	65.99 (10.33)	45.27 (25.10)
Low Specialization	68.89 (11.21)	51.21 (25.24)
Moderate Specialization	69.41 (13.22)	50.50 (24.60)
High Specialization	69.93 (10.99)	55.27 (24.50)

The Effect of Concussion History on Lower Extremity Injury Risk in High School and Collegiate Athletes: A Systematic Review and Meta-Analysis Ramirez VR, McCann RS, Schussler E, Martinez JC: Old Dominion University, Norfolk, VA

Context: Sport-related concussions are a prevalent injury that result in sensorimotor dysfunction and altered neuromuscular control. Individuals recovering from a concussion display decreased postural sway during balance assessment, but then experience increased sway after return-to-play (RTP). Individuals who suffer a concussion may possess prolonged balance deficits even after clearance for RTP. Athletes who are experiencing impairments following RTP after a concussion may be at increased risk of lower extremity (LE) injury, but the systematic examination of this evidence has yet to be completed. The purpose of this study was to conduct a systematic review and meta-analysis of studies examining risk of lower extremity musculoskeletal injury following a concussion in high school and collegiate athletes. **Methods:** An electronic database search of PubMed, CINAHL, MEDLINE, and SPORTDiscus was conducted on November 19, 2019 using the following terms: (“lower extremity” AND “injury” AND “concussion”). Articles were included if they were published between January 2000 and November 2019 and examined high school or collegiate athletes’ risk of sustaining a lower

extremity musculoskeletal injury following a concussion. Methodological quality of included studies was performed with the modified Downs and Black Checklist. Random effects meta-analysis modeling calculated summative relative risk (RR) for studies that reported sufficient data. Relative risk was calculated using the formula in Figure 1. Heterogeneity was examined using the I² statistic and publication bias was assessed with Egger’s test. **Results:** Sixty-five studies were initially retrieved. Following removal of duplicates and abstract assessment, nine studies were included in the systematic review. Eight of the studies were of good or excellent quality. The sports frequently investigated were football, men’s and women’s soccer, men’s and women’s basketball, and swimming. Control athletes, when implemented, were matched by sport and sex. Some studies matched athletes by exposure and position as well. Five of the 9 studies were included in the meta-analysis. High school and college athletes who suffered a concussion possessed a 49% greater risk of sustaining a lower extremity musculoskeletal injury than those without a history of a concussion. (RR = 1.49[1.04, 2.14]). High heterogeneity was detected with an I² value of 66.8%. Egger’s test (bias = 0.72[-8.31, 9.76]; P = 0.82) indicated that publication bias likely did not influence the results of this analysis. **Conclusions:** Lower extremity injury risk is potentially increased in high school and college athletes following a concussion compared to those without recent history of a concussion. Detection of heterogeneity reveals that the small

sample of studies varied in their findings; a larger number of studies may be needed to verify this early finding. Further research is needed to investigate the mechanism behind this increased risk. Clinical assessments throughout the concussion return-to-play protocol may need to be improved in order to detect lingering impairments caused by concussions.

Figure 1. Formula for calculation of relative risk.

$$\text{Relative risk} = \frac{\frac{(\text{number of individuals with a history of concussion with a LE injury})}{(\text{total number of individuals with a history of concussion})}}{\frac{(\text{number of individuals with a LE injury without a history of concussion})}{(\text{total number of individuals without a history of concussion})}}$$

Digital and Musculoskeletal Health Literacy of Collegiate Student-Athletes
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Context: In sports medicine, the increasing burden of musculoskeletal complaints warrants further examination into musculoskeletal health literacy, or the ability to know the anatomy, diagnosis, and conditions associated with orthopedic care. The same is true of digital health literacy, or the skills needed to search, select, appraise, and apply online health information. We sought to assess the digital and musculoskeletal health literacy levels of collegiate student-athletes. **Methods:** We used a cross-sectional survey to assess the health literacy levels of collegiate student-athletes. Student-athletes were recruited using snowball sampling via emails to athletic directors and compliance officers at the institution. Student-athletes (n=160) participated in the study (male=48, 30%, female=111, 69.4%; age=20±4y; Caucasian=133, 83.1%, Multiracial=17, 10.6%, Black/African-American=5, 3.1%, Hispanic=4, 2.5%, Other=1, 0.6%). Most participants stated they had used on-campus athletic training services previously (n=133/160, 83.1%). For the purposes of this abstract, we report digital health literacy measured using the 21-item Digital Health Literacy

Instrument (DHLI) and musculoskeletal health literacy measured using the 9-item Literacy in Musculoskeletal Problems (LiMP) tool. The DHLI is scored as an overall mean (1=low literacy, 4=high literacy) with additional means for the 7 subscales. An additional six general and health-related Internet questions were also evaluated. The LiMP explores 3 constructs of orthopedic care and is scored as an overall mean, which is sorted into 3 literacy levels (inadequate=0-3, limited=4-5, adequate=6-9). Data were analyzed using descriptive statistics for all items, as well as the 7 subscales and 3 literacy levels. Independent samples t-tests were used to compare the digital and musculoskeletal health literacy to the participant's gender and race. **Results:** Participants shared they used smart phones to use the Internet and felt the Internet was both important and useful to their health (Table). Most participants used the Internet to search for health/illness information (93.8%, n=150). The average DHLI score was 3.36±0.38. Highest scores were reported for operational skills (mean=3.90±0.26) and protecting privacy (mean=3.67±0.48). The lowest subscale was evaluating reliability (mean=3.05±0.61). No significant differences were found between races on DHLI scores (Caucasian vs non-Caucasian, p=0.063) or gender (male vs female, p=0.504). The LiMP score was 6.29±1.36, and 26.8% (n=15/56) of participants who completed the tool had limited or inadequate musculoskeletal health literacy. We did not identify any significant difference in LiMP scores between race

(Caucasian vs non-Caucasian, p=0.678) or gender (male vs female, p=0.163). **Conclusions:** Most student-athletes possess adequate musculoskeletal health literacy. The findings directly impact patient education as student-athletes are often using their phones to access health related information, which they feel comfortable with, but may not know if the source is trustworthy. As health information technology continues to expand in athletic training, the data suggest we can create patient education materials for all regardless of race or gender.

Table 1. General and health-related Internet use among collegiate student-athletes (n=160)

Item	N (%)
Frequency of Internet Use	
(Almost) every day	158, 98.8%
Several days a week	1, 0.6%
About 1 day a week	0, 0%
(Almost) never	0, 0%
Missing responses	1, 0.6%
Means of Internet Use	
Smart phone	158, 98.8%
Laptop	148, 92.5%
Personal computer	67, 41.9%
Tablet	30, 18.8%
Computer provided by work/school	27, 16.9%
Public computer	14, 8.8%
Self-rated Internet Skills	
Excellent	61, 38.1%
Good	74, 46.3%
Average	24, 15.0%
Reasonable	0, 0%
Poor	0, 0%
Missing responses	1, 0.6%
Internet Task Use	
Search for information on health or illness	150, 93.8%
Schedule an appointment with a healthcare provider	108, 67.5%
Read on health-related forums or social media websites	113, 70.6%
Read a healthcare provider or facility review	79, 49.4%
Use a health-related smart phone app	98, 61.3%
Ask a question of your healthcare provider	57, 35.6%
Monitor disease symptoms	70, 43.8%
Share personal medical information with others	34, 21.3%
Log on to review your electronic medical record	78, 48.8%
Post a health care review	15, 9.4%
Take a web-based self-assessment related to health/wellness	79, 49.4%
Engage in a telemedicine visit with a healthcare provider	40, 25.0%
Usefulness of the Internet in helping you make health decisions	
Not useful at all	4, 2.5%
Not useful	19, 11.9%
Unsure	38, 23.8%
Useful	78, 48.8%
Very useful	20, 12.5%
Missing response	1, 0.6%
Importance in being able to access health resources on the Internet	
Not important at all	2, 1.3%
Not important	13, 8.1%
Unsure	25, 15.6%
Important	85, 53.1%
Very important	35, 21.9%

Examination of Eating Disorder and Depression Risk Across Collegiate Student-Athletes

Weber SR, Monsma E, West D, Wilcox S, Torres-McGehee TM: University of South Carolina, Columbia, SC

Context: Male and female collegiate student-athletes are at risk for various mental health disorders. Sport and academic stressors may prevent student-athletes from performing at their best. A change or increase in individual stressors can cause physiological disturbances and mental health disorders such as eating disorders (ED) and depression (DEP). Therefore, the purpose is to estimate the prevalence of ED and DEP by sex, sport-type (e.g., endurance, aesthetic, power, ball, technical), and academic status (i.e., freshman, sophomore, junior, senior) and furthermore describe the relative risk (RR) and odds ratio (OR) by sex for ED and DEP.

Methods: A cross-sectional study design was used to examine the prevalence of ED and DEP risk by sex, sport-type, and academic status and further describe the RR and OR for female student-athletes through an online survey. Student-athletes (n=1167, female: n=800, male: n=367, age: 19.61.3years) were recruited from multiple NCAA, NAIA, and NCCAA institutions to participate in the survey. Demographic information, Eating Attitudes Test, and the Center for Epidemiologic Studies Depression Scale were

completed. Descriptive statistics were used for the distribution of demographic information and chi-square analyses were used to examine the proportion of participants classified at risk for ED or DEP for the total sample and by sex, sport-type, and academic status. Furthermore, RR and OR were used to describe the association of ED and DEP by sex. **Results:** The overall ED risk prevalence was 15.7% (n=183); with significant differences found for sex ($p<.007$), with females and males respectively at 17.6% (n=141) and 11.4% (n=42). There were no significant differences found for ED risk by academic status or sport-type. DEP prevalence was 21.4% (n=250), where within sex, females (24.0%) were higher than males (15.8%) with significant differences for sex ($p<.002$) and sport-type ($p<.01$). The ball sport category has the highest percentage of at-risk participants with 26.8% (n=108) for DEP risk. No significant differences were found for academic status for DEP risk. The RR and OR for females and ED was 1.54 (95% CI: 1.12, 2.12) and 1.66 (95% CI: 1.14, 2.40) respectively. For DEP, the RR and OR was 1.52 (95% CI: 1.16, 1.98) and 1.68 (95% CI: 1.22, 2.33) respectively. **Conclusions:** Participation in sport, specifically at the collegiate level can place additional pressures on student-athletes that may predispose them to numerous mental health disorders (i.e., eating disorders, depression). Our findings highlight the prevalence rates of eating disorders and depression among both female and male student-athletes and suggest that both

are at risk for the development of ED and DEP. Furthermore, sport-type may serve as a risk factor for depressive symptoms in student-athletes. It is vital health professionals are aware of the signs and symptoms of mental health disorders so that they can make appropriate referrals.

Bowel Intussusception in a Collegiate Basketball Player

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Background: The patient is a 19-year-old male collegiate basketball player. During team travel, he began complaining of stomach pain, nausea, and bloody stool progressively worsening until the athlete could not participate in practice. He has no previous history of gastrointestinal diseases. **Differential Diagnosis:** Influenza, Campylobacteriosis, Gastroenteritis.

Intervention & Treatment: The patient was transported to the local hospital by the team athletic trainer. Based on the signs and symptoms, the attending physician ordered comprehensive blood work and a CT scan. Muscle relaxant and pain relief were administered intravenously at the emergency department. The CT scan revealed three telescoping sections of the small intestine. Based on the CT scan results, the patient was admitted to the hospital and placed on a floor. The patient was kept in hospital for 36 hours, then discharged and instructed to keep a light diet. He was transported back to home university (6 hours) by the head athletic trainer. The following day, he reported to the head athletic trainer (as his team was at another away competition) with recurrence of original symptoms. He was transported to the team general physician and was admitted to the hospital via the doctor's office. He was administered pain medication and muscle relaxant. A general surgeon performed laparoscopic surgery the next day.

During the surgery, three telescoping segments of the small intestine were found and released. The patient was monitored for three days as an in-patient. As diet was progressed appropriately by hospital staff, the patient was release after a bowel movement. Four days later, the patient reported to the athletic trainer with abdominal pain again. He was admitted to the hospital and underwent open abdominal surgery. Present intussusception was not observed, however noticeable inflammation was appreciated in the area of previous intussusception leading to the conclusion that intussusception was present recently. Biopsy of the bowel resection showed eosinophilic infiltrate of the mucosa, submucosa, and subserosal tissue. The patient was observed in-patient for five days post-operatively and then released. The patient was unable to participate in the remainder of the basketball season. **Uniqueness:** Intussusception is the most common cause of obstruction in children under the age of 3. Adult cases of intussusception are usually the result of an underlying medical condition, such as a tumor. The patient in this case is well above the childhood age and is otherwise healthy with no personal nor family history of bowel issue. Biopsies taken during surgery revealed no tumors. Additionally, surgery to correct intussusception are generally successful and have a low recurrence rate (10%). However in this case, reoccurrence of the intussusception occurred about 96 hours after the reversal surgery leading to a bowel resection. **Conclusions:** The patient reported with typical signs and symptoms of influenza, but additional investigation by the athletic trainer to reveal bloody stool

lead to more prompt action. Multiple surgeries and slow reintroduction of food caused significant time loss for this patient. Management of intussusception is generally out of the scope of athletic trainers, but early symptom recognition can lead to better pain management and interventions. Education of the patient of reintroduction of solid food is also key to avoid overloading the gastrointestinal system post-operatively.

POTS Diagnosis and Treatment in a Collegiate Diver

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Background: A 20 year old collegiate female diver collapsed suddenly while performing wall bar pull-ups during practice in September. Before this condition started, this athlete had no past medical history of disease or illness nor did she have any episodes regarding mental wellness. After the collapse she was conscious but unable to stand due to dizziness and complaints of nausea. The certified athletic trainer's physical exam revealed a heart rate of 155 bpm with normal breathing. An immediate referral to the team physician was sought by the ATC. **Differential Diagnosis:** Supraventricular tachycardia (SVT), dysautonomia, Postural Orthostatic Tachycardia Syndrome (POTS) **Intervention & Treatment:** In October the team physician ordered an electrocardiogram (EKG) and blood tests. These tests revealed a "normal" EKG and low iron and ferritin levels. She was encouraged to eat more foods that were high iron or take iron supplements. She competed on 10/4 and only mentioned "light-dizziness" but stated it was not enough to be taken out of activity. One week post symptoms, SVT became a potential diagnosis, determined by local cardiologists therefore the patient underwent a cardiac stress test which was normal. The athlete continued to have a resting HR above 150

bpm and was starting to have episodes of syncope during classroom activities. A follow up appointment with the head team physician 2 weeks after symptoms started resulted in a new diagnosis of dysautonomia. The patient met with a Cardiologist 3 weeks after symptoms and another EKG (results normal) was ordered. A heart rate monitor was issued for 2 weeks to record daily HR (results clear). On October 22nd the patient presented with tight limbs and inability to feel arms temporarily. In November, she was prescribed amitriptyline and metoprolol, and allowed to practice as able. The new medication prescribed caused several side effects and did not manage any of the patient's symptoms. She had completed a cardiac stress test, heart rate monitor, 2 EKGs, 3 tilt tests and was officially diagnosed with POTS by the end of November. In January (4 months post onset) the patient was prescribed fludrocortisone and propranolol and she gradually began practicing comfortably. **Uniqueness:** High resting HR, light-headedness, and fatigue, present similarly to all of the stated differential diagnoses'. Months of varied unsuccessful treatments delayed the safe return to sport for this case. Diving requires constant postural changes which exaggerates the POTS symptoms and requires constant monitoring of heart rate to avoid further injury. Observing an athlete's mental wellness is unique to POTS due to the side effects of different medications, the total disruption to normal ADL, and the duration of time it takes to determine the best course of action for this particular diagnosis.

Conclusions: If an athlete is experiencing symptoms of POTS the Athletic Trainer needs to understand the basic treatment options of taking blood pressure, pulse, and allowing the athlete to conform to an incline resting position to allow HR to drop safely. The medications prescribed for POTS have side effects that could hinder an athlete's ability to safely train, therefore, the patient should continuously be monitored by medical staff upon RTP. Emotional health should also be a consideration during the return to play treatment. The stress related to fainting, fatigue, and/or unconsciousness may lead to anxiety disorders. Consulting with a team physician should be an immediate priority, with expedited specialized referrals to ensure the patient's care and diagnosis are not delayed or misdiagnosed. After 4 months of multiple diagnoses and varied treatments, this athlete was successfully return to sport with varying degrees of little to no symptoms of high HR, fatigue, and light-headedness.

Stability of Factors Associated With Well-Being Across Decades of Life in Former National Football League Players

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Context: Participation in collision-sports such as football has been purported to lead to deteriorating long-term health-related quality of life (HRQoL). Although most studies have focused on negative outcomes like depression symptoms, a more holistic approach including important factors associated with well-being would advance the understanding of health-related concerns in former football players as they age. We hypothesized that measures of social, emotional, and mood-related HRQoL would decline with increasing age in a sample of former National

Football League (NFL) players. **Methods:** In this cross-sectional study, a general health survey questionnaire was completed by former NFL players (n=1,591; aged 51.2±15.9 years; 17.4±4.4 total years of organized football play) in a setting of their choosing. The questionnaire was designed by a multidisciplinary group that included athletic trainers, neuropsychologists, physicians, epidemiologists, and former NFL players, among others. Participants reported demographic information and completed the following Short-Form Patient-Reported Outcome Measurement Information System (PROMIS) measures, which were developed with support from the National Institutes of Health and correlate with single and multi-domain measures of HRQoL (rs>0.50): Ability to Participate in Social Roles and Activities; Self-Efficacy; Meaning and Purpose; Emotional Support; Depression; and Anxiety. Raw scores for each measure were transformed to T-Scores based on U.S. population normative data (mean±standard deviation=50±10). Higher scores for Ability to Participate in Social Roles and Activities, Self-Efficacy, Meaning and Purpose, and Emotional Support were considered better outcomes, while higher scores for Depressive Symptoms, and Anxiety Symptoms reflected greater difficulties in that domain. Current participant age was binned into decade groups: <30; 30-39; 40-49; 50-59; 60-69; 70-79; 80+. Kruskal-Wallis tests were used to compare each outcome among age groups with a-priori $\alpha=0.05$. Summary statistics

(median, interquartile range) were calculated for each measure within each age group. **Results:** Generally, each outcome approximated U.S. population norms across the lifespan, though elevated Emotional Support (1SD above population mean; better emotional support) was observed among former players in the 80+ age category (Table 1). Each outcome was significantly different across age groups (ps<0.002); however, there was not a clear linear trend of decline (e.g., constant rate of change) across successive age groups. **Conclusions:** This study provides evidence that social, emotional, and mood-related HRQoL may not inherently worsen over time in former professional football players—though longitudinal studies are required in order to comprehensively address this question. Examination of factors that influence social, emotional, and mood-related HRQoL across the lifespan of former athletes may help identify potential interventions to improve well-being. Athletic trainers and other clinicians who work with athletes should consider the potential benefit of measuring HRQoL and other factors associated with well-being as they may fluctuate throughout the lifespan.

Table 1. Social, Emotional, and Mood-Related Health-Related Quality of Life in Former NFL Players.

Measure	T-Scores, median (interquartile range)							
	Full Sample n = 1,591	< 30 years old n = 143	30-39 years old n = 342	40-49 years old n = 266	50-59 years old n = 291	60-69 years old n = 317	70-79 years old n = 192	80+ years old n = 40
Ability to Participate in Social Roles and Activities	51.6 (44.8, 58.1)	58.1 (48.1, 64.1)	51.6 (44.8, 64.1)	48.1 (44.8, 55.6)	49.8 (44.8, 55.6)	51.6 (44.8, 58.1)	51.6 (44.8, 57.5)	44.8 (37.7, 55.6)
Self-Efficacy	49.5 (42.0, 64.7)	52.2 (46.9, 64.7)	49.5 (44.4, 64.7)	49.5 (39.7, 58.9)	49.5 (39.7, 64.7)	49.5 (39.7, 58.9)	49.5 (44.4, 58.9)	46.9 (31.2, 52.2)
Meaning and Purpose	53.5 (46.1, 65.5)	53.5 (46.1, 65.5)	53.5 (43.9, 60.0)	50.8 (43.9, 60.0)	56.5 (46.1, 65.5)	56.5 (48.4, 65.5)	56.5 (48.4, 65.5)	56.8 (42.8, 65.5)
Emotional Support	53.0 (45.4, 62.0)	55.6 (45.4, 62.0)	50.8 (42.1, 62.0)	50.8 (42.1, 62.0)	50.8 (45.4, 62.0)	53.0 (47.2, 62.0)	55.6 (47.2, 62.0)	62.0 (49.0, 62.0)
Depression	49.0 (41.0, 57.3)	41.0 (41.0, 57.3)	51.8 (41.0, 59.3)	55.7 (41.0, 62.2)	49.0 (41.0, 58.9)	49.0 (41.0, 55.7)	41.0 (41.0, 53.9)	50.4 (41.0, 56.9)
Anxiety	53.7 (40.3, 61.4)	53.7 (40.3, 61.4)	55.8 (48.0, 63.4)	57.7 (48.0, 65.3)	53.7 (40.3, 63.4)	51.2 (40.3, 57.7)	48.0 (40.3, 55.8)	52.5 (40.3, 59.1)

Treatment with Tarp Assisted Cooling with Oscillations Compared to Cold Water Immersion Following Exertional Hyperthermia

Richins J, Cutler BZ, Barker BT, Rigby BR, Butts CL: Weber State University, Ogden, UT

Context: Rapid treatment of exertional heat stroke is crucial to preventing negative health outcomes, with the gold standard of cold water immersion (CWI) providing optimal cooling rates. Tarp assisted cooling with oscillation (TACO) is a recommended alternative method for treating exertional heat stroke, however, it has not been directly compared to CWI. Therefore, the purpose of this study was to evaluate the effectiveness of the TACO method compared to CWI following exercise-induced hyperthermia. We hypothesized that the TACO method would produce acceptable cooling rates but would be slower than CWI. **Methods:** This randomized, crossover, counterbalanced study was conducted in an outdoor area (21.5°C) using a treadmill. Eight participants (3 female, 5 male, age 25±3y, wt 75.3±12.4kg, ht 1.74±0.08m, body fat 20.4±8.3%) volunteered from the university to complete two trials consisting of an initial 10-minute seated baseline, treadmill exercise, and treatment (TACO or CWI). Treadmill exercise was conducted while wearing an impermeable sauna suit under a cotton sweat suit and involved 30 minutes of jogging at 64-76% age predicted max heart rate followed by 15 second

running bouts at a rating of perceived exertion of 17-19 until the participant reached a rectal temperature (Tre) of ≥39.0°C. Participants then completed the cooling portion (TACO or CWI at ~2°C) until a Tre of 38.2°C, with a 15-minute recovery. Cooling rates were calculated using the change in Tre divided by the cooling time and were compared using a paired samples t-test (alpha = 0.05). Additional outcome variables (Tre, heart rate) were analyzed using two-way (time by tx) repeated measures analysis of variance. Post-hoc analyses were conducted using Bonferroni corrected alpha. All data are reported as mean ± standard deviation. **Results:** Urine specific gravity was similar between CWI (1.010±0.007) and TACO (1.012±0.009, $t_6 = -0.48$, $P = 0.65$). Baseline (CWI 83±10 bpm vs TACO 76±12 bpm) and pre-cooling heart rates (CWI 145±18 bpm vs TACO 144±20 bpm) were not different between trials ($F_{1,7} = 0.80$, $P = 0.40$). Baseline Tre (CWI 37.49±0.55°C vs TACO 37.39±0.48°C) and pre-cooling Tre (CWI 39.20±0.21°C vs TACO 39.15±0.26°C) were not different between trials ($F_{1,7} = 0.66$, $P = 0.44$). Cooling rates were not different between CWI (0.15±0.10°C/min) and TACO (0.17±0.12°C/min, $t_7 = -0.46$, $P = 0.66$, $d = 0.16$). **Conclusions:** These preliminary findings suggest that the TACO method provides similar cooling compared to CWI following exertional hyperthermia. Therefore, the TACO method may be an effective alternative for reducing core body temperature when CWI is not available.

Vigorous Water Stirring Does Not Improve Cold Water Immersion Cooling Rate

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Context: Exertional heat stroke is a life-threatening illness with potentially deadly consequences if not treated appropriately. The National Athletic Trainers' Association position statement on exertional heat illness states that cold water immersion (CWI) with vigorous water stirring is the optimal patient treatment, however, no studies have determined the impact of vigorous stirring during CWI on body cooling rate. The purpose of this study was to determine if there is a difference in cooling rates of hyperthermic individuals during CWI with and without vigorous water stirring. **Methods:** Seven subjects (female=2, age: 22 ± 4 y, height: 173 ± 14 cm, weight: 77.4 ± 20.3 kg, percent body fat: $11\pm 6\%$) volunteered for this randomized, counterbalanced, crossover laboratory study. Subjects completed treadmill exercise in the heat (40°C , 66% relative humidity) until one of the following was achieved: 1) rectal temperature (T_{re}) = 40°C , 2) 95% age-predicted maximal heart rate (HR) for 5 minutes, or 3) volitional fatigue. Subjects were then cooled from the neck down in $15.3\pm 0.5^{\circ}\text{C}$ water in

one of two ways: 1) CWI with vigorous water stirring (Stir) or 2) CWI without water stirring (No Stir). Condition prior to cooling and T_{re} cooling rate were analyzed using paired t-tests. Water temperature was compared using a two-way ANOVA and paired t-test. Thermal (8.0 =unbearably hot, 0.0 =unbearably cold) and shivering (0 =none, 10 =most shivering ever) sensations were compared using Friedman's two-way ANOVA. **Results:** Exercise protocols were similar, indicated by similar end of exercise HR (184 ± 17 bpm, 189 ± 13 bpm, $p=0.480$), sweat rate (1.8 ± 0.6 L/h, 1.7 ± 0.6 L/h, $p=0.591$), and percent body mass loss ($1.3\pm 0.4\%$, $1.4\pm 0.4\%$, $p=0.669$) between Stir and No Stir, respectively. Immediately before cooling, T_{re} ($39.64\pm 0.55^{\circ}\text{C}$, $39.63\pm 0.46^{\circ}\text{C}$, $p=0.941$), thermal sensation (7 ± 0 , 7 ± 0 , $p=0.356$), water temperature ($15.4\pm 1.0^{\circ}\text{C}$, $14.2\pm 2.0^{\circ}\text{C}$, $p=0.280$), and ambient temperature ($30.5\pm 4.8^{\circ}\text{C}$, $32.2\pm 3.3^{\circ}\text{C}$, $p=0.409$) were similar between Stir and No Stir, respectively. T_{re} cooling rate was similar between Stir ($0.14\pm 0.1^{\circ}\text{C}/\text{min}$) and No Stir ($0.16\pm 0.1^{\circ}\text{C}/\text{min}$, $p=0.716$), resulting in similar cooling time (12.2 ± 3.4 min, 11.9 ± 5.1 min, $p=0.896$), respectively. End of cooling water temperature 1 inch from subjects and 1 inch from the tub wall were similar during Stir ($15.4\pm 1.1^{\circ}\text{C}$, $15.3\pm 1.1^{\circ}\text{C}$, $p=0.132$) and No Stir ($14.5\pm 2.2^{\circ}\text{C}$, $14.3\pm 1.8^{\circ}\text{C}$, $p=0.591$), respectively, with no difference between trials ($p=0.824$). Cold sensation was exacerbated from the start (7.0 ± 0.5) to the end (1.5 ± 0.5 ,

$p\leq 0.001$) of cooling, with no difference between trials ($p=1.000$). Shivering sensation did not change from the start (0 ± 0) to the end (1.5 ± 0.5 , $p=0.265$) of cooling, with no difference between trials ($p=1.000$). **Conclusions:** Vigorous water stirring during CWI did not improve cooling rate of hyperthermic individuals compared to CWI without water stirring. When personnel available to treat an exertional heat stroke patient is limited, medical providers can consider replacing water stirring efforts with providing other essential medical care such as retrieving advanced medical equipment and blood pressure and heart rate assessment.

Clostridium Difficile Infection With Gastroesophageal and Immunological Complications in a Female Division I Collegiate Soccer Player: Level 3 Exploration CASE Study

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Background: *Clostridium difficile*, also referred to as *C. difficile*, is a bacterium often associated with hospital-associated infection in patients between 50-and 60-years old. *C. difficile* is primarily spread by fecal-oral route, however, it is possible for *C. difficile* to occur in patients taking antibiotic medication. Gastrointestinal signs and symptoms of distress are commonly associated with *C. difficile*. This CASE study is a Level 3 exploration case. The case is unique because *C. difficile* infection developed in a 21-year old female athlete and required an extensive multi-disciplinary approach throughout follow-up care, while the common patient population is usually that of 50 to 60-year-old hospitalized patients. **Patient:** The subject of this case is a 21-year-old female Division I collegiate soccer player who presented with constant diarrhea, nosebleeds, abdominal pain and tenderness. During her initial evaluation by the athletic trainer, she reported she had not had a solid bowel movement after taking 2 different antibiotics in the span of 2 weeks; a macrolide antibiotic, prescribed by the team physician, and amoxicillin, prescribed by a Minute Clinic. Following these incidents, she stated every meal induced diarrhea or vomiting. The team physician ordered a stool sample collection, referral to a gastroenterologist, and prescribed nausea medication. The patient became severely dehydrated from the constant diarrhea and vomiting and required intravenous

fluid administration in the athletic training facility. At the gastroenterologist appointment, a complete bloodwork panel revealed she had *C. difficile* infection. **Intervention & Treatment:** To treat her *C. difficile*, the gastroenterologist prescribed fidaxomicin (Dificid), and an endoscopy was scheduled for 10 days after her final dose. The endoscopy revealed the *C. difficile* had resolved, however she was left with gastroesophageal reflux disease, erosion of stomach lining by the pyloric sphincter, significantly increased count of mast cells in her colon, gastric discomfort, and vomiting. She was prescribed palliative medications for nausea and stomach pain. She was seen by an immunologist for her increased mast cell activity, and was prescribed antihistamines. The athletic trainer collaborated with the team registered dietician, and recommended she begin with a clear liquid diet. Once able to hold clear liquid, she could integrate foods such as oats, bananas, noodles, rice, and fruit. The patient's vomiting subsided after 10 days of medications and gradual reintroduction of foods into her diet. During her recovery, the athlete experienced chronic low energy availability and immunological complications, and was referred to a psychologist for follow-up treatment. **Outcomes or Other Comparisons:** As this case depicts a *C. difficile* infection in a young, collegiate athlete, the treatment for this patient required a combination of expertise of the athletic trainer, gastroenterologist, dietician, psychologist, and immunologist. The occurrence of this infection in this particular population is less common, although she was taking 2 antibiotics prior to its initial occurrence. The series of complications that followed her course of treatment highlight the importance that this infection can occur outside of an older hospital-bound patient even though she had no history of hematological malignancy, and maintained her personal hygiene very well. **Conclusions:**

This case, although rare, is an important example of the danger of concurrent antibiotic use. The importance of a multidisciplinary approach to patient-oriented clinical practice was evident as the providers collaborated throughout the course of her follow-up care plan. When an athlete must overcome an infection that brings on a multitude of complications, including chronic low energy and immunological complications, the athletic trainer and provider team must adapt a biopsychosocial approach. **Clinical Bottom Line:** Concurrent antibiotic use can put any person at risk for developing *C. difficile* infection; proper treatment requires early recognition, proper symptom reporting, and a multidisciplinary healthcare approach.

Examination of Eating Disorder Risk Among Collegiate Student-Athletes

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Context: Collegiate student-athletes are at risk for eating disorders (ED) and long-term use of these behaviors may have a negative impact to their sport performance and quality of life. Sport type (ST) categorized by sport specific task demands is limited and/or outdated; therefore, we examined the prevalence of ED risk and pathogenic behaviors across ST [i.e., endurance (ES), aesthetic (AS), power (PS), ball/team (BTS), technical (TS)] and sex. **Methods:** As part of a larger cross-sectional study, NCAA student-athletes (n=2054, female: n=1423, male: n=631, age: 19.8±1.4 years) completed a basic demographic survey and the Eating Attitudes Test. Basic descriptive statistics were used for demographic information. Cross-tabulations and Chi-square analyses examined the proportion of participants classified as “at risk” across ST and sex. **Results:** Overall, 23.3% (n=478; females=371/1423, 26.1%; males=107/631, 17%) student-athletes were classified “at-risk” for ED with significant differences between “at risk” for ED and sex ($\chi^2=20.3$, $p \leq .01$; female

18.1% vs. males 5.2%). No significant differences were found across ST. Significant differences were found between sex and binge eating (9%, n=184; $\chi^2=6.8$, $p=.009$); females 7.0% vs. 2.0% males. Significant differences were only found across ST and females ($\chi^2=14.7$, $p=.005$), ES reported the highest 13.8% (n=66/480). No differences between sex and ST or within males and ST. Student-athletes (3.7%, n=75) reported vomiting to control weight, with no significant differences across sex and ST. Significant differences were found between sex (9.5%, n=195; $\chi^2=19.3$, $p \leq .01$) and sex and ST ($\chi^2=12.2$, $p=.016$) for use of diet pills, laxatives, or diuretic to lose weight. Females were 7.9% vs. males 1.6%, with TS reporting the highest use (13.4%, n=48/357). Significant differences were found across ST and males ($\chi^2=10.4$, $p=.034$) with AS reporting the highest use (10.5%, n=6/57). Student-athletes (5.1%, n=104) reported using exercise to lose or control weight. Significant differences were found between sex and ST ($\chi^2=32.1$, $p \leq .01$) with ES reporting the highest use 8.5% (n=65/765), ST and females ($\chi^2=25.7$, $p \leq .01$) with AS reporting the highest (9.0%, n=43/480). Student-athletes (2.2%, n=46) reported losing 20 lbs or more in the last 6-months. Significant differences were found between sex and ST ($\chi^2=10.2$, $p=.037$) with PS reporting the highest 4.9% (n=9/184) and across ST and females ($\chi^2=10.1$, $p=.037$) with PS reporting the highest (6.1%, n=7/114).

Conclusions: Increased prevalence of ED risk exists in student-athletes, with females displaying higher risk than males. Females in ES displayed a higher prevalence compared to other ST. Student-athletes across all ST are engaging in pathogenic behaviors to lose or control weight, which may have a negative impact in their performance or place them at risk for injuries. Athletic trainers should be aware of risk factors, signs and symptoms of EDs and collaborate with a multi-disciplinary healthcare team to provide student-athletes with the appropriate care.

Survey of Running Volume, Behaviors, and Motives During the COVID-19 Pandemic

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Context: The COVID-19 pandemic imposed a unique and sweeping demand worldwide to perform self-isolation behaviors and limit interpersonal exposures to mitigate the viral spread. These wholesale changes led to gym and exercise training facility closures, termination of formal and informal group activities, and restrictions on parks and trails that disrupted the norms of physical activity behaviors worldwide. Given the accessibility of running as exercise, it would be important to ascertain how the pandemic influenced running behaviors and motives during social isolation directives that may have a bearing on clinicians treating running patients. Therefore, the purpose of this study was to assess the influence of the COVID-19 pandemic on running volume, behaviors, and motives changes from the year prior to the pandemic to the timeframe during social isolation restrictions. **Methods:** Runners of all abilities were recruited via social media to complete a custom Qualtrics survey between May 4th and June 4th of 2020 to capture the time period

during peak social isolation restrictions in North America. Respondent demographics (age, biological sex, geographical location, running experience), running volume (total runs per week, sustained runs per week, workouts per week, and weekly mileage), behaviors (pace, running locations, typical running time blocks), and selection of applicable running motives (fitness, competition, socialization, stress relief, pleasure, occupy free time) were self-reported for the year prior to the pandemic, and during the social isolation timeframe. Descriptive statistics and Student's t-tests were used to assess changes in running outcomes during the pandemic. Logistic regressions were used to determine the influence of age, sex, years of running experience, and geographical region on running behaviors, with alpha set a priori to .05 for all analyses. **Results:** A total of 1147 runners (66% females, median age: 35 years) across 15 countries (96% United States) completed the survey. On average, runners reported an increased number of total runs per week (Mean Difference with Standard Error [MD]: 0.30 [0.05], $p < .001$), number of sustained runs per week (MD: 0.44 [0.05], $p < .001$), weekly mileage (MD: 0.87 [0.33], $p = .01$), and typical running time blocks (MD: 0.11 [0.03], $p < .001$) during the pandemic, yet reported lesser number of running workouts per week (i.e. sprint intervals; MD: -0.33 [0.06],

$p < .001$), and less motives for training (MD [SE]: -0.41 [0.04], $p < .001$). Results of the logistic regressions reflected that behavior changes were influenced by running experience, age, and sex (Table). **Conclusions:** The COVID-19 pandemic influenced runners' behaviors such that overall training volume increased, running intensity decreased, and runners reported less extrinsic motives for embarking in running training. These results provide insights into how physical activity patterns were influenced by large-scale social isolation directives associated with the pandemic.

Table. Logistic regression results assessing the influence of demographic factors on running behavior changes during the pandemic.

Predictor	Comparison	Total N Runs Odds Ratio (95% CI)		Sustained Runs Odds Ratio (95% CI)		Workouts Odds Ratio (95% CI)		Motives Odds Ratio (95% CI)		Times of Day Odds Ratio (95% CI)		Mileage Odds Ratio (95% CI)	
		↓ vs. No Change	↑ vs. No Change	↓ vs. No Change	↑ vs. No Change	↓ vs. No Change	↑ vs. No Change	↓ vs. No Change	↑ vs. No Change	↓ vs. No Change	↑ vs. No Change	↓ vs. No Change	↑ vs. No Change
Age	18-25 vs. 26-35	1.20 (0.78, 1.84)	0.81 (0.52, 1.27)	0.98 (0.55, 1.72)	0.98 (0.64, 1.50)	0.53 (0.32, 0.86) *	1.02 (0.35, 2.96)	1.12 (0.72, 1.73)	1.06 (0.59, 1.89)	0.30 (0.12, 0.73) *	0.74 (0.35, 1.54)	0.60 (0.38, 0.93) *	0.79 (0.51, 1.21)
	18-25 vs. 36-45	0.88 (0.56, 1.41)	0.61 (0.37, 1.01)	0.73 (0.39, 1.36)	0.82 (0.52, 1.29)	0.60 (0.36, 1.01)	1.93 (0.70, 5.33)	1.02 (0.64, 1.62)	0.60 (0.29, 1.21)	0.35 (0.14, 0.89) *	0.92 (0.44, 1.95)	0.57 (0.35, 0.92) *	0.73 (0.46, 1.17)
	18-25 vs. 46-55	1.02 (0.60, 1.73)	1.44 (1.23, 1.86) *	0.58 (0.27, 1.25)	0.68 (0.40, 1.18)	0.56 (0.28, 1.12)	1.91 (0.55, 6.67)	1.02 (0.60, 1.72)	0.47 (0.18, 1.22)	0.38 (0.13, 1.10)	0.48 (0.18, 1.23)	0.40 (0.22, 0.71) *	0.70 (0.42, 1.18)
	18-25 vs. 56+	0.77 (0.39, 1.54)	1.15 (0.60, 2.22)	0.96 (0.42, 2.18)	0.49 (0.24, 1.01)	0.53 (0.22, 1.27)	3.47 (0.92, 13.13)	1.11 (0.60, 2.07)	0.48 (0.13, 1.78)	0.33 (0.08, 1.35)	0.41 (0.13, 1.30)	0.50 (0.26, 0.97) *	0.43 (0.22, 0.84)
	Male vs. Female	1.04 (0.75, 1.43)	1.19 (0.82, 1.72)	0.75 (0.49, 1.14)	1.06 (0.76, 1.46)	1.30 (0.87, 1.96)	1.84 (0.83, 4.09)	1.35 (0.97, 1.87)	1.22 (0.72, 2.06)	1.70 (0.81, 3.58)	1.31 (0.77, 2.23)	0.66 (0.47, 0.93) *	0.47 (0.34, 0.64) *
Sex	0-3 vs. 4-10	0.60 (0.42, 0.88) *	0.94 (0.62, 1.41)	0.85 (0.51, 1.43)	0.66 (0.45, 0.97) *	0.90 (0.57, 1.41)	0.42 (0.18, 1.00)	1.28 (0.86, 1.92)	0.35 (0.20, 0.60) *	1.35 (0.59, 3.11)	1.03 (0.50, 2.14)	1.80 (1.17, 2.76) *	0.90 (0.61, 1.32)
	0-3 vs. 11-15	0.62 (0.38, 0.99) *	0.64 (0.36, 1.14)	0.59 (0.29, 1.17)	0.49 (0.29, 0.82) *	0.43 (0.22, 0.83) *	0.42 (0.15, 1.21)	1.04 (0.63, 1.72)	0.20 (0.08, 0.48) *	1.39 (0.47, 4.17)	2.55 (1.18, 5.51) *	1.43 (0.82, 2.49)	1.27 (0.79, 2.02)
	0-3 vs. 16-20+	0.79 (0.50, 1.23)	0.68 (0.39, 1.19)	0.73 (0.38, 1.40)	0.84 (0.53, 1.33)	0.39 (0.20, 0.75) *	0.25 (0.08, 0.73) *	1.14 (0.71, 1.83)	0.23 (0.10, 0.53) *	1.72 (0.57, 5.17)	2.70 (1.23, 5.89) *	1.56 (0.91, 2.65)	1.10 (0.70, 1.74)
Location	US EC vs. US Mw	0.79 (0.56, 1.11)	1.00 (0.69, 1.44)	1.51 (0.74, 1.78)	1.05 (0.75, 1.46)	0.94 (0.64, 1.39)	0.61 (0.28, 1.35)	1.28 (0.93, 1.76)	1.17 (0.70, 1.95)	0.89 (0.44, 1.82)	0.73 (0.42, 1.29)	1.03 (0.73, 1.47)	1.12 (0.81, 1.55)
	US EC vs. US WC	1.73 (0.87, 3.46)	1.34 (0.56, 3.19)	0.50 (0.11, 2.17)	1.70 (0.84, 3.43)	0.48 (0.14, 1.64)	1.35 (0.30, 6.19)	0.94 (0.42, 2.10)	1.49 (0.49, 4.59)	1.82 (0.51, 6.45)	0.61 (0.14, 2.62)	1.16 (0.52, 2.59)	1.21 (0.58, 2.50)

Caption: Table presenting the results of the logistic regression model. The odds ratios presented are the results when comparing the first listed group to the second, such that if the odds ratio is less than one that the first group listed was less likely to change behaviors, and conversely if the odds ratio is greater than one the first group listed was more likely to change. The odds ratio reference was no change in running behavior, and both likelihoods to increase or decrease running behaviors were assessed and presented in the table columns.

Abbreviations: N, number; CI, confidence interval; US, United States; EC, East Coast; Mw, Midwest; WC, West Coast.

*Significant at $p < .05$.

Free Communications, Poster Presentations: Healthcare Administration and Professional Development

On Demand: June 22, 2021-September 30, 2021

A Parental Perspective of the Work-Life Interface of College Athletic Trainers: A Descriptive Qualitative Design

Cairns AH, Rynkiewicz KM, Eason CM, Singe SM: University of Connecticut, Storrs, CT

Context: The collegiate athletic setting is often described as arduous (i.e. long hours, travel, pressure to win). This workplace climate has been found to increase conflicts experienced between work, home, and life roles. Guilt is a newer concept that has been related to work family conflict among athletic trainers. The concept, however, has yet to be fully explored from a descriptive, in-depth perspective. Thus, we aimed to better understand experiences of work-family conflict and guilt from intercollegiate athletic trainers who are parents. **Methods:** We used a purposive sampling process to recruit athletic trainers working in the collegiate setting who were also parents. In total, 12 college athletic trainers (6=female, 6=male) participated in the study. All 12 were married (12 ± 7 years) with children (range 1-4; 2 ± 1). Participants were 39 ± 7 years old and had been working as a certified

athletic trainer for 17 ± 7 years. Participants were asked questions regarding work-family conflict and guilt through a semi-structured interview. All interviews were transcribed verbatim and a phenomenological approach was employed to analyze the data. Data saturation was achieved, and a peer review and multiple analyst triangulation satisfied credibility. **Results:** Our descriptive analyses revealed 3 main themes: 1) conflict and guilt, 2) guilt is bidirectional, and 3) management of guilt. Conflict and guilt were discussed as unavoidable as the role of athletic trainer and parent are equally demanding. Our participants described feelings of conflict and guilt because they wanted to spend time, equally, in each role. Guilt was bidirectional as each role was described as equally important to the athletic trainer. Participants described guilty feelings due to the demands of each role (parent and athletic trainer), creating interference between those roles. The management theme was specifically defined by three subthemes, which included creating a separation between work and parenting roles, the benefits of having a supportive workplace, and the importance of having co-workers and supervisors with shared life experiences, such as the role of being a

parent. **Conclusions:** Work-family conflict and guilt were reported by our participants largely in part due to the demanding nature of both being a parent and an athletic trainer. Life stage of the children has the potential to impact experiences of conflict and guilt, and thus should be further explored. Moreover, our findings suggest that guilt for the athletic trainer in the college setting, who places a high level of importance on their life and work roles, will likely experience guilt due to wanting to perform well in each. Athletic trainers felt they had several coping strategies to manage their conflict and guilt, but still recognized they experienced it regardless.

Athletic Trainers' Perceptions and Frequency of Use of Health Care Core Competencies

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Context: The core competencies (CCs) have been a standard for all healthcare professions since 2001. Although the CCs have been included in post-professional accreditation standards since 2014, they have only recently have they been integrated into professional-level education in athletic training. It is understood that it takes years, in some cases 17 years, for evidence to become common clinical practice, and we have surpassed this timeframe for the core competencies. The purpose of this study was to evaluate athletic trainer (AT) perceptions and frequency of use of the CCs and the perceived preparedness by their educational program.

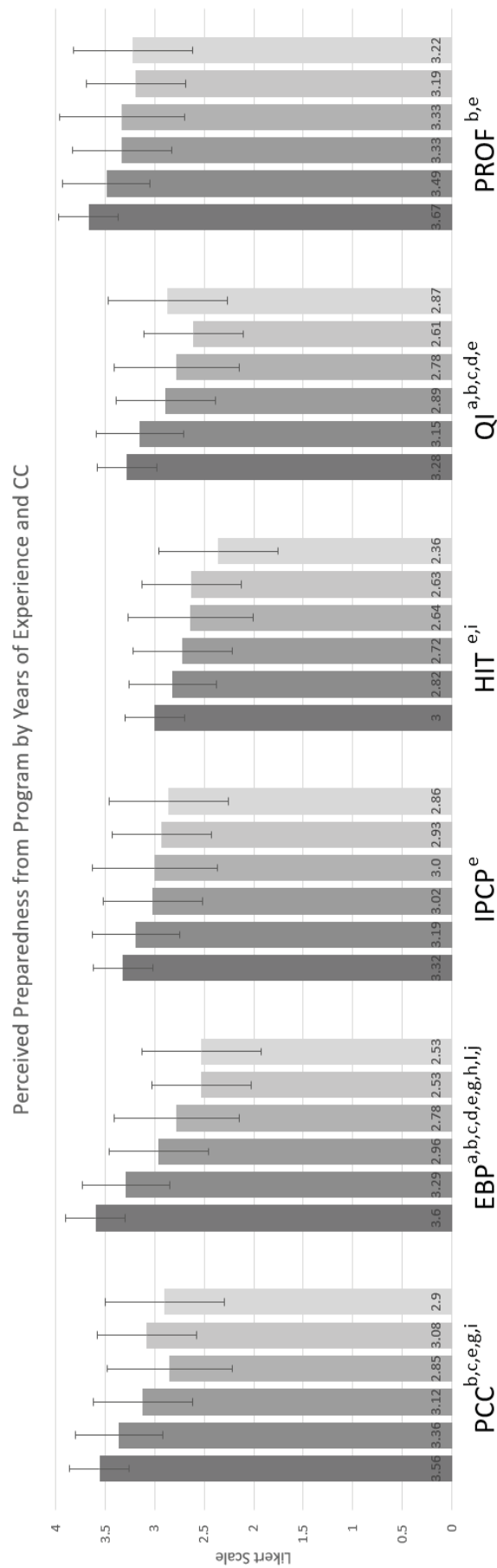
Methods: We used a cross-sectional, web-based survey to randomly sample 7,440 clinically practicing ATs; 674 participants accessed the survey (9.1% access rate) and 554 provided valid responses. We modified a validated survey, which was reviewed by 2 experts for content and face validity. The survey addressed demographics (5 items), perceived use for CCs (22

items), perception of educational preparedness (6 items), and perceived frequency of use with in patient encounters (PEs; 6 items). Descriptive statistics were calculated to characterize overall perception of importance and frequency of use in clinical practice. We used One-Way Analysis of Variance tests to compare perceived preparedness for each of the CCs on years of experience (5 year intervals up to 25+ years of experience).

Results: ATs strongly agreed patient centered care (PCC) is important to their clinical practice (PCCGM=3.59±0.630, Mode=4) and reported frequent use in 85.0±21.8% of their PEs. Evidence based practice (EBP) had the lowest perceived importance, (EBPGM=3.38±0.581, Mode=3) but is still frequently used (73.3±25.6%). ATs agreed interprofessional and collaborative practice (IPCP) is important to their clinical practice (IPCPGM=3.42±0.683, Mode=3) but its integration into practice was the second least used. (67.0±27.7%). Healthcare informatics (HIT) is important to ATs' clinical practice (HITGM=3.21±0.657, Mode=3) and frequently used in PEs (70.8±28.9%). Participants strongly agreed quality improvement (QI) is important to their clinical practice (QIGM=3.42±0.562, Mode=4); however, it is the least often integrated into practice (66.1±26.27%). ATs strongly agreed professionalism (PROF) is important to their clinical practice (PROFGM=3.42±0.562, Mode=4) and frequently used in PEs (85.9±22.9%). We

identified significant differences between years of experience intervals and educational program preparation to integrate the CCs into practice with those that more recently completed their professional education feeling more prepared (Figure). EBP, QI, and PCC showed the greatest differences between subgroups respectively. **Conclusions:** The degree to which ATs find the CCs important in their practice is consistent with previous research in athletic training education. Clinically practicing ATs who have less than 10 years of experience largely believe their programs have adequately prepared them, but more work needs to be done to create and deliver professional development to aid more experienced ATs in feeling prepared to integrate the CCs into practice.

Figure 1: Perception of Preparedness from Program



^a 0-5 years of experience compared to 6-10 years of experience

^b 0-5 years of experience compared to 11-15 years of experience

^c 0-5 years of experience compared to 16-20 years of experience

^d 0-5 years of experience compared to 21-25 years of experience

^e 0-5 years of experience compared to 25+ years of experience

^f 6-10 years of experience compared to 11-15 years of experience

^g 6-10 years of experience compared to 16-20 years of experience

^h 6-10 years of experience compared to 21-25 years of experience

ⁱ 6-10 years of experience compared to 25+ years of experience

^j 11-15 years of experience compared to 25+ years of experience

**Athletic Training Specialty
Certifications: Athletic Trainers'
Perception and Knowledge**

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University, Springfield MO, and
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Context: Health care is constantly evolving. Providers must stay up to date with continuing education and professional development, which includes a need for recognition. One way health care professionals are recognized for their advanced care abilities is through specialty certifications. These certifications recognize the clinician for obtaining more knowledge and skills to improve clinical practice and provide optimal care to patients. The practice of a profession can be validated by a systematic study called a practice analysis. Although athletic training has not yet implemented specialty certifications, the BOC Orthopedic Practice Analysis became available for public comment in the fall of 2020. If formally approved, the practice analysis will validate the existence of the first athletic training specialty in orthopedics. It is unclear what athletic trainers know and perceive about specialty certifications in athletic training. The purpose of our study was to examine the following issues: (1) identify what athletic trainers know about specialty certifications; (2) identify values

and barriers athletic trainers perceive to be associated with specialty certifications; and (3) examine differences in these findings based on athletic trainer state practice acts being more or less restrictive. **Methods:** We utilized a non-equivalent group, cross-sectional survey design. We developed a survey aimed at describing the participants' knowledge and perceptions about specialty certifications. After drafting our initial questions, we recruited 6 athletic trainers with expertise in the areas of specialty practice, certifications/credentialing, and athletic training education. Four of these 6 experts completed the content validity index for the instrument, and from their responses, we calculated an S-CVI/Ave of .925. We recruited our participants from the BOC database of credentialed athletic trainers who identified as practicing in 1 of 6 states, 3 of which we identified as having more restrictive practice acts and 3 we identified as having less restrictive practice acts. We sent recruitment emails to 4,503 athletic trainers. We received 342 responses for a 7.6% response rate and an 87% completion rate. **Results:** Of the 9 knowledge questions, 7 of them were answered incorrectly or do not know by more than 50% of the participants. Using nonparametric analyses, we calculated no statistically significant differences in perceived intrinsic rewards, extrinsic rewards, or barriers when comparing the participants' state practice act restrictions and sex. We did calculate statistically significant differences

in the level of agreement regarding the intrinsic rewards, extrinsic rewards, and barriers from specialty certifications. **Conclusions:** Athletic training specialty is a relatively new concept in athletic training. We concluded athletic trainers have limited knowledge about specialty certifications. In addition, state practice act restrictions did not affect perceptions about the value and challenges of specialty certifications. Participants agreed most with the intrinsic rewards of specialty certifications.

Athletic Training Students' Knowledge and Attitudes of Transgender Athletes
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Context: Limited research exists on athletic training students' (ATS) knowledge or attitudes toward transgender athletes. The purpose of this study was to determine ATS knowledge and attitudes of transgender athletes using the Athletic Training Student Transgender Knowledge Survey (ATSTKS) and Attitudes Towards Transgender Patients (ATTP) scales. **Methods:** A cross-sectional survey with purposeful sampling of ATS in CAATE Accredited Professional Athletic Training Programs was conducted. ATS were contacted through their Program Director, Clinical Education Coordinator, or via NATA student members database. Independent variables were gender, sexual orientation, ethnicity, training on lesbian, gay, bisexual, transgender and queer (LGBTQ+) populations. Dependent variables were scores on the ATSTKS and ATTP scale. We analyzed 356 surveys (age = 22.37 ± 1.8 years; 26.4% male, $n=94$; 71.3% female, $n=254$; .3% transgender male, $n=1$; .3% non-binary, $n=1$; 84.6% heterosexual, $n=301$; .6% gay, $n=2$; 3.9% lesbian, $n=14$; 6.7% bisexual, $n=24$; .3% asexual, $n=1$; 1.1% pansexual, $n=4$; 1.4% queer,

$n=5$). Descriptive statistics were calculated and MANOVAs ($P = .05$) compared gender, sexual orientation, ethnicity to ATSTKS and ATTP scores. An independent t-test on training/no training with ATSTKS and the ATTP scores was calculated. Point biserial correlation was calculated to determine the relationship between ATSTKS and ATTP scores. **Results:** The mean ATSTKS score was 19.09 ± 4.55 . The ATSTKS scores indicated main effects for gender (female 19.1 ± 4.5 , male 18.8 ± 4.72 , transgender 28, non-binary 23; $F_{3,49}=2.242$, $P = .05$), sexual orientation (lesbian 21.7 ± 3.8 , gay 22 ± 9.9 , bisexual 19.9 ± 3.8 , straight 18.8 ± 4.5 , pansexual 23.5 ± 5.8 , queer 22.4 ± 8.1 ; $F_{3,47}=1.984$, $P = .048$), and ethnicity (Caucasian 19.3 ± 4.3 , Black 20.4 ± 5.8 , Asian 17.3 ± 4 , American Indian/Alaskan Native 13 ± 2.7 ; $F_{3,51}=4.414$, $P = .002$). The average ATTP score was 39.4 ± 7.25 . The ATTP scores indicated main effects for gender (female 40.3 ± 7 , male 36.8 ± 7.1 , transgender 35, non-binary 49; $F_{3,49}=2.242$, $P = 0.05$) and sexual orientation (lesbian 45.5 ± 4.4 , gay 40 ± 14.1 , bisexual 42.7 ± 7 , straight 38.6 ± 7.2 , pansexual 47.5 ± 2.1 , queer 42.8 ± 5.6 ; $F_{3,47}=1.984$, $P = 0.048$). Formal training on LGBTQ+ populations was completed by 21.2% ($n = 75$) of participants, of which 5.6% received specific to transgender populations ($n = 20$). Participants receiving training on transgender populations had significantly higher scores on the ATSTKS (22 ± 5.27) compared to those without training (18.9 ± 4.45 ; $t_{353}=2.956$, $P = .003$). A significant correlation was found between the ATTP and ATSTKS scores ($r = .198$; $P <$

.01). **Conclusions:** ATS had positive views of transgender patients and treating transgender athletes. Females, lesbians, and pansexuals demonstrated more positive views of transgender patients than other genders and sexual orientations. ATS with previous training on transgender populations had higher knowledge scores. Higher knowledge scores were correlated with more positive attitudes. ATS have little training on specific needs of the transgender population with few reporting having skills to discuss medical conditions or athletic policies concerning transgender patients.

College/University Independent Medical Care in the COVID-19 Era

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IN

Context: Legislation was created for NCAA Divisions I, II, and III to guarantee an independent medical care administrative structure designed to give “unchallengeable autonomous authority” regarding diagnosis, management, and return to play decisions to primary athletics health care providers (physicians and athletic trainers). Legislation required each institution to designate an “athletics health care administrator” (AHCA) to oversee athletics health care administration and delivery. The purpose of this project was to 1) explore the structure of athletic health care in NCAA athletic institutions as it relates to independent medical care and 2) describe changes in those structures that have occurred as a result of the COVID-19 pandemic.

Methods: We used a cross-sectional survey design that included open and closed ended questions. This was a web-based survey distributed using Qualtrics® (Provo, UT). The instrument included questions about AHCA roles and selection at NCAA Division I, II, and III institutions. We compiled a database of Head Athletic Trainers and Directors of Sports Medicine from

NCAA Division I, II, and III institutions. They were emailed for their responses, and a reminder email was sent out every week for 4 weeks. We included partial data in the descriptive analysis. Open-ended questions were evaluated using inductive coding. **Results:** A total of 202 participants (age=45±11y; experience=22±10y; male=108, 52.4%, female n=65, 31.6%) responded to the survey. A majority of participants indicated their institution followed an athletics health care model (n=163, 79.1%) and the Head Athletic Trainer/Director of Sports Medicine was the individual most commonly chosen for the AHCA role (n=155, 75.2%). The vast majority of participants (n=190, 92.2%) indicated they were involved in policy development at their institution related to sport participation and COVID-19. Participants reported that a team physician or athletic trainer were the most involved in the decision making structure at their institution. Approximately one third of participants (n=67, 32.5%) indicated there would be a change in their decision-making structure due to a positive COVID result. Specifically, a positive COVID result would introduce local health departments, student health services, and other specialists into the decision-making structure. Participants indicated team physicians, coaches, athletic administrators, and other team support staff were most commonly included in the reporting structure for an injury/illness that resulted in

>10 days lost. Approximately one fourth of participants (n=54, 26.2%) indicated there would be a change in their reporting structure due a positive COVID result. Changes included the need to inform local health departments, campus housing, and the Dean of Students for contact tracing purposes. **Conclusions:** While most participants reported their health care structures have stayed consistent despite COVID-19, some participants did indicate an increased need to include others outside of athletic health care for reporting and decision-making purposes due to COVID-19.

Documentation Behaviors of Athletic Trainers Employed in College/University Clinical Settings

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Context: It is important to understand the documentation practices of athletic trainers (ATs) practicing in a variety of clinical settings, as this helps shape our knowledge of the behaviors and challenges related to documentation. While documentation practices have been examined for those practicing in secondary school, clinic, physician practice, and emerging settings, investigations of the college/university AT population are limited. Therefore, the purpose of our study was to examine the documentation behaviors of ATs employed in college/university clinical settings. **Methods:** Using the qualitative consensual qualitative research (CQR) approach, we recruited 13 ATs, averaging 36 ± 7.6 years old and 14 ± 7.6 years' experience as an AT using purposeful, convenience, and snowball sampling strategies. Participants practiced in the community college ($n=1$), NCAA Division I ($n=8$), Division II ($n=2$), and Division III ($n=2$) clinical

settings. We used an established semi-structured interview guide to obtain participants' perceptions and behaviors of their patient care documentation practices via an individual telephone interview. Interviews were recorded, transcribed, and de-identified prior to analysis. We used the CQR approach to analyze the data with the primary research team ($n=3$) analyzing and serving as internal rotating auditors, along with one external auditor. Data were analyzed over 2 rounds, a consensus codebook was established, then data were analyzed by 1 investigator and audited by 3 auditors (2 internal, 1 external) prior to finalizing the results. We established stability of the data and saturation was achieved. Several measures of trustworthiness were used including multiple analysts, analytic memos, an established interview guide, and an external auditor. **Results:** We identified three themes related to collegiate ATs' documentation practices, including culture of documentation, motivations to document, and documentation strategies. Participants perceived that the culture of documentation within the athletic training profession is improving, but challenges to documenting remain, including prioritizing patient care over documentation and a lack of guidance from employers on what to document. Participants were motivated to document in order to monitor treatment effectiveness and coordinate care among

multiple providers, and used strategies such as electronic medical records and point-of-care documentation to facilitate timely and efficient documentation. **Conclusions:** Positively, ATs in the collegiate setting perceived the professional emphasis and prioritization of documentation is improving across the profession. Similar to ATs employed in secondary schools, they are motivated to document to improve patient care and communication. However, participants desired more professional and employer guidelines to clarify what they are supposed to document. Unlike ATs in the secondary school, but similar to ATs employed in clinic, physician practice, and emerging settings, ATs in the collegiate setting used strategies including electronic medical records and appointment-based treatments to help facilitate thorough and efficient point-of-care documentation. Other ATs may consider implementing these strategies to improve their own documentation practices.

Employment Models of Athletic Trainers in Secondary Schools With Title I Support

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Context: The Elementary and Secondary Education Act of 1965 (more commonly known as Title I) from the United States Department of Education was created in order to provide fair and equitable education for all public school students that are in lower socioeconomic areas. These funds may be allocated to improve infrastructure in schools along with other support services. Secondary schools that receive Title I support may have healthcare inequities among student-athletes in addition to other socioeconomic disadvantages. It has yet to be explored how many secondary schools in the United States receive Title I support and have athletic training (AT) services. The purpose of this study is to identify likelihood of secondary school AT (SSAT) services by employment model in schools that receive Title I support. **Methods:** Athletic Training and Locations and Services (ATLAS) survey data from the 2019/20 academic year. All schools with complete Title I

support categories (n=10271) were matched with National Center for Education Statistics (NCES) data on Title I support for that time period. Schools with incomplete or missing Title I information were excluded from analysis. To identify AT services in these schools, SSATs that completed the ATLAS Survey were included in final data analysis (n=3918). Respondents that did not answer questions related to employment were excluded. SSAT employment models include School district employee (SD), Medical/university facility (MUF), and Independent Contractor (IC). SD included ATs whom also had teaching responsibilities. 2x2 Contingency tables, Pearson's Chi-Square (χ^2) and likelihood ratios were utilized in order to determine the likelihood of employment model of the SSAT and schools that receive partial Title I support and school-wide Title I support. **Results:** The contingency table of SSAT employment provider and Title I supported schools are included in Table 1. Percent of SSATs employed by SD accounted for 36.1% of the dataset, (n=1414/3918) while MUF employed SSATs were 59.0% (n=2313/3918) and lastly 4.9% SSATs are employed by IC (n=191/3918). Employment provider of SSATs and schools that receive partial Title I support did not have a significant relationship ($\chi^2=0.69$, $p=0.71$, $LR=1.05$). In contrast, in schools that receive school-wide Title I

support, it is 23.3 times more likely to have an athletic trainer that is employed by MUF than SD or IC ($\chi^2= 22.96$, $p=0.00$, $LR=23.29$). **Conclusions:** SSATs are more likely to be employed by a Medical University Facility and serving a school that receives school-wide Title I support. These findings are critical to help identify healthcare disparities in low socioeconomic status areas. The findings of this research study may also help provide insight into strategic planning amongst key stakeholders in order to provide equitable healthcare opportunities for those involved in secondary school athletics.

Table 1. Employment Provider of Secondary School Athletic Trainers and School-Wide Title I Supported Schools. *indicates statistical significance, $p<0.05$.

Employment Provider	School-wide Title I Support No	Title I Support School-Wide Yes	Total	χ^2 , LR, p-value
SD	371	1043	1414	22.96, 23.29, $p=0.00^*$
MUF	779	1534	2313	
IC	62	129	191	
Total	1212	2706	3918	

Hiring Patterns Among Collegiate Athletic Trainers in Leadership Positions

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Context: The purpose of this study was to gain knowledge of hiring patterns in collegiate athletic training clinical settings. The emphasis was placed on decision-making factors related to a job applicant's qualifications. Of most interest is whether previous collegiate athletic training experience is favored versus candidates with only secondary school setting experience.

Methods: 608 athletic trainers (AT) identified by the NATA's Survey Research Service met the criteria for. A total of 130 (21%) AT completed the survey (QualtricsTM) via email. The survey was accessible for 4 weeks with a weekly reminder. ATs in leadership positions, defined as the "head athletic trainer" or "director of sports medicine" in accordance with NATA membership classification, were invited to identify professional qualities and skill sets deemed essential when hiring ATs aspiring to work in the collegiate setting. All responses were provided anonymously. **Results:** 93% of participants held the title of "head athletic trainer" while the 14% selecting other held titles like "associate head athletic trainer", "associate director of athletics-internal operations", and "assistant athletic

director for sports performance." 75% of participants were male with no participants identified as non-binary. 50% of participants have experience working in the secondary school setting but only 26% of ATs surveyed would be willing to hire an AT coming from the secondary school setting. 72% are more likely to hire an AT coming from another collegiate job compared to a secondary school AT. When asked if they would hire an AT coming from the secondary school setting applying for a position in their current collegiate environment, 70% stated they would not be able to determine on that criteria solely. Reasons why ATs in leadership positions believe secondary school ATs would not be a good fit include travel and time responsibilities, demands of the setting, and pressure from coaching staffs. Many participants agreed that the ability to multitask, strong work ethic, dependability, good communication skills, and time management are essential qualities considered when hiring a new candidate but experience at the collegiate level overwhelmingly increases the chances of being hired. **Conclusions:** Results of this survey demonstrate that while specific skill sets and characteristics are valued by decision-making AT's in the collegiate setting when hiring an AT, previous experience working at the collegiate level is perceived to be advantageous. Therefore, AT's interested in transitioning from the secondary school setting to the collegiate

setting are encouraged to gain additional experience in a collegiate setting regardless of other experience. The clinical take home message is ATs hiring for collegiate positions should emphasize their perceived importance of previous experience in a similar setting. Doing so will assist in preparing those wanting to transition to the collegiate setting from a different athletic training environment.

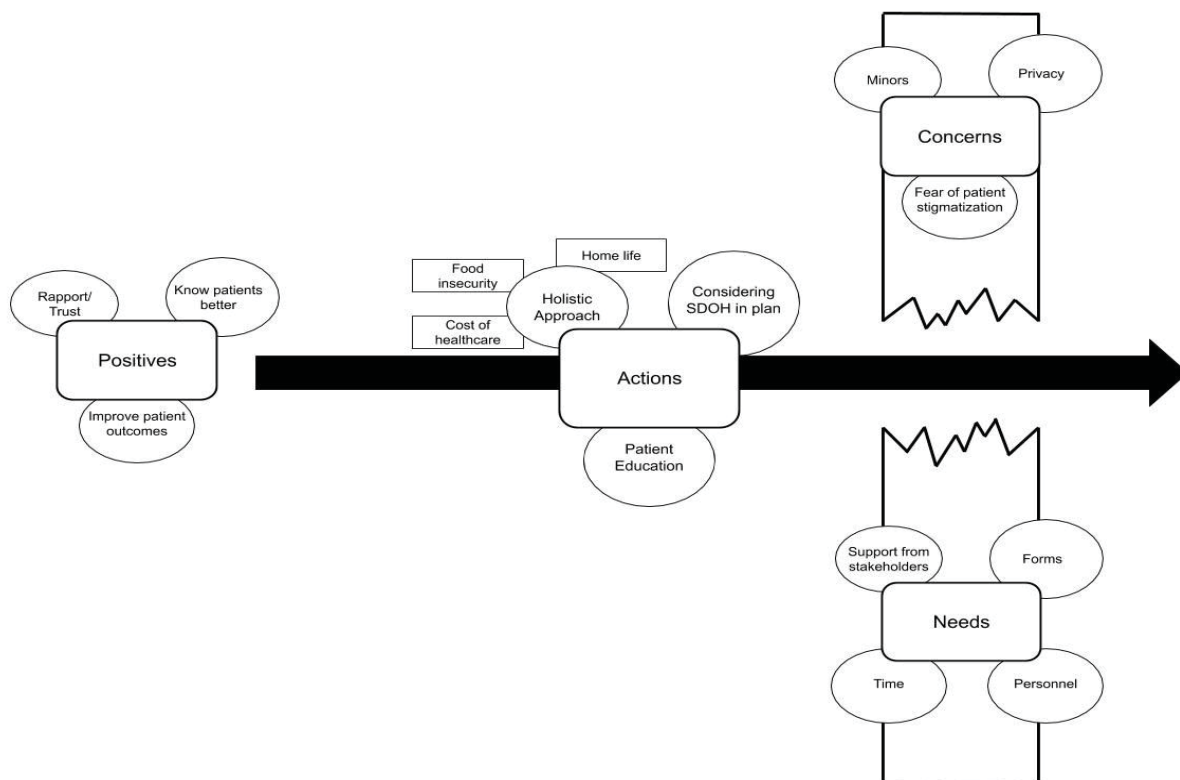
Incorporating the Social Determinants of Health in Healthcare Delivery Among Secondary School Athletic Trainers

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Context: The social determinants of health (SDOH) are the circumstances that govern how we are born, live, work, play, and age and how these factors influence health. Athletic trainers (ATs) traditionally lack the knowledge of SDOH in practice. We sought to analyze how exposure to SDOH concepts influenced ATs potential for integration into practice. **Methods:** Following a randomized controlled trial exploring an intervention to educate ATs on the SDOH, we asked participants to share their lived experiences contemplating the integration of SDOH in practice using a qualitative survey approach. In total, 258 ATs were enrolled in the control (n=129) or intervention (n=129) group. The control group were made aware of the SDOH through a preliminary assessment of their knowledge, where the intervention group received 12 weekly infographics about the SDOH. Qualitative data were collected through open-ended survey questions (Qualtrics®, Provo, UT) at the conclusion

of the study from participants of both groups (n=74/258 responses; control group=42, intervention group=32) on the integration of SDOH in practice (6 questions). We used a 2-person data analysis team with an inductive coding approach. The researchers reviewed the responses independently, met to develop a codebook, and applied the codes. Trustworthiness was established through multiple-analyst coding and internal auditing. **Results:** Four themes emerged from the responses, representative of both groups: (1) positives, (2) actions, (3) needs, and (4) concerns (Figure). The ATs described anticipated positives effects of implementing SDOH in their practice. They believed using the SDOH would help them build rapport and trust with their patients and would lead to improved patient outcomes, such as better patient care, higher adherence, and enhanced treatment planning. The ATs desired to approach care more holistically, ensuring they addressed food insecurities, focused on healthcare cost, and took an interest in the patient outside of school. The ATs also described taking action to consider the SDOH in their care plans and incorporating more patient education. The ATs identified needing more support from stakeholders in their practice, such as parents, coaches, and administration. They also expressed a desire for pre-made forms to implement SDOH screening or a more comprehensive patient history. The ATs indicated more time and personnel would help them integrate the SDOH

with more ease. However, the ATs were also concerned about asking intrusive questions to minors and the lack of privacy in their facility, which would not allow for honest information gathering. Those concerns were coupled with the fear that patients might feel stigmatized if their truths were known. **Conclusions:** Overall, SS ATs believe that implementing SDOH into their practice can create positive outcomes in patient care. Although many ATs expressed needs and concerns toward implementation, the introduction of SDOH education led SS ATs to desire to approach patient care more holistically.



Interprofessional and Collaborative Practice for Athletic Trainers in the Secondary School Setting

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IN, and Western Carolina, Cullowhee,
NC

Context: Engaging in interprofessional and collaborative practice (IPCP) is one of the Institute of Medicine's core competencies for all health-care professionals. In collegiate athletic training, IPCP is perceived to be beneficial to patients but is not consistently practiced. Currently, little is known about IPCP practices in the secondary school setting. The purpose of our research was to investigate the perceptions and practices of athletic trainers practicing in secondary schools (SSATs) regarding IPCP. **Methods:** We employed a cross-sectional, survey design and used a modified version of the Clinician Perspectives of Interprofessional Collaborative Practice Survey, a web-based, validated survey consisting of six individual constructs and four open-ended response questions. The constructs in this survey are divided into two sections, the first containing constructs 1-4 and the second containing constructs 5-6. Section 1 focuses on perceptions and uses a 5-point Likert scale of 1=Strongly Disagree to 5=Strongly Agree. Section 2 focuses on practices and uses a 4-point

Likert scale of, "this statement is always true in regard to my clinical setting" to "I am not familiar with the concept in this statement." We calculated descriptive statistics to characterize the scores on each construct. The open-ended items ask participants to describe their perceived challenges, resources, drawbacks, and benefits relative to IPCP. We analyzed the open-ended, qualitative data using a general inductive coding process and multiple analysts and auditing to establish trustworthiness. **Results:** We sent the survey to 4,666 SSATs. Five hundred and seven (10.9%) SSATs responded, and 379 (74.8%) completed the survey in its entirety (Table 1). SSATs agreed with constructs 1-4 regarding the importance of working with other healthcare providers (construct 1=3.41±0.33), engagement in collaborative practice (construct 2=3.27±0.43), influences on collaborative practice (construct 3=3.37±0.38), and influences on roles, responsibilities, and autonomy in collaborative practice (construct 4=3.09±0.34). In Section 2, ATs marked the statements were either always true or sometimes true in their clinical setting on impact of communication on collaborative practice (2.08±0.48) and patient involvement in collaborative practice (1.85±0.49). Three main themes emerged from the qualitative data: 1) communication, 2) infrastructure, and 3) learning. Communication was critical to IPCP, whereby having access to shared information, specifically through an

electronic medical record improved collaboration. Not having shared mechanisms for communicating made collaboration more difficult. SSATs were often responsible for initiating communication. A strong infrastructure that enhanced access to other providers, incorporated parents, and improved efficiency helped support IPCP. When an infrastructure was absent, IPCP deteriorated. IPCP resulted in learning between providers, including roles and responsibilities, which yielded stronger trust and respect. IPCP resulted in idea sharing and improved patient outcomes. **Conclusions:** SSATs and collegiate athletic trainers have similar perceptions and practices regarding IPCP. Communication and infrastructure lead to improved outcomes and trust between providers.

Demographic Characteristics	
	Mean ± SD
Years BOC Certified	12.04 ± 10
	No. (%)
Gender	
Male	146 (38.5)
Female	232 (61.2)
Transgender	1 (0.3)
Highest Degree Earned	
Bachelors	110 (29)
Masters	257 (67.8)
Doctorate (PhD, EdD, etc.)	1 (0.3)
Clinical Doctorate (DAT, DPT, etc.)	10 (2.6)
Other	1 (0.3)
Description of Employment	
School District Employee	104 (27.4)
School District Employee with Teach Responsibilities	38 (10)
Medical or University Employee	142 (37.5)
Independent Employee	9 (2.4)
Other	85 (22.4)
Have you had formal interprofessional education? (classes, workshops, CEU courses, etc.)	
Yes	339 (89.4)
No	40 (10.6)
Which of the following healthcare providers do you collaborate with on patient care?	
Physician	346 (91.3)
Chiropractor	75 (19.8)
Physical Therapist	287 (75.7)
Occupational Therapist	30 (7.9)
Nurse	134 (35.4)
Physician Assistant	157 (41.4)
Other	52 (13.7)

Job Satisfaction of Athletic Trainers' During the COVID-19 Pandemic

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University of South Carolina, Columbia, SC;
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Context: The COVID-19 global pandemic has impacted the way the modern world operates. For athletic trainers (ATs) in the college/university and secondary school settings, the day-to-day operations with athletics were immediately halted with the cancellation of athletics and in-person education. The purpose of this study was to explore the impact the COVID-19 pandemic had on AT employment and job satisfaction. **Methods:** We performed a cross-sectional web-based survey amidst the COVID-19 pandemic during September 2020. Participants were recruited from Facebook® (19 posts) and Twitter® (25 tweets) related athletic training accounts resulting in 426 viable responses for the analysis. The cross-sectional survey explored their current job setting, status, and

duties during the pandemic. Additionally, we utilized the 26-item Employee Job Satisfaction and Engagement instrument from the Society of Human Resources which is scored using a 5-point Likert scale (1=very dissatisfied, 5=very satisfied). Participants were predominantly women (n=276, 64.8%; men=150, 35.2%) and mid to early career (age=32±9y; years of experience=10±9y). Most participants were currently employed in the secondary school (n=169, 39.7%) or college/university (n=122, 28.%) settings. We analyzed the data using descriptive statistics for all survey items with independent samples t-test comparisons for job satisfaction compared to job setting changes. **Results:** Overall, 60% of ATs (n=255) had not changed their job setting during the pandemic while the others had changed job settings as a result (n=145, 34.0%) and not as a result (n=25, 6.0%) of the pandemic. Most ATs felt that their job setting (n=296, 64.5%) and daily job duties (n=303, 71.1%) would return to a typical presentation following COVID-19. However, ATs reported they had little to no role (n=231, 54.2%) in deciding their job duties such as front line screening for COVID-19 (n=145, 34.0%),

providing patient care to a new patient panel (n=110, 27.9%) and performing healthcare administrative tasks (n=170, 39.9%). Despite the changes due to COVID-19, only 4.7% (n=20) of participants stated they were on unpaid furlough or laid off as compared to 85.9% who had no change in job status including pay (n=366). Overall, most participants felt either extremely or moderately secure (n=278, 65.3%) in being employed as an AT. The finding was consistent with participants expressing overall satisfaction with employment (3.59±0.69) on the job satisfaction tool. Job satisfaction means were lowest for those unemployed due to COVID-19 (n=15, mean=2.68±0.86) and highest for those in the military setting (n=10, 4.06±0.68). We did not identify any significant difference in overall job satisfaction between ATs who did and did not have a job setting change during the pandemic (p=0.142). **Conclusions:** Although large number of participants were forced into new positions due to the pandemic, there high levels of satisfaction with their current employment. ATs continue to demonstrate the ability to adapt to changes in their job.

Table – Mean scores for the respondents on the Employee Job Satisfaction and Engagement Tool

Instrument item	Mean	Mode
Autonomy and independence	4.08±0.96	Satisfied
Feeling safe in the work environment	3.82±1.00	Satisfied
Relationship with co-workers	4.09±0.93	Satisfied
Opportunities to use skills/abilities	3.77±1.11	Satisfied
The work itself	3.74±1.03	Satisfied
Meaningfulness of job	3.88±1.06	Satisfied
Relationship with immediate supervisor	3.87±1.10	Satisfied
Job security	3.74±1.09	Satisfied
Overall culture	3.61±1.04	Satisfied
Organization's commitment to a diverse and inclusive workplace	3.76±0.98	Satisfied
Organization's financial stability	3.55±1.10	Satisfied
Variety of work	3.69±0.92	Satisfied
Contribution of work to organization's goals	3.73±0.95	Satisfied
Benefits	3.78±1.09	Satisfied
Networking	3.56±0.94	Satisfied
Communication between employees and management	3.32±1.18	Satisfied
Organizations' commitment to professional development	3.42±1.13	Satisfied
Organization's commitment to social responsibility	3.53±1.01	Satisfied
Administration's recognition of employee job performance	3.29±1.12	Satisfied
Flexibility to balance life and work issues	3.53±1.17	Satisfied
Job-specific training	3.51±0.99	Satisfied
Career development opportunities	3.35±1.05	Satisfied
Organization's commitment to a "green" workplace	3.12±0.97	Neutral
Paid training and tuition reimbursement programs	3.13±1.19	Neutral
Compensation/pay	3.28±1.18	Satisfied
Career advancement	3.21±1.04	Neutral
Overall job satisfaction	3.59±0.69	Satisfied

Score of 1.0 is very dissatisfied and 5.0 is very satisfied.

Locus of Control in Athletic Training

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University, Terre Haute, IN

Context: Locus of control (LOC) is the range someone feels they have control over outcomes in their life; work locus of control (WLOC) is the control someone feels over their work. LOC and WLOC are categorized by being internally (results based on self) or externally (results based on circumstances) affected. Athletic trainers describe difficulty changing their circumstances, whether it's implementing new concepts into practice, or their overall feelings of control over work-life integration. To understand how athletic trainers perceive their ability to control their lives and work situations, we sought to examine both the LOC and WLOC in athletic trainers. **Methods:** We used a cross-sectional design with ATs who have daily patient care responsibilities and were randomly sampled and self-selected (n=288) to complete the assessment. Incomplete surveys were omitted from the analysis (n=288, response rate=6.5%). A 27-item web-based survey was created and included demographic (9-items), the validated Rotter LOC survey (10-item), and Spector WLOC survey (8-item). The

independent variables in the study included age, gender, work setting, ethnicity, education level, years of experience, part-time or full-time work status, supervisor duties, and personnel that directly report. LOC and WLOC scores were calculated and classified participants with tendencies to be internally or externally controlled, referred to as calculating the internal/external (I-E) for each scale. **Results:** The study had 213 participants (age: 34.9 ± 9.7 y, White/Caucasian N=192, 90.1%) ranging from 23 to 68 years old. There were 118 female and 95 male participants with 1-48 years of experience (mean= 11.7 ± 9.1). Nearly all (N=206, 96.7%) participants were full-time employees. The most common level of education for participants was the professional master's degree (45.1%) and post-professional master's degree (31.9%), while the most common work settings were the secondary (38.8%) and college/university (35.7%). There were no significant differences between any independent variables and LOC or WLOC ($p > 0.05$). Athletic trainers more often held an external LOC view (N=108, 50.7%) in their personal lives, they held an internal LOC view at work (N=197, 92.5%), a statistically significant difference ($p < 0.001$). **Conclusions:** We hypothesized that athletic trainers would have a stronger internal LOC compared to external WLOC. However, we found that athletic trainers expressed an

external LOC in their personal lives while reporting an internal WLOC. Having a better understanding how athletic trainers perceive their own control over their lives and work situations can help focus staff development or changes to clinical practice in a way that meets their perception of control. This study provides foundational information that could allow us to explore why ATs with internal WLOC claim lack of control in implementing changes into their clinical practice

Mindfulness Based Stress Reduction as an Intervention for Musculoskeletal Pain: A Systematic Review

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Context: Athletic trainers frequently address and treat musculoskeletal (MSK) pain. Complementary and alternative techniques for treating pain are becoming more widely accepted and utilized in clinical practice. Mindfulness based stress reduction (MBSR) is a meditation-based program that is designed to help patients learn to feel things in a non-judgemental way. MBSR has been used for a variety of conditions including studying the effects of MBSR on MSK pain. Previous studies and systematic reviews have focused a range of conditions including IBS, fibromyalgia, and migraines. The purpose of this systematic review was to examine if the literature supports the use of MBSR as an intervention for MSK pain. **Methods:** We completed a systematic review utilizing the PRISMA guidelines. Inclusion criteria were English language, human subjects, peer reviewed, randomized controlled trial, mindfulness training as an intervention, and MSK pain as an outcome measure. An electronic search

was conducted using the single phrase “mindfulness training and musculoskeletal pain”. PubMed, Cochrane Database, EBSCOhost, and Google Scholar were searched. The initial search resulted in 1018 articles. Articles were first eliminated by title, and then by abstract contents. Remaining articles were given a full review and articles not meeting inclusion criteria were eliminated. Articles were then assessed using the PEDRO scale with a cutoff score of 6 used to determine inclusion in the systematic review. Studies below a score of 6 were deemed to be low quality and were not included in the analysis. The final analysis included 19 articles.

Results: Study populations included patients diagnosed with cancer, nonspecific low back pain, chronic MSK pain, chronic tension headache, Gulf War illness, upper extremity injury, and one study employed healthy subjects and used experimentally induced pain. The total number of subjects was 2283. Intervention lengths ranged from a single day to 10 weeks with follow-up periods up to 1 year. The majority of articles used MBSR as the primary intervention. Those that did not use MBSR used mindfulness based cognitive therapy (MBCT), mindfulness oriented recovery enhancement (MORE), or general mindfulness training. The average PEDRO score for the articles was 7. Of the 19 studies in

the analysis, nine of them indicated statistically significant results in favor of the meditation group for pain outcomes. Other studies noted improvement in the meditation group, but results did not reach statistically significant levels.

Conclusions: MBSR has the potential to provide a beneficial effect in the treatment of MSK pain. The results of this systematic review indicate that the benefits of MBSR treatment may depend on the specific patient population and type of MSK pain. Further research is needed, but the systematic review suggests that MBSR may be an effective tool as part of a larger, complementary and patient-centered care plan.

Perspectives of Structured Policies and Organization as Ways to Improve Work-Life Balance: A Critically Appraised Topic

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Context: Work-life balance (WLB) has become an essential topic of interest for health care providers and athletic training professionals alike as the literature has documented WLB is related to retention, quality of care, and higher job satisfaction. Several studies from related professions stated WLB occurred through implementation of multi-faceted work policies. The purpose of this critically appraised topic was to determine if policies and organizational skills impacted WLB and if so, to further identify effective in increasing job satisfaction and retention. **Methods:** Sources searched were PubMed, MEDLINE, ScienceDirect, and Google Scholar. The following terms were used to conduct the search: athletic training, work, burnout, organization, and policy. The inclusion criteria for articles in the appraisal was limited to studies pertaining to athletic trainers employed in collegiate settings (clinical and/or educational role), qualitative or phenomenological study design with interviews, and written in the last 5 years. Studies focused on athletic trainers immediately

after certification (within 1 year of certification) were excluded. Each study used was scored using the Standards for Reporting Qualitative Research (SRQR). **Results:** Three articles were identified out of 47 from the search and achieved a moderate level of evidence (Table). Two of the 3 articles resulted in the perception that achievement of work-life balance was possible through proper structuring of demands and time. Individuals recognized demand for time could be balanced through policies and a culture of support in a clinical and educational setting. One study found participants were not aware of policies related to work-life balance that were offered, and stated improved policies were the key to attaining work-life balance in their current position (Table). **Conclusions:** All 3 studies recommended similar policy improvement strategies to achieve WLB regardless of the work setting, clinical or higher education. Organizational strategies included increased effective communication and supportive networks, which were the most critical factors in achieving balance and flexibility. This led to decreased individual workload and increased peer support. The evidence from this appraisal highlighted personalized strategies, management of individual responsibilities, and echoed the importance of solidifying a time management plan. All of these policies and strategies

increased work productivity and reduced overall stress. Management of WLB is a necessary focus for all stakeholders because it is essential for well-being, increased retention, and for a more productive work environment.

Table. Summary of study design, emerging themes, and appraisal.

	Goodman et al. Achieving Work-Life Balance in the National Collegiate Athletic Association Division I Setting, Part II: Perspectives From Head Athletic Trainers (2015)	Mazerolle et al. Perceptions of Work-Life Balance Practices Offered in the Collegiate Practice Setting (2017)	Mazerolle and Barrett. Work-Life Balance in Higher Education for Women: Perspectives of Athletic Training Faculty (2018)
Design	Qualitative snow-ball sampling; asynchronous web-based interview	Phenomenological analysis; structured interviews	Interpretative phenomenological analysis; semi-structured interviews
Sample	18 head ATs (Age: 44±8 years) with 22±7 clinical experience	21 NCAA ATs (Age: 33±9 years) who worked average 56±9 hours/week	16 female AT faculty members (Age: 35±6.2 years) with 14±5.9 years of clinical experience
Results/Emerging Themes	Higher-order themes: Organizational challenges, WLB strategies Lower-order themes: Prioritization of commitments, strategic boundary setting, and work-family integration	Primary theme: Lack of knowledge of formal workplace policies related to WLB throughout the sample	Emergent themes: Working mothers/motherhood, culture within higher education, networks of support in and out of work, and personal strategies
Score	19 SRQR	18 SRQR	19 SRQR

Primary Mental Health Resources Utilized by Student-Athletes as Compared to Their Non-Athlete Peers
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Context: Approximately 31% of male and 48% of female NCAA athletes report symptoms of depression or anxiety each year, with some stressors specifically attributed to participating in collegiate athletics. No recent literature has examined the types of mental health resources used by student-athletes as compared to their non-athlete peers. Therefore, the purpose of this study was to examine the types of individuals that student-athletes and non-athletes viewed as primarily mental health resources for specific mental health conditions. It was hypothesized that student-athletes would use their athletic trainers as a primary resource, while non-athlete students would utilize the counseling center as a primary resource. **Methods:** A cross-sectional survey was administered via Qualtrics at a private NCAA D3 institution in the northeastern United States. Participants were recruited through voluntary participation at pre-participation physicals, classrooms, and outside the cafeteria of the institution. The survey described specific mental health conditions and asked who

at the institution participants would use as a primary resource. The survey was tested for reliability with all questions having a $p < 0.05$, r -values ranging from .528-.833. 118 students (aged 19 ± 1.865) fit the inclusion criteria and were enrolled (76 athletes, 42 non-athletes) in the study. The independent variable was athlete status (athlete/non-athlete). The dependent variable was the primary mental health resource (counseling center, health center, faculty, staff, resident assistant, other individual at college, would not use anyone from the college, college's athletic trainer, member of college's coaching staff). A separate chi-square test of independence was conducted for each mental health condition (depression, anxiety, substance abuse, bipolar disorder, suicide, eating disorder, self-harm, post-traumatic stress disorder (PTSD)). Athletic trainer and coach were included in the "other" category for analysis. **Results:** Statistically significant association for anxiety ($p = 0.044$, $\chi^2 (4) = 9.807$, Cramer's $V = .288$), substance use ($p = 0.005$, $\chi^2 (4) = 14.736$, Cramer's $V = .353$), and bipolar disorder ($p = 0.020$, $\chi^2 (4) = 11.612$, Cramer's $V = .314$) where more athletes selected "other individual" as their primary resource. For anxiety, 32.2% of participants selected "other individual", for substance abuse 22.0%, and for bipolar disorder 18.6%. There was no

association between athletes and non-athletes for depression, eating disorder, self-harm, suicide, or PTSD. **Conclusions:** Student-athletes in our sample use different individuals as primary mental health resources than their non-athlete peers, specifically for concerns related to anxiety, substance use, and bipolar disorder. Individuals in these roles should be trained at identifying risk factors and warning signs of mental health concerns, and how to facilitate proper referral to an appropriate mental health provider.

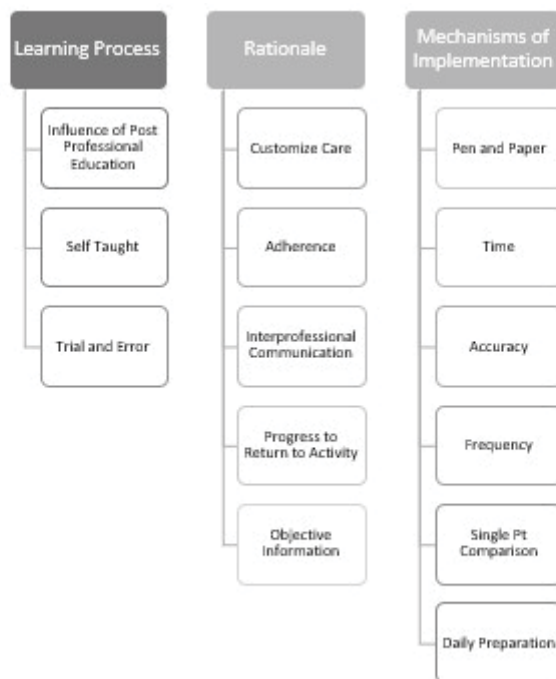
Secondary School Athletic Trainers' Implementation of Patient Rated Outcome Measures in Practice

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Context: Patient-reported outcome measures (PROs) are a simple way to incorporate patient values and preferences into care. Much of the previous research on PROs in athletic training have focused on the barriers to implementation and as such the purpose of our study was to explore the ways athletic trainers in the secondary school setting are actively overcoming the barriers to implementing PROs in their daily practice. **Methods:** We used an inductive phenomenological design with criterion sampling to identify secondary school athletic trainers who have successfully implemented PROs, beyond that of a single item questionnaire. Sixteen participants (age=30±7y; female=7, male=9; experience=8±8y) participated in an audio-recorded (Zoom®, San Jose, CA) semi-structured one-on-one interview, which were deidentified and transcribed verbatim. A 2-person data analysis team used a multi-phase process to identify emerging themes and sub-themes, ultimately demonstrating consensus. Trustworthiness and credibility were established with member

checking, multi-researcher analysis, and auditing. **Results:** We identified three emergent themes within the data: 1) learning process, 2) rationale, and 3) mechanisms of implementation. While most participants described hearing about PROs within their professional programs they did not truly understand and begin to attempt to implement them until their postprofessional education. After the participants learned more about how to implement PROs within their practice, they were more willing to engage in trial and error of different PROs to find what worked best for them. Participants also had varying rationale for using PROs within their clinical practice. Several participants stated they were able to take data points from the patient, create objective information they could monitor and compare over the course of care, and then customize care plans as the information changed. A few participants expressed the progress seen in return to activity as a tool which helped to keep patients adherent. Participants described mechanisms that allowed them to successfully implement PROs. Specifically, they discussed a need for easy delivery, which was achievable through pencil/paper modes, selecting PROs that take minimal time and yield highly accurate responses. Although somewhat variable, several participants indicated they implement the PROs every two weeks to allow for single patient comparisons over the course

of the care timeline. Most importantly, the participants indicated daily preparation allowed them to be most successful in implementing the PROs. **Conclusions:** Athletic trainers in the secondary school setting implement PROs by using trial and error to find what works for them and the patients they serve. The continued use of objective data garnered from PROs helps to show the patient's progress in return to activity. This provides more data driven decisions from PROs, allowing for patient feedback and shared-decision making in their care.



Self-Care Strategies Used by Athletic Trainers

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Context: Much of the research in athletic training regarding the vitality of the profession has been qualitative in nature, limiting its generalizability. Self-care strategies, like exercise, setting boundaries, and mindful meditation are well established in the literature as effective for improving overall wellbeing. The purpose of this study was to evaluate the self-care strategies used by athletic trainers on a weekly basis.

Methods: We used a cross-sectional design with web-based survey. By way of the NATA Research Survey Service, we sent emails to 8000 athletic trainers and 887 opted into the survey (11.7% response rate) and 720 completed the self-care multiple select item indicating the self-care strategies used on a weekly basis (81.2% completion rate). The item included 17 potential options related to contemplative/meditative, physical, creative, and interpersonal self-care strategies, as well as an “other” option and a “nothing” option. The options were derived from the literature and reviewed by members of the research team to evaluate inclusion. The survey also included 7 demographic items. Data were analyzed using descriptive statistics

(mean, standard deviation, sum, and frequency).

Results: Participants were mostly female, in their mid-career (age=33±9y; experience=10±8y), predominantly White, working in the college/university setting, holding a professional masters degree. We identified participants engage in 6.5±2.6 self-care strategies on a weekly basis (range 1-15; mode=6, 15.3%). Only 25 (3.5%) participants indicated they engaged in no self-care strategies weekly. Most participants engage in between 4 and 8 strategies weekly (474, 65.8%). Participants most often engage in exercise (645, 89.6%), specifically moderate exercise (418, 58.1%), positive social relationships (522, 72.5%), laughter (476, 66.1%), hydration (472, 65.6%), and healthy diet and nutrition (407, 56.5%) (Table). These commonalities confirm participants most often select physical (2.3±0.9; range 1-4; mode=3, 304, 42.2%) or interpersonal (2.0±0.8; range 1-4; mode=2, 273, 37.9%) self-care strategies on a weekly basis. In fact, 95.1% (n=685) of the total participants engaged in at least one physical self-care strategy weekly. Less common were the contemplative/meditative strategies (2.0±1.2; range 1-6; mode=1, 217, 30.1%) and creative strategies (1.4±0.5; range 1-4; mode=1, 355, 49.3%). Although the mode for contemplative/meditative strategies was low, a majority of the participants (437, 69.3%) engaged in at least one of these strategies weekly. **Conclusions:** The self-care strategies explored in this study are effective at mitigating work-related stress

in various professions including those with both high time demands as well as those with intense psychological demands. Athletic trainers are actively engaged in several self-care strategies that should mitigate feelings of work-life conflict and burnout, while also building resilience. Future research should explore the use of self-care strategies on resilience and likelihood to persist in the profession. In addition, employers should consider implementing organization level self-care strategies to retain staff and prevent burnout.

Table. Self-Care Strategies used by Participants Weekly (n=720)

Self-Care Strategy	n	%
Contemplative and Meditative Strategies		
Deep breathing	253	35.1
Meditation	86	11.9
Mind-body exercise (Yoga, Tai Chi, Qigong, etc.)	160	22.2
Mindfulness	186	25.8
Reflective writing or journaling	96	13.3
Spiritual practice	211	29.3
Physical Strategies		
Exercise (all)	645	89.6
Exercise (light)	276	38.3
Exercise (moderate)	418	58.1
Exercise (vigorous)	185	25.7
Healthy diet and nutrition	407	56.5
Hydration	472	65.6
Progressive muscle relaxation	36	5.0
Creative Strategies		
Poetry	5	0.7
Reading	334	46.4
Interpersonal Strategies		
Engage in positive social relationships	522	72.5
Laughter	476	66.1
Setting personal and professional boundaries	265	36.8
Other (please describe)	44	6.1
Nothing	25	3.5

Self-Perception of Leadership Styles and Behavior in Secondary School Athletic Trainers

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Context: Leadership has been considered an important part of advancing the profession, but investigations into leadership styles of clinically practicing athletic trainers are scant. The purpose of this study was to explore the leadership styles of secondary school athletic trainers and to determine if differences in leadership style practices existed across demographic characteristics. **Methods:** Using a cross-sectional survey design, leadership style was assessed via the Multifactor Leadership Questionnaire (MLQ-5x). Athletic trainers, who were identified using the Athletic Training Locations and Services (ATLAS) Project database, were invited to participate in the study via email (n=2593). A total of n=472 secondary school athletic trainers completed the survey (18.2% response rate). Transformational, transactional, and passive/avoidant leadership behaviors were evaluated by respondents indicating how frequently, or to what degree, they engage in 32 specific behaviors on a five-point Likert scale (0=not at all; 1=once in a while; 2=sometimes; 3=fairly often; 4=frequently, if not always). Demographic specific characteristics examined included gender, age, years of experience, degree level, previous

didactic or voluntary leadership development training, employment provider, role identification, and preceptorship. Respondents' predominant leadership style were assessed by converting raw MLQ-5x scores into percentiles. Each of the leadership styles were grouped to examine which style was most prominent among secondary school athletic trainers. Differences between respondents were evaluated using independent samples t tests and Cohen d was used to determine the effect size of any differences in MLQ-5x dimensions. Data were analyzed using parametric statistics as the sample size was sufficient to result in stable means and standard deviations, representative of the larger population. **Results:** Secondary school athletic trainers practice transformational leadership behaviors (2.99±.47) more often than transactional (2.37±.56) or passive/avoidant behaviors (.79±.51) (Table 1). The transformational leadership behavior of individualized consideration was practiced most often (3.16 ± .56). The demographic characteristics of having a professional leadership role, serving as a preceptor, having didactic leadership education, and pursuing leadership development courses outside of formal education were found to have higher transformational leadership scores (p<.05). Transactional leadership behavior ratings were higher in male respondents and those who had previous leadership training within formal education and outside of formal education (p<.05). Passive/avoidant behaviors were used more often by respondents who had previous leadership training outside of formal education and those with a bachelor's degree (p<.05). **Conclusions:** Secondary school athletic trainers

predominantly use transformational leadership behaviors, specifically those relating to mentoring, developing standards for compliance, and using forward thinking in decision making. Formal and informal leadership development trainings are important factors for transformational leadership practices and should be utilized as support in an athletic trainer's professional role. Determining the leadership styles of athletic trainers will inform the athletic training education sector in how to best prepare its students for performing as proficient leaders.

Table 1. Comparisons between Leadership Styles

Leadership Styles	Mean ± SD	t	df	p	Cohen's d
Transformational vs. Transactional	2.99 ± .47 2.37 ± .56	27.674	471	<.001	1.19
Transformational vs. Passive Avoidant	2.99 ± .47 .787 ± .51	63.500	471	<.001	4.49
Transactional vs. Passive Avoidant	2.37 ± .56 .787 ± .51	48.034	471	<.001	2.96

Standing Order Requirements Increase Odds of State Practice Act Compliance in Secondary School Athletic Trainers

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Context: Current best practices require secondary school (SS) athletic trainers (ATs) to collaborate with their supervising physician and have standing orders signed annually. However, the requirement level of AT supervision by a physician or other licensed healthcare provider varies in state practice acts. The potential lack of AT supervision may lead to increased risk of liability. Therefore, the purpose of this study was to determine if AT supervision requirements in state practice acts impact the odds of having standing orders in SSATs. **Methods:** A total of 6019 SSATs completed the Athletic Training Locations and Services (ATLAS) survey from August 15th, 2018 to September 30th, 2020 and 90.3% of these ATs (n=5434) were included in the analysis because they answered the question specific to standing orders. Questions regarding employment provider types including medical/university facility (MUF) and school district employee/teacher (SD), the level of AT employment including full time (FT) and part time (PT), and school type including public (PUB) and

private (PRV) were also included. Additionally, the state practice acts of all 51 states were divided into 3 groups based on AT supervision requirements: 1) AT supervision with required documentation (ATS+D; 14 states), which requires an AT to have an evidence of supervision by a physician, 2) AT supervision without required documentation (ATS+ND; 29 states), which defines AT supervision by a physician, but does not require evidence, 3) AT supervision not defined by state (ATSND; 7 states), which does not define AT supervision by a physician. Pearson's Chi-Square, odds ratio (OR) with 95% confidence intervals (CI), and likelihood ratios (LR) were calculated in order to identify the compliance of AT supervision requirements in SSATs. **Results:** Ninety-seven percent of ATS+D respondents indicated standing orders are signed annually by a physician or other healthcare provider, compared with 84% of ATS+ND and 69% of ATSND respondents. The odds of having standing orders by employment provider, the level of AT employment, and school type are displayed in Table 1. ATs working at MUF demonstrated significantly greater odds of having standing orders compared to ATs working at SD in ATS+ND and ATSND, 1.2 times and 4.2 times respectively. FT ATs had significantly greater odds of having standing orders than PT ATs in all groups (ATS+D: OR=2.55; [CI:1.39-4.66]; X²=9.76; P=0.002, ATS+ND: OR=1.55; [CI:1.25-1.93]; X²=15.57;

P<0.001, ATSND: OR=1.94; [CI:1.40-2.69]; X²=16.20; P<0.001). There was no significant difference between school types amongst groups. **Conclusions:** ATS+D respondents had significantly greater odds of having standing orders compared to ATS+ND and ATSND respondents. Employment provider type and the level of AT employment also affect the odds, especially in ATS+ND and ATSND. Therefore, these findings suggest that clearly defined AT supervision with required documentation in state practice acts results in increased compliance with best practices in SSATs.

Table 1. The Odds of Having Standing Orders by Secondary School Athletic Trainers

	n		χ ²	p	OR (95% CI)	LR
MUF vs. SD	MUF	SD				
ATS+D	917	597	0.07	0.792	1.08 (0.60–1.97)	0.07
ATS+ND	1848	1281	4.27	0.039 *	1.23 (1.01–1.50)	4.24
ATSND	496	295	83.61	0.001 *	4.25 (3.09–5.85)	82.37
FT vs. PT	FT	PT				
ATS+D	1200	314	9.76	0.002 *	2.55 (1.39–4.66)	8.37
ATS+ND	2438	691	15.57	0.001 *	1.55 (1.25–1.93)	14.77
ATSND	568	223	16.2	0.001 *	1.94 (1.40–2.69)	15.73
PUB vs. PRV	PUB	PRV				
ATS+D	1307	207	2.06	0.152	0.43 (0.13–1.41)	2.47
ATS+ND	2622	507	0.26	0.638	0.93 (0.71–1.22)	0.26
ATSND	650	141	1.15	0.284	0.80 (0.53–1.20)	1.17

*p≤ 0.005

ATS+D: AT supervision with required documentation, ATS+ND: AT supervision without required documentation, ATSND: AT supervision not defined by state, MUF: Medical/university facility, SD: School district employee/teacher, FT: Full time, PT: Part time, PUB: Public school, PRV: Private school

The Effect of Reflective Journaling on Athletic Trainers' Diagnostic Competency: A Pilot Study

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Context: Diagnostic competency, defined as making a correct diagnosis, is a critical skill in health care professions. Reflective practices such as journaling may help increase the skills of information synthesis and processing because they promote active-learning and self-awareness during the activity. The purpose of the study was to determine whether a reflective journaling prompt improved advanced practice clinicians' diagnostic competency over the course of 6 standardized cases. **Methods:** The study was a two-phase experimental study, taking place over two weeks. Recruitment emails were sent to Doctor of Athletic Training (DAT) program directors to recruit program graduates who have successfully earned the DAT degree. Twenty-four graduates who responded to recruitment methods and volunteered were randomly assigned to an intervention ($n = 10$) or control group ($n = 14$). Using a video conferencing platform (Zoom®, San Jose, CA) and web-based tool (Qualtrics®, Provo, UT), participants completed prompts for the diagnosis of 6 cases, which were split

into 3 pairs. Patient cases were constructed by researchers following standardized patient case development procedures and content was validated by clinical experts. In the first week of the study, participants completed two sets of case pairs. Participants were allotted 7 minutes to provide a diagnosis for each case. In each case, the control group completed the prompt and was assigned a puzzle to work on for the remaining time. The intervention group completed the same four cases, however in the first case pair, they completed the prompt and were assigned a puzzle to work on for the remaining time. During the second case pair intervention participants completed reflective journaling prompts about their final and differential diagnoses. At follow-up, both groups completed a third case pair, providing a diagnosis within 7 minutes with a puzzle to complete for the remaining time. Cases were scored on the accuracy of their diagnoses, using a three-point scale, correct (2), partially correct (1), and incorrect (0). We used a repeated measures ANOVA to compare the groups' mean scores among case pairs. **Results:** Eleven female and 13 male participants completed the study. The participants' average age was 28.42 ± 4.09 years; the participants' average years of experience were 6.04 ± 3.94 . We found no significant differences between the control and intervention groups ($F(1,22) = 0.51$, $p = 0.48$). The intervention group's mean scores

were higher on case sets 2 and 3 (2.90 ± 1.10 and 3.00 ± 0.94 , respectively) than the control group's (2.79 ± 0.89 and 2.57 ± 0.85 , respectively). **Conclusions:** Reflective journaling has previously been shown to improve diagnostic competency in health care providers. This study did not show differences in diagnostic competency with the use of reflective journaling. However, reflective practices may be beneficial in improving patient care. Future research should examine reflective practices across a larger range of conditions and across athletic trainer backgrounds and practice settings.

Obstacles to Athletic Training Healthcare for University Performing Artists

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Context: Performing artists are considered an underserved population in the university setting due to their lack of access to specialized healthcare. Determining the obstacles that restrict access to healthcare for these individuals may shed light on possible solutions for circumventing the barriers to care. **Methods:** Participants in university athletic training and performing arts communities were recruited via email. BOC-certified head athletic trainers (ATs) and performing arts directors and department chairs at 215 universities holding memberships in both the National Collegiate Athletic Association (NCAA) and one or more of the National Association of Schools of Music, Theatre, and/or Dance were recruited by e-mail, with 505 ATs; performing arts program directors; and dance, theatre, and music department chairs contacted. They were asked to send a survey to staff ATs or performing arts students, respectively. Upon survey completion, respondents were invited to participate in a semi-structured online interview. Eighty-nine participants completed the survey, and 11 of those consented to be interviewed to qualitatively identify potential

obstacles in offering healthcare to university performing artists. The raw data were transcribed and a thematic analysis was conducted by two independent coders. Major themes and sub-themes were identified through an inductive process. Interview validity was triangulated by reviewing findings with participants so they could confirm, deny, and/or comment on the themes identified from their responses. **Results:** The survey response rate was 18%. Of the 89 survey participants, 11 (12%) agreed to be interviewed. We categorized our findings into major and minor themes. Major themes included athlete versus performing artist; this identified similarities in physical demands and time spent in activity. It also included physicality differences between the groups. Even though performing artists sustain injuries similar to NCAA athletes, they contend with the added pressure of maintaining artistic performance aesthetics. Another major theme revealed the differences in healthcare access between NCAA athletes and university performing artists. This reflects the limited resources available to university performing artists compared to NCAA athletes, as well as a gap in medical professionals' knowledge about performing arts injuries. NCAA athletes have easier access to onsite care in athletic training facilities, whereas performing artists generally cannot visit these facilities. Minor themes identified barriers to providing performing arts healthcare, with the most common being university policy, financial limitations, and perceived university liability. **Conclusions:** Our results suggest that collegiate performing artists cannot access the

same type of healthcare that is traditional for intercollegiate athletes. Though both groups sustain injuries, a dichotomy exists that precludes care delivery to most artists. Therefore, recognition by university administrations about injury incidence in performing arts is required before healthcare resources for performing artists can be implemented. Identification of resources and possible mechanisms to initiate performing arts injury care programs is needed.

Telemedicine Use by Athletic Trainers During the COVID-19 Pandemic

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Context: The severe acute respiratory syndrome coronavirus 2 virus, or coronavirus (COVID-19) has resulted in 44 million confirmed global cases. The COVID-19 pandemic forced closures of educational, healthcare, and sport institutions throughout the United States since March 2020, however several have begun reopening in September 2020. As face-to-face interactions begin to increase, there is a need to explore the continued use of telemedicine by athletic trainers, or the delivery of healthcare using some form of digital technology at a distance, which became popular due to the pandemic. **Methods:** We performed a longitudinal study to explore the changes in telemedicine use during the COVID-19 pandemic. Participants completed the initial assessment during March 2020 when stay-at-home orders were issued. At the end of the pre-assessment, 448 individuals expressed interest in completing a follow-up study six months later (September 2020) as businesses reopened that explored the same aspects as the pre-assessment. For the purposes of this data, we explored telemedicine use, delivery mechanisms, and domains of practice. In total, 274

individuals (age=32±9y; females=176, 64.2%, males=98, 35.8%; years of experience=9±8y) completing the entirety of the follow-up survey (84% completion rate) to be included in the data analysis. Data were analyzed using descriptive statistics with a paired samples t-test for telemedicine use in March compared to September 2020. **Results:** At pre-assessment, 102 participants (37.2%) expressed they were practicing telemedicine via synchronous live video (n=67, 24.5%), asynchronous store-and-forward (n=70, 25.5%), or other indirect methods such as text messages and emails (n=93, 33.9%). We identified a significant difference in telemedicine users ($P=0.013$) from March to September 2020. Overall, 33 participants (12%) were using telemedicine at both data collection periods, 68 participants (24.8%) were using telemedicine at the start of the pandemic but had since stopped, 42 participants (15.3%) were categorized as new telemedicine users in September, and 131 participants (47.8%) had never used telemedicine during the pandemic. Post-assessment rates of telemedicine use had dropped to 27.4% (n=75/274) with synchronous (n=55, 20.1%), asynchronous (n=54, 19.7%), or other indirect methods (n=68, 24.8%) also appearing lower than at that the start of the pandemic. Of the ATs doing synchronous telemedicine at post-assessment, 96.4% (n=53/55) reported doing this via individual appointments. The domains of athletic training that were being practiced via telemedicine most commonly were

patient check-ins for therapeutic rehabilitation (n=56/75, 74.7%), injury and illness prevention (n=50/75, 66.7%), and initial musculoskeletal examinations (n=41/75, 54.7%). **Conclusions:** Though the use of telemedicine in general has increased during the pandemic, athletic trainers utilized it less during this period. When it was incorporated into care, it was primarily used for therapeutic rehabilitation check-ins on an individual basis. The barriers that impede the long-term adoption of telemedicine by athletic trainers on a broad scale have not been explored.

Perceived Social Support Given by Athletic Trainers to Injured Collegiate Athletes

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Context: Injuries sustained during an athlete's career can be detrimental and may not only cause physical harm but may cause psychological distress. Social support is commonly defined as individuals whom are readily available, reliable, and let the recipient of social support know that they care. Despite the importance of social support, there is currently limited evidence on sources and types of support that are provided to student athletes following injury. The purpose of this study was to determine the perceived satisfaction of social support by student athletes from head coaches, assistant coaches, teammates, and athletic trainers throughout an injury. **Methods:** A modified version of the Social Support Questionnaire was used to examine eight different types of social support (listening, emotional, emotional challenge, reality confirmation, task appreciation, task challenge, tangible assistance, and personal assistance) and how much student athletes were satisfied with the social support that they received from their head coaches (HCs), assistant coaches (ACs), teammates (TMs), and athletic trainers (ATs). Higher scores indicated greatest satisfaction. An

anonymous online survey link was distributed to eligible student athletes at one NCAA Division III and two NAIA universities in central Illinois. Sixty complete surveys (60.6% response rate) were available for analysis (males = 18(30%), females = 41(68.3%), prefer not to answer = 1(1.7%) with an average age of 20.1 ± 1.2 years). Respondents were excluded if their injury kept them out for less than one day or if they were younger than 18 years old. **Results:** A one-way repeated measures MANOVA was conducted to compare overall satisfaction scores of perceived social support between the four sources of social support (HCs, ACs, TMs, and ATs). Student athletes perceived that athletic trainers provided more satisfying social support following injury (Wilks $\Lambda=0.76$, $p=0.002$, $\eta^2=0.89$), specifically in reality confirmation (HCs: 4.9 ± 1.2 , ACs: 4.9 ± 1.2 , TMs: 5.0 ± 1.1 , ATs: 5.5 ± 0.9 ; $p=0.002$), task appreciation (HCs: 5.0 ± 1.0 , ACs: 5.0 ± 1.1 , TMs: 5.0 ± 1.2 , ATs: 5.6 ± 0.9 ; $p<0.001$), task challenge (HCs: 5.0 ± 1.1 , ACs: 4.9 ± 1.2 , TMs: 4.9 ± 1.2 , ATs: 5.6 ± 0.9 ; $p<0.001$), and tangible assistance (HCs: 4.9 ± 1.2 , ACs: 4.8 ± 1.3 , TMs: 4.8 ± 1.2 , ATs: 5.4 ± 1.1 ; $p<0.001$) compared to the other three sources of support. **Conclusions:** Athletic trainers were perceived to have the greatest impact on social support in confirming perspective of the injury (reality confirmation), acknowledging efforts (task appreciation), motivating student athletes towards injury recovery (task challenge), and providing financial assistance such as transportation to physician

appointments (tangible assistance) compared to social support provided by head coaches, assistant coaches, and teammates. This research may help guide clinicians with understanding the significance of the social support they provide to their student athletes following injury, thus highlighting the influence athletic trainers may have on the recovery process.

Free Communications, Poster Presentations: Hip

On Demand: June 22-September 30, 2021

Labral Injury or Reproductive Complication? Hip Pain in an Adolescent Female Athlete

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Background: 18-year-old female high school multi-sport athlete complaining of right hip pain for the past 8 months. She first noticed pain while kicking a soccer ball but denies inciting injury. The patient stated that 2 months ago she dove during volleyball and experienced pain throughout the season with similar activities. Pain is located at the right anterior hip and groin. The patient describes pain as a “C-shape pain in the front of my hip and the pain is deep”. The patient reports pain with prolonged standing, going up and down stairs, pain upon waking in the morning, transitioning from sitting to standing and ambulating throughout the school day. She denies numbness or tingling down the leg, locking or catching, instability, previous injuries or surgeries. Pain is rated as 6/10 on Numerical Pain Rating Scale. Manual muscle testing reproduced pain in right anterior hip. Hip scour and hip flexed to 90 degrees with posterior shear causes pain. Fulcrum test, hop test and heel strike were positive. Ober’s test positive. She was referred from the Athletic Training Facility to the team physician. **Differential Diagnosis:** Femoral acetabular impingement, Labral hip tear, Femoral neck stress fracture, Relative Energy Deficiency Syndrome, Right inguinal hernia. **Intervention & Treatment:** : During

physician encounter, the mother was concerned of the child’s nutrition and caloric intake given how active she is in sports. The patient states she skips breakfast and sometimes lunch but does eat a large dinner. She endorses intermittent menstrual irregularities over the past year, getting multiple periods in any given month and periods can sometimes be prolonged more than 7 days. She endorses difficult to control acne. She has had hair loss in the past but denies facial hair growth. She denies sexual activity. The hip exam by the team physician was consistent with the AT exam. A MRI of the right hip was obtained and was negative for hip pathology or inguinal hernia but revealed numerous ovarian cysts of varying size on the left and right ovaries, measuring up to 3.3cm. MRI results raise concern for Polycystic Ovarian Syndrome (PCOS), therefore, laboratory studies were obtained including Complete Blood Count, Comprehensive Metabolic Profile, Hemoglobin A1c, Thyroid Screen, Follicle Stimulating Hormone, Luteinizing Hormone, Prolactin, Estradiol and Lipid Profile; all of which were unremarkable. The patient was given a prescription for Naproxen and was referred to OB/GYN for PCOS. The patient was treated medically by placing her on an oral contraceptive pill. Ultrasound performed 3 months after treatment indicates that the cysts had resolved, along with her hip pain. **Uniqueness:** Ovarian cysts are fluid-filled sacs that grow on the ovaries. They usually have no symptoms, although when they do manifest symptoms, it is often described as pain that radiates to the hip and groin. PCOS is a complex condition that affects approximately 7% of

reproductive-aged women in the United States. Work-up for PCOS is sometimes prompted by incidental findings of multiple ovarian cysts after imaging modalities such as ultrasonography, MRI or CT scans (Williams, Mortada, & Porter, 2016). **Conclusions:** The location of hip pain is sometimes difficult to isolate as pain is often referred to the groin, thigh, and buttock, in accordance with the innervations of the hip joint from the obturator, femoral and sciatic nerves (Taunton, 2007). Special considerations should be made with each individual patient’s unique history, as the female athlete presented in this case had no clear mechanism of injury, concomitant pelvic sources of pain must be considered.

Isolated Hip Arthroscopy Versus a Combined Arthroscopy and Periacetabular Osteotomy for the Treatment of Hip Dysplasia

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Background: Hip dysplasia's prognosis and treatment varies in the literature. However, dysplasia may lead to mechanical breakdown of the acetabulum, labrum, and articular cartilage. Positive outcomes of hip arthroscopy including labral repair, augmentation, and segmental and circumferential labral reconstruction to treat chondrolabral pathology are reported in the literature. The periacetabular osteotomy (PAO) technique has been shown to preserve the hip joint by reorienting the acetabulum and providing optimal coverage of the femoral head, therefore reducing pressure on the labrum/articular cartilage. Utilized in combination with hip arthroscopy to repair the labrum, this is an ideal procedure for preserving the hip joint and preventing total hip arthroplasty in younger patients. This is a Level 3 CASE report of a 40-year-old female with insidious onset of hip pain who failed two hip arthroscopic labral repairs. PAO combined with an arthroscopic labral reconstruction is a joint-preservation surgery for acetabular dysplasia. **Patient:** Patient is a 40-year-old female CrossFit athlete who experienced insidious acute onset of hip pain. Symptoms persisted and worsened over time. At 7-months post-onset of symptoms, she demonstrated a positive impingement test and pain with hip flexion. Radiographs demonstrated an Alpha angle of 62°, elevated Tönnis angle, and lateral central edge angle of 25°. MRI demonstrated an anterosuperior labral tear and Cam lesion. Patient sought a second opinion after undergoing two failed hip arthroscopic labral

repairs within a 4-month period when symptoms remained one year later. Additional imaging demonstrated an anterosuperior labral tear and acetabular anteversion. Physical findings included positive impingement sign, positive Stinchfield test, and pain with flexion and internal rotation. She consented to surgical treatment.

Intervention & Treatment: Patient underwent a PAO with an arthroscopic segmental labral reconstruction. Postoperative protocol included toe-touch weight bearing for 6-weeks, then progress to full weight bearing. At 3-months aggressive ROM and strengthening began, with full return to activity after 9-months. Multiple studies show positive long-term outcomes of segmental reconstruction using an IT band allograft for irreparable labral tears, specifically in younger patients with >2mm joint space narrowing. These results are comparable to this case in terms of primary diagnosis and surgical indications. However, the outcomes of PAO used in combination with hip arthroscopy is not represented well in the literature, specifically when recurrent labral pathology is present from acetabular dysplasia. **Outcomes or Other Comparisons:** Hip arthroscopic techniques to repair/reconstruct the labrum generally have positive outcomes, however this intervention failed resulting in re-tearing of the labrum due to acetabular dysplasia. In these cases, a PAO is indicated to correct acetabular orientation on the femoral head. These procedures preserve the hip joint because the femoral head is adequately covered by the acetabulum with minimal shearing force on the labrum during weightbearing movements. Studies on the outcome of PAO reveal 10 to 20-year survivorship rates of the hip joint with full return to functional activities. This case study reveals positive outcomes after undergoing a labral reconstruction and PAO for hip dysplasia, acetabular anteversion, and recurrent labral pathology. **Conclusions:** Indications for surgical intervention of hip dysplasia can be identified via radiographic measurements,

subjective and objective findings. Appropriately identifying hip dysplasia on radiographic imaging can help avoid failed hip arthroscopy. There is increased risk of chondrolabral injury with high impact activities requiring extreme hip ranges of motion. The more athletic trainers accurately identify hip dysplasia upon physical examination and radiographic measurements, interventions will be more effective in preserving the hip joint in active patients. **Clinical Bottom Line:** The evidence for hip arthroscopy in treating labral pathology is known as the gold standard of treatment for pre-arthritis patients. However, more evidence is needed to interpret hip dysplasia and the significance of insufficient coverage of the femoral head in patients who have recurrent labral pathology.

Self-Efficacy and Previous Activity Level are Associated With Self-Reported Hip Function in Patients Presenting to a Hip Preservation Clinic
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Context: High resiliency and self-efficacy are related to better functional outcomes for a variety of orthopaedic conditions. Although psychosocial factors are being investigated with increasing frequency, the relationships between these positive, potentially protective, psychosocial factors and function in individuals with hip pathology is not well understood. Understanding these relationships is increasingly relevant and with help shed light on potential adjunct treatments that may help improve functional outcomes. As such, this study aimed to evaluate the relationships between resiliency, self-efficacy, age, sex, previous activity level, and self-reported hip function in individuals presenting to a hip preservation clinic. We hypothesized that higher resiliency, higher self-efficacy, younger age, male sex, and higher previous activity level would be associated with higher self-reported

hip function. **Methods:** Participants provided demographic information including age, sex, and previous activity level, and completed the Brief Resilience Scale (BRS), Pain Self-Efficacy Scale (PSEQ), and the Hip Outcome Score Activities of Daily Living Scale (HOS-ADL). Predictors of HOS-ADL scores were assessed using a stepwise linear regression with forward variable selection. If a significant model was identified, correlation coefficients were reported. **Results:** Of the 82 participants (48F/34M, 28.7 ± 6.4 kg/m², 43.8 ± 17 years) 56.1% were diagnosed with a non-arthritic intra-articular hip condition, 18.3% with an extra-articular hip condition, 20.7% with hip osteoarthritis, and 4.9% had multiple diagnoses. The average BRS score was 3.9 ± 0.7 , PSEQ 36.7 ± 13.3 , and HOS-ADL 61.8 ± 20.4 . A model including self-efficacy ($r=.68$) and previous activity level ($r=-.41$) predicted 55% of the variance in HOS-ADL scores ($P<.001$). **Conclusions:** Higher self-efficacy and previous activity level were related to higher self-reported hip function for individuals presenting to a hip preservation clinic. As an adjunct to functional rehabilitation athletic trainers may explore using targeted evidence-based interventions, such as goal-setting, to improve self-efficacy.

Identifying Neural Activity Associated With Kinesiophobia After Anterior Cruciate Ligament Reconstruction

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Context: There is a high percentage of re-injury risk in patients that have sustained an anterior cruciate ligament reconstruction (ACLR), even after completing a traditional rehabilitation protocol and clearance from a physician. Furthermore, many patients experience kinesiophobia following return to activity. Kinesiophobia is defined as irritational or debilitating movement resulting in the feeling of vulnerability to painful injury or re-injury. Kinesiophobia may be a main obstacle preventing patients from returning to play and increasing re-injury rate after ACLR. However, no previous studies have measured the relationship between psychological factors and brain activation in ACLR patients. Therefore, the purpose of this study was to determine the correlation between the Tampa Scale for Kinesiophobia (TSK) and brain activation during a hip-knee joint movement in ACLR patients. **Methods:** The current study was a cross-sectional study

that enrolled ten individuals post ACLR (4 males and 6 females, 20.3 ± 2.00 years, 172.2 ± 14.8 cm, 68.7 ± 14.8 kg, 29.1 ± 25.7 months from injury). Individuals were included if they had sustained an isolated ACL injury, received reconstruction, between 18-35 years old, and indicated they were intending to return to their previous activity level after ACLR. All participants completed the TSK-17 questionnaire prior to the functional neuroimaging season. Functional magnetic resonance imaging (fMRI) was used to measure brain activation during hip-knee joint extension-flexion movements in a supine position. The hip-knee joint extension-flexion test was performed between 40° of hip flexion and full extension along a track, similar to a heel slide movement. The task consisted of 4 cycles of 30 seconds of movement and 30 seconds rest. The variables of interest were TSK-17 scores and brain activation levels, which were measured as Blood Oxygen Level Dependent (BOLD) signal. The fMRI image analyses, and statistical analyses were performed using the Oxford Centre for Functional MRI of the Brain Software Library. Full model analysis was setup as a general linear model with two explanatory variables, group, and TSK-17 scores. General linear model was set with three contrasts, group mean, TSK-17 score, and TSK-17 reverse. A priori threshold set at $z=3.1$ and alpha level of

0.05 cluster corrected significance threshold for multiple comparisons was used. **Results:** Mean TSK-17 scores was 31.3 ± 3.65 (range: 26-37). Higher TSK scores were positively correlated with three clusters. Cluster 1 was the left thalamus ($z=5.41$, $p<0.001$), cluster 2 was the left corticospinal tract ($z=6.12$, $p<0.001$), and cluster 3 was the right corticospinal tract ($z=5.93$, $p<0.001$). **Conclusions:** Elevated kinesiophobia after ACLR is associated with increased bilateral corticospinal and ipsilateral thalamic activation during a hip-knee motor task indicating that ACLR patients with elevated kinesiophobia may require increased neural processing to execute basic movements. Healthcare providers could incorporate additional rehabilitation strategies to manage psychological factors and reduce attentional focus on the injured limb.

**Anterior Cruciate Ligament
Reconstruction of a College
Student with a Prosthetic Limb:
A Level 4 CASE Study**

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Background: This case study examines a Caucasian 19-year-old male college student who had a left ACL reconstruction (ACLR) with a quadriceps tendon autograft secondary to a motor vehicle accident (MVA). The accident caused numerous gross injuries to his lower limbs including a below-knee amputation (BKA) of his right leg. Before the accident, the patient was a high school varsity cross country and track athlete with the expectation of continuing in college. **Differential Diagnosis:** In addition to other injuries, the differential diagnosis for the left knee included PCL tear, meniscal tear, MCL sprain, and LCL sprain. **Intervention & Treatment:** The patient had many severe injuries at the time of the accident and was rushed to the hospital where an emergency MRI revealed a multitude of injuries including untreatable right lower leg injuries. Also present were left femur fracture, left knee ACL and MCL tear, left ankle deltoid ligament tear, and left arm Triangular Fibrocartilage Complex tear. Based upon the severity of injuries, the patient underwent several procedures including a right leg BKA and left femur open reduction internal fixation (ORIF). As part of his initial recovery, the patient was fit for a prosthetic leg and performed intensive rehabilitation to regain independent ambulation and restore normal ADLs. Approximately three years following the MVA, after resolution of other more severe injuries, the patient underwent a left knee

ACLR with a quadriceps autograft. Three weeks following surgical reconstruction, the patient reported to the rehabilitation clinic and began standard ACLR rehabilitation practices including lower leg and proximal hip strengthening, attaining full knee ROM, and balance exercises. Gait training was essential due to the presence of an antalgic gait and complicated by the presence of the right leg prosthesis. He progressed as expected with balance and strengthening exercises. Progress with rehabilitation was inhibited by many factors including global left knee swelling, his inability to achieve or maintain full left knee extension ROM, intense pain with full left knee extension, and leg length discrepancies (LLD) between his remaining limb and daily prosthetic limb. Psychological factors from fatigue after years of physical therapy may have hindered progress and contributed to higher pain sensations as there was decreased motivation towards rehabilitation. Approximately three months after surgery, the patient was showing improvement in pain reduction and extension ROM; but care was discontinued secondary to the COVID-19 global pandemic when the patient was required to leave the local community to return home. **Uniqueness:** Athletic trainers do not typically work with individuals who have sustained injuries leading to a BKA. The complex medical history of the patient, his constant intense pain with knee extension, and the presence of psychological fatigue from years of rehabilitation all contributed to a challenging rehabilitation process. Irritation of the right lower extremity stump made progress challenging. Additionally, the patient's daily prosthesis presented a LLD making gait training difficult. With the use of his running prosthetic, LLD appeared to diminish, and the patient was able to ambulate with no pain, full knee extension, and less pronounced drop foot. The patient

was referred to his prosthetist for further evaluation. **Conclusions:** The patient's prosthetic leg increased the complexity of this case and exacerbated many symptoms that continued to impede rehabilitation. This case shows the impact of a prosthetic limb on the overall healing time of a patient and highlights how factors that can be easily overlooked such as LLD, psychological stressors, and kinetic chain disruptions can greatly impact a patient's rehabilitation and healing time. By practicing patient-centered care, and not only focusing on the injured area, we can make connections to improve the patient's rehabilitation and healing.

Chronic Anterior Knee Pain in a Professional Hockey Player: Level 3 Case Study

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Background: Anterior knee pain (AKP) is very common in the athletic population and associated with many different pathologies. The anterior interval of the knee is defined as the space between the infrapatellar fat pad, patellar tendon anteriorly, anterior border of the tibia and the transverse meniscal ligament posteriorly. Normal mechanics of the anterior interval during flexion involves posterior displacement of the infrapatellar fat pad due to pressure from the patellar tendon as the angle formed by the patellar tendon and anterior tibia decreases. Extension moves the fat pad anteriorly away from the tibia. Anterior interval scarring (AIS) after surgery or injury causes dysfunction including decreased excursion of the patellar tendon in relation to the anterior tibia. Scarring and stretching of the synovium likely activates pain receptors and created a limited flexion arc which increases patellofemoral contact forces. AIS significantly increases the patellofemoral contact forces across all flexion angles by causing significant distal patellar translation at all test angles, contributing to AKP. Physical examination findings for AIS may include decrease in cranial and coronal excursion of the patella, positive Hoff test, peripatellar tenderness, and limited knee flexion. MRI is a useful diagnostic tool to evaluate AIS, shown as extensive fibrotic reaction. This Level 3 CASE report discusses AIS as a unique diagnosis for anterior knee pain after multiple conservative and surgical treatments. **Patient:** A healthy 6'1", 205lb, 24-year-old male professional hockey

defenseman presented with bilateral chronic AKP, despite previous bilateral patellar tendon debridement and Tenex procedures. Past treatment also included bilateral bone marrow concentrate and leukocyte poor platelet rich plasma injections intraarticular and in the distal quadriceps tendon, which provided minimal to no relief. Upon physical examination pain was exacerbated in a weighted lunge, squat position, and descending stairs. MRI was obtained and demonstrated bilateral AIS. Patient consented to bilateral surgical intervention. **Intervention & Treatment:** Bilateral knee arthroscopy, anterior interval release (AIR), and lysis of adhesions was performed. Extensive scarring between the patellar tendon and underlying fat pad was released with radiofrequency probing down to the tibial plateau. Losartan was given for 30-days to prevent scar tissue formation. Certain individuals respond to conservative treatment including hip and glute strengthening and biologics. Rehabilitation focused on patellar mobility, decreased effusion, and pain control to protect against potential AIS. Restrictions included 5-7-days partial weight bearing, no closed kinetic chain resistance exercises for 3-weeks. Return to full activity, including deep squats and lunges, occurred at 6-weeks. **Outcomes or Other Comparisons:** Following AIR, research shows patients have at least 2cm of increased superior/inferior passive patellar excursion, equal medial/lateral patellar excursion, and increased inferior tilt. Patients reported decreased pain, stiffness, and normal knee function following an AIR. In follow up, this patient had minimal pain and progressed through his protocol without incident. He experienced intermittent aching along the patella due to the prolonged increase in patellofemoral contact. Upon return to full activity, patient denied functional limitations. **Conclusions:** This case study reinforces the importance of imaging after chronic AKP, especially in a post-operative setting. Differential

diagnosis for AKP includes chondral pathology, AIS, patellofemoral maltracking, patellar subluxation or dislocation, patellar and quadriceps tendon pathology. Trauma to the knee may initiate an inflammatory cascade and development of adhesions between anterior knee structures and increase in patellofemoral contact forces. AIR reduces patellofemoral contact forces and concomitant AKP. If AIS is not addressed, potential chondral damage may occur due to the prolonged patellofemoral contact forces. Postoperative recommendations after AIR must focus on patellar mobilizations to prevent reformation of scar with limited weight bearing for 1-2 weeks. **Clinical Bottom Line:** This case highlights the importance of advanced imaging and critical evaluation of anterior interval scarring in patients with chronic anterior knee pain in the presence of a prior surgery.

Knee Pain in a High School Wrestler
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Background: A 17-year-old high school wrestler reported to the athletic training room with right knee pain, unable to flex his knee. He reported he was duck walking 2-days prior and pain developed in his right knee. The next day he was walking down the stairs when his knee went into valgus, after which he could not bend his knee without pain. He tried to participate in wrestling practice but had a “strong sting” pain on his patella. The evaluation revealed point tender pain over the patella and small knee edema. Knee ROM was limited with pain over the patella, and right quad strength was 2/5. All knee joint laxity tests were negative, while the patella apprehension test was positive. The patient had normal vascular and neurological exam to the distal extremity. The patient was braced for support and provided crutches for ambulation. The next day he reported to the Athletic Training Room, the knee was re-examined. The examination revealed additional edema around the patella, with no other changes. Basic knee strengthening exercises began, and participation in wrestling activities were discontinued. Two days later, he returned to the Athletic Training Room and was full weight bearing, and his knee exercises continued and advanced as tolerated. 4-days post-injury, he reported that he was pain free and agility drills began for return to play. The drills were stopped due to the return of patella pain. The athlete was referred to a sports medicine clinic. The physician’s exam of his

knee revealed edema around the patella, all laxity and special tests were negative. Patella grind was positive with crepitus and limited quad activation, which caused increased patella pain. X-rays and MRI were ordered for further diagnosis. **Differential Diagnosis:** 1. Patella subluxation 2. Patella chondromalacia 3. Bipartite Patella 4. Patella Fracture. The x-rays ruled out a bipartite patella, but revealed a lateral patella fracture. Two-weeks later, he followed-up with the physician for reexamination and review of MRI. He was walking pain free with a brace. On exam, the edema was unremarkable, and no other changes were noted. The results of the MRI revealed no other injury and confirmed the lateral patella fracture. **Intervention & Treatment:** The patient was instructed to continue wearing the brace and to use crutches. Basic knee rehab begun, progressing to cardio on stationary bike and slide board. He continued strengthening, and sports specific exercises were integrated. At 6-weeks post injury, he followed up with the physician. He was pain free with knee extension, and squatting repeated times. He was cleared to start return to play progression after which he performed strength-training exercises and agility drills specific to wrestling. When his bilateral strength and motion were equal, he returned to wrestling. During his second match, he received a lateral blow to the patella, after which he reported to the athletic training room with renewed patella pain. He was referred to the sports medicine clinic for evaluation, where he reported symptom free and with no further injury. **Uniqueness:** Patella fractures are rare, and account for only 1% of all fractures. This patient suffered a patella sleeve fracture, which is the most common of patella fractures in

skeletally immature athletes. This athlete was skeletally mature which adds uniqueness to this case study. The common mechanism of injury is a forceful sudden contraction of the quadriceps, which is what occurred for the patient. **Conclusions:** Diagnosis of a patella sleeve fracture is difficult. Rapid diagnosis and evaluation of this injury can increase positive outcomes in these patients. Athletic trainers should rule out these fractures in skeletally immature patients presenting with these symptoms.

Multi-Lig Knee Injury With Acute Patellar Dislocation in a Football Player
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Background: A 17-year-old, male, high school quarterback, went down on the field after being tackled by multiple players. The Athlete complained of right knee pain as the athletic trainer arrived out on the field to assess injury. During the initial assessment, the athlete had an obvious laterally dislocated patella. The patellar dislocation was reduced, with gentle passive knee extension. The athlete reported acute pain relief and release of pressure on the joint. Upon evaluation, he had limited range of motion and described being “hit from the outside” and “felt a pop”. The athlete had a normal dorsal pedis pulse and normal sensation both proximal and distal to the knee. With further examination, the athlete had a positive Lachman test, positive Anterior drawer and positive valgus stress at both 30 and 0 degrees, as compared to the contralateral side. It was explained to the parent and coach that based on exam he should be transported to the emergency room, to rule out vascular injury or complication. The patient was then immobilized and wrapped with ice, placed on crutches and transported to a nearby hospital. Upon x-ray review, there was no evidence of acute bony abnormality or fracture. However, based on exam, there was concern for multi-ligamentous injury as well as indication of patellar dislocation. The patient was administered NSAIDs, was to be non-weightbearing with crutches and was scheduled for an MRI and a follow-up with the orthopaedics and sports medicine department, the following Monday.

Differential Diagnosis: Medial patella femoral ligament injury, Quad tendon rupture, Patellar tendon rupture, ACL injury, PCL injury, MCL injury, Meniscal pathology, Multi-ligamentous injury, proximal fibula fracture, tibia fracture, femoral fracture. **Intervention & Treatment:** Evaluation of the Right knee by MRI as well as evaluation by the orthopedic surgeon, presented findings consistent with multi-ligamentous injury. MRI findings indicated ACL rupture, distal PCL Grade II, MCL rupture, Grade II LCL, PLC tear, posterior horn medial meniscus tear, MPFL tear, and lateral femoral condyle fracture. Based on these clinical findings, surgery was planned for recon of the ACL and MCL as well as repair of the menisci, as indicated. MPFL included in recon of the medial ligamentous structures, all being torn from the medial side of the femur. The patient was given exercises to regain motion prior to surgery and was locked at 30 degrees of knee flexion in brace, due to menisci pathology. **Uniqueness:** While ACL and multi-ligament injuries frequently occur in the game of football, it's exceptionally rare to see these injuries with an associated patellar dislocation and MPFL tear. Given the mechanism of injury, with substantial valgus force, all ligamentous injuries sustained are consistent with the particular direction and stress to the knee. However, based on the mechanism and the ligamentous structures involved with the injury, other than a subluxation, a true patellar dislocation is very uncommon. **Conclusions:** A high school football player with an acute patellar dislocation was diagnosed with a multi-ligamentous and meniscal injury. As a result, these injuries were surgically reconstructed based on indication of an MRI. Based on the force and mechanism applied to the knee, the ACL, MCL and MPFL as well as menisci were disrupted. Because the Patella was

acutely dislocated and reduced, one would suspect a possible MPFL injury or injuries to the quad or patellar tendons, respectively. However, this draws great importance to a thorough on-field exam to identify associated injury that may not be indicated upon initial assessment. This also proves great importance to taking a good history and determining differential diagnosis based on understanding of directional force and mechanism of injury, as well as the possibilities with contact vs. non-contact knee injury.

Multi-Ligament Tibiofemoral Dislocation in a 15-Year-Old Softball Shortstop: A Level 3 CASE Study

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Background: The condition presented in this Level 3 CASE study is a posterolateral tibiofemoral dislocation that resulted in complete tears of all four major ligaments supporting the joint, partial tearing of the patellar tendon and bruising of the patella. The dislocation was reduced without radiographs, the patient was brace-free for 3 weeks before surgery, and the surgery was not performed within 3 weeks of injury, all of which are not consistent with prior literature. Despite these considerations, the young patient successfully returned to varsity level competition for three additional years post surgery. **Patient:** The patient involved with this case was a 15-year-old female softball shortstop athlete with no history of serious lower extremity injury. The patient suffered a posterolateral tibiofemoral dislocation which resulted in complete ruptures of the ACL, PCL, MCL, LCL, partial tearing of the patellar tendon and patellar bruising. The patient tripped during a game, causing her to fall on her flexed knee. The dislocation was immediately reduced by a physician on-site. Once EMS was summoned, an IV was administered and the athlete was placed in an immobilizer. The patient was transported to the local emergency department, where further imaging was not performed due to swelling. MRI was not completed until 4 days later, which confirmed the ligamentous ruptures and

patellar bruising. Although distal pulses were not located on physical exam, angiographs were negative for vascular damage. **Intervention & Treatment:** Initially, the patient was placed in an immobilizer for 2 weeks. During this time, a family decision was made to switch to a new surgeon, who removed the immobilizer and had the patient resume ambulating normally. Prehabilitation, performed by the athletic trainer and a physical therapist three times a week, consisted of pain management, passive knee flexion exercises, quadriceps and hamstring strengthening, and electrical muscle re-education. Surgery was performed approximately 2 months after injury, beyond the recommended 3 weeks in the literature. Arthroscopic reconstruction was conducted on all four knee ligaments, despite best outcomes being associated with open reconstruction for the MCL and LCL. Rehabilitation followed the same schedule, administration, and activities as the prehabilitation, with the addition of leg presses, squats, lunges, biking, and elliptical use as the patient progressed. **Outcomes or Other Comparisons:** Return to play occurred within 9 months of injury, with the athlete successfully returning to her pre-injury level. The athlete reported no incidences of instability, and no re-injuries to any structures to her athletic trainer. The athlete continued to play at the varsity level for her remaining three years of high school. This is a rare occurrence, and the initial shift in approach altered the trajectory for this young athlete when decisions were made seemingly against the recommendations documented in the literature. Regardless of the combination of removal from the immobilizer early, resumption of ambulation, delayed surgery, and reconstruction of all 4 ligaments arthroscopically, this individual returned to sport

without incident. **Conclusions:** The case presented numerous challenges that made the full return to play surprising. Additionally, her lack of experience with an injury of this magnitude could have contributed to a negative outcome. Proper management of rehabilitation was vital in allowing the patient to return to her pre-injury state. Without consistency of the rehabilitation portion of her care, the patient may have experienced major physical or psychological complications with returning to sport. **Clinical Bottom Line:** In injuries that have the potential to be catastrophic and career ending, proper management is critical. This case is beneficial to athletic trainers as it demonstrates how important the prehabilitation and rehabilitation are in these serious injuries for return to play at pre-injury levels, especially in a young athlete.

Psychological Readiness Predicts Reduced Physical Activity Level 6 Months After ACL Reconstruction

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Context: Patients with ACL reconstruction (ACLR) demonstrate decreased physical activity (PA) levels when compared to pre-ACLR PA levels. These patients report participation in competitive and recreational sports pre-ACLR; however, only two-thirds of patient report a return to sport within 2 years of surgery. Fear of reinjury and confidence are important considerations for successful reintegration into PA, given that these indicators or psychological readiness have are associated with return to sport 2 years after ACLR. However, the impact of psychological readiness on the change in PA levels from pre-ACLR to the end of formalized clinical care has not been explored. Therefore, the purpose of this study was to determine if psychological readiness for sport is associated with change in activity level from pre-surgery to 6-months post-ACLR among a cohort of patients with primary, unilateral ACLR. **Methods:** One hundred eleven individuals who had undergone primary, unilateral ACLR (62 women, 49 men; age=

18.8±3.4 years) 6±1-months prior to assessment were included in this secondary analysis of data from a prospective cohort study. Participants completed the Tegner Activity Scale (0= no activity to 10= national elite) to assess pre-injury (median=9, range= 5-10) and current physical activity level (median=6, range= 2-10). The change from pre-injury to current activity level was calculated. Psychological readiness for sport was assessed using the ACL-Return to Sport after Injury Scale (ACL-RSI). The ACL-RSI is scored on a 0-100% scale, with a score of > 56.0% score indicative of acceptable psychological readiness to return to sport. ACL-RSI score was used to predict change in PA level using linear regression. We controlled for participant age, sex, and pre-injury activity level in our regression analysis. **Results:** Median decrease in activity level was 2 levels [range= 0-7 levels]. ACL-RSI (mean= 68.2±22.2) significantly predicted change in activity level ($p<0.001$, $R^2=0.29$) while controlling for age ($p=0.24$), sex ($p=0.06$), and pre-injury activity level ($p<0.001$) (Figure 1). **Conclusions:** Unacceptable psychological readiness is associated with decreases in PA level from pre-ACLR to 6 months following ACLR. Therefore, clinicians should develop home exercise programs focused on increased frequency of physical activity to begin the reintegration process into regular physical activity and improve confidence and decrease fear of

re-injury. A higher frequency of participation in aerobic and anaerobic activities may decrease fear of reinjury as patients have the opportunity to increase repetitions and practice of sport-related skills. Also, these types of programs would provide a variety of environments for patients recovering from ACLR to practice their skills and improve their confidence outside the clinic in preparation for reintegration into their preferred environment of physical activity.

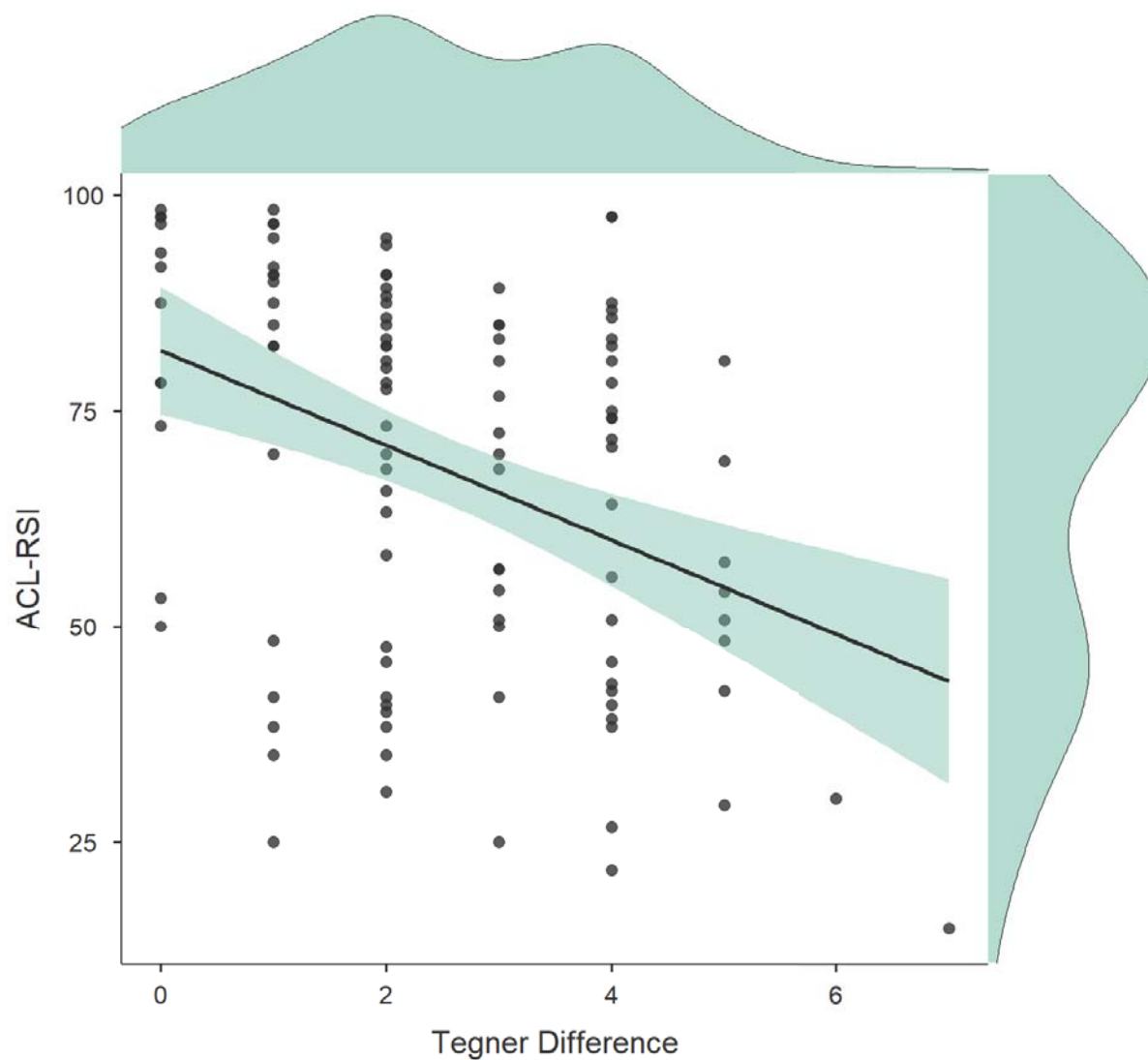


Figure 1. Linear regression analysis of ACL-RSI score predicting the change in Tegner Activity Scale score from pre-injury to 6-months post-ACLR ($R^2=0.29$, $p<0.001$). The graph features density plots of both variables opposite their respective axes and a line of best fit with its standard error across the distribution.

Recurrent Patellofemoral Instability in a Collegiate Wrestler: A Level 4 CASE Study

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Background: This case examines a 21-year-old, male, collegiate wrestling athlete who suffered a recurrent patellofemoral subluxation of the left knee. Past medical history includes a fracture of the left ankle, chronic subluxation/dislocation of the right elbow, Grade 1 medial collateral ligament (MCL) sprain of the left knee, and repeated subluxations/dislocations of the left knee patellofemoral joint. Although not diagnosed by a physician, the medical staff suspected chronic connective tissue laxity as the patient presented with numerous joint instabilities and dislocations in his past medical history. Before the current injury, the patient had received a lateral release surgery with repairs to the medial patellofemoral ligamentous structures of the left knee. Rehabilitation followed the surgery until he was able to return to full activity. In this case, the patient injured his left patellofemoral joint during practice after a fall to the mat. No noticeable swelling, full range of motion, and full strength were noted by the athletic trainer who evaluated the patient. He was held from further activities though as the patient described knee discomfort and felt unable to continue participating in wrestling activities. After the discomfort had not subsided for almost a week, he was referred to the team physician. He was diagnosed with a repeat subluxation of the left patellofemoral joint leading to the decision of a second surgical intervention. **Differential Diagnosis:** Possible differential diagnoses include patellofemoral subluxation, meniscal tear, synovial plica tear, patellofemoral pain syndrome, patellar fracture, bursitis,

and contusion. **Intervention & Treatment:** Diagnostic imaging was not performed following the second subluxation injury as the patient received an MRI, diagnostic ultrasound, radiograph, and skyline view radiograph following the first subluxation. The patient was scheduled for a tibial osteotomy to prevent the recurrence of subluxations. However, surgery was postponed for several months due to COVID-19 implications. Until surgery was allowed, the patient participated in pre-surgical rehabilitation consisted of a HEP focused on strengthening the lower leg and balance exercises for joint stability. The goal was to strengthen the surrounding muscles while maintaining as much knee ROM as possible. Following surgical intervention, post-operative rehabilitation and recovery progressed per the protocol from the surgeon. Surgical hardware was removed approximately five months following surgery. Return to full wrestling activity occurred one month afterward.

Uniqueness: This case has two unique factors. The first is the complication incurred by the COVID-19 global pandemic. This necessitated the use of telemedicine to help treat the patient. Despite this complicating factor, the patient was able to experience a successful, although delayed outcome. The second factor is the patient's undiagnosed laxity. This led to repeated dislocations throughout both the upper and lower extremities. Since the left patellofemoral joint had sustained repeated subluxation and dislocation episodes, the surgeon opted to perform a tibial osteotomy to better align the joint and hopefully prevent future dislocation episodes. This followed a failed soft tissue lateral release and medial imbrication surgery that failed to restore patellofemoral stability. **Conclusions:** In most cases, patellofemoral instability can be treated non-surgically through rehabilitation and bracing. However, in recurrent cases,

surgery may be the best intervention. In this case, the patient had failed initial surgical intervention, possibly due to underlying congenital laxity. Following the bony patellofemoral joint realignment surgery, this patient was able to recover and progress to full activities without subsequent instability. This case highlights recurrent patellofemoral instability in a collegiate wrestler and the management plan that helped successfully return him to full activities. It highlights the importance of transitioning healthcare from face-to-face interactions to telemedicine. Athletic trainers must realize the importance of maintaining patient contact and creating rehabilitation programs for athletes that are unable to receive in-person care.

Relationship of a Patient-Reported Outcome Measure at Time of Knee Injury to Days Missed Due to Injury
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Context: Patient reported outcome measures are habitually used in non-acute patient care settings. It is possible that the information derived from these self-reported measures differs in an acute care setting such as in collegiate athletic training facilities. Therefore, the purpose of this study was to determine if any of the Knee Injury and Osteoarthritis Outcome Score (KOOS) subscales were associated with the number of days missed following acute injury to the knee. We hypothesized that athletes who sustained a ligamentous knee injury would have KOOS scores that were associated with days missed compared to athletes with a non-ligamentous knee injury. **Methods:** 746 collegiate athletes from 3 collegiate institutions currently participating in sport and medically cleared by a team physician for full participation during preseason physical examinations participated in this study. Following the occurrence of non-ligamentous or ligamentous athletic-related knee injury not requiring surgery, subjects completed 4 subscales of the Knee Injury and Osteoarthritis Outcome Score (KOOS): pain (PN), symptoms (SX), sport/recreation function (SP), and knee-related quality of life (QL). Athletes were treated by their

respective athletic trainer and total number of days missed was reported to the research team. Between group comparisons for the KOOS subscales at time of injury were analyzed with Mann-Whitney-U tests. Pearson correlations were performed to assess for relationships between the number of days missed and each individual KOOS subscale. A forward stepwise multiple linear regression was performed to determine if a combination of the 4 KOOS subscales were significantly associated with the number of days missed for each type of injury. All analyses were considered significant if $p \leq 0.05$. **Results:** 33 athletes (Age: 19 ± 1 year, Height: 180 ± 9 cm, Weight: 80 ± 14 kg) were found to only have one significant difference between KOOS Subscales. Only the KOOS SX score was significantly decreased for the ligamentous injury group compared to the non-ligamentous injury group (See Table 1). Days missed was significantly correlated with KOOSQL for athletes with ligamentous knee injuries ($r = -0.491$, $p = 0.033$) but no other correlation was found to be significant for the non-ligamentous group ($r < -0.266$, $p > 0.19$). Multiple linear regression revealed that the KOOSQL was only significantly associated with days missed ($R^2 = 0.242$, adjusted $r^2 = 0.189$, $p = 0.033$) for ligamentous knee injury. No significant model was generated for non-ligamentous injuries. **Conclusions:** This study supports previous research that the KOOSQL is an important measure of knee function following injury. Previously the KOOSQL

was found slowest to recover following an injury and the current study moderately suggests lower scores at the time of injury is likely associated with more days missed. Clinical athletic trainers could provide better prognosis to the athlete and coaches regarding time to return to participation by incorporating the four simple questions of the KOOSQL during the initial evaluation and follow-up examinations.

Table. Median (Interquartile Range) KOOS subscale scores on the day of injury

	KOOS SX	KOOS PN	KOOS SP	KOOS QL
Non-Ligamentous (n=14)	84 (67-91)	72 (57-88)	50 (25-78)	66 (36-91)
Ligamentous (n=19)	64 (43-79)	70 (44-81)	50 (20-70)	50 (17-69)
P value	0.008	0.462	0.768	0.353

KOOS=Knee Injury and Osteoarthritis Outcome Score; SX=Symptom; PN=Pain; SP=Sport and Recreation Function; QL=Knee-Related Quality of Life

Removal of Medial Plica in College Volleyball Athlete

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Background: The term plica is used to describe a fold in the lining of the knee joint. The medial plica attaches on the distal patella and runs sideways to attach to the femur. When overuse or repetitive movements occur, inflammation and irritation of the plica occurs, causing plica syndrome. Cases involving medial plicas are usually resolved with anti-inflammatory medication, stretching and rest however this case is unique because the typical prescribed treatments did not work, thus making this an irregular presentation. **Patient:** 22-year-old female collegiate volleyball player with 8+ years of experience and no previous history reported to the athletic trainer after a competition with a chief complaint of immediate pain and tenderness on the superomedial aspect of the right knee that began after landing on her single leg unstably. During the initial clinical examination, it was noted that the patient was very point tender with a palpable medial plica and pain along the anterior femoral condyle with full extension. Pain occurred with deep knee flexion. During special testing, the patient had (+) Bounce Test and a (-) Apprehension test on the right side. Differential diagnosis included a medial knee sprain. An MRI 10 days post injury revealed mild insertional tendinopathy of the central attachment of the quadriceps without a high-grade partial tear, mild edema within the quadriceps/patellar fat pad, no joint effusion, intact patellofemoral cartilage and retinacula attachments, and a thickening of the medial patellofemoral plica with no tear. **Intervention**

& Treatment: Treatment occurred over the span of 10 weeks until the athlete went home for break. Upon return, a follow up evaluation found that pain was the same, despite the lack of physical activity. The athlete had soft tissue mobilization performed on the medial knee and patella to allow for proper patellar tracking, as well as ultrasound, rehabilitation and strengthening exercises and several dry needling sessions performed by the team chiropractor. The patient was put through a rigorous rehabilitation and strengthening routine where she performed mobility exercises, passive ROM, assisted ROM, stretching, progressive strength training, and proprioception exercises. The patient also received manual therapy, Toradol shots, lidocaine, and medication (naproxen, omeprazole). With none of the aforementioned management routes or interventions being successful, the patient underwent a right knee arthroscopy to remove the thickened medial patellofemoral plica on January 16, 2020. The patient was cleared to begin a running program and perform impact activities 1-month post operation. **Outcomes or Other Comparisons:** Athlete no longer felt pain in the medial aspect of the knee where the medial plica was located. Pain free active ROM, activities of daily living and athletic participation were achieved post-operation. ROM and flexibility both increased after the medial plica was removed. Active ROM increased from 120 degrees with pain to 125 degrees pain free post-operation. Athlete was able to return to athletic related activity 4 weeks after surgery and fully cleared to return to play with no limitations 29-weeks post-operation due to COVID-19 and Summer break. **Conclusions:** This was a Level 3 exploration with concentration on the diagnosis and treatment of an athlete with inflammation of the medial patellofemoral plica. This case highlighted that a closer examination

at treatment outcomes could have avoided long-term pain for the patient. This case illustrates the challenges and complexities associated with treatment of the medial patellofemoral plica, which included finding a beneficial treatment plan before deciding to operate on an athlete to save the patient from being taken out of competition while in-season. **Clinical Bottom Line:** This case is an example of how a quicker surgical decision, due to the lack of beneficial treatment outcomes, would have a better impact on the patient.

Side-To-Side Differences in Squat Symmetry After ACL-Reconstruction

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Context: After an anterior cruciate ligament reconstruction (ACLR), persistent strength and functional deficits could lead to increased reinjury risks. Persistent muscle weakness leading to strength asymmetry may lead to compensatory movement patterns during functional movements. Functional movements such as the squat exercise are used for strengthening during rehabilitation post-ACLR. Compensatory movement patterns during squatting, if unrecognized or untreated, may further magnify strength asymmetry in recovering patients, thereby increasing the difficulty for clinicians to treat, and patients to recover. The purpose of this study was to compare force distribution bilaterally in patients with ACLR during a squatting task. **Methods:** Participants ($n=58$) with primary, unilateral, and uncomplicated ACLR (37M/21F, 23.7 ± 10.2 years, 173 ± 11.1 cm, 79.2 ± 18.3 kg, 6.35 ± 2.44 months post-ACLR) volunteered for this study. Evaluations were conducted as part of a larger point-of-care research study, prior to clearance to unrestricted physical activity. Peak and average force distribution between limbs were measured during a bilateral squatting task. Participants completed three sets of

three consecutive squat repetitions standing with feet shoulder-width apart, moving at a standardized pace. Each foot was on an independent, instrumented pressure mat (SBmat, Tekscan, Inc) which utilizes matrix mapping sensor grids to measure pressure changes which are subsequently converted to a composite force output used for analyses. Peak force (N) during the overall squat task was recorded and averaged for analysis. In addition, the average force distribution (%) across all squat cycles was recorded for each limb and expressed as a percentage of total composite force. A resultant 50% distribution for each limb would indicate equal average force distribution between limbs. Peak and average force distribution values were compared between limbs with paired samples t -tests. Cohen's d effect sizes were calculated and reported. Results were considered statistically significant if the p -value was 0.05 or less.

Results: During squatting trials, ACLR participants exhibited significantly lower peak force on the ACLR limb (1806.22 ± 617.73 N) compared to the contralateral limb (1992.57 ± 653.33 N, $t(57) = -2.712$, $p < 0.01$, Cohen's $d = 0.36$). Additionally, participants showed significantly lower average force distribution on the ACLR limb ($0.48\pm 0.08\%$) compared to the contralateral limb ($0.52\pm 0.08\%$; $t(57) = -2.03$, $p < 0.05$, Cohen's $d = 0.27$). **Conclusions:** Significant, low-moderate magnitude side-to-side differences in peak and average force distribution during bilateral squat task were observed. Potentially indicating a pre-existing asymmetry or an

adaptation to persistent muscle weakness over the course of post-ACLR rehabilitation. This asymmetry may be subtle and unrecognizable to treating clinicians, however, may have clinical relevance during the rehabilitation process and return to physical activity. Recognizing subtle asymmetries may be clinically important in guiding early treatments and avoid replacement strategies potentially increasing consequences in post-ACLR.

Test-Retest Reliability of Clinician-Based Outcomes in Individuals With History of ACL Reconstruction

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Context: The goal of anterior cruciate ligament reconstruction (ACLR) is to restore joint stability and return patients to previous levels of function. Despite this, current literature demonstrates deleterious outcomes after ACLR including decreased knee function, quality of life, and participation in physical activity. Decreased knee function, such as strength deficits, balance impairments and diminished hop performance, continues to be observed after medical clearance for activity. This indicates that additional intervention strategies are warranted beyond standard rehabilitation. A critical first step to improving functional outcomes in individuals with a history of ACLR is to identify clinician-based outcomes that are reliable and can identify

clinically relevant improvements in this population. Therefore, the purpose of this study was to determine the test-retest reliability and minimal detectable change (MDC) of the Star Excursion Balance Test (SEBT) and a series of hop tests in participants with a history of ACLR. **Methods:** A total of 20 participants (age: 22.8±3.2years, height: 171.5±7.9cm, weight: 72.1±10.4kg) who were an average 5 years (±2.7) post-ACLR reported to the laboratory on two separate occasions, separated by one-week. Participants were included if they were 18-35 years of age, injured their knee playing or training for organized or recreational sports, cleared for physical activity by their physician, <10 years from their ACLR surgery, and had no evidence of osteoarthritis on radiographs (KL<1). Patients with a history of multiple ACLR surgeries were excluded. At each testing session, participants completed the SEBT and hop test series. For the SEBT, participants completed the anterior, posteromedial, and posterolateral reach. For each direction, participants completed four practice trials followed by three test trials. Reach distances were normalized to leg length (% leg length) for analysis. For the hop series, participants completed

single limb, cross over, and triple hop for distance measured in centimeters, and the 6-meter hop for time measured in seconds. For each hop, participants completed one practice hop followed by three test hops which were averaged for analysis. The testing order (SEBT and hop series) was randomized between participants and completed on the uninvolved limb followed by their involved limb each session. Separate Intraclass Correlate Coefficients (ICC_{2,1}) and 95% minimal detectable change (MDC) values were calculated for each subscale. The ICCs were interpreted as clinically acceptable if >0.75. **Results:** Means, standard deviations, ICC values and MDC for SEBT and hop series can be found in Table 1. All measures had clinically acceptable reliability (ICC>0.75) for each limb tested. **Conclusions:** Clinician-based measures of knee function demonstrated clinically acceptable test-retest reliability in this post-ACLR population. The MDC values calculated here can be utilized for clinical decision-making and to evaluate continued intervention in this population. Future research should investigate intervention programs aimed at improving these outcomes in this population.

Table 1. Descriptive statistics (mean±standard deviation) and statistical results for the Star Excursion Balance Test and hop series testing.

Measurement	Time 1	Time 2	ICC _{2,1}	95% MDC
Star Excursion Balance Test Involved limb (% leg length)				
Anterior	.60±.08	.60±.06	0.89	0.07
Posteromedial	1.01±.13	1.02±.13	0.97	0.06
Posterolateral	.94±.15	.96±.13	0.93	0.10
Star Excursion Balance Test Uninvolved limb (% leg length)				
Anterior	.63±.05	.60±.05	0.87	0.05
Posteromedial	1.02±.11	1.04±.11	0.95	0.07
Posterolateral	.96±.10	.97±.12	0.91	0.09
Hop series Involved limb				
Single leg (cm)	143.07±40.06	146.70±37.25	0.96	20.34
Triple hop (cm)	414.05±115.33	411.20±114.00	0.99	33.34
Crossover hop(cm)	343.92±103.99	348.25±106.99	0.80	131.10
6-meter timed hop (sec)	3.18±1.88	3.32±3.11	0.93	1.83
Hop series Uninvolved limb				
Single leg (cm)	148.44±35.94	153.36±35.37	0.97	18.22
Triple hop (cm)	422.31±97.32	430.02±103.14	0.96	57.64
Crossover hop (cm)	340.14±87.75	378.95±101.85	0.79	120.17
6-meter timed hop (sec)	2.82±.54	2.74±.56	0.97	0.28

Tibial Spine Avulsion Fracture With Surgical Screw-Fixation in a High School Basketball Player: Level 3 Clinical Case Study

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Background: Forced, sudden anterior translation of the tibia on the femur can result in injury to the anterior cruciate ligament (ACL). The incidence of ACL injury in adolescent athletes has increased by approximately 150% in the last decade; with more than half of these injuries occurring as a result of athletic activity. Tibial spine fractures (TSF) with avulsion injury of the ACL at the intercondylar eminence, occur far less commonly than injury to the ligament. The most common mechanism for these fractures is bicycle accidents, with only 20% occurring related to athletic activity. Younger males have a higher incidence (greater than 2:1) of suffering a TSF than their female counterparts. Common management of TSF includes surgical repair, although no consensus regarding arthroscopic versus open-surgical repair exists at this time. The most commonly performed repair techniques utilize either suture or screw-fixation via arthroscopic reduction. **Patient:** The patient is a 14-year-old male basketball player with a chief complaint of right knee injury secondary to performing a layup while practicing. The patient describes what he believes to be a twisting mechanism of injury. At the time of injury, the patient is unable to weight-bear on the involved

lower extremity. The patient is subsequently referred for plain radiographs. Diagnostic imaging reveals a potential tibial plateau fracture, although radiographs are inconclusive due to poor image quality. The patient is placed in an immobilizer with crutches and referred to an orthopedic surgeon. Two days later, the orthopedic surgeon confirms a TSF on plain radiograph. Imaging confirms persistent superior displacement of the fracture and internal fixation is recommended. At the time of this visit, the patient demonstrates 100-10 degrees range of motion (ROM), diffuse swelling, and laxity with the Lachman's Test. **Intervention & Treatment:** Five days after initial injury, the patient undergoes arthroscopic surgery to repair the fracture site. All ligaments and menisci are intact, the tibial plateau and all articular surfaces show no sign of injury. Avulsion fracture of tibial spine is identified, K-wire is used to secure the avulsed bone and sutures are placed through the ACL. The patient is instructed to remain NWB for 4 weeks and use a ROM brace for 8 weeks following surgery. Rehabilitation consists of immediate tibiofemoral joint ROM and involved lower extremity strengthening, beginning 8 weeks after surgery. The patient begins running at 12 weeks and initiates light agilities and plyometric exercise 13 weeks after surgery. The patient begins single-leg strengthening at week 15 and progresses functional rehabilitation over the next month. **Outcomes or Other Comparisons:** At five months post-surgery, the patient is discharged from rehabilitation and is instructed to continue strength training at a local gym. He is cleared to return to recreational activity at this time. **Conclusions:** This case is

unique because avulsion fractures at the knee are usually caused by a tendon, such as the patellar tendon, and this avulsion was caused by a ligament. Avulsion injuries are rare and are isolated to adolescent patients where bone growth is incomplete. Appropriate surgical management of this condition varies across the medical literature and the course of post-surgical rehabilitation remains undefined. **Clinical Bottom Line:** Tibial spine avulsion fractures are uncommon occurrences in athletics. These injuries require surgical repair via suture or screw-fixation in order to reattach the avulsed bone to the fracture site. Delayed repair of this injury may result in decreased range of motion, loss of strength, loss of function, and arthritic change.

Assessment of a Knee Injury in a Men's Basketball Player

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Background: Clinical special tests of the knee vary regarding diagnostic accuracy. In some cases, clinical exam may indicate the need for diagnostic testing but may not be helpful in correctly diagnosing an injury. These situations can cause increased stress for patients waiting for test results to provide a diagnosis. **Patient:** A men's basketball player presented for examination after landing off-balance on one leg and experiencing a rotation mechanism. He came out of the game complaining of sharp knee pain and difficulty bearing weight. **Intervention & Treatment:** The Athletic Trainer performed a clinical exam and found there was mild knee effusion and pain over the lateral joint line. During range of motion testing, pain free range was limited to 90 degrees of flexion and an inability to achieve full extension due to worsening pain. The McMurray's test caused increased pain when approaching 90 degrees of flexion and worsening with combined rotation, Thessaly's test was positive for pain. Stress testing showed no ligamentous instability. Follow up exam the next day revealed clicking in the knee with extension and flexion. The patient was referred to the team physician for suspicion of a meniscus tear, and x-rays were ordered, which were negative. An MRI was ordered, but the patient had to

wait 2 weeks to be scheduled due to challenges with health insurance authorization. Throughout this time the patient did not report significant decreases in pain level or improvement in function. There was heavy reliance on modalities for pain control. **Outcomes or Other Comparisons:** MRI was eventually scheduled and showed a bone bruise to the anterior portion of the medial and lateral tibial plateau and the anterior portion of the medial and lateral femoral condyle. There was no evidence of meniscal pathology. The patient was cleared to continue therapeutic exercises and began loading the knee. When the patient received negative MRI results, he reported immediate improvement in pain levels and ability to tolerate rehab progression compared to during the waiting period. Within a 3-week period, he progressed back to functional activities. He was returned to sport and was able to play as the team progressed into playoffs, without incident. This patient indicated that the uncertainty about the injury to his knee and the prolonged wait time for imaging impacted his mental health negatively. When presenting after a rotation mechanism, the special tests to assess for meniscal pathology were helpful in the decision-making process for referring the patient but were not accurate at arriving at the correct diagnosis. This is consistent with what has been reported in the literature regarding low diagnostic accuracy. These tests rely on a subjective report of pain by the patient or reported sensation of clicking and locking. Despite this, any

patient with key features of meniscal pathology, warrants further evaluation and potential imaging. **Conclusions:** It is important for Athletic Trainers to educate patients on the challenges of assessing for a meniscal injury on clinical examination alone, imaging is needed for confirmation. Athletic trainers should be aware of the stress experienced by patients awaiting test results. In this case during the waiting period, the patient displayed high levels of anxiety due to the potential of a season-ending injury, and even referenced his injury as season ending to teammates. **Clinical Bottom Line:** Increases in anxiety can impact the athlete's mental well-being. Dealing with an injury, and delay in testing and diagnosis, only compounds these factors. Athletic Trainers should recognize and discuss the psychological impact this can have for a patient's well-being and its impact on the ability to progress and tolerate rehabilitation.

Blood Flow Restriction Use For Knee Pathologies to Address Knee Extensor Strength and Function

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Context: The knee is one of the most frequently injured joints. Blood flow restriction resistance training (BFR-RT) incorporating low loads between 20-30% 1 repetition maximum (RM) are suggested to improve knee extensor (KE) strength and function. BFR-RT occludes venous blood flow creating a hypoxic environment causing greater recruitment of Type II muscle fibers resulting in strength adaptations similar to high load resistance training (HL-RT) of 70% 1 RM. **Methods:** A comprehensive computerized search was conducted in October 2020. Sources of evidence searched: PudMed, CINAHL, Medline, SPORTDiscus, PEDro. Search inclusion criteria: English language, published within last 5 years, utilized BFR on knee injuries, utilized controlled BFR devices, investigated effects of BFR on KE strength, functional outcomes, and limited to Level 1 evidence. **Results:** Four randomized controlled trial studies met the inclusion criteria. Ladlow et al. reported significant improvements in

5RM KE strength (40%, $p<0.01$), Multistage Locomotion testing (306+246 m, $p=0.01$) and composite YBT score (15+20cm, $p=0.03$) following 3-week twice daily BFR-RT in lower limb injured patients. There were no significant differences between BFR-RT and HL-RT for any outcome measure. Tennent et al. reported a significant isokinetic KE strength improvement (77.92%, $p<0.001$) in BFR-RT following knee arthroscopy over 6-weeks (12 sessions) which did not differ from the control group ($p>0.05$). A significant improvement in timed-stair-ascent (3.77 s, 95%CI:[1.3-7.3]s, $p<0.001$) was observed in the BFR-RT compared to controls ($p<0.05$). Hughes et al. reported significant improvements, but no group differences, between BFR-RT and HL-RT for 10RM leg press (104+30% vs 106+43%, $p>0.05$ for group differences), isokinetic KE peak torque (ES=0.1-0.4, $p>0.05$ for group differences in all conditions), mSEBT reach distances (ES=0.1-0.4, $p>0.05$ for group differences in all directions) of injured limb ACL post-surgical patients following an 8-week (16 session) intervention. Ferraz et al. reported significant improvements (all $p<0.001$) in knee OA patients using BFR-RT and HL-RT for 1RM leg press (26% and 33%; ES=1.01 and 0.82, respectively), 1RM KE strength (22% and 23%; ES=0.83 and 0.86, respectively) and timed-stand-test (7% and 14%; ES=0.43 and 0.52, respectively) following a 12 week intervention. There were no significant differences between BFR-RT and HL-RT for

any of these outcome measures. **Conclusions:** Grade A evidence included in this review supports the use of BFR-RT as an early treatment intervention following acute and chronic knee injury to improve KE strength and function. Findings suggest intensity loads of 20-30% of an individual's 1 RM are comparable to high intensity resistance training. Limitations of the included studies exist: inconsistency in BFR-RT protocols, variation across outcomes used to assess strength and function. Furthermore, long-term outcomes changes were not measured. Current evidence is promising and clinicians may consider incorporating BFR-RT as a means of promoting strength gains when high loads are contraindicated.

Complicated ACL and Meniscus Tear in a Division I Wrestler

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Background: A 19-year-old freshman male collegiate wrestler complained of left knee pain. He reported worsening knee pain after wrestling in a tournament. The knee received a valgus stress while he was twisting. He immediately experienced sharp pain. He denied any popping, snapping or clicking, or instability. There was no obvious swelling upon initial examination. Pain was present along the medial joint line, end ROMs, and going downstairs. Athlete had positive valgus, McMurray's, and Apley's compression/distraction tests with negative anterior/posterior drawers, Lachman's and varus stress tests. He had a left ACL reconstruction (ACL-R) with a hamstring graft and internal bracing two years prior. **Differential Diagnosis:** Based on initial examination, a medial meniscus tear with possible MCL involvement was suspected. ACL rupture was considered, but ruled out with firm end feel during Lachman's and anterior drawer tests. **Intervention & Treatment:** Rehabilitation was started and physician consultation was obtained. The physician found mild swelling, and tenderness along the medial joint line. Thessaly and McMurray's tests were positive, with negative Lachman's, anterior/posterior drawer, and valgus/varus stress tests. Diagnostic ultrasound showed a mild protrusion of the medial meniscus. MRI indicated a ruptured ACL, intact PCL and collateral ligaments, without a meniscus

tear. After viewing the MRI, the previous surgeon was unconvinced of any ACL involvement. Arthroscopy performed on the affected knee found an intact ACL; however, the internal bracing had torn with part of the femoral attachment damaged, in addition to a medial meniscus tear. During the first operation, the surgeon used the Single-Anteromedial Bundle Biological Augmentation (SAMBBA) Technique in which the semitendinosus graft is placed within the old ACL to bring in blood supply and nerve endings. The internal brace is added for reinforcement. During the second operation, the surgeon performed a partial meniscectomy and augmented the anterior aspect to damaged anterior aspect. Seven weeks post-operation, the wrestler felt a pop in his left knee while drilling. The athlete tore his ACL and the internal bracing. A third operation was performed by a new surgeon with a patellar tendon graft ACL-R. A strict RTP protocol was followed with full clearance 9 months post-operation. **Uniqueness:** During the first surgery, the surgeon used a relatively new surgical SAMBBA technique. This surgical procedure utilizes the preserved ACL remnant and augments it to the new ACL graft. The surgeon also utilized synthetic internal bracing to provide added support and allow for early ROM and weight bearing exercises. The wrestler was walking the same day of the initial operation. The MRI of the second injury suggested a torn ACL because the remnants of the ruptured ACL remained in the knee to encourage the healing process. The surgeon decided to repair the internal bracing and new ACL by suturing, as

oppose to performing a reconstruction, during the second operation. While returning to the mat, the wrestling re-tore his reconstructed and repaired ACL, requiring a third reconstruction. **Conclusions:** The athlete ultimately had three surgeries on his left knee in two years. He underwent two ACL reconstructions, an ACL repair, and a partial meniscectomy. It is necessary to understand the different surgical techniques and how each can affect recovery. Certain techniques may be better suited for different patient populations. Being knowledgeable on patient history can produce a more accurate injury diagnosis.

Presence of a Symptomatic Ligamentum Mucosum in an International Recreational Soccer Player

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Background: The infrapatellar plica, also referred to as the ligamentum mucosum (LM) is a dense connective tissue structure which transverses from the intercondylar notch of the femur to insert on the Hoffa's infrapatellar fat pad just anterior to the anterior cruciate ligament (ACL). Lying within the synovial layers of the tibiofemoral joint capsule, the LM seldom causes pathology. However, in rare cases, the LM can present as a problematic source of anterior knee pain. In this study, we discuss a patient with a challenging diagnosis of a symptomatic, thickened LM.

Patient: This is a Level 3 Exploration CASE study of an 18-year-old male, freshman international student with 12 years of experience playing recreational soccer in Mexico. Patient reported to athletic training clinic with complaints of R anterior knee pain rated 7 out of 10 on a visual analog scale (VAS). Sensations of clicking and locking were also reported without the presence of instability. Patient described medical history of R lateral meniscectomy 18 months prior followed by 12 visits of physical therapy. At discharge, patient was cleared for return to soccer activities despite persistent pain, swelling, and disability associated with injury. Initial clinical diagnosis by the Athletic Trainer was a Grade III Lateral Meniscus Sprain subsequent to moderate swelling, limited knee extension range of motion (ROM) and positive Sweep, Thessley, and Steinman's tests. All tests for ACL sprain and medial synovial plica

were negative at initial athletic trainer evaluation. Patient was referred to an Orthopedic physician for further evaluation. Physician evaluation following Magnetic Resonance Imaging (MRI) revealed intra-articular effusion, edema of the ACL, synovitis, profound Hoffitis, and Grade I Chondromalacia Patellae prompting arthroscopy. Final surgical diagnosis disclosed Chondromalacia of the Lateral Femoral Condyle and Lateral Tibial Plateau in addition to a Thickened Ligamentum Mucosum.

Intervention & Treatment: Patient underwent an arthroscopic resection of the LM and successive untethering of the infrapatellar fat pad on the R knee. Initial goals of rehabilitation included decreasing pain and increasing range of motion with restrictions on high-impact activities for the first 4 weeks post-operation. The expected return-to-participation outlook for this patient was 4 to 6 weeks.

Outcomes or Other Comparisons: At week 2, patient progressed to full weight bearing. Full ROM was achieved by the third post-operative week. Functional activities began at week 4 with patient reporting minimal pain (VAS Score: 2) and function of knee comparable to pre-injury levels when reporting using an International Knee Documentation Committee (IKDC) questionnaire (IKDC Score: 73/87 = 83.9%). Patient-rated outcome measures indicate good prognosis for a full and successful return to soccer participation. **Conclusions:** The uniqueness of this case rests on a clinical presentation similar to that of a lateral meniscus sprain. Differential diagnoses from this case include lateral meniscus sprain, lateral collateral ligament (LCL) sprain, osteochondral lesion, anterolateral rotational instability (ALRI) and posterolateral (PL) corner injury. Final diagnosis of this pathology was made after arthroscopy by an extensively trained and well experienced orthopedic physician. We believe that persistent

disability in this patient was a result of failure to release the infrapatellar fat pad from its tether of the LM during the initial surgical procedure. Based on the evidence provided in this case, we believe clinical presentation for LM pathology may include anterior knee pain in the presence of hemarthrosis and end-range flexion contracture. This case demonstrates that symptomatic LM can be successfully treated through minimally invasive surgical procedures which efficiently and effectively return patients back to functional activity. **Clinical Bottom Line:** Although rare, we encourage athletic trainers to explore the LM pathology as a potential cause of persistent anterior knee pain, hemarthrosis, and disability in patients with no suspicion of internal derangement.

The Clinical Utility of Multiple Patient-Reported Outcomes in People With History of ACL Reconstruction

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Context: Activity limitations and participation restrictions persist after ACL reconstruction (ACLR), even after completion of formal rehabilitation and clearance from healthcare providers. While decreased patient-reported outcomes (PROs) have been well documented in this population, there is a dearth of strong indicators of patient-perceived function and quality of life which can be used to guide continued intervention after clearance. Further investigating PROs which can effectively guide continued intervention to mitigate activity limitations and participation restrictions is critical for increasing activity levels and preventing irreversible joint damage. An important first step is the identification of reliable PROs which provide benchmarks for clinical improvement in individuals who are post-ACLR. Therefore, the purpose of this study is to determine the test-retest reliability and minimal detectable change (MDC) of multiple PROs in participants with a history of ACLR. **Methods:** Twenty participants (age: 22.8±3.2years, height: 171.5±7.9cm, weight: 72.1±10.4kg) who averaged 5 years (±2.7) after ACLR were included. Participants were

included if between the ages of 18-35 years, injured their knee playing or training for organized or recreational sports, cleared for physical activity, <10 years from their index surgery, and had no evidence of osteoarthritis (KL>1) on radiographs. Patients with a history of multiple ACLR surgeries were excluded. Participants reported to the laboratory on two-separate occasions separated by one-week. At each testing session, the participants completed a battery of PROs including the Knee Injury Osteoarthritis Outcome Score (KOOS), modified Disablement in the Physically Active Scale (mDPA), Fear-Avoidance Belief's Questionnaire (FABQ), and Tampa Scale of Kinesiophobia-11 (TSK-11). The order of PRO administration was randomized to prevent an order effect. Intraclass-correlation coefficients (ICC_{2,1}) and 95% minimal detectable change (MDC) values were calculated for each PRO or subscale. ICCs were interpreted as clinically acceptable if >0.75. **Results:** The mean and standard deviation, ICC value and MDC for each of the PROs can be found in Table 1. The mDPA-Physical summary component, mDPA-Total, KOOS-Symptoms, KOOS-Pain, KOOS-Sport, KOOS-Quality of Life, FABQ-Sport, and TSK-11 all had clinically acceptable test-retest reliability (ICC>0.75). The mDPA-Mental summary component, FABQ-Physical Activity and the KOOS-Activities of Daily Living did not have clinically acceptable reliability (ICC<0.75, Table 1). **Conclusions:** The test-retest reliability of many of the PRO subscales included in this investigation were clinically acceptable. Additionally,

the MDC values calculated can be used to determine treatment effectiveness, from the patient's perspective, that exceeds the measurement of error for the included PROs. These finding support the use of these PROs in future studies investigating effective intervention strategies for continued mitigation of limitations and restrictions in this population. Future research should investigate the efficacy of rehabilitation and health promotion programs to improve limitations and restrictions in people with a history of ACLR, using these PROs as clinical indicators.

Table 1. Descriptive statistics (mean±standard deviation) and statistical results for each patient-reported outcome instrument. All minimal detectable change values have been rounded to the nearest point.

Patient-Reported Outcome	Time 1	Time 2	ICC _{2,1}	95%MDC
KOOS-Pain	93.6±8.4	94±7.0	0.86	8
KOOS-Symptoms	89.3±9.2	89.3±9.2	0.90	8
KOOS-Activities of Daily Living	98.6±2.3	99.5±1.4	0.47	4
KOOS-Sport	90±9.5	93.5±8.6	0.79	12
KOOS-Quality of Life	84.4±15.6	84.7±15.1	0.97	7
mDPA-Physical	4.9±6.5	3.3±4.9	0.79	7
mDPA-Mental	1.6±2.3	1.2±2.0	0.66	4
FABQ-Physical Activity	6.65±4.6	4.8±4.3	0.64	7
FABQ-Sport	9.1±7.4	7±7	0.87	7
TSK-11	16.7±3.7	16.2±4.9	0.75	6

Relationship of Intra-Individual Pain Variability and Subjective Function in Individuals With Patellofemoral Pain
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Context: Long-lasting pain, decreased subjective function and disability are impairments seen in patients experiencing patellofemoral pain (PFP). PFP is a challenging condition due to both the chronicity of the condition, but also the day-to-day fluctuation in pain levels. Pain intensity is often assessed at a single timepoint, which might not measure the intra-individual variability of pain in those experiencing PFP. Pain variability might also better relate to subjective function than a single pain measure in individuals with PFP. Therefore, the purpose of this study was to compare the relationship of subjective function between a single assessment of pain intensity and intra-individual pain variability in those with PFP. **Methods:** Sixteen individuals (3 males, 13 females; 22.7±2.9 years, 71.29±11.16kg, 1.67±0.07m) with PFP participated in this observational study. Self-reported function was assessed on the initial day of data collection by the anterior knee pain scale (AKPS). Participants were then provided a diary and recorded their worst knee pain (0=no pain, 10=worst pain imaginable) with the

numeric pain rating scale (NPRS) every day for a 10-day period. The worst NPRS during the 10-day period was selected as the single assessment of pain. Two methods were selected to calculate intra-individual pain variability – coefficient of variance (CoV) and mean square of successive differences (MSSD). CoV is the ratio of standard deviation to a mean. The MSSD is the average of squared successive changes between two adjacent days. Greater CoV and MSSD values indicate greater intra-individual pain variability. Separate spearman rho correlations were used to evaluate the relationship of subjective function and the three measure of pain, with significance set a priori at $p < 0.05$. Additionally, stepwise linear regressions were used to identify the strongest pain assessment to predict subjective function. **Results:** The mean values of the AKPS was 74.00±10.78 and worst pain was 5.31±1.40. MSSD had a strong negative relationship with the AKPS ($\rho = -.704$, $p = .002$). CoV ($\rho = -.646$, $p = .007$) and worst NPRS ($\rho = -.539$, $p = .007$) had moderate negative correlations with the AKPS. MSSD emerged as the only significant predictor of AKPS in those with PFP ($F = 16.191$, $p = .001$), accounting for 53.6% of the variance. **Conclusions:** The MSSD variability assessment had the strongest relationship to the AKPS and predicted subjective function, accounting for over half of the variance of the AKPS. CoV and worst NPRS were moderately correlated to subjective function, however, were

not significant predictors of subjective function. Clinicians should be aware that intra-individual pain variability has a relationship with subjective function in those with PFP, which should be considered when treating chronic condition. Future research should evaluate how the extent of pain variability influences functional tasks suggested to be impaired in PFP cohorts.

Novel M-Mode Ultrasound Synchronization Method of Gluteal Muscle Activation: Intra-Rater Reliability and Agreement

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Context: Motion mode, or M-mode, ultrasound reflects tissue movement throughout a muscle contraction. It provides visualization and quantification of delay in muscle activity, such as in the gluteus maximus (Gmax) and gluteus medius (Gmed), following contraction cueing. Synchronization of muscle contraction in M-mode measurement with electromyography, movement sensors, or motion capture has wide application in the laboratory and clinical settings but has been heavily based on customized computer-based programming and considered a limitation in prior literature. This study aimed to determine reliability of M-mode measurement of Gmax and Gmed delay following cueing of contraction using a single surface electromyography (sEMG) and inertial measurement unit (IMU) sensor for synchronization. **Methods:** Sixteen healthy, physically active adults (Age: 21.6 ± 2.4 years, Height: 169.0 ± 7.4 cm, Weight: 66.9 ± 12.7 kg, 9 females and 7 males) participated in this study. A series of still images were captured for familiarization with movements; 3

in a rested prone position, 3 in a rested side-lying position, 3 during prone hip extension with knee flexed (Gmax contraction), and 3 during side-lying hip abduction (Gmed contraction). The investigator initiated recording through the sEMG/IMU system and the M-mode clip recording. Then the participant was cued to contract as the investigator simultaneously tapped the wireless sEMG/IMU sensor, which was attached directly next to the M-mode record button on the ultrasound cart. This denoted timing of the contraction cue in the sEMG/IMU recording to match the cue in the M-mode clip. Participants returned 48-72 hours for a second session and repeated imaging. Time of cueing was measured in seconds from the sEMG/IMU output and subsequently marked in the M-mode clips. Delay of contraction was analyzed from investigator cueing to contraction measured through fascial border motion. Means and standard deviations for delay of contraction (sec) were calculated. Intraclass correlation coefficients (ICC2,k) values were calculated with 95% confidence intervals (CI). Bland-Altman plots were created using mean of the differences and limits of agreement. **Results:** Delay of contraction from M-mode clips from session 1 showed 1.36 ± 0.67 sec from cue to contraction for Gmax and 1.25 ± 0.46 sec for Gmed. Session 2 revealed 1.40 ± 0.30 sec delay for Gmax and 1.04 ± 0.34 sec from cue to contraction for Gmed. Inter-rater reliability was moderate for

Gmax (ICC2,k=0.685, CI: 0.121, 0.889) and Gmed delay of contraction (ICC2,k=0.668, CI: 0.076, 0.883). Bland-Altman plots (Figure) showed good agreement for Gmax delay with one participant above the limits of agreement. Gmed delay had two outliers above the limits of agreement with remaining participants scattered randomly around the mean. **Conclusions:** Test-retest reliability for a novel M-mode measurement of delay of contraction was moderate for Gmax and Gmed. In the absence of computerized synchronization or advanced customized programming, these methods achieved an acceptable, user-friendly approach to M-mode imaging of the posterolateral hip musculature during movement.

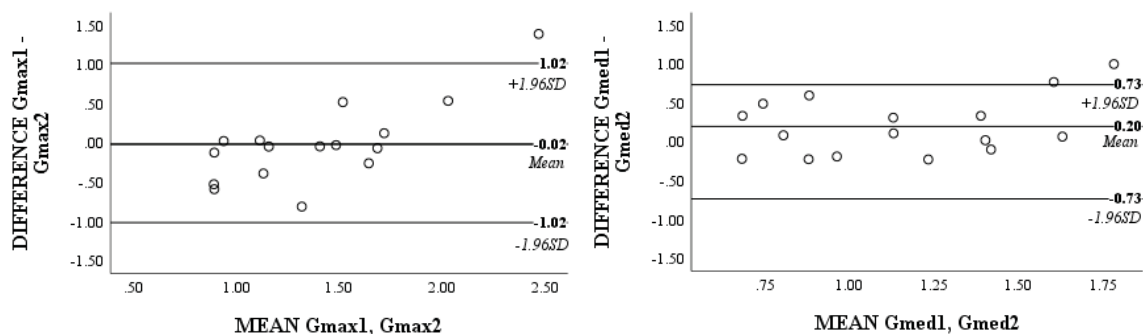


Figure. Bland-Altman plots of agreement for test-retest measurements of delay of contraction for gluteus maximus (Gmax) and gluteus medius (Gmed)

A Novel Sprinting Progression Following a Distal Fibular Stress Fracture in a Division I Track and Field Athlete

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Background: An 18 y/o female Division I collegiate sprinter noticed focal pain on the distal end of her left fibula during the fall season of her freshman year. She did not have any previous injury to the area, had been experiencing normal menstruation over the past 12 months, and had no other pertinent medical history. Her pain was insidious in nature and she was referred to a team physician for X-Rays and additional examination. She was also placed in a tall walking boot at the time of initial evaluation. Her three view X-Ray was negative upon initial examination, but it was recommended that she discontinue activity and follow up for additional imaging in two weeks. **Differential Diagnosis:** Fibular bony stress injury (BSI) **Intervention & Treatment:** Upon follow-up at two weeks after reported symptoms, her X-Rays were again negative. At this time, she also had some swelling over the area in addition to pain while weight bearing without the boot. An MRI was performed 4-weeks after her initial complaint that

showed a distal diaphyseal fibular stress fracture. This stress fracture was very well defined on MRI with both T1 and T2 weighting. She was placed in a tall walking boot for 4 weeks total before being released to do low impact exercise on the bike. At this time, she was also allowed to return to all weight lifting activities excluding jumping. This athlete was cleared to return to modified running on an Alter-G treadmill following her return to campus after winter break. At 12-weeks after initial complaint of her injury, she returned to ground based running utilizing a 15% distance progression consisting of 30, 50, 60, 120, and 150m sprints. She ran every other day, starting at 120m total volume, ending 4 weeks later running 560m. She was unable to compete in the outdoor track and field season due to the COVID-19 pandemic. **Uniqueness:** Not much literature exists regarding return to running for sprinters that have stress fractures. Distal fibular stress fractures are rare in female collegiate athletes as well. This athlete also has a low risk profile: no previous injury history, high serum 25-hydroxyvitamin D level, and 12 months of normal menstruation. **Conclusions:** Fibular stress fractures remain an uncommon source of stress fractures in collegiate runners, and not much literature exists for return to running after initial injury. The introduction of this novel sprinting progression allowed her to return to full training 16 weeks post injury without complications.

Acute Thrombophlebitis Management and Return to Activity in a NCAA Division I Pole Vaulter
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Background: An eighteen-year-old female division I pole vaulter initially presented with intense sharp pain in her left anterior superficial shin, accompanied by a prominent and raised superficial vein. She reported that it was mildly uncomfortable while weight-bearing, and very tender with palpation. The athlete reported the vein becoming firm to the touch and somewhat blue and discolored, while denying experiencing any previous redness or irritation to the anterior lower leg. She denied having taken any medications other than her prescribed contraceptive medication, and had no history of injury or trauma to the area. This athlete was referred to a team primary care physician for initial consultation on September 17th, 2019. Physical examination yielded a linear two centimeter area across the anterior shin where there appeared to be a raised superficial vein. At the time of examination, the vein did not appear to be prominent or swollen. The area at the anterior middle two thirds of the shin, overlying the tibialis anterior, was extremely tender with palpation. The

remainder of the shin, including the tibial cortex, fibula, and the more distal or more proximal aspect of the tibialis anterior musculature were all nontender to palpation. The athlete was able to exhibit full ankle range of motion in all planes. The athlete also had normal sensation to light touch distally and a single leg hop test yielded minor discomfort. **Differential Diagnosis:** Superficial thrombophlebitis. **Intervention & Treatment:** Recommendations included conservative management with warm compresses, NSAIDs, gentle compression, and elevation to decrease any present edema. The athlete and the athletic training staff were instructed to continue monitoring the site for worsening or changing symptoms such as signs of infection, worsening pain, duration of pain, and to follow up for further evaluation as needed. The athlete was given a compression sleeve to wear during training and ADLs, but was allowed to continue running as long as symptoms did not become exacerbated. She was withheld from pole vaulting initially, and was allowed to continue ground based running and jumping exercise limited by her pain tolerance. **Uniqueness:** There was no imaging or surgical intervention required to obtain a diagnosis or return to participation, and there was very little in the way of participation modification. There was no need for subsequent physician examination as the combination of NSAIDs and compression stocking proved to decrease pain and prominence of the superficial vein, resulting in no future complications

or predispositions. **Conclusions:** There is an inherent risk that a superficial thrombophlebitis could develop into a more serious condition such as a deep vein thrombosis. However, with the utilization of compression stockings and NSAIDs, superficial thrombophlebitis potentially would not limit participation in athletic activity or require surgical intervention.

Anterior Compartment Hematoma With Impending Compartment Syndrome Caused By Heterotopic Ossification of the Femur in a Collegiate Football Player

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Background: A 20-year old collegiate football player with a history of multiple thigh contusions sustained a blow to the thigh during Fall 2019 which caused moderate debilitation due to pain and swelling. An ossification was noted weeks later, but the athlete was able to compete for the remainder of the season and post-season. During recreational workouts in January of 2020 the athlete suffered from extreme swelling in the left thigh approximately two hours after lifting weights. Normal ambulation was difficult, and he suffered from severe pain and throbbing despite doing an upper body workout. It was presumed by the medical team that the athlete injured his leg by dropping the weights on them following chest press. Within 48 hours the athlete was unable to walk. **Differential Diagnosis:** Anterior compartment syndrome, deep vein thrombosis, stress fracture, contusion, muscle strain. **Intervention & Treatment:** In Fall 2019 X-rays and an MRI was performed where minimal calcification was noted. The athlete was given a course of indomethacin however throughout the season he continued to describe a “pinching” feeling with certain movements, specifically squats, getting into

his stance and bending his knee. He was able to complete his season as a fullback by partaking in manual therapies and various therapeutic modalities. In January 2020, X-rays were taken of four views of the femur and a second MRI was completed. The results showed the previously identified heterotopic ossification at the midshaft of the femur. There was no significant change of the phenomena when compared to the previous diagnostic result in Fall 2019 and the athlete was cleared to continue activity. One week later he suffered severe pain in his thigh following a recreational off-season lift. An X-ray and ultrasound were performed which was unremarkable at the thigh; however, it did show some fluid collection above the knee. A third MRI was ordered, which revealed a large anterolateral hematoma deep to the vastus lateralis and vastus intermedius. A left thigh fasciotomy with hematoma evacuation and irrigation with knee aspiration was performed. Approximately 1 L of blood and a clot was evacuated from the thigh. Additionally, 50 mL of serous fluid was obtained from the superior aspect of the knee. One course of radiation treatment was also performed to prevent the growth of the ossification. Rehabilitation was performed via telemedicine due COVID-19 shutdown, bilateral isokinetic testing of the quadriceps and hamstrings was performed 2.5 months post-op. The results showed the left leg was restored to 80-85% strength when compared to the right leg. The athlete was able to participate in summer 2020 conditioning and returned to play in Fall

of 2020. **Uniqueness:** The questionable mechanism of injury of this case brings a new etiology of impending compartment syndrome to light in sports medicine. No existing journals support such a mechanism of injury for this particular diagnosis. **Conclusions:** A heterotopic ossification of the femur can potentially create risk for compartment syndrome of the anterior upper leg. Although ossifications can often present as benign, it is important to monitor these abnormal growths as they can inadvertently result in other medical complications. When injuries are identified early and properly referred, it is possible to return a high impact athlete to play after recovering from a fascial release due to compartment syndrome.

Bone Density Loss in a High School Cross-Country Runner Due to Accutane: Level 4

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Background: In April 2020, an 18-year-old male cross-country runner with a body mass index of 17.1 reported to the athletic training facility complaining of pain in his right knee surrounding the patella and along the patellar tendon. He reported pain for the last few weeks as aching and 7/10 that increased with running and decreased with rest. During the initial evaluation, the patient denied any specific mechanism of injury or trauma to the knee. The patient participated in cross-country for the previous 5 years focusing on the 5K distance. He reported running approximately 50-75 miles per week. The patient stated he had been taking Accutane to treat acne for the past 5-6 months as well as Tylenol and Ibuprofen for pain management. There was no edema present, but point tenderness was noted over the semitendinosus tendon, lateral anterior portion of the tibial condyle, patellar tendon, and around the border of the patella. There were no range of motion or strength deficits. The athletic trainer found negative results for Pivot Shift, Patellar Apprehension, Apley's Compression and Distraction, and McMurray's. The patient was given rehabilitation for the treatment of patellar tendonitis, but the pain remained. In May 2020, the patient's symptoms worsened, and he was removed from all activity and referred for x-rays. **Differential Diagnosis:** Patellar Tendonitis, Quadriceps

Tendonitis, Stress fracture of the distal femur, Osteoporosis, Osteopenia **Intervention & Treatment:** The patient saw an orthopedic physician and reported localized pain to the distal right anterior femur. A bilateral x-ray was performed which showed signs of a stress reaction bilaterally. The physician ordered a magnetic resonance image (MRI) and dual-energy x-ray absorptiometry (DEXA) scan to further evaluate the injury. The MRI revealed a full stress fracture in the right distal femur and a stress reaction in the left distal femur. The DEXA scan revealed significant bone density loss. The patient was informed to stop taking Accutane as bone density loss is a symptom of the medication and was removed from activity for 3 months. After 3 months of no activity, the patient began a gradual run progression program. The program included progressions in speed, distance, and change in terrain based on his symptoms and performance until he was able to run at full pace and distance. He was also placed on high doses of vitamin D and calcium to help reverse the side effects of the Accutane and increase his bone density. The patient completed a strengthening program focusing on quadriceps and hamstring muscle groups. The patient's right knee pain resolved, but he continued to complain of similar pain in the left knee. **Uniqueness:** Stress fractures account for less than 1% of all high school athletic injuries and occur most commonly in female athletes. Additionally, only approximately 1% of the stress fractures occur in the thigh region. Accutane also known as Isotretinoin has a known side-effect of bone density loss after extended use. A study showed an average of 4.4% loss in bone density in Ward's triangle which is the base of the femoral neck after the use of

Accutane. The patient's injuries were potentially caused by an uncommon side-effect of Accutane and were located in a rare location of the femur as the bone density losses seen in other patients occurred in the femoral neck. **Conclusions:** Stress fractures should be considered within the differential diagnoses in cross-country runners when symptoms fail to resolve after conventional treatments. The potential side-effects of any medication should be thoroughly discussed with the patient. Clinicians should keep this side-effect in mind particularly for high school and college aged athletes that are commonly prescribed Accutane for the treatment of acne.

Freiberg's Infraction Present in an Active 15-Year-Old Male: A Level 2 Case Study

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Background: Freiberg's infraction was initially described in 1914 by Dr. Alfred Freiberg. With what is considered to be an uncommon event, Freiberg's is the fourth most common osteochondrosis in the whole body and second most common of the foot. Freiberg's can be seen at any age; however, its peak age demographic is adolescents. Typically occurring in females at a 5:1 ratio, this case study presents an adolescent male who was diagnosed with early stage Freiberg's infraction. **Patient:** This is a case of Freiberg's infraction present in an active 15-year-old male. The patient was first seen by his athletic trainer at his local high school for a chief complaint of left foot second toe pain. His second toe pain began in the middle of basketball season with no known mechanism of injury. He had been experiencing pain occasionally for about one year. Initial evaluation showed mild tenderness on the dorsum of the left second metatarsal and pain with passive ROM at the second Metatarsophalangeal (MTP) joint. This pain was at its worse when walking around school throughout the day. Conservative measures of insoles and toe taping were unsuccessful for pain management. Patient was instructed to present to a foot and ankle orthopedic clinic.

Upon physician's examination, the patient presented with left foot tenderness and palpable effusion of the second MTP joint, along with crepitus and pain in terminal plantarflexion of the joint. The x-ray revealed what appeared to be a collapse, flattening, and suspected fragmentation of the second metatarsal head. The MRI showed the final diagnosis of osteonecrosis of the second metatarsal head. The patient was then diagnosed with left second metatarsal Freiberg's infraction. **Intervention & Treatment:** Non-operative conservative measures of utilizing a walking boot and carbon footplate and operative measures of a corrective osteotomy were both discussed and conservative measures for treatment were elected. The patient opted for conservative measures. He was instructed to wear a tall walking boot for a total of four weeks. After this time, the patient was to transition into a carbon footplate to wear regularly. He was to begin a return to play program with his high school athletic trainer after his three-month follow-up.

Outcomes or Other Comparisons: At the patients three month follow up repeat x-rays were obtained and revealed a stable second metatarsal head Freiberg's infraction without interval change from prior radiographs, with no evidence of loose fragments or subluxation. The patient was back to playing basketball with no pain, just minor soreness that resolved itself spontaneously while wearing his carbon footplate. He's evaluation showed no appreciable edema, no palpable instability, minimal crepitus, and limited motion when compared to the contralateral side. Due to his success with

conservative treatment the patient was released to full activity. **Conclusions:** According to the literature, Freiberg's infraction is a progressive disease that if found in early stages can be treated successfully with non-operative measures leading to spontaneous healing on occasion. As Freiberg's progresses it is harder to manage conservatively and may then, unfortunately, require surgery. **Clinical Bottom Line:** With its poorly understood etiology, it is important for medical providers, including athletic trainers, to recognize risk factors of Freiberg's such as: a longer second toe when compared to the first, pain and edema at the MTP joint, compromised blood flow, and an active adolescent individual in a sport that can undergo microtrauma to the foot, at an early stage.

Gunshot Wound with Associated Tibial Fracture and Acute Compartment Syndrome in a College Football Athlete
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Background: Athlete is a 20 y/o male football linebacker who was shot in the lower leg. He was taken to the emergency department and diagnosed with an acute, comminuted, minimally displaced ballistic-related fracture of the mid-diaphysis of left tibia with a fragment displaced 5mm anteriorly. Two days post trauma, he underwent an irrigation and debridement of the open fracture, intramedullary nailing of the left tibial shaft, and application of a negative pressure wound VAC. A second surgery to remove the wound VAC and close the wound occurred five days later. At this time no evidence of necrotic tissue was identified and the athlete was discharged two days post-surgery. The athlete reported to the Athletic Trainer (AT) one month post-surgery and was full weight bearing at the time. He was referred to an orthopedic physician six days later for follow-up care. X-rays showed bone healing and intact tibial rod as well as ballistic fragments. Due to the condition of the external wound, he was then referred to a plastic surgeon for an in-house debridement of a 4x4cm black eschar. There was necrotic tissue in the anterior compartment of the lower leg and an immediate referral to trauma surgeon and admission to the hospital followed. **Differential**

Diagnosis: compartment syndrome, muscle necrosis, osteomyelitis, drop foot **Intervention & Treatment:** Eight weeks post injury, the athlete underwent an anterior compartment fasciotomy and soft tissue debridement. An infectious disease doctor was consulted to determine the appropriate medication for the infection. A second surgery was performed four days later to remove a significant amount of tissue. Antibiotic beads were inserted in the soft tissue between the tibia and fibula. Three days later a third surgery was done to remove the original rod from tibia. It was replaced with an antibody rod and new antibiotic beads and a PIC line was put in place. A fourth surgery occurred approximately five weeks later to remove the beads and rod and insert a titanium rod to allow for weight bearing. *Staphylococcus epidermidis* was still present post-surgery and was managed with oral antibiotics. White blood cell count were monitored and daily wound care was performed by the AT staff. There have not been any skin grafts at this point and bone healing has been progressing as expected. The athlete will progress through rehab over several months to include open kinetic chain hip exercises, core stabilization exercises, and soft tissue mobilization for the lower leg. He will progress to partial weight bearing with a brace for the drop foot. Gait training will begin when indicated. He currently remains on oral pain management. Currently there is limited evidence of anterior compartment activation with no great toe movement and only minimal muscle contraction upon dorsiflexion. **Uniqueness:**

The athlete did test positive for COVID during the initial hospitalization which could have delayed surgical intervention. There was no evidence of necrosis upon discharge; however, a large portion of his left lower leg muscles were necrotic less than two months later. There is limited information in the literature regarding non-fatal GSW in a collegiate athlete. **Conclusions:** This case highlights the treatment and subsequent recovery of an athlete with a tibial fracture and anterior compartment muscle necrosis due to a gunshot wound. The athlete underwent six surgeries over 4 months and is expected to have another surgery to transfer the soleus tendon into his anterior compartment. If successful, the prognosis is positive and he may be able to return to physical activity. This case emphasizes the need for interprofessional care to provide the best possible outcomes.

Sesamoidectomy in a Female High Jumper with Ehlers-Danlos Syndrome: A Case Report

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Background: A 20-year-old female collegiate high jumper reported to the athletic training staff complaining of persistent pain and tenderness underneath the fibular sesamoid of the right foot. The patient reported increasing symptoms that began to adversely affect activities of daily living in addition to her high jumping form. The patient stated she could not recall a singular incident that led to the onset of pain. Further evaluation did not reveal any swelling, loss of motion, or decrease in strength throughout the foot or ankle. Additionally, the patient was known to have Ehlers-Danlos Syndrome. After conservative treatment with anti-inflammatories and padding failed, the patient was referred for diagnostic imaging. **Differential Diagnosis:** Sesamoiditis, First Metatarsophalangeal Sprain, Contusion **Intervention & Treatment:** Upon physician exam, x-rays were taken for further evaluation. The sesamoids were difficult to

make out in the x-ray, and an MRI was ordered. The MRI revealed avascular necrosis of the fibular sesamoid. Upon reviewing the results, the patient consented for surgical resection. Next, the patient underwent an excision of the right fibular sesamoid. Immediately after incision into the joint capsule over the fibular sesamoid, serous fluid began draining from the site. Apparently, arthritic fluid was present in the capsule, and the surgeon believed the presence of the fluid accounted for some of the patient's symptoms. Following excision of the necrotic sesamoid, the patient was placed in a walking boot and given instructions to follow up with the surgeon two weeks after surgery. At the two week follow up, the patient appeared to be healing well, but was advised to remain in the walking boot until able to ambulate pain free. A plan was made to begin therapeutic exercise upon receiving clearance from the surgeon, with a goal of working back to functional exercises and high jumping in time for the indoor track and field season. **Uniqueness:** While tissue fragility has been reported in athletes suffering from Ehlers-Danlos Syndrome, the reported incidence of Ehlers-Danlos Syndrome is approximately one in 5,000 patients. Avascular necrosis of the sesamoids appears to be a rare condition that is not well described in athletes. To the authors' knowledge, there does not appear to be

any previously reported cases of avascular necrosis of the sesamoid in an athletic population. **Conclusions:** When caring for patients, it is important for the clinician to take into account all possible pathologies when considering signs and symptoms. In the event that a patient experiences persistent symptoms, it is paramount that timely and appropriate referral take place. Furthermore, all treatment and rehabilitation plans must be evaluated and re-evaluated for effectiveness.

Sport Affects Overall Score on a Clinical Lower Extremity Movement Screening Tool

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Context: Sports require different movement patterns, place different stresses on the body, and may place certain athletes at higher injury risk. Gymnastics and volleyball athletes commonly perform double-leg movements (jumping), while soccer athletes perform single-leg movements (cutting, kicking). The purpose of this study was to investigate between sport differences using 3 lower extremity clinical movement assessments. We hypothesized gymnastics and volleyball athletes would display better movement on the double-leg assessments but worse movement on the single-leg assessment compared to soccer athletes. **Methods:** We conducted a cross-sectional laboratory study of female collegiate athletes (soccer: n=20, age=19.3±0.9yrs, BMI=21.6±1.7kg/m²; gymnastics: n=15, age=19.5±1.6yrs, BMI= 23.4 ±1.8kg/m²; volleyball: n=9, age=20.3 ±1.7yrs, BMI=23.0±1.9kg/m²). Athletes completed 1 set

of 3 repetitions each of a double-leg squat, double leg-squat with heel-lift, and single-leg squat. Trials were filmed from the front (Qualisys Miquis camera; 60Hz), side, and back (Logitech C920 camera; 30Hz). An expert clinical rater scored all assessments using a standardized rubric (Fusionetics LLC). An error was recorded if it was observed on at least 2 of the 3 repetitions and scored as 1; a score of 0 was given when no error was observed. Errors were summed by assessments with a max score of 13, 11, and 10 on the double-leg squat, double-leg squat with heel-life, and single-leg squat respectively. Ordinal data were analyzed using a Kruskal-Wallis H test and Conover-Iman post hoc with a Bonferroni adjustment. Vargha and Delaney's A effect size was interpreted between pairwise comparisons as small (0.56-0.63), medium (0.64-0.70), and large (≥0.71). **Results:** Between group differences were observed for the double-leg squat with heel-lift (P=0.044), but no differences were observed for the double-leg squat (P=0.076) or single-leg squat (P=0.085). Gymnasts performed better than soccer (P=0.045) and volleyball (P=0.043) athletes on the double-leg squat with heel-lift, but soccer and volleyball athletes did not differ (P=0.962). Median values with corresponding interquartile ranges and effect sizes are presented in the table. **Conclusions:** These findings may be the result of greater familiarity and practice with squatting. Limited dorsiflexion can negatively affect proximal joint kinematics during squatting, and gymnasts may have greater ankle mobility

allowing for more symmetrical and desired movement patterns. However, the heel-lift theoretically removes dorsiflexion limitations; thus, our findings of between sport differences on the double-leg squat with heel-lift were unexpected. Several medium-to-large effect sizes were observed suggesting there may be important clinical differences between sports that would become more evident with a larger sample size. Different sporting activities, both between sports and within the same sport, require various movement patterns. Therefore, no single assessment should be used to characterize movement patterns. Clinicians should utilize a variety of movement assessments of varying difficulty (single- vs double-leg) and intensity (closed vs open kinetic chain) to comprehensively assess athlete movement patterns.

Table 1: Comparison of lower extremity screening movement scores between sports.

	Double-Leg Squat	Double-Leg Squat with Heel Lift	Single-Leg Squat
Median (Interquartile Range)			
Soccer	5.0 (4.0)	2.5 (2.0)	5.0 (2.0)
Gymnastics	3.0 (5.0)	1.0 (2.0)	4.0 (3.0)
Volleyball	5.0 (3.0)	3.0 (3.0)	4.0 (3.0)
Vargha and Delaney's A			
Soccer – Gymnastics	0.72	0.71	0.71
Soccer – Volleyball	0.57	0.56	0.54
Gymnastics – Volleyball	0.67	0.75	0.68

Vargha and Delaney's A effect size: small (0.56 - <0.64), medium (0.64 - <0.71), and large (≥ 0.71)

Systematic Review of Common Lower Extremity Movement Assessment Rubrics

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Context: Lower extremity (LE) musculoskeletal pain and injury are commonly associated with poor movement patterns at the trunk, hip, and knee. Therefore, efforts have been focused on identifying poor LE movement using clinically friendly movement assessment tools (MATs). Rubrics are a common form of rating criteria used in MATs to determine quality of movement and also serve as a clinician-friendly substitute for 3D motion analysis systems. Any MAT that is used clinically or for research should have acceptable measurement properties, such as reliability and validity. To our knowledge, there has not been a systematic review of studies that investigated measurement properties of rubric-based MATs. Therefore, the purpose of this study was to systematically review the literature about the measurement properties of rubric-based MATs commonly used to determine LE movement quality. **Methods:** : The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines were followed. The search was performed in Pubmed, SportDiscus, and Web of Science

databases from years 2004-2019. Search filters included synonyms for “assessment”, variants of “single leg squat” (SLS), “double leg squat” (DLS), “stepdown” (SD), and “jump landing”, and the measurement property terms “reliability” and “validity”. The initial search yielded 910 studies and after exclusion criteria were applied, 49 studies were included in the full-text review. Two independent reviewers used the Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) checklist to determine the quality of methodology and measurement property results of studies. Best evidence synthesis results were scored according to the COSMIN checklist thresholds (Table 1). **Results:** Thirteen studies that used a rubric-based MAT scored very good or good quality on methodology and were included in the best evidence synthesis. Studies included one or more of the SLS (n=12), SD (n=5), and DLS (n=1) tasks. Search results did not find any studies reporting on jump-landing tasks. Three different rubrics used comparable criteria and samples to be pooled for best evidence synthesis including: Knee-medial-to-foot (KMF) position, Crossley et al. rubric (CR1), and Chmielewski et al. rubric (CH2). The KMF rubric demonstrated moderate evidence of good intra-rater reliability during the SD but not during SLS or DLS tasks. The CH1 rubric demonstrated moderate evidence of poor inter-rater reliability during the SLS and poor intra- and inter-rater

reliability during the SD. All other results were conflicting or unknown evidence (Table 1). **Conclusions:** Only the KMF rubric during the SD task was supported by moderate evidence of good intra-rater reliability. There was poor or conflicting evidence of the reliability and validity of the CR1 or CH2 across any task. Due to the prevalence of conflicting findings, more research should be done to evaluate measurement properties of rubric-based MATs to ensure proper conclusions of LE movement quality can be made clinically.

Table 1: Best Evidence Synthesis

<i>Rubric</i>	<i>Reliability</i>	<i>Measurement error</i>	<i>Validity</i>
KMF SLS	Intra: +/- Inter: +/-	? [∅]	+/-
KMF SD	Intra: ++ Inter: +/-		+/-
KMF DLS	Intra: ?* Inter: ?*	? [∅]	? ^a
CR1 SLS	Intra: +/- Inter: +/-	? [∅]	+/-
CH1 SLS	Intra: +/- Inter: --	? [∅]	
CH1 SD	Intra: -- Inter: --	? [∅]	

(++) = moderate, positive rating: ICC or weighted kappa $\geq .70$ in multiple fair or at least one good quality study and a total sample of ≥ 50 . (--) = moderate, negative rating: ICC or weighted kappa $\leq .70$ in multiple fair or at least one good quality study and a total sample of ≥ 50 . (+/-) = conflicting findings within or between pooled studies, (?*) = total sample of ≥ 25 , (?[∅]) = no minimal important change (MIC) established, (?^a) = criteria for positive rating not met

The Effect of Blood Flow Restriction on Muscle Hypertrophy and Tendon Thickness in Healthy Adults Distal Lower Extremity: A Critically Appraised Topic

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Context: The effectiveness of Blood Flow Restriction (BFR) in muscle groups such as the quadriceps and biceps has been frequently studied with positive results, however investigation in the distal lower extremity is infrequent and has important clinical implications for populations with contraindications to high-load resistance training, are unable to sustain high-load resistance training, or want the benefits of high-load resistance training without increased joint stress. **Methods:** PubMed, SPORTDiscus, and Web of Sciences were searched in August 2020 using phrases: “Blood Flow Restriction” OR “Occlusion Training” AND “Hypertrophy.” Studies were limited to publication within 5-years. Seven titles were reviewed for relevance to the clinical question, the abstract, then full text. Articles were excluded/included depending on relevance to the focused clinical question. Studies were excluded if they only included patients completing rehabilitation. Four high-quality randomized control studies

were included with scores on the PEDro scale of 6, 7, 7, and 8. **Results:** Three articles demonstrated increases in hypertrophy of triceps surae in Low-Load BFR group versus control. Two studies measured Achilles thickness and found positive effects of BFR: one study found significant increases with Low-Load BFR ($73.5 \pm 14.4 \text{ mm}^2$; $p < .05$; effect-size=0.151) and High-Load Resistance Training ($73.5 \pm 17.2 \text{ mm}^2$; $p < .01$; effect-size=0.139) versus control ($68.9 \pm 15.5 \text{ mm}^2$), while a second study found Low-Load BFR had greater thickness post-exercise ($4.85 \pm 0.91 \text{ mm}$) compared to control ($4.70 \pm 0.71 \text{ mm}$, $p < .05$, effect size=0.091). Two studies measured gastrocnemius hypertrophy in Low-Load BFR group: one found significant difference ($18.0 \pm 4.5 \text{ cm}^2$) compared to control ($14.3 \pm 1.6 \text{ cm}^2$; $p < .001$, effect-size=0.048) while the other did not (BFR $22.0 \pm 3.9 \text{ mm}$, control $21.0 \pm 2.0 \text{ cm}$; $p = .926$). One article found increased soleus hypertrophy in Low-Load BFR ($17.2 \pm 2.9 \text{ mm}$; $p < .001$; effect-size=.238) and Low-Load Resistance Training ($16.7 \pm 1.9 \text{ mm}$; $p < .01$; effect size=.185) versus control ($15.8 \pm 2.8 \text{ mm}$). Three studies demonstrated increased hypertrophy of triceps surae with Low-Load BFR compared to High-Load Resistance Training or Low-Load Resistance Training and control groups. The fourth article did not show significance in Achilles thickness however this study used lower occlusion pressure (30% versus 50-60%) and measured thickness after a single exercise bout (1-day versus multiple times

for 4-14 weeks). **Conclusions:** Low-load BFR resistance training demonstrated significant effects on triceps surae hypertrophy to high-load resistance training and was superior to control groups. One study demonstrated no significant increases of hypertrophy in the gastrocnemius compared to the control. The intervention for this study was only 6 weeks and there were still increases in hypertrophy seen in both groups, demonstrating that Low-Load BFR can aid in training the gastrocnemius. Based on the Centre for Evidence-based Medicine there is Grade B evidence BFR increases hypertrophy of triceps surae.

Hardware Removal and Postoperative Tightrope Fixation Complications in a Male Collegiate Football Player: Level 3 Exploration CASE Study

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Background: The incidence of distal tibiofibular syndesmotic disruption in high risk sports, like football, occurs in 17-74% of all ankle sprains. Ankle syndesmotic disruption can result in future complications with improper diagnosis or joint fixation. Currently, the preferred surgical intervention for syndesmotic injury repair is the screw internal fixation method. However, suture-button fixation, also known as Tightrope™ fixation, has become increasingly popular due to several advantages, including higher functionality scores on patient-reported outcome measures, faster return to activity, decreased infection, and decreased malreduction.

Patient: The patient is a 21-year-old, male, Division I defensive lineman with a previous medical history including a right, Grade 1 lateral ankle sprain with no return-to-play complications 3 months prior. The mechanism of injury was direct impact on the lateral aspect of the right ankle, forcing subtalar eversion while the patient's foot was planted. The patient presented with observable mild swelling around the entire ankle joint, reported pain at 6/10, and was tender to palpation over the inferior portion of the right tibialis anterior muscle, the anterior talofibular ligament, and the anterior tibiofibular ligament. The patient tested positive for syndesmotic disruption with the squeeze test and medial ankle sprain with the inversion talar tilt. The patient was referred for an MRI one day post-injury, which confirmed a right high ankle sprain with syndesmotic disruption. **Intervention & Treatment:** Typically, ankle syndesmotic

injuries are repaired with screw fixation, but research is revealing the advantageous effects of suture-button techniques like Tightrope™ fixation when compared to syndesmotic screw fixation. Documented issues that could arise from screw fixation include screw loosening and breakage, discomfort, reoperation, and loss of reduction due to early implant removal. Two days post-injury, this patient was treated with a right ankle open reduction and internal fixation with two Tightrope™ anchors, a small plate by Arthrex®, and right ankle arthroscopy to provide effective stabilization, with the patient's goal to return-to-play for the upcoming Bowl Game in 5 weeks. Approximately 5 months after the initial surgery, the patient underwent a second surgical procedure involving hardware removal, revision of the syndesmotic fixation, deltoid ligament reconstruction, and arthroscopic debridement. Sixteen weeks after the revision surgery, the patient was hospitalized for an infection at the surgical site, resulting in hardware removal surgery and cleaning of the surgical site. This patient revealed the disparity and lack of studied complications following Tightrope™ fixation. **Outcomes or Other Comparisons:** Literature reports that Tightrope™ fixation has lower rates of implant removal, implant failure, and malreduction, as well as better objective range of motion measurements and earlier return to activity, compared to screw fixation. After nearly 2 years post-initial injury, the patient has returned to competitive play. Since the hardware removal surgery, patient-reported outcomes revealed an ability to functionally perform all tasks required for activities of daily living with no or slight difficulty, such as stepping up and down stairs or squatting. However, the patient still described extreme difficulty at times in performing sport-specific activities like cutting and jumping with residual pain. **Conclusions:** Based on limited research on complications following Tightrope™ fixation, the challenges faced by this patient were atypical, especially

having 2 Tightrope™ fixation surgeries and then complete hardware removal. Clinicians should be cognizant of potential postoperative complications, able to recognize infections, and provide patient-centered care to treat patients holistically. **Clinical Bottom Line:** Research related to the negative effects of Tightrope™ fixation are limited, with many resources praising its use. The aim of this case study was to present the effects and complications of a syndesmotic disruption repaired with Tightrope™ fixation and its impact on a collegiate football player's life. The lack of literature discussing complications post-Tightrope™ fixation creates challenges for clinicians when developing a patient-centered approach for injured patients.

Dynamic Ankle Immobilization Alters Proximal Joint, But Not Ankle Fronto-Transverse Kinematics After Three Days of Use

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Context: Ankle injuries are the most prevalent orthopedic injury among the physically active, and boot immobilizers (BI) are commonly used during rehabilitation. However, wearing a BI generates several changes to the gait cycle, including inducing a leg-length discrepancy, and increasing demand on proximal joints to clear the foot during the swing phase. Previous studies have examined gait alterations while wearing BI, but none have done so after BI use. We aimed to evaluate the effects of 72-hour dynamic ankle immobilization on lower extremity joint kinematics in an uninjured population. We hypothesized motion at the hip and knee would increase, while motion at the ankle would decrease following BI. **Methods:** A crossover design was implemented using twelve healthy individuals (20.8±1.4 yrs, 1.7±0.1 m, 75.2±9.9 kg). Participants were asked to wear one of two treatments – BI; or compression sock (CS – for three days, with at least a 7-day

washout between conditions. Lower extremity 3-dimensional joint angles were assessed using Vicon-Vantage motion capture system (Oxford, UK) while participants walked on a split-belt treadmill at 1m/s. Participants were measured before and after BI & CS interventions, with post measures being after removal of the intervention. Peak positive & negative joint angles in each plane were extracted for analysis and assessed using repeated-measures analysis of variance. Continuous joint angles were also assessed across conditions using statistical parametric mapping (SPM) ($\alpha=0.05$). **Results:** Peak and continuous measures for ankle kinematics revealed no differences in neither stance nor swing phases across conditions ($p>0.05$). Peak knee abduction angle during stance ($F=5.720$, $p=0.001$) and swing ($F=6.051$; $p=0.001$) decreased following BI use, while peak adduction increased during swing only. Also during swing, peak knee external rotation angles increased ($p=0.044$) (Table). No differences were observed at the knee for continuous joint angles. At the hip, peak external rotation decreased ($F=5.252$ $p=0.002$) and peak internal rotation increased ($F=5.120$; $p=0.002$) following BI use during stance. During swing, only increased peak hip internal rotation was observed ($p<0.012$) (Table 1). SPM analysis revealed significantly more increased internal rotation angles ($p<0.001$) during stance and swing phases after BI use.

Conclusions: Our results suggest that 72 hours of BI use increased fronto-transverse motion at the knee & hip, but did not impact the ankle. While this type of motion is often associated with risk factors for various pathologies, it is unclear whether BI would increase risk for subsequent injury. However, this increase in motion is likely due to increased attempts to clear the foot during swing, which may suggest clinicians should focus on maintaining sagittal motion to achieve this. Further, the lack of changes at the ankle joint are promising, suggesting BI may not impact biomechanical function; however, studies in injurious populations would be needed to confirm this.

Table: Peak Knee and Hip Joint Angles

		Pre-BI		Post-BI		Post-CS	
		Frontal	Transverse	Frontal	Transverse	Frontal	Transverse
Knee	Stance (+,-)	-0.85±2.48; -7.09±1.89	-3.58±8.80; -14.59±7.25	0.63±3.44; -3.35±3.41*	-9.49±7.29; -19.44±7.67	0.10±3.06; -5.68±3.02	0.29±5.80; -10.93±5.90
	Swing (+,-)	-1.25±2.98; -10.60±2.06	-6.97±8.25; -19.58±7.55	3.50±4.27*; -4.70±4.33*	-11.49±8.28; 25.58±7.12*	0.04±2.81; -9.17±3.87	-3.57±6.14; -15.40±6.05
Hip	Stance (+,-)	5.66±4.62; -3.97±3.69	12.41±6.25; 3.33±7.19	5.70±5.16; -3.11±6.26	3.35±9.70*; -5.72±8.79*	7.79±3.85; -1.65±3.61	11.67±4.74; 0.96±5.72
	Swing (+,-)	6.56±3.72; -0.73±4.47	13.08±5.63; 4.63±7.00	7.30±5.19; -0.03±6.74	4.22±10.02*; -4.14±8.58*	8.95±3.46; 1.32±3.95	13.03±6.05; 3.83±6.57

Note: *Significantly different from Pre-BI.

Dynamic Postural Stability Declines When Initiated by a Choice Reaction Task

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Context: Hop-to-stabilization assessments are commonly utilized to examine dynamic postural stability following a range of different sport-related injuries. The traditional methods of hop-to-stabilization testing afford the patient the ability to strategically coordinate around an internally-initiated postural strategy for optimal performance. However, the addition of a choice reaction task to cue an externally-initiated hop-to-stabilization may alter postural strategies and emulate more contextually relevant task demands of sport environments. Therefore, the purpose of this study was to compare dynamic postural stability between internally-initiated and externally-initiated conditions. **Methods:** Thirteen physically active adults (Male=7, Female=6 Age: 20.1±1.4 years; Height: 174.6±14.3 cm; Weight: 82.0±25.3 kg) volunteered to participate. Participants completed a dynamic hop-to-stabilization task under internally-initiated and externally-initiated conditions. For the internally-initiated condition, the hop-to-stabilization task involved a forward double-limb jump (40% of participant's height) over a 30.5cm hurdle with a single-limb landing. Participants stabilized as quickly as possible and held single-limb balance for at least 3 seconds. For the externally-initiated condition, participants initiated the jump as quickly as possible in response to an

illuminated LED disc which created a choice reaction task (green light=left leg landing, red light=right limb landing). A second LED disc positioned on the hurdle captured the time from the onset of disc illumination to the participant crossing of the hurdle. Following three practice trials, three successful attempts were completed on each leg for each condition. Acceleration and gyroscopic data were recorded using a nine-axis IMU placed at the lower lumbar vertebrae. Acceleration and gyroscope axes were each combined to create a resultant vector and the root-mean-square (RMS) was calculated for each leg. Higher RMS values represented greater acceleration or rotational velocities. Paired t-tests with corresponding effect sizes compared RMS values between conditions. The relationship between reaction time (RT) and the resultant RMS values for the externally-initiated condition was examined through Pearson product-moment correlations. The alpha level was set at $p \leq 0.05$. **Results:** The externally-initiated condition was associated with greater gyroscopic RMS values on the right (Internally-Initiated: 60.13±23.42, Externally-Initiated: 77.74±25.54, $p=0.003$, ES=1.04) and left (Internally-Initiated: 63.21±20.21, Externally-Initiated: 77.60±24.26, $p=0.03$, ES=0.65) limb. No differences were identified between conditions for accelerometer RMS values on the right (Internally-Initiated: 12.45±1.15, Externally-Initiated: 12.88±1.41, $p=0.12$, ES=0.46) or left (Internally-Initiated: 12.25±1.03, Externally-Initiated: 12.74±1.54, $p=0.13$, ES=0.44) limb. RT and RMS measures exhibited weak-to-moderate negative correlations ($r \leq -0.47$, $p \geq 0.11$). **Conclusions:** This study determined that the externally-initiated condition

demonstrated greater overall rotational velocities or poorer postural stability compared to the internally-initiated condition. Additionally, postural stability on the externally-initiated condition was not strongly related to the participant's RT. Therefore, the external cue and neurocognitive load created by the choice reaction task may challenge perceptual-cognitive control of the athlete in a context more consistent with sport situations that require rapid coordination of movements in response to external stimuli.

Dynamic Postural Stability Index is Not Altered During Dual-Task Single-Leg Landing in Healthy Participants

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Context: Sport is an extremely dynamic environment; because of this, it is critical that post-injury and return-to-activity assessments more closely simulate the dynamic demands of sport. The environment and cognitive-motor load during typical post-injury assessments may not be demanding enough to truly evaluate readiness to return-to-activity. The dynamic postural stability index (DPSI) has been widely used to examine neuromuscular control and postural stability and takes into consideration the kinematic and muscular control requirements of dynamic postural stability, expressing both global and directional measures. The DPSI has not been explored in a cognitively demanding environment; the purpose of our study was to explore the impact of a cognitive task on dominant and non-dominant single-leg landing DPSI in healthy young adults. We hypothesized that participants would take longer to stabilize with a cognitive task than without, and longer to stabilize on their non-dominant limb than their dominant limb. **Methods:** This cross-sectional study was conducted in a research laboratory. Forty-one participants

(49% female; 22.5 ± 2.1 yrs; 172.5 ± 11.9 cm; 71.0 ± 13.7 kg, 92.7% right-leg dominant) from a convenience sample of healthy, physically active young adults completed the study. Participants completed 16 total single leg landing trials; 4 trials on each limb (dominant/non-dominant; 8 per leg) performed with and without a cognitive task (subtracting by 6s or 7s). Participants started on a 30cm-tall box set 50% of their height behind the target force plates (Bertec; 1,500Hz). Participants were instructed to jump off of the box, land on one foot with their hands on their hips and stabilize as quickly as possible. Trials were discarded and repeated if participants were not fully on the force plates, tapped their contralateral limb on the floor, or moved excessively. Trials were averaged and compared between task. A 2 (cognitive) x 2 (limb) repeated-measures ANOVA was used to explore DPSI between single- and dual-task and between dominant and non-dominant limbs ($\alpha=0.05$). Cohen's d was used to calculate effect sizes. Higher DPSI scores represent worse dynamic postural stability. **Results:** There was no significant interaction between limb and cognitive condition ($p=0.840$; dominant single-task [0.404 ± 0.007 , 95%CI: 0.390,0.418]; dominant dual-task [0.405 ± 0.007 , 95%CI: 0.390,0.420]; non-dominant single-task [0.397 ± 0.009 , 95%CI: 0.379,0.414]; non-dominant dual-task [0.396 ± 0.007 , 95%CI: 0.382,0.411]). There were no significant main effects for DPSI scores with or without a dual-task ($p=0.922$; $d=0.143$) or when landing on dominant or

non-dominant limbs ($p=0.130$; $d=1.143$). **Conclusions:** Neither the addition of a cognitive task nor limb landed on significantly impacted the dynamic postural stability of healthy young adults. While differences in pathologic populations have been observed, our findings indicate that DPSI remains relatively stable in physically active, healthy young adults, and may be beneficial for observing deficits post-injury that are indicative of altered sensory or neuromuscular function that may benefit from rehabilitation.

Balance Training: Does Anticipated Balance Confidence Correlate With Actual Balance Confidence for Different Unstable Objects?

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Context: The primary purpose of this investigation was to explore the correlation between anticipated and actual balance confidence on different unstable objects for static double and single leg stance among healthy individuals. The secondary purpose was to explore the correlation between anticipated and actual unstable object difficulty rankings. **Methods:** Sixty-five active, healthy adults (M=35, F=30) (mean age=24.38 ± 3.56) participated in the study. All subjects consented and signed a university approved waiver form. All participants underwent two sessions of testing with a 5-day “wash out” period in between testing sessions. During session I, participants took an online survey,

rating their anticipated balance confidence after observing images of 6 different scenarios: stable ground, foam pad, air filled discs, Bosu® (dome up), Bosu® (dome down), and wobble board. During session II, participants stood on the ground and each unstable object under two conditions (static double leg stance and single leg stance with eyes open) and rated their actual balance confidence. The main outcome measure was an ordinal balance confidence score adapted from the activities-specific balance confidence scale. Statistical analysis included subject demographic calculations and appropriate non-parametric tests. **Results:** For the double leg stance and single leg stance conditions, there was an excellent relationship between anticipated and actual balance confidence scores on the stable ground ($\rho=1.0$, $p<.001$). For both conditions, there was little to no relationship between scores for foam pad, air-filled discs, Bosu® (dome up), Bosu® (dome down), and wobble board. For unstable object rankings, there was an excellent relationship between anticipated and actual scores ($\rho=1.0$, $p<.001$). The objects were ranked as the following: level 1- ground, level 2- foam pad, level 3- air-filled discs, level 4- Bosu®, and level 5- wobble board. **Conclusions:** Study findings suggest

that actual measures of balance confidence may provide insight into an individual’s confidence level and may help with prescribing and progressing their rehabilitation or training program appropriately. The suggested object difficulty rankings may help clinicians to better match the objects to their patients to produce optimal outcomes.

Unstable Object (Difficulty Level)	Ground	Foam pad	Air-filled discs	Bosu®	Wobble Board
Level 5-Hard			5% (N=3)	23% (N=15)	72% (N=47)
Level 4			25% (N=16)	52% (N=34)	23% (N=15)
Level 3			70% (N=46)	25% (N=16)	5% (n=3)
Level 2		100% (N=65)			
Level 1-Easy	100% (N=65)				

Table- Unstable object rankings

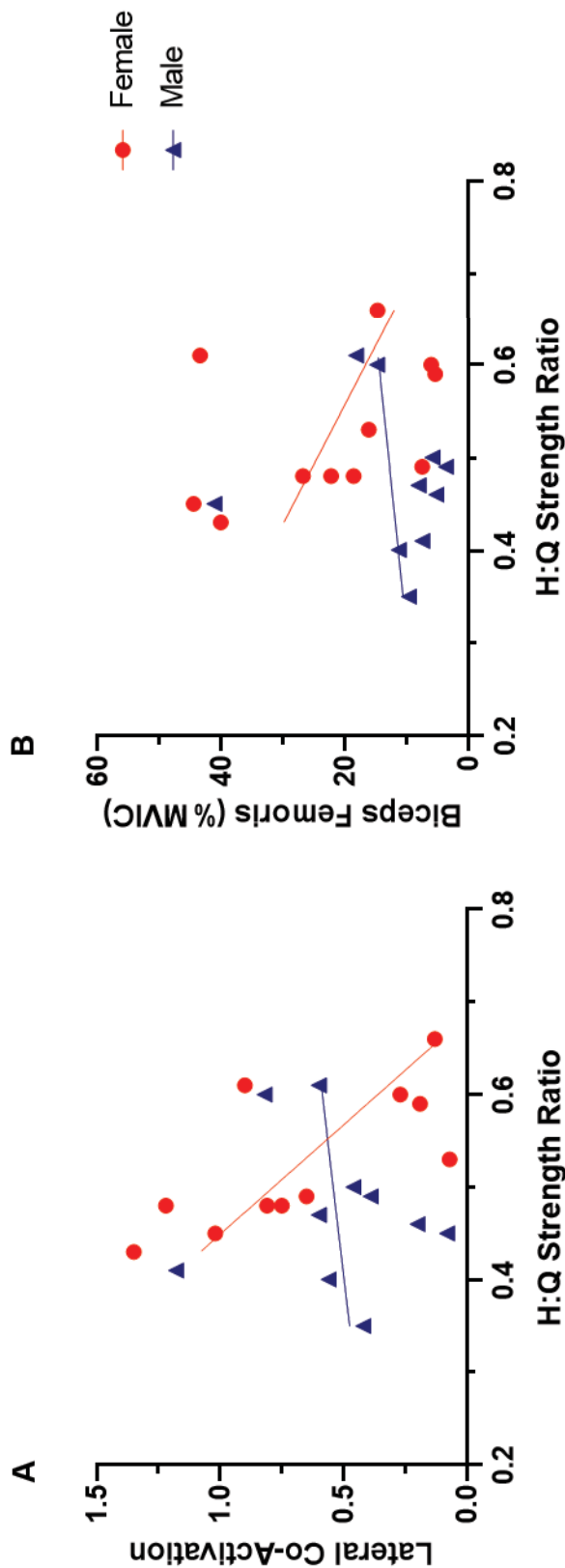
Sex Influences the Relationship Between Hamstrings-to-Quadriceps Strength Imbalance and Co-Activation During Walking Gait

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Context: Hamstrings-to-quadriceps (H:Q) strength imbalances are common among females. Females are reportedly more quadriceps dominant than male counterparts, which increases shear forces at the knee, increasing risk of joint injury. Co-activation of the muscles surrounding the knee increases joint compression for dynamic stability, yet, excessive co-activation may be detrimental to joint health if present during repetitive motions over time. Our objective was to compare the relationships between H:Q strength and co-activation between sexes during walking and jogging. We hypothesized lower H:Q strength (greater imbalance) would associate with greater co-activation in females, but not males. **Methods:** We conducted a cross-sectional study of 23 healthy individuals (12 female, 11 male; age: 22.5 ± 1.5 years, height: 175.0 ± 8.5 cm, mass: 75.0 ± 6.6 kg) in a research laboratory. H:Q strength ratios were derived using the peak isokinetic hamstrings and quadriceps torques from five concentric-concentric repetitions at 60°/s. Surface electromyography (EMG) recorded vastus lateralis (VL),

vastus medialis (VM), semitendinosus (ST), and biceps femoris (BF) activity during treadmill walking (1.34 m/s) and jogging (2.68 m/s). Mean EMG amplitudes of each muscle were averaged from 30 strides over the first 15% of the gait cycle to represent the loading response, and normalized to their respective maximal voluntary isometric contraction (MVIC) amplitudes. Normalized EMG amplitudes were used to calculate co-activation indices: medial (ST/VM), lateral (BF/VL), and composite (ST+BF/VM+VL). Correlation coefficients (Pearson's r or Spearman ρ) were used to assess relationships between H:Q strength ratio and co-activation indices and constituent EMG amplitudes. The slopes of statistically significant regression lines were compared between sexes using independent t-tests. Co-activation indices and EMG amplitudes were compared between sexes using independent t-tests and Cohen's d effect sizes with 95% confidence intervals (CIs). **Results:** In female participants, lesser H:Q strength ratios were associated with greater lateral co-activation ($r = -.715$, $p = .007$) and BF EMG amplitude ($\rho = -.532$, $p = .046$) during the loading response of walking gait. Slopes of the relationship between H:Q strength ratio and lateral co-activation ($p = .026$), but not BF EMG ($p = .235$), differed between sexes (Figure 1). No associations were identified during jogging (all $p > .05$). Female participants demonstrated greater VL EMG amplitudes compared to males during the loading response of walking (32.58 ± 12.22 vs. $20.61 \pm 9.64\%$ MVIC, $d = 1.09$ [95% CI 0.15-2.03], $p = .026$) and jogging (109.29 ± 45.52 vs. $72.79 \pm 23.09\%$ MVIC, $d = 1.01$ [95% CI 0.08-1.94], $p = .036$). **Conclusions:** Females

demonstrated greater quadriceps muscle activity, supporting previous findings of quadriceps dominance. Females with greater thigh muscle imbalances demonstrated greater lateral compartment co-activation during walking, suggesting that relative weakness of the hamstrings is associated with higher magnitude compressive loading in the lateral compartment. Increased lateral hamstrings activity may suggest a compensatory mechanism to H:Q strength imbalances to stabilize the knee. However, excessive compressive forces may lead to decreased joint health when extrapolated to steps taken over the lifetime.



	Female	Male
Correlation	-.715	.117
P value	.007	.373
Equation	$Y = -4.24 * X + 2.90$	$Y = 0.44 * X + 0.32$
Slope P value	.026	

	Female	Male
Correlation	-.532	.030
P value	.046	.467
Equation	$Y = -77.81 * X + 63.37$	$Y = 15.60 * X + 5.16$
Slope P value	0.235	

Figure 1. Scatterplots depicting the relationships between hamstrings-to-quadriceps co-activation in the lateral compartment (A) and biceps femoris EMG amplitude (B) with hamstrings-to-quadriceps strength ratio for females and males. Correlation coefficients, *p* values, and a sex-comparison between the slopes of each regression line are presented.

Curricular Practice of Patient Reported Outcome Measures

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Context: Within the athletic training profession, researchers have investigated the psychometric properties of specific Patient Reported Outcome (PRO) measures to understand the benefits of their inclusion in clinical practice since use of these measures supports patient centered care. Athletic training faculty must consider how and where to integrate patient oriented evidence that matters into the curriculum to ensure students are familiar with best practices regarding the use of PRO measures in clinical practice. Additionally, it is not well documented how athletic training educators are aligning their curriculum with the 2020 Commission on Accreditation of Athletic Training Education (CAATE) standards; therefore, the purpose of this investigation was to evaluate the curricular practice of PRO measures in CAATE accredited athletic training programs. **Methods:** The cross-sectional study was conducted on a non-random, convenience sample of CAATE accredited program directors. An anonymous survey was developed based on existing literature related to PRO measures, and the authors' knowledge of athletic training curriculum design. The survey was pilot tested multiple times to ensure question clarity and relevance. A total

of 267 directors of professional athletic training programs were emailed (Qualtrics, Provo UT) an informed consent and survey link. A total of 57 (21.25%) program directors (n=30 female; n=27 male; age 44.21+/- 8.41 years) returned the survey. Excluded from the study were directors of programs categorized as voluntarily withdrawing their accreditation. The survey demographic data were analyzed through the calculation of means and standard deviations and descriptive statistics were used to examine identified PRO measure implementation strategies.

Results: Of the program directors surveyed, 68.42% (n=39) acknowledged implementing PRO measures in clinical practice which was most frequently shaped by journal articles (26.06%), National Athletic Trainers' Association resources (22.54%) and through clinical practice (21.83%). When examining if PRO measures are taught in their curriculum, 95% (n=64) of program directors indicated this occurred. The most frequently utilized content areas for implementation of PRO measures was therapeutic intervention (23.79%), clinical examination and diagnosis (21.36%), and evidence based practice (20.87%). In regards to instructional methods used to educate students on PRO measures, program directors utilize individual assignments, lectures with discussion and case studies to teach a combination of region specific, single item and global PRO measures instruments. **Conclusions:** To address reported barriers of integrating PRO measures, specifically a lack of inclusion due to clinician inexperience and confusion, athletic training

educators should consider how programs educate on patient oriented evidence that matters. Additionally, programs must align with new curricular standards associated with evidence based medicine. Recognizing the current landscape may help educators reflect on their promotion of PRO measures to foster future clinician knowledge and comfort with implementation strategies in clinical practice.

Pre-Athletic Training Students' Confidence, Skills, and Anxiety With Ankle Simulation Models: A Pilot Study

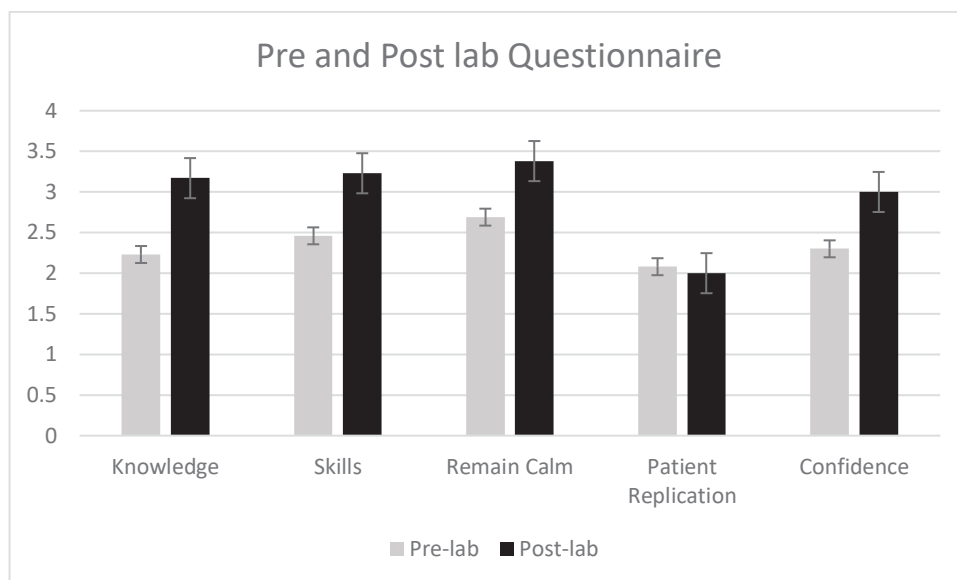
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Context: Approximately 23,000 ankle sprains occur each day in the United States. An accurate clinical diagnosis by athletic trainers is important to ensure proper management. In athletic training education, students learn clinical diagnostic techniques for the evaluation of ankle injuries. Recent efforts have implemented patient simulation models to enhance student learning for clinical experience application. However, there are minimal simulation resources available to mimic ligamentous injuries to enhance student confidence and skills. Recent efforts to develop a synthetic ankle model have been made and begun implementing in student learning. Therefore, the purpose of this pilot study is to determine if a synthetic ankle model would improve athletic training students' confidence in performing clinical diagnostic tests on the ankle. **Methods:** This was a cross-sectional pilot study with 13 pre-athletic training (Pre-AT) students. All data collection was performed during in-class time. Before data collection, each Pre-AT student was educated on clinical diagnostic tests for assessing a Grade 1-3 ankle sprain. Following education and skill practice, each Pre-AT student responded to a pre-lab questionnaire assessing current clinical confidence on ankle

diagnostic tests. Pre-AT students were then asked to perform two trials (5 tests per trial) on ankle synthetic models with randomly assigned injuries, recording their diagnosis. Four synthetic model ankles were used 1.) intact model (uninvolved), 2.) torn anterior talofibular (ATF, 3.) torn ATF and calcaneofibular (CF) ligaments, and 4.) Torn ATF, CF, and posterior talofibular ligaments (PTF). A post-lab questionnaire was completed following trials. Pre-AT students' confidence was assessed using paired sample t-tests between pre-and post-lab assessments ($p < 0.05$). Descriptive statistics (frequencies and percentages) were also reported. **Results:** Pre-AT students improved from pre-lab to post-lab assessments on knowledge ($p = 0.006$), skills ($p < 0.001$), ability to remain calm ($p = 0.002$), and confidence to differentiate between positive/negative findings ($p < 0.001$), but did not differ on experiencing anxiety before performing the test on a patient ($p = 0.790$) (Figure 1). Following the use of the models, the majority of Pre-AT students agreed ($n = 6, 46.2\%$) or strongly agreed ($n = 7, 53.8\%$), they felt more prepared to assess a lateral ankle sprain, agreed ($n = 6, 46.2\%$) or strongly agreed ($n = 3, 23.1\%$) that they felt the ankle model replicated a real patient experience, and were moderately ($n = 7, 58.3\%$) to extremely ($n = 4, 33.3\%$) confident in performing clinical tests following the lab. **Conclusions:** Pre-AT students demonstrated improvements in knowledge, skills, their ability to remain calm and increased confidence in accurately performing

clinical tests following the use of ankle simulation models. Implementing ankle simulation models into athletic training clinical education may enhance student learning and decrease student stress when clinical experiences begin. Future research should explore the impact ankle simulation models pose on professional athletic training students and use of them in the classroom.

Figure 1



Assessing Athletic Training Students' Attitudes and Knowledge of Lesbian, Gay, Bisexual, and Transgender Healthcare

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Context: As the lesbian, gay, bisexual, and transgender (LGBT) patient population increases, healthcare educators should prepare future clinicians to provide care for LGBT patients. Determining the knowledge and attitudes of students and evaluating educational methods can help meet this goal. The purpose of this study was to assess professional athletic training students' knowledge and attitudes of LGBT health care before and after an educational intervention. **Methods:** The study occurred at a mid-western university using a proof of concept randomized control study. Twenty-three undergraduate professional athletic training students volunteered to participate (21.13 mean age ranging 20 -22 years; Gender: 20 Females, 2 Males, 1 Declined to identify; Sexual orientation: 20 straight, 1 Lesbian, 1 Bisexual, 1 Declined to identify). Participants completed the Attitudes Towards Lesbian, Gay, Bisexual Patients (ATLGBP) and Attitudes Towards Transgender Patients (ATTP) instruments. Individuals were randomized based on junior and senior cohorts with one cohort being the control (n=7) and the other the intervention (n=16) group. The intervention group received a one-hour education

session about attitudes towards LGBT patients, knowledge of LGBT healthcare, and strategies to improve clinical settings. Six weeks after the intervention, students completed the ATLGBP and the ATTP instruments along with a written assignment reflecting on attitudes and knowledge of LGBT health care. The control group completed the ATLGBP and ATTP at the beginning and end of the six-week period. A multivariate repeated measures ANOVA was conducted for the independent variable group (control and intervention) and time (pre- and post-intervention) with the dependent variables ATLGBP and ATTP score ($p<0.05$). Thematic analysis of the written assignment was completed phenomenologically. Peer review was used to establish trustworthiness. **Results:** There was no significant difference over time or between groups on the ATLGBP or ATTP ($p>0.05$). The ATLGBP baseline scores were 26.67 ± 4.32 (control) and 27.29 ± 8.10 (intervention). Post-intervention scores on the ATLGBP were 28.50 ± 4.09 (control) and 27.57 ± 5.32 (intervention). The ATTP baseline scores were 20.29 ± 4.19 (control) and 21.81 ± 5.19 (intervention). Post-intervention scores on the ATTP were 21.57 ± 3.60 (control) and 22.06 ± 4.02 (intervention). Qualitative data revealed an increase in awareness of the LGBT population and increased knowledge of LGBT healthcare following the study. Participants indicated comfort in caring for LGBT patients but desired further education to become more competent providers. The participants indicated more incorporation of LGBT topics in the

program curriculum would be beneficial to future clinical practice. **Conclusions:** The intervention did not increase scores on the ATLGBP or ATTP instruments. The reflection assignment did indicate students desire additional education on LGBT healthcare topics. Assessing students' attitudes and knowledge of LGBT patient care can identify limitations in education and increase self-awareness. Professional athletic training programs may benefit from incorporating LGBT healthcare topics into the curriculum to increase competence of future athletic training professionals.

Athletic Training Students' Exposure to, Comfort With and Perceptions of High Fidelity Patient Simulation Manikins in Athletic Training Education: A Pilot Study

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Context: Athletic training (AT) programs have begun to incorporate high fidelity patient simulation manikins (HFPSM) into professional education. HFPSMs are used to mimic real patient experiences when a patient may not be available. They provide students the opportunity to practice, learn, and make mistakes without harming patients. However, it is unclear what comfort level, confidence, and preparation simulation manikins provide to students. Therefore, the purpose of this pilot study was to assess students' comfort level with, confidence in, and preparation for real patient experiences following HFPSM use in the classroom. **Methods:** Eight Master's level professional AT students completed coursework with HFPSMs incorporated into regular class teaching. Before the classroom experiences AT students were asked to complete a pre-course questionnaire on their past experiences with HFPSMs. Following the conclusion of HFPSMs in class and exposure to cardiac, respiratory, and systemic illnesses and conditions, AT students were provided a post-course questionnaire to assess comfort, confidence, and preparation for real patient scenarios based on their experience with HFPSMs.

Descriptive statistics (frequency, percentages, means, and standard deviations) were reported.

Results: Four first year professional AT students (50%) had prior experience with HFPSMs with $1.24 \pm .43$ previous exposure hours. Prior to course orientation students were minimally ($n=2$, 25%), moderately ($n=5$, 62.5%) or extremely ($n=1$, 12.5%) comfortable with using HFPSMs and were not confident at all ($n=2$, 25%), minimally confident ($n=2$, 25%), or moderately confident ($n=4$, 50%) with using HFPSMs. Following the use of HFPSMs in class, students were moderately ($n=3$, 37.5%) to extremely comfortable ($n=5$, 62.5%) and moderately ($n=4$, 50.0%) or extremely confident ($n=4$, 50%) in using HFPSMs. Students felt HFPSMs were moderately ($n=7$, 87.5%) to extremely representative ($n=1$, 12.5%) to clinical practice patient experiences. Students felt moderately ($n=5$, 62.5%) to extremely prepared ($n=3$, 37.5%) for clinical experiences after using HFPSMs in class. Students felt they were moderately ($n=3$, 37.5%) to extremely prepared ($n=5$, 62.5%) to be able to recognize patient illnesses after using the HFPSMs in AT education. The majority of students felt HFPSMs to be extremely valuable ($n=7$, 87.5%) for AT education and felt their exposure to HFPSMs specific illnesses/injuries will moderately ($n=4$, 50%) or extremely ($n=4$, 50%) prepare them for AT student clinical experience. **Conclusions:** Overall, AT professional education students, felt the use HFPSMs in AT education, will prepare them for clinical experiences, felt comfortable

and confident in using HFPSMs, and reported HFPSMs to be extremely valuable for AT education. AT education programs should incorporate HFPSMs into AT education to expose students to patient scenarios that might not be feasible in clinical experiences and allow them to practice and learn before beginning clinical experiences. Future research should evaluate AT preparation in clinical experiences following the use of HFPSMs.

Challenges to and Support for Interprofessional Education in Athletic Training

Manspeaker SA, Hankemeier DA, Kirby JL, Feld SF: Duquesne University, Pittsburgh, PA; Ball State University, Muncie, IN; Western Carolina University, Cullowhee, NC

Context: To prepare students to practice within the collaborative healthcare system, educational programs must include opportunities for students to engage with individuals from other professions and specialties. This type of education is termed interprofessional education (IPE), and it requires students not only learn about members of other professions but with and from them as well. However, little research exists in the field of athletic training as to how IPE experiences are created and subsequently incorporated for student learning. Therefore, the purpose of our study was to explore ways in which faculty develop and integrate IPE into their athletic training programs. **Methods:** We used a consensual qualitative study design including conduction of semi-structured phone interviews with athletic training faculty members regarding their perspectives on creating and integrating IPE. We audio recorded and transcribed each interview verbatim. Upon reaching data saturation, the research team of three experienced

qualitative researchers used a consensual qualitative approach to analyze the data. To establish trustworthiness, we asked an external auditor to examine the themes and supporting quotes to ensure alignment and we used accuracy member checks. **Results:** Seventeen athletic training faculty members (1 program director, 14 coordinators of clinical education, and 2 non-administrative faculty members) completed interviews. We drew two main themes from this data, Challenges to IPE and Institutional Support. We composed Challenges to IPE on the subthemes 1) scheduling, 2) student buy-in, 3) faculty/program buy-in, and 4) clinical experience clearances. We composed Institutional Support, using the subthemes 1) IPE director, 2) administrative structure, 3) resources, 4) program/faculty buy-in, and 5) quality improvement. Athletic training faculty described challenges related to creating buy-in around IPE and then finding opportunities and times to integrate it into already busy schedules and loaded curriculums. Additionally, faculty found specific challenges in the areas of deciding what IPE content to cover, which student levels/disciplines to include, and where in the curriculum to place these opportunities. Supportive areas for IPE integration were identified in the areas of committees or workgroups specifically dedicated to developing IPE opportunities. Additionally, openness to new connections and learning opportunities as well as seeking opportunities for collaborating

with other faculty, programs, and the community were identified as valuable to successful integration. **Conclusions:** Significant challenges to implementing robust IPE in athletic training curricula exist, but there are also several opportunities that can make the process easier. Institutions that have strong administrative support and structure for IPE have effective IPE curriculum. Athletic training faculty should aim to create institutional and/or community buy-in if they are facing significant challenges to IPE implementation.

Cornerstone Activities and Opportunities for Developing Interprofessional Education in Athletic Training

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Context: Accrediting bodies across healthcare are mandating the inclusion of interprofessional education (IPE) activities within professional programs. As a method of bringing students from various professions together to learn with, from, and about each other, IPE is a critical step in preparing students to enter professional practice and provide patient care in a collaborative environment. One of the foundational components of IPE is learning about the roles and responsibilities of others, and research related to IPE indicates these types of experiences allow students to do so. The purpose of our study was to explore ways in which IPE activities are being integrated into athletic training programs and how athletic training faculty members interact with other healthcare programs at their institutions. **Methods:** Using a consensual qualitative method, we conducted semi-structured phone interviews with athletic training faculty members regarding their perspectives on integrating IPE in their curriculum. We audio recorded

each interview, transcribed them, and used a consensual qualitative approach to analyze data. We based the total number of interviews on data saturation, and to establish trustworthiness, we used an external auditor and invited participants to complete accuracy member checking. **Results:** We completed interviews with 17 faculty members (15 administrators and 2 non-administrative faculty, 16.71 ± 6.96 years BOC certified). We drew two main themes from this data, Cornerstone Activities for IPE and Opportunities for IPE. The Cornerstone Activities for IPE theme included the following subthemes 1) IPE definition, 2) grand rounds, 3) guest speakers, 4) interprofessional collaborative modeling. Faculty members described activities such as bringing in clinicians from other professions to deliver guest lectures on specific topics and encouraging students to interact with clinicians from other fields during their clinical experiences. In Opportunities for IPE, we included the subthemes 1) community, 2) institutional, 3) clinical, 4) face-to-face encounters, 5) immersive. Faculty recognized opportunities like building simulations where multiple professions can contribute or intentionally seeking clinical experiences where students from other professions are also participating. **Conclusions:** Athletic training faculty appear to be engaging students in several educational experiences rooted in the ideas and traditions of IPE but that may not fit the definition of IPE. However, many activities are focused on knowledge and

skills that are foundational to IPE (e.g., understanding roles and responsibilities and communication). These experiences may form a foundation on which other IPE activities can be built and can help faculty cultivate connections with educators and clinicians outside of their field. However, faculty members should seek further opportunities to directly engage students in learning from, about, and with students in other fields. Faculty members should consider building or leveraging relationships with other programs at their institutions and engage members of the surrounding community when building IPE activities.

Influence of Preceptor/Student Gender Bias on the Implementation of Core Competency Professional Behaviors During Clinical Experience: A Report From the AATE Research Network

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Context: Professional athletic training students (ATs) are now required to incorporate core competencies (evidence-based practice [EBP], patient-centered care [PCC], health information technology [HIT], interprofessional education and collaborative practice [IPECP], quality improvement [QI], professionalism) into their patient care during clinical experiences. Gender bias has influenced the inclusion of such behaviors in other healthcare education experiences, and gender bias in the pairing of preceptors and students has impacted student opportunities in such programs. The objective of this study was to determine if the inclusion of five core competency-related professional behaviors during patient encounters (PEs) is influenced by the gender dyad between student and preceptor.

Methods: A multi-site, panel design was used. Twelve (7 graduate, 5 undergraduate) CAATE-accredited professional athletic training programs participated by allowing ATs to track PEs using E*Value (MedHub, Minneapolis,

MN) that occurred during the 2018-2019 academic year. The ATs documented personal gender (female/male) and preceptor/supervisor gender (female/male), and their self-reported inclusion of professional behaviors when conducting the PE. Composite scores (counts) for the professional behaviors within each core competency were calculated and descriptive statistics were used to summarize professional behaviors performed relative to gender dyads during PEs. Professional behaviors were analyzed to assess dyad differences using general estimated equations with negative binomial links to accommodate the multiple reported PEs within participants ($p < 0.05$). QI, as a dichotomous response, was assessed using a general estimated equation with a logit link ($p < 0.05$).

Results: 363 ATs contributed data on 30,446 PEs. The distribution of encounters by student-preceptor dyad included: 9,646 (31.7%) female students/male preceptors, 6,784 (22.3%) male students/male preceptors, 9,901 (32.5%) female students/female preceptors, and 4,115 (13.5%) male students/female preceptors. A significant main effect was observed for both PCC and IPECP. For PCC ($\chi^2(3)=10.8$, $p=0.013$), female students/female preceptors implemented fewer PCC behaviors ($M=0.75$) than male students/female preceptors ($M=1.14$; 95% CI: $-0.75--0.03$, $p=0.025$). For IPECP ($\chi^2(3)=16.6$, $p=0.001$), female students/female preceptors implemented fewer IPECP behaviors ($M=0.14$) than female students/male preceptors ($M=0.23$; 95% CI: $-0.17--0.02$, $p=0.009$), and fewer than

male students/male preceptor ($M=0.27$; 95% CI: $0.01-0.21$, $p=0.024$). **Conclusions:** Female students with female preceptors were provided fewer opportunities to implement behaviors associated with PCC and IPECP than male students with female preceptors during PEs. Female students with male preceptors also have the opportunity to experience more IPECP behaviors than female students with female preceptors. Preceptor development, especially with female preceptors, should emphasize how gender bias may influence behaviors that students ultimately are able to include during PEs, and the subsequent effect that this may have on the patient's experience and outcomes. Female students assigned to female preceptors should be instructed to seek out opportunities to engage and include PCC and IPECP during PEs that occur during clinical experiences.

Sociocultural and Demographic Factors Associated With the Future Educational Goals of Athletic Training Students

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Context: Athletic training students have diverse goals and expectations related to their educational experiences. Despite their common goal to become certified athletic trainers, athletic training students have diverse backgrounds and bring unique perspectives to their education. Our study aimed to identify sociocultural (race/ethnicity, gender) and demographic (age, athletic training program type) factors associated with the pursuit of future educational plans of athletic training students. **Methods:** Athletic training students (n=832, 11.5% response rate; 629 females; mean age=22.2±2.7 years) completed a validated cross-sectional questionnaire on sociocultural and demographic variables, and future educational plans. A multinomial logistic regression examined the effect of race/ethnicity (Caucasian, African-American, Asian, Latino/

Hispanic, multi-race, other), gender (male, female, other), age category (<20, 20-24, 25-29, ≥30 years), and athletic training program type (undergraduate professional, graduate professional) on their future plans (further education in athletic training, further education not in athletic training, work clinically after graduation, unsure). Odds Ratios (OR) with 95% confidence intervals were estimated for the multivariable model, with Caucasian, female, ≥30 years old, and graduate professional serving as the referent groups. **Results:** Most participants were female (n=629; 75.6%), Caucasian (n=614; 73.8%), 20-24 years old (n=700; 84.1%), and from an undergraduate professional-level program (n=651; 78.3%). Most participants felt somewhat (n=244; 34.7%) to moderately (n=327; 46.5%) prepared for clinical practice and planned to further their education in some capacity (n=539; 68.9%), either inside (n=255; 32.6%) or outside of athletic training (n=284; 36.3%). The remaining participants desired to work clinically after graduation (n=102; 13.0%) or were unsure about their future plans (n=141; 18.0%). In the multivariable model, athletic training students who were part of an undergraduate professional-level program had higher odds of selecting to continue their education in athletic training (OR=5.50; 95%CI=2.98-10.15) or outside of athletic training (OR=5.93; 95%CI=3.22-10.93) compared to having uncertainty in their future plans. Additionally, athletic training students had lesser odds of selecting working clinically upon graduation compared to uncertainty in their future plans if they were part of an undergraduate professional-level program (OR=0.18; 95%CI=0.10-0.34) or Latino/Hispanic (OR=0.24; 95%CI=0.03-0.90). **Conclusions:** Our findings suggest athletic training students of different athletic training program types and from different racial/ethnic backgrounds may have differing experiences and expectations related to their educational plans post-graduation. Athletic training programs should consider athletic

training student-specific differences relative to race/ethnicity and their potential to impact perceived preparedness for independent clinical practice and subsequent future planning. Further research is needed to understand why certain groups are more likely to desire immediate versus delayed transition to practice and the factors contributing to that decision. Further, understanding of how and why such disparities exist may help to prioritize program-driven cultural competency including inclusive and equitable preparation of athletic training students for transition to practice.

The Educational Experiences of Professional Program Directors and Athletic Training Students Regarding Patient-Centered Care

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Context: Patient-centered care (PCC) is a core competency that has been part of healthcare since 1987 and emphasizes the shared decision making of the patient. More recently, the CAATE has added PCC to the 2020 Standards of Accreditation for Professional Athletic Training Programs highlighting patient advocacy and health literacy. As new curricular content, program directors (PDs) and athletic training students (ATs) must be well-versed in the delivery and implementation of these skills. Therefore, the purpose of our study was to investigate the educational experiences of PDs and ATs regarding PCC with respect to comfort, competence, and implementation. **Methods:** We used a cross-sectional survey that was content validated by a panel of experts. The tool was curated specifically for PDs or ATs and contained similar questions relevant to comfort, competence, and educational experiences. In total, 365 PDs

and 3548 ATs from either professional bachelor or master programs were recruited to participate via email. Completed surveys from the PDs ($n=74$, males=32, females=42; age=46 \pm 9 years old; PD experience=9 \pm 8 y) and the ATs ($n=452$; males=118, females=331, other=3; age=23 \pm 3 y; bachelor=318, masters=101, combination program=33) were analyzed using descriptive statistics. **Results:** Most PDs expressed that PCC was an important concept to teach (98.6%, $n=73$), and accordingly, 95.9% ($n=71$) of PDs taught the core competency in their professional AT program. Most PDs agreed or strongly agreed that they felt comfortable (98.6%, $n=73$) and competent (94.6%, $n=70$) teaching PCC. The PDs reported using several different instructional strategies, with the most common being class discussions (88.7%, $n=63$), and assessment methods, with the most common being practical exams (74.6%, $n=53$), to teach PCC. The PDs reported ATs learned about PCC in class (100%, $n=71$) and during clinical education (83.1%, $n=59$). All the PDs stated the ATs practiced PCC in clinical education (100%, $n=71$). When examining the ATs respondents, all agreed/strongly agreed (100%, $n=452$) that they believed it was important to integrate PCC into their clinical practice and they felt comfortable (100%, $n=452$) doing so. The majority of ATs reported perceived competence (98.7%, $n=446$) in providing PCC. Of the ATs who learned about PCC in their professional athletic training program (96.7%, $n=437$), most reported they learned about it in

class (86.7%, $n=379$) or during clinical education (86.0%, $n=376$). However, when ATs were asked where they practiced PCC, the majority reported in the classroom (95.9%, $n=419$), while only 12.4% of participants ($n=54$) reported practicing PCC skills during clinical education. **Conclusions:** The results suggest that PDs feel comfortable, competent, and create PCC educational experiences for ATs. In addition, ATs reported similar comfort and confidence in providing PCC. However, a discrepancy between the PDs and ATs was noted for what they believe is being practiced specific to PCC during clinical education.

Students' Perceptions of Standardized Patient Encounters in Professional Education

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Context: Standardized patient (SP) use is growing within professional athletic training programs to supplement students' clinical experiences because SP encounters authentically replicate real-time patient encounters. Previous researchers have identified benefits of SP encounters, but most research focused on SP use from the educator's perspective. Therefore, the purpose of this study was to examine student's perceptions of SP experiences and determine what characteristics of SP encounters students perceived to be most helpful to their professional growth. **Methods:** We used a phenomenological qualitative design. One-on-one semi-structured interviews were conducted with 12 professional master's athletic training students (3 males; 9 females; 24.2 ± 1.3 years old) via a videoconferencing platform. Using a convenience sample of participants, we recruited current students ($n=9$) and recent graduates ($n=3$) who had experiences with SP encounters. Interviews were transcribed, de-identified, and checked for accuracy. Researchers independently coded and analyzed the data using a multi-pass approach to identify significant statements, code the statements, and group them into themes. We established

trustworthiness through member checks and peer review. **Results:** Four themes were identified: 1) fidelity of the encounter, 2) personal and clinical growth, 3) feedback and reflection, and 4) transition to practice. Participants described fidelity as a contributing factor to improving confidence, indicating the most important factors impacting fidelity were faculty investment in planning, SP recruitment, and proper scaffolding of encounters. Personal and clinical growth included comments related to improvements in soft skills (e.g., communication and collaboration) as well as clinical skills (e.g., evaluation efficiency and synthesis of information). Notably, some participants' most impactful SP encounters were those aimed at improving communication with coaches or other healthcare providers. Feedback and reflection included comments related to how SP encounters helped participant's build confidence, facilitate self-reflection, and learn from their mistakes. Specifically, participants noted substantial confidence gains from debriefing with peers and having the ability to discuss encounters candidly. Despite these benefits, participants also expressed a strong desire for immediate and individualized feedback. The final theme revealed how SP encounters helped participants transition to practice, highlighting opportunities to evaluate patients independently and make clinical decisions on their own, an experience often missed from patient care during clinical education. **Conclusions:** Students were not always emphatic about SP experiences during professional education, but greatly valued the added opportunity to practice their

clinical skills when SP encounters were planned and implemented intentionally. Ultimately, participants valued authenticity most throughout the SP experience. To maximize learning gains, faculty should be meticulous and deliberate in planning, ensuring the SP encounter feels authentic and offers different experiences from patient care during clinical education to encourage further development of students' clinical skills. When planned appropriately, SP encounters can result in confidence gains and transition students to autonomous clinical practice.

Attitudes Towards Participation in the Dynamic Integrated Movement Enhancement Program Worsen After Participation

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Context: There is a lack of participation in Exercise-Related Injury Prevention Programs (ERIPPs) within athletic and military populations. There is a need to determine how attitudes change after participation in an ERIPP and understand what motivates individuals to participate in an ERIPP. Therefore, the purposes of the study were to compare attitudes pre and post participation in an ERIPP within Reserve Officer Training Corps (ROTC) cadets and identify factors associated with participation in an ERIPP. **Methods:** Thirty-four ROTC cadets (Male: $n=28$, Age: 19.67 ± 1.45 years, Height: 175.57 ± 8.30 cm, Mass: 75.38 ± 14.30 kg) volunteered to participate in a repeated measures study design. Participants completed a demographic questionnaire and the Theory of Planned Behavior Scale (TPBS) before and after participation in the ERIPP. The TPBS consisted of 20 items and 5 subscales (perceived benefits, perceived barriers, social norms, social influence, and intention to participate) that assess attitudes towards participating in an ERIPP. Response

choices ranged along a 7-point Likert scale from strongly agree (3) to strongly disagree (-3). The Dynamic Integrated Movement Enhancement (DIME) program was implemented during physical training sessions twice per week for 12 weeks. The train the trainer method was used as cadet leaders led study participants through the DIME each week and tracked compliance during each session. For the primary purpose, the independent variable was time (pre/post) and dependent variables were the subscales of the TPBS. Total scores and associated median and interquartile range were calculated for the subscales of the TPBS. Wilcoxon tests were used to detect differences in attitudes between the pre and post measures. For the secondary purpose, the independent variables were the subscales of the TPBS as well as demographic variables and the dependent variable was compliance with the DIME. A backwards multiple linear regression was used to determine if significant associations between the subscales of the TPBS and participation in the DIME existed. Alpha was set at $P \leq 0.05$ for all analyses. **Results:** The average DIME compliance over the 12 weeks was 87.20%. Perceived benefits, barriers, social norms, social influence, and intention to participate worsened after participation in the DIME ($p \leq 0.01$, effect size ≥ -0.43 , Table 1). There was a significant association between the TPBS social norms and previous exposure to an ERIPP with participation in the DIME ($F(2,31)=3.43$,

$p=0.05$). Previous exposure had a negative and significant association with participation in the DIME ($\beta=-0.10$, $p=0.02$, $\eta^2=0.15$). **Conclusions:** ROTC cadets had more negative attitudes towards participating in an ERIPP after participation. Additionally, individuals who had previous exposure to an ERIPP were less likely to participate. Implementation strategies may need to be focused on changing the attitudes of individuals who have previous exposure to ERIPPs to increase compliance. Furthermore, impacting social norms may also provide an avenue to enhancing participation in ERIPPs.

Table 1. Differences in Attitudes Pre and Post Participation in the DIME Program (Median, Interquartile Range)

Variable	Pre-Participation	Post-Participation	P-Value	Effect Size
TPBS Benefits	10.00 (6.00)	8.00 (7.00)	<0.001	-0.70
TPBS Barriers	-1.00 (4.50)	0.00 (4.50)	0.01	-0.43
TPBS Social Norms	8.00 (3.50)	8.00 (3.00)	0.01	-0.45
TPBS Social Influence	7.00 (3.00)	6.00 (4.50)	0.01	-0.48
TPBS Intention	10.00 (6.00)	8.00 (6.00)	<0.001	-0.73

DIME: Dynamic Integrated Movement Enhancement; TPBS: Theory of Planned Behavior Scale

Coaches', Athletes', and Athletic Trainers' Impressions of the Therapeutic Effects of Tart Cherry Juice

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Context: Tart cherries are rich in antioxidants and anti-inflammatory properties, which have been shown to reduce pain and inflammation after exercise. Tart cherries also contain melatonin which is linked to sleep regulation. Perceptions of the therapeutic effects of tart cherries from athlete stakeholders remain unknown. The purpose of this study was to determine perceptions of the effectiveness of tart cherry supplements among sport and strength and conditioning coaches, athletes, and athletic trainers. **Methods:** Our qualitative research study was conducted online by receiving responses to a questionnaire from Division I, II, and III sports coaches (N=50), strength and conditioning coaches (N=4), athletes (N=25), and athletic trainers (N=21) across the state of Virginia. We sent a recruitment email to stakeholders based on website searches and asked coaches to forward the recruitment email to their athletes. Data saturation drove recruitment which we met. The questionnaire obtained face, content, and construct validity by peer and expert review. The data was analyzed via a general inductive approach and we

used multianalyst triangulation and peer review as credibility strategies. **Results:** We identified 5 themes related to tart cherry juice and recovery from athletic activity. The use of tart cherry supplementation is not widespread, but many athletes would use it and coaches would recommend it if evidence existed and the cost was not a barrier. Many stakeholders referenced a lack of research supporting tart cherry supplementation and the fact that budget restraints do not currently allow them to have it available. Most participants used or recommended using tart cherry supplementation because of a perception that it assists in recovery after practices and in between games. The therapeutic effects appear especially helpful when turnaround time was short between competitions or training sessions. Stakeholders provided many alternatives to using tart cherry supplementation, including consultation with athletic trainers and athletic trainer provided modalities for improving recovery as well as avoiding blue light and maintaining good habits for sleep improvement. Education was a common factor in facilitating muscle recovery, lowering pain and inflammation levels, and improving sleep quality. Participants relied on athletic trainers, other medical staff, and dietitians to provide information on supplementation, performance enhancement, and recovery. **Conclusions:** Although the use of tart cherry supplementation was not widespread, some participants described using it or recommended using it for performance enhancement. If tart

cherry supplementation is advised, providing evidence of effectiveness and financial support for acquiring it is warranted. Many alternatives to tart cherry supplementation were described, most notably a reliance on athletic trainers and others to provide advice and interventions to maximize performance. Medical professionals should continue to educate coaches and athletes on ways to maximize performance as knowledge gaps exist for coaches and athletes.

Collegiate Athletes Demonstrate a Positive Association Between Self-Reported Sleep and Stress

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Context: Substantial weekly demands, over 72 hours per week dedicated to sport and academic responsibilities,¹ are placed on student-athletes which may influence risk of serious injury and/or illness. Student-athletes may experience significant stress from sport activities, education demands, or personal relationships. Student-athletes also demonstrate very poor sleep habits,^{2,3} and these habits may influence an athlete's perceived stress. The purpose of this study was to determine the relationship between perceived stress and self-reported sleep quality in collegiate student-athletes during preseason and mid-season timepoints.

Methods: Men's soccer, women's soccer, and baseball student-athletes were recruited to participate in the study (n=99, 66M, 33F, age=20.66 ± 1.30y). Athletes were asked to complete the Pittsburgh Sleep Quality Index (PSQI) and the Perceived Stress Scale (PSS) during a preseason and midseason testing

session. PSQI and PSS were reduced into their global scores and assessed for normality. The PSS and PSQI were not normally distributed, therefore a Spearman Rank correlation coefficient was used to determine relationship between the PSS and PSQI outcome scores. All analyses were considered significant at $p < 0.05$.

Results: At preseason, student-athletes reported average PSQI and PSS scores of 4.91 ± 2.77 and 10.14 ± 5.65 , respectively. At midseason, PSQI scores of 5.00 ± 3.07 and PSS scores of 11.73 ± 5.95 were reported. There was a significant positive relationship between PSQI and PSS during preseason ($\rho = 0.43$, $p < 0.001$) and midseason ($\rho = 0.60$, $p < 0.001$), where higher sleep-quality scores (worsening sleep quality) were associated with high perceived stress scores. **Conclusions:** Student-athletes experience an extensive amount of stress that negatively impacts their sleep during both the pre and mid-season. A stronger relationship between sleep and stress was seen during the mid-season compared to preseason. This may be explained by an increase in demand of academic coursework and mid-term exams. Additionally, at the mid-season time point, student athletes may be in the peak of their competitive season and under a demanding schedule, which may further contribute to

physical fatigue and limited recovery. The use of standardized sleep measures and perceived stress scales may provide athletic trainers with a cost-efficient, clinically relevant, and feasible measure of student-athlete wellness. These data may be used to modify training load, incorporate scheduled recovery, and implement stress management strategies in an effort to optimize student-athlete wellness.

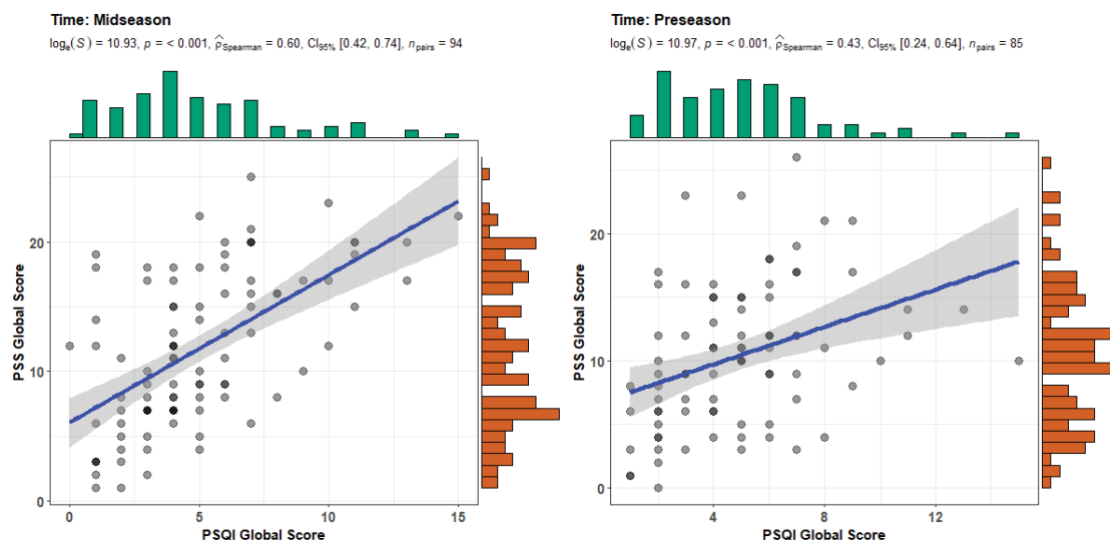


Figure 1. Spearman Rank Order correlation plot between the Pittsburgh Sleep Quality Index (PSQI) Global Score and the Perceived Stress Scale (PSS) Global Score at the preseason and midseason testing times.

Current Barriers and Facilitators of Warm-Up Practices in Secondary Schools

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Context: Preventive training programs (PTPs) are recommended and proven to reduce lower extremity sport-related musculoskeletal injury. Although there is much support of these programs, there is low reported adoption in the literature. The purpose of this project was to evaluate the current facilitators and barriers of PTPs in existing team-based warm-ups among secondary school athletic trainers (ATs) and athletic directors (ADs). **Methods:** A cross sectional study design included 20 secondary school ATs and 18 secondary school ADs in North Carolina and Connecticut who volunteered to complete a pre-validated online questionnaire via Qualtrics (Provo, UT). The questionnaire development was guided by the 2018 NATA Position Statement: Prevention of Anterior Cruciate Ligament Injury. ATs and

ADs were asked questions pertaining to facilitators and barriers of any team-based dynamic warm-up at their school. Questions were formatted for the respondents to select all that applied. Frequencies were calculated for each barrier and facilitator. Prevalence ratios (PR) with 95% confidence intervals (CI) were also calculated to compare barriers and facilitators reported between ATs and ADs. **Results:** The most commonly reported barriers to implementation of team-based warmups, as reported by ATs, were resistance or apprehension from the head coach (40%, n=8), that the school would need more information/ assistance to implement the program (35%, n=7), and not applicable (30%, n=6). The most commonly reported barriers, as reported by ADs, were resistance or apprehension from the head coach (11%, n=2), financial limitations (11%, n=2), and that the school would need more information/assistance to implement a program (11%, n=2), with 12 (67%) reporting this question was not applicable. The most commonly reported facilitators as reported by ATs were: have a team-based warm-up developed and demonstrated (70%, n=14), support from someone in an authoritative position (40%, n=8), seeing how other schools/ programs facilitate training (35%, n=7), and having medical professionals at the school (35%, n=7). The most commonly reported facilitators as reported by ADs were to have a team-based warm-up developed and demonstrated (33%, n=6) and having policies in place to require training (22%, n=4), with 7 (39%) of ADs reporting this question was not applicable. ATs reported a higher prevalence of having a

team-based warm-up developed and demonstrated to be a facilitator compared to ADs (70% vs. 33%; PR=2.10; 95% CI=1.03,4.29). No other significant comparisons between facilitators and barriers were noted between ATs and ADs. **Conclusions:** Evidence-based PTPs are critical in reducing injury. Identifying the most common barriers and facilitators of PTPs can guide future dissemination strategies. It is also important to recognize that ATs and ADs may have different perceptions of barriers and facilitators regarding implementation of a PTP. Therefore, dissemination strategies should include a socio-ecological approach to ensure community buy-in to facilitate compliance with a PTP.

External Load in Men's Division III Lacrosse Athletes

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Context: Little data exists regarding external load in the sport of lacrosse and none has been collected at the Division III level or since the initiation of a shot clock. This research sought to determine external load and impact differences between positions during men's NCAA Division III lacrosse participation. **Methods:** We recruited 47 males (age=19.87±1.10 years, height=183.15±8.27 cm, mass=82.03±9.74 kg) for an observational study during the 2020 spring lacrosse season to examine the external load experienced by lacrosse athletes. SPT2 GPS units (Sports Performance Tracking, Melbourne, Australia) collected external load metrics during practices and games. We divided participants into positional categories: attack (AT), defense (DEF), offensive midfield (OM), and defensive midfield (DM). We used 2-way ANOVAs with Bonferroni post hoc analyses for comparisons between positions and activity type (game or practice) with total distance (TD), walking distance (WD, 0-4.0 km/h), jogging distance (JD, >4.0-13.9

km/h), running distance (RD, >13.9-21.6 km/h), sprinting distance (SD, >21.6 km/h), work rate (WR, m/minute) and intensity (based on SPT's intensity algorithm) as dependent variables. **Results:** We found a significant interaction between position and activity for TD (F3,545=10.328, $p<.001$, $\eta^2=.54$), JD (F3,545=16.260, $p<.001$, $\eta^2=.082$), RD (F3,545=8.841, $p<.001$, $\eta^2=.046$), WR (F3,545=16.702, $p<.001$, $\eta^2=.084$), and intensity (F3,545=9.976, $p<.001$, $\eta^2=.052$). No interaction occurred for WD (F3,545=.933, $p=.425$, $\eta^2=.005$) or SD (F3,545=.157, $p=.925$, $\eta^2=.001$). Main effects for activity occurred with TD (F1,545=147.617, $p<.001$, $\eta^2=.213$), JD (F1,545=62.716, $p<.001$, $\eta^2=.103$), RD (F1,545=145.877, $p<.001$, $\eta^2=.211$), and intensity (F1,545=136.707, $p<.001$, $\eta^2=.201$). Main effects for position occurred with TD (F3,545=22.234, $p<.001$, $\eta^2=.109$), JD (F3,545=45.736, $p<.001$, $\eta^2=.201$), RD (F3,545=9.983, $p<.001$, $\eta^2=.052$), WR (F3,545=53.733, $p<.001$, $\eta^2=.228$), and intensity (F3,545=17.441, $p<.001$, $\eta^2=.088$). Post hoc results can be found in the Table. AT and DEF recorded higher values than midfielders for TD, JD, and WR during games. AT, DEF, and DM ran more than OM during games. All positions recorded higher TD, WD, RD, and intensity in games compared to practices. AT, DM, and DEF jogged more in games. DEF recorded higher WRs in games. OM and DM recorded a higher

WR in practice. All other comparisons were not significant ($P>.05$). **Conclusions:** AT and DEF experience higher levels of external load during games than other positions and may require conditioning that focuses on maintaining a higher work rate and total volume compared to other positions. Coaches and athletic trainers should be aware of positional differences when creating training and injury prevention programs that adequately prepare athletes for safe game participation. Additionally, AT and DEF players may need more recovery time following games compared to OM and DM. Wearable GPS microtechnology can assist in monitoring external loads while planning and implementing practices and rest.

Table 1. Mean ± SD (CI₉₅) by position during events. *=greater values in games ($p<0.05$) ******=greater values in practice ($p<0.05$)

Activity	Position	Total Distance (m)	Walk Distance (m)	Jog Distance (m)	Run Distance (m)	Sprint Distance (m)	Work Rate (m/min)	Intensity
Games	Attack	8931.99 ± 616.65* (8132.65-9731.33)	3234.06 ± 507.13* (2911.18 - 3556.94)	4652.48 ± 439.72* (4187.47 - 5117.49)	942.96 ± 381.92* (788.44 - 1097.49)	102.48 ± 50.82 (-90.44-295.40)	50.67 ± 4.67 (47.07 - 54.26)	55.84 ± 7.41* (49.98-61.70)
	Offensive Midfield	6468.15 ± 1568.13* (5923.49-7012.80)	3013.68 ± 645.20* (2793.68-3233.69)	2785.23 ± 1061.59 (2468.38 - 3102.08)	614.06 ± 331.47* (508.77 - 719.35)	55.17 ± 33.64 (-76.29-186.62)	34.99 ± 7.67** (35.55 - 37.44)	37.97 ± 12.62* (33.98-41.97)
	Defensive Midfield	6901.05 ± 815.67* (6335.83-7466.27)	2876.42 ± 373.65* (2648.10-3104.73)	2896.10 ± 480.87* (2567.29 - 3224.91)	995.34 ± 487.13* (886.08 - 1104.61)	133.19 ± 66.84 (-3.23-269.61)	38.42 ± 5.24** (35.88 - 40.96)	43.93 ± 9.27* (39.78-48.07)
	Defense	9350.42 ± 1165.15* (8606.28-10094.57)	3270.54 ± 527.96* (2969.95-3571.13)	4931.93 ± 645.25* (4499.03 - 5364.83)	1011.50 ± 408.76* (867.65 - 1155.35)	136.45 ± 64.15 (-43.15-316.05)	53.45 ± 4.53* (50.11 - 56.80)	58.37 ± 9.72* (52.91-63.83)
	Significant position differences ($p<0.05$)	AT,DEF > OM,DM	No significant differences	AT,DEF > OM,DM	AT,DM,DEF > OM	No significant differences	AT,DEF > OM,DM	AT,DEF > OM,DM
Practice	Attack	6095.37 ± 1433.66* (5766.93-6423.82)	2238.17 ± 587.97* (2105.50-2370.84)	3428.04 ± 896.74* (3236.97-3619.10)	397.25 ± 209.27* (333.76-460.74)	31.92 ± 26.07 (-47.35-111.19)	51.04 ± 6.31 (49.56-52.51)	35.32 ± 9.57* (32.91-37.73)
	Offensive Midfield	5526.56 ± 1390.06* (5288.04-5765.08)	2170.03 ± 573.63* (2073.68-2266.38)	2853.86 ± 835.87 (2715.10-2992.62)	461.20 ± 246.41* (415.09-507.31)	41.47 ± 33.89 (-16.09-99.04)	43.75 ± 5.68** (42.68-44.83)	32.28 ± 9.72* (30.53-34.03)
	Defensive Midfield	5209.52 ± 1530.58* (4991.65-5427.38)	2116.83 ± 603.92* (2028.82-2204.83)	2490.82 ± 823.12* (2364.08-2617.56)	495.80 ± 282.01* (453.69-537.92)	106.07 ± 623.82 (53.49-158.65)	41.83 ± 7.93** (40.86-42.82)	30.78 ± 11.77* (29.18-32.38)
	Defense	5782.89 ± 1758.32* (5445.57-6120.21)	2195.25 ± 669.40* (2058.99-2331.50)	3066.24 ± 1002.56* (2870.01-362.48)	472.95 ± 260.40* (407.75-538.16)	48.45 ± 49.78 (-32.97-129.86)	46.16 ± 5.51* (44.64-47.68)	33.93 ± 11.74* (31.46-36.41)
	Significant position differences ($p<0.05$)	AT > OM DEF > DM	No significant differences	AT > OM, DM DEF, OM > DM	No significant differences	No significant differences	AT > OM,DM,DEF DEF > DM	AT > DM

Interrater Reliability of the FMS Among Novice Raters and Certified Clinicians Testing Adolescent Athletes

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Context: The purpose of this study was to determine the interrater reliability among examiners of varying experience when scoring adolescent athletes using the Functional Movement Screen (FMS). The reliability of scoring on functional tests between providers can lead to efficiency of screening in the clinical setting and allow for collaborative healthcare. **Methods:** Three pairs of examiners were recruited for participation in the study (2 second-year athletic training (AT) students, 2 second-year physical therapy (PT) students, and 2 FMS-certified clinicians. The novice examiners completed a 1-hour training session with 2 certified FMS clinicians prior to data collection. Each pair then rated an adolescent (13-18 yo) athlete performing all FMS components in live sessions until all pairs rated 40 individual athletes. Testing was conducted in multiple different athletic facilities, across a wide variety of sports, and over a time period of eight months. Agreement scores from the 3 pairs (ATS, PTS, FMS-Certified) were calculated for each FMS component and composite score to

determine interrater reliability using intraclass correlation coefficients (ICC). Agreement within groups of scoring at or below the cut-off composite value of 14 was calculated using a weighted Kappa statistic. **Results:** Individual component score ICCs of the three examining pairs ranged from 0.68-0.98. The AT student pair demonstrated good to excellent interrater reliability ($ICC > 0.75$) when scoring 6/7 of the FMS component tests while both the PT student pair and clinicians demonstrated good to excellent interrater reliability when scoring 5/7 of the FMS component tests. The pair of AT students ($ICC = 0.50$) demonstrated moderate interrater reliability ($ICC = 0.50-0.75$) while pairs of PT students ($ICC = 0.43$), and clinicians ($ICC = 0.30$) demonstrated poor interrater reliability ($ICC < 0.50$) when determining composite FMS scores. All 3 pairs of examiners demonstrated strong agreement ($\kappa \geq 0.80$) when determining if a subject's composite score was ≤ 14 (AT students κ : 0.84, PT students κ : 0.90, Clinicians κ : 0.82). **Conclusions:** This study demonstrated that both novice and FMS-certified examiners have moderate to excellent interrater reliability between component scores of the FMS when scoring adolescent athletes. While composite scores alone showed poor interrater reliability between examiners of similar experience, there was good to excellent interrater reliability with determining whether the composite scores were at or below a cut-off score of 14. The evidence

from this study supports that the FMS is a reliable screening tool for use with adolescent athletes when scored by both novice and FMS-certified examiners who have undergone at least a one-hour training session. Novice examiners and FMS-certified clinicians had moderate to excellent interrater reliability when scoring adolescent athletes using the FMS, suggesting that a one-hour training session may be sufficient for reliable utilization of the FMS.

Knowledge, Attitudes, and Beliefs Toward Noise, Hearing Loss and Protective Equipment Usage Among Professional and Collegiate Athletic Trainers

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Context: Despite the potential risk of hearing-loss, athletic trainers (ATs) working in collegiate and professional settings routinely expose themselves to noise levels that can exceed health and safety standards. To better understand hearing health behaviors of ATs in these settings, this study examined the knowledge, attitudes, and beliefs of ATs towards noise, hearing-loss, and the use of hearing protection. **Methods:** A cross-sectional study design was used. 225 ATs in the professional (n=32) and collegiate (n=193) settings were recruited through the NATA Data Collection Service Program to participate. ATs were classified into five groups: NAIA (n=11), Division III (n=47), Division II (n=27), Division I (n=108), and Professional Sports (n=32). Participants completed an online survey assessing their knowledge, attitudes and beliefs towards noise, hearing-loss, and the use of hearing protection. Distinctions in attitudes and beliefs scores were made between negative (lower-quartile), neutral (two middle-quartiles) or positive (upper-quartile). A negative attitude towards noise means

that noise is seen as something harmful, whereas a positive attitude means noise is not seen as something dangerous. A neutral attitude reflects an indifferent attitude towards noise. A one-way ANOVA was conducted to determine if knowledge scores were different between groups. Chi-square tests of independence were conducted to determine if there were associations between work setting and attitudes and beliefs towards noise. **Results:** Data are mean \pm standard deviation, unless otherwise stated. 225 ATs (collegiate=193, professional=32) completed the knowledge assessment. Knowledge scores increased from NAIA (4.18 ± 0.98), to Division II (4.63 ± 1.33), to Division III (4.64 ± 1.05) to Division I (4.89 ± 1.15), to Professional Sports (4.97 ± 1.26) groups, but the differences between groups was not statistically significant, $F(4, 220) = 1.458$, $p = .216$. 201 ATs (collegiate=178, professional=23) completed the attitudes section and 214 ATs (collegiate=182, professional=32) completed the beliefs section of the survey. 22.9% of respondents (n=49) demonstrated positive attitudes and beliefs towards noise and 77.1% (n=165) demonstrated neutral attitudes and beliefs. There were no statistically significant associations between work setting and total attitudes, $\chi^2(4) = 1.45$, $p = .836$, or beliefs, $\chi^2(4) = 5.55$, $p = .697$. Both associations were small, Cramer's $V = 0.11$. **Conclusions:** ATs in both the collegiate and professional settings demonstrated a lack of knowledge about noise and hearing-loss. In general, participants had neutral attitudes and beliefs towards noise,

hearing-loss, and hearing protection. Due to their apparent lack of knowledge and overall indifferent attitudes towards noise, ATs working in the collegiate and professional settings may be putting themselves at risk of noise-induced hearing-loss. Hearing conservation education may therefore be an important first step in promoting positive hearing health behavior changes among ATs.

Match and Practice Demands of NCAA Division III Women's Soccer Athletes

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Context: Data from Global Positioning Systems (GPS) can be used by athletic staff to condition, treat, and prepare athletes for their competitive season. The majority of research studying the internal and external loads placed on soccer athletes is focused on professional and National Collegiate Athletic Association (NCAA) Division I men's soccer teams. The purpose of this study was to understand the demands placed on an elite Division III women's soccer team by position and by session type and explore the relationship between environmental conditions and intensity. **Methods:** Our cohort study analyzed data from a complete season of one NCAA Division III women's soccer team. We collected data from 17 players during practices (N=26) and competitions (N=26) using SPT2 GPS units (Sports Performance Tracking, Melbourne, Australia). Position (forward, midfielder, defender, and a hybrid midfield/defender position based on coaching strategy) and

session type (practice, competition) served as the independent variables. Dependent variables included total distance traveled (km), work rate (m/minute), and intensity (SPT calculated overall measure of the difficulty of the session). We also collected weather data from the start of each session and explored the correlation between WetBulb Globe Temperature (WBGT) and intensity. **Results:** The interaction between position and session type was significant for intensity ($F_{3,805}=9.05$, $p<0.001$, $\eta^2=0.02$), work rate ($F_{3,805}=9.218$, $p<0.001$, $\eta^2=0.05$), and distance ($F_{3,805}=7.696$, $p=0.001$, $\eta^2=0.02$). In addition, we found main effects for event ($F_{1,805}=256.86$, $p<0.001$, $\eta^2=0.23$) and position ($F_{3,805}=10.48$, $p<0.001$, $\eta^2=0.03$) when examining intensity, event ($F_{1,805}=11.916$, $p<0.001$, $\eta^2=0.13$) and position ($F_{3,805}=14.887$, $p<0.001$, $\eta^2=0.50$) for work rate, and event ($F_{1,805}=287.286$, $p<0.001$, $\eta^2=0.25$) and position ($F_{3,805}=8.872$, $p<0.001$, $\eta^2=0.02$) for distance. Standard deviations, 95% confidence intervals, and means for session types across the 4 positions can be found in the attached table. The mean WBGT measurement was 26.52 degrees C (practice=29.2 degrees C, competition=24.93 degrees C). The correlation between WBGT and intensity was significant ($r=-.39$, $p<.001$, $CI_{95}=-.48, -.30$). **Conclusions:** Defense and midfielders experienced both

higher intensities and work rates during practices and competitions indicating these positions may require a more specialized type of conditioning to better prepare them to meet the specific demands they face in competition. As WBGT increased, intensity decreased suggesting difficulty exercising in hot and humid environments. Athletic trainers should collaborate with coaching staff to plan practices with appropriate external loads to maximize performance while minimizing injury risk.

Table 1. Mean \pm SD (CI_{95}) by position during events. * = ($p<0.01$)

Activity	Position	Intensity	Work Rate (m/minute)	Distance (km)
Practice	Forward	24.184 \pm 9.596* (14.588 – 33.78)	40.046 \pm 6.955 (33.091 – 40.001)	4.422 \pm 1.450* (2.972 – 5.872)
	Mid/Def	27.582 \pm 13.437* (14.145 – 41.019)	43.264 \pm 10.362 (32.902 – 53.626)	4.600 \pm 1.992* (2.608 – 6.592)
	Midfield	26.978 \pm 11.770* (15.208 – 38.748)	43.606 \pm 8.463 (35.143 – 52.069)	4.620 \pm 1.718* (2.902 – 6.338)
	Defense	26.505 \pm 11.241* (15.264 – 37.746)	43.274 \pm 9.109* (34.165 – 52.383)	4.723 \pm 1.565* (3.158 – 6.288)
Significant position differences		Defense, Midfield > Mid/Def, Forward	No significant differences	No significant differences
Competition	Forward	44.315 \pm 27.262* (17.053 – 71.577)	42.435 \pm 16.554 (25.881 – 58.989)	7.260 \pm 3.570* (3.69 – 10.83)
	Mid/def	40.888 \pm 26.258* (14.63 – 67.146)	39.000 \pm 16.018 (22.982 – 55.018)	6.758 \pm 3.266* (3.492 – 10.024)
	Midfield	59.548 \pm 28.865* (30.683 – 88.413)	51.065 \pm 13.593 (37.472 – 64.658)	8.924 \pm 3.686* (5.238 – 12.61)
	Defense	56.194 \pm 26.871* (29.323 – 83.065)	49.827 \pm 14.965* (34.862 – 64.792)	8.936 \pm 3.675* (5.261 – 12.611)
Significant position differences		Midfield > Mid/Def > Defense	Forward > Defense, Midfield	Defense, Midfield > Forward, Mid/Def

Subjective Measures of Well-Being is Influenced By Amount of Play During Competitive Soccer Games

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Context: Subjectively rated well-being is related to injury in soccer athletes, but little is known about how these variables change around a single athletic competition. Well-being could be influenced by volume of participation, however, there is little research in this area. Therefore, the purpose of this study was to identify differences in subjective well-being measures before, and after match day in high- and low-participation volume groups, as measured by minutes played. **Methods:** Fifty-three soccer athletes (25M, 30F, age: 20.73±1.39 years) provided daily subjective well-being measures each morning over an entire competitive season. Well-being was captured on a mobile-compatible survey via scales, with readiness rated from 0-100, fatigue, sleep quality, and stress rated from -5 to +5, and soreness rated from 0-10. Higher numbers indicated high readiness, sleep quality, and soreness, and low fatigue and stress. These measures of

subjective well-being were recorded on match days (D00), one day post-match (D01), two days post-match (D02), and standard practice days. Based off minutes played during the season, participants were then split into high-volume (n=26, 1269±320 minutes) and low volume groups (n=29, 175±202 minutes). Two-way analysis of variance (group by day) was used to compare the subjective well-being variables. Post-hoc testing was performed with Bonferroni adjustments, and Cohen's d effect sizes were also calculated. **Results:** There was a significant group by day interaction for self-reported soreness (F=35.88, p<0.001), fatigue (F=18.98, p<0.001), and readiness (F=57.98, p<0.001). Between groups, soreness was significantly higher in the high-volume group on D01 (mean difference: 1.63, p<0.001, d=1.07) and D02 (mean difference: 0.79, p<0.001, d=0.60), fatigue was significantly higher in the high-volume group on D01 (mean difference: 1.47, p=0.005, d=0.78), and readiness was significantly lower in the high-volume group on D01 (mean difference: 17.8, p<0.001, d=1.57) and D02 (mean difference: 7.56, p=0.002, d=0.87, Figure 1). Soreness, fatigue, and readiness were not statistically different on D00 or during practice days. There was also a main effect of sleep quality

(F=35.44, p<0.001); post-hoc testing revealed a significant decrease in sleep quality from D00 to D01 (mean difference: 0.88, p=0.14, d=0.59). There were no differences in self-reported stress between groups or within day. **Conclusions:** Soccer athletes demonstrate significant changes in self-reported well-being variables around competitive matches. These changes are similar to physical variables potentially indicating that the well-being variables may be used to track athletes' recovery from competition. The use of daily surveys could aid athletic trainers in identifying those who may be in a negative state. By identifying student-athletes who are in a suboptimal state, athletic trainers can create targeted recovery interventions to aid athletes return to a positive state of well-being. Athletic trainers should identify high-volume athletes and be vigilant for potential changes that may be present surrounding competition.

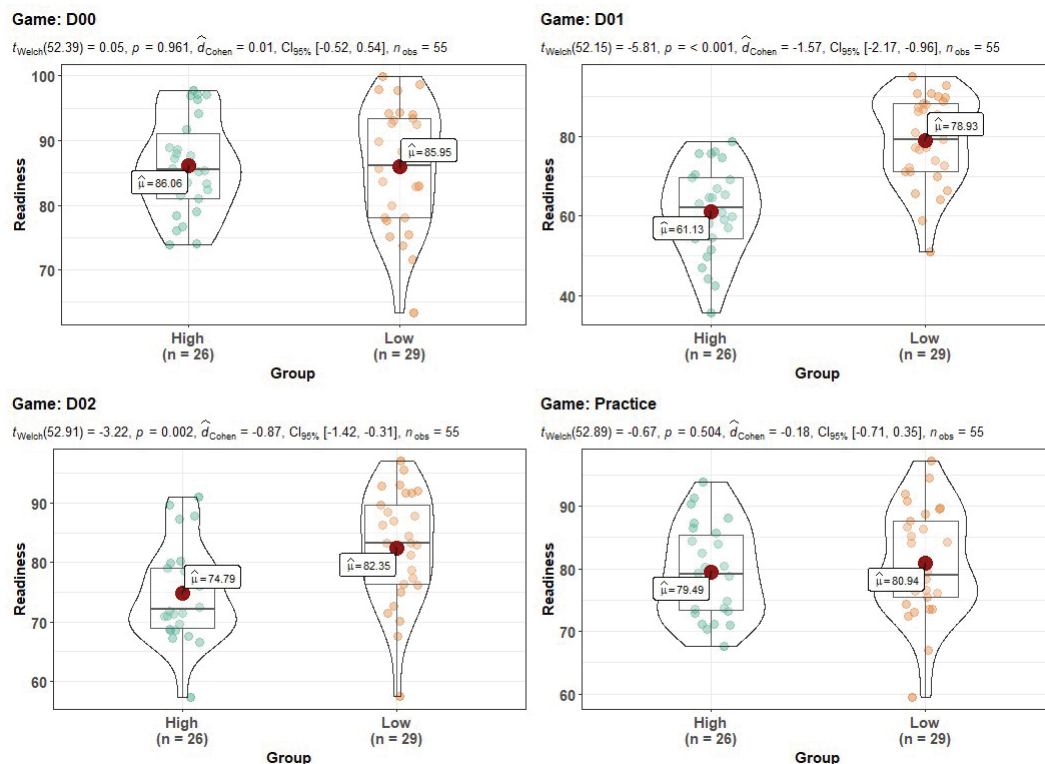


Figure 1. Boxplot and violin plots comparing the differences in Readiness between different loading groups by day. Statistics from the post-hoc Welch t-tests with a Bonferroni correction are presented in the subtitles.

The Effects of Hand and Ocular Dominance: Implications for Rehabilitation

Boham M, Altiner BLM, Spaniol F, Stiltner S: Texas A&M University-Corpus Christi, Corpus Christi, TX

Context: Vision is the primary sense utilized by athletes during sports and accounts for 85% to 90% of an individual's sensory processing demands. Without the ability to accurately and quickly visually process environmental stimuli, performance will be hindered. Visual training in sports has become increasingly popular to attempt to provide athletes an edge over their competition. Visual acuity can be trained and used in sports rehabilitation. The purpose of this study was to investigate the effect of hand and ocular dominance on the reaction time of NCAA Division I athletes. **Methods:** Fifty-eight male and female NCAA Division I athletes (age = 20.05 ± 1.28 years) from multiple sports were evaluated for hand-eye coordination (touches) and reaction time using the Dynavision D2 Light Board®. Participants completed 30 second testing sessions with 30 seconds of rest three times. Peak values were assessed for coordination and lowest values were taken for reaction time. Hand dominance was determined with preferred sport skill and ocular dominance was judged with the hole in the card test

prior to Dynavision D2 Light Board® testing. Participants were coded as same-side dominant or cross-lateral dominant. **Results:** Thirty-one participants were same-side dominant and had an average of 44.45 ± 2.79 touches during the 30-second interval and had an average reaction time of 0.67 ± 0.04 seconds. Twenty-seven participants were cross-lateral dominant and had an average of 43.40 ± 3.10 touches during the 30-second interval and had an average reaction time of 0.69 ± 0.05 seconds. No significant differences between touches or reaction time were found with dependent samples t-tests ($p < 0.05$). Gender was also examined for differences with no significant findings. Sport differences were not examined. **Conclusions:** The results of this study suggested there were no significant differences in hand-eye coordination (touches) or reaction time between same-side or cross-lateral dominant Division I collegiate athletes. Having so many cross-lateral participants was unusual compared to the general population and could be attributed to the participants athletic background. This could be an important part of rehabilitation training if cross-dominance can be developed and trained in athletes. Differences in the reaction time between the genders has been previously reported and gender differences have been noted in other sport specific testing: balance, agility, speed, and power; however, there were no differences between the genders for touches or reaction time in this study. Vision

is important to sports performance. Hand-eye coordination and reaction time are vital for the successful execution of skills. Visual tracking should be utilized to identify predisposition to injury and during rehabilitation to reduce the risk of future injury. It is often used in concussion rehabilitation; but Athletic Trainers should consider employing visual training for other orthopedic injuries as well.

Free Communications, Poster Presentations: Spine

On Demand: June 22-September 30, 2021

Unilateral Pedicle Stress Fracture in the Lumbar Spine of a Collegiate Basketball Athlete

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Background: A 21-year-old male collegiate basketball athlete, with no previous history of low back injuries, began to experience low back pain after his basketball game a few days prior. Pain was noticeable after performing a layup and was predominantly located on the left aspect of his lumbar spine. The physical exam revealed tenderness to palpation over on the left posterior superior iliac spine (PSIS), sacroiliac (SIJ), and paraspinal musculature around L3, L4, and L5. Pain was provoked during active and passive lumbar extension, active extension with left rotation, and Gaenslen's test of the left SI joint. Neurological screening was found to be within normal limits. **Differential Diagnosis:** Lumbago, Erector Spinae Strain, Sacroiliac Joint Dysfunction, Spondylolisthesis. **Intervention & Treatment:** A non-steroidal anti-inflammatory injection administered 10 days after the initial onset of symptoms was unsuccessful in alleviating the pain. Magnetic resonance imaging revealed bone edema in the L5 pedicle consistent with a non-healed stress fracture. Once a pedicle stress fracture was identified, conservatively treatment included rest, therapeutic physical agents for pain, therapeutic exercises for core and lumbo-pelvic stability, daily consumption of 1000mg of calcium,

500mg of vitamin D, 500 mg of vitamin C, and a lumbar orthosis support brace for 24hrs each day for the first seven days. After the two weeks of conservative treatment, a gradual return to sport participation occurred over the following two weeks. Sport specific drills included an advancement through noncontact to contact drills, jog-run-sprint progression, and finally limited to full practice involvement. The patient resumed full pain-free practice and game participation approximately four weeks at the same preinjury level of function and sport ability. A daily core-lumbo-pelvic stability regimen was followed for the remainder of the competitive season. **Uniqueness:** A frequently missed pathology and a common cause of low back pain in competitive athletes are stress fractures. In particular, pedicle stress fractures, known as pediculolysis, are a rare but arising pathology that is usually misdiagnosed in the lumbar spine. Literature describes pediculolysis as a hypertrophic fracture of the pedicle showing a non-union relative to other bony defects in the posterior elements of the spine such as spondylolysis and laminolysis. Pedicle stress fractures are typically diagnosed as either bilaterally or contralaterally in the lumbar spine when associated with spondylolisthesis, trauma, surgical procedures that occur in the spine, or spinal diseases like osteoporosis or scoliosis. The occurrence of a pediculolysis is usually a result of a contralateral spondylolysis, causing stress on the weak point of the vertebral arch. Being often missed on normal radiographic images, these stress

fractures are best found with magnetic response imaging (MRI) or a computed tomography scan (CT scan). Patients normally respond well to conservative treatment, rehabilitation, and activity modifications. **Conclusions:** Knowledge of pedicle stress fractures in the lumbar spine, known as pediculolysis, in patients with low back pain is necessary to avoid overlooking and late diagnosis.

Low Back Pain Disability Improved Consistently Regardless of Stabilization or General Exercise Comparison: A Critically Appraised Topic

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Context: Low back pain (LBP) becomes chronic with documented prevalence of up to 23% lasting longer than 3 months. Often patients with LBP are concerned about time lost at work or in sport participation and seek rehabilitative treatment. Therefore, it is important to understand if training patients specifically on increasing spinal stability throughout their daily life and in workouts, may be more beneficial in decreasing LBP disability compared to general exercise. **Methods:** A computerized search of PubMed, EBSCO, and Medline was performed in November 2019 for studies that were level 3 or 4 evidence, written in English, and published within the last 5 years. Search terms used were low back pain, spine stability, core stability, and exercise. The initial search resulted in 849 studies and was screened for relevance, including assessing general exercise compared to stabilization programs. Three relevant studies were assessed using the PEDro scoring system (Table) and disability using the Oswestry

Disability Index (ODI) to be included in this review. **Results:** All three studies showed a decrease in ODI scores after the lumbar or core stability protocols were implemented (Table). One study showed at least a 5-point decrease in each of the exercise groups in the ODI after the 6 weeks of intervention. The flexibility exercise (Pre:38.0±21.1, Post:31.9±18.6, P<.05) and stabilization exercise groups (Pre:31.4±13.2, Post:25.3±9.9, P<.05) saw the largest decrease in the ODI. Another study showed a decrease from 50.5±12.1 to 32.8±10.5 in the ODI for their core stability group, and also decreased from 50.1±11.3 pre-intervention to 37.6±10.9 post-intervention in its general exercise group. In a different study, chronic LBP patients experienced a larger decrease in ODI scores in the motor control exercise group (Pre:50.1±12.7, Post:33.3±11.0, P<.05) compared to a general exercise group (Pre:49.8±10.8, Post:37.4±11.1). The studies were not able to show that one stabilization or general exercise was more effective than another (P>.05). All three studies noted that the majority of participants were able to exercise more frequently following the intervention. One study noted that a participant with chronic LBP experienced difficulty performing the exercises after 60 minutes, therefore the investigators recommended an exercise regimen lasting 30 minutes. **Conclusions:** The studies reviewed demonstrated a reduction in

LBP disability following stability and general exercise programs. Moderate evidence indicated that completion of lumbar stabilization programs, not a singular exercise, improved overall health and activities of daily living in those with chronic low back pain. Exercise time and frequency increased in individuals who completed the spinal stabilization programs, which in turn allowed for added protective physical activity.

Table. Summary of articles appraised related to low back pain disability, stabilization and general exercise programs.

	Shamsi et al. The effect of core stability and general exercise on abdominal muscle thickness in non-specific chronic low back pain using ultrasound imaging (2016)	Shamsi et al. Comparison of spinal stability following motor control and general exercises in nonspecific chronic low back pain patients (2017)	Suh et al. The effect of lumbar stabilization and walking exercises on chronic low back pain: A randomized controlled trial (2019)
Study design	Randomized controlled trial	Quasi- randomized controlled trial	Quasi-randomized controlled trial
Participants	48 patients with chronic low back pain	51 patients with chronic low back pain	48 patients with non-specific chronic low back pain
Assessment method	Visual analogue scale, endurance in 3 postures (supine, side-lying, and prone), strength of lumbar extensors, Oswestry Disability Index , Beck depression inventory	Measured trunk muscle EMG, Oswestry Disability Index , Pain	Ultrasound with a 15 MHz linear transducer, visual analogue scale, Oswestry Disability Index
Exercises implemented in study	Low levels of core isometric contractions, progression of functional task with heavier loads	Motor control exercises (isometric contraction of local stabilizer muscles of the back)	Core stability, flexibility, walking with abdominal bracing, individualized graded lumbar stabilization exercises
Oswestry Disability Index improvement	Core stability group	Motor control exercise group	Stabilization exercise group
PEDro Score	5	7	9

Lumbar Disc Injury From a Sneezing Mechanism in a Collegiate Rower

von Kessel JR, Powers ME, Gildard MJ: Marist College, Poughkeepsie, NY

Background: Low back pain (LBP) is a common ailment in an athletic population. Sports that use repetitive impact, twisting motion or weight loading at end range are commonly associated with lower back pathology. The incidence of LBP in rowers has been estimated to be around 1.67/1000 exposure-hours and non-specific lumbar pain has been reported in 32-53% of collegiate rowers. While muscle injury is a common cause of LBP, it is important to identify when it might be associated with a structural abnormality or disc pathology. We present a case of disc herniation in a collegiate rower with a very unique mechanism of injury. A 20-year-old male collegiate rower was training on an ergometer when he sneezed mid-row. He immediately felt pain in his lower back and presented to his team athletic trainer. The athletic trainer diagnosed him with a muscle strain as his pain was localized to the lumbar area and he was not experiencing any numbness, tingling or radicular symptoms. The patient was treated with heat, electrical stimulation and stretching over the next 48 hours and he continued to row as tolerated. During this time, his pain increased and he began to experience numbness and paresthesia in his left foot, progressive lower extremity weakness and an altered gait. The patient was then referred to an orthopedist. Physician assessment revealed an abnormal Achilles tendon reflex with decreased sensation bilaterally at the L5 distribution. Bilateral weakness was also noted during dorsiflexion and great toe extension.

Magnetic resonance imaging revealed disc herniation at the L4-L5, bulging disc at the L5-S1, severe lumbar spinal stenosis and early cauda equina syndrome. **Differential Diagnosis:** Disc herniation, cauda equina syndrome, spinal stenosis, facet sprain, degenerative disk disorder, spondylolisthesis. **Intervention & Treatment:** Initial conservative treatment for a muscle strain was unsuccessful, ultimately leading to physician referral. Following diagnosis, the patient underwent a central laminectomy with bilateral partial facetectomy and foraminotomy at L4 with discectomy and neural decompression. He was placed in an Ankle Foot Orthotics brace for drop foot and was provided with a cane for support during gait. He began therapy shortly after surgery and was able to regain motor and sensory function. There are conflicting reports regarding the optimal management of lumbar disc herniation. Some research suggests that surgical intervention provides symptomatic relief sooner than conservative treatment however the long-term benefits do not appear to be different. Others have found that patients who underwent surgery for lumbar disc herniation have improved outcomes in comparison to non-operatively treated patients. Our patient experienced significant pain and radicular symptoms suggesting the need for surgery. Although the period of conservative treatment was brief, the symptoms only worsened. **Uniqueness:** Lumbar disc herniation should always be suspected in those presenting with low back pain. Thorough evaluation is necessary as evident by the unusual mechanism of injury and delayed onset of neurological symptoms. The degree of herniation often dictates the course of treatment. Conservative treatment of this patient was bypassed and surgical intervention

was performed, resulting in very positive outcomes. **Conclusions:** Sneezing is the result of expiratory muscle contraction and increased intra-abdominal pressure, which often can be considered sudden and violent. Paraspinal muscles will often contract and even spasm in response. Our patient had no previous history of lumbar injury and had not previously complained of lumbar pain. This case is clinically significant and unique, as a sneezing mechanism for acute disc herniation is unreported. It is possible that asymptomatic disc abnormalities were already present, however there is no way to determine that for our patient. It is also possible that his spinal stenosis and cauda equina comorbidities, or at least their causes, contributed to the sudden sneeze-induced disc injury.

Associations Between History of Ankle Sprains and Future Ankle Sprain During a One-Month Military Training Course

Dartt CE, Clifton DR, Barrett AS, Gregory AB, de la Motte SJ: Consortium for Health and Military Performance, Department of Military and Emergency Medicine, F. Edward Hébert School of Medicine, Uniformed Services University, and Henry M. Jackson Foundation for the Advancement of Military Medicine, Bethesda, MD

Context: Ankle sprains (AS) are one of the most common musculoskeletal injuries (MSK-I) sustained by US military service members (SM) and can result in lost training days, delayed graduation, or discharge from training. Those who sustain AS are also more likely to report recurrent AS and chronic instability, which may lead to dysfunction or disability during and after training. Identifying whether SM entering training with a history of AS are more likely to sustain a future AS may help inform injury risk mitigation strategies. The purpose of this study is to determine whether self-reported history of AS at entry to a one-month training course is associated with AS during training. **Methods:** Male enlisted SM (N=60, age=19.7±1.3 years) completed surveys at entry to, and graduation from, a one-month long training course as part

of a larger study. At entry to training, participants were asked “Have you ever sprained your ankle?” Upon graduation from training, participants were asked whether they sustained an AS during the previous one-month course. The association between AS history and AS during training was assessed using a Fisher’s exact test. Relative risk (RR) and 95% confidence intervals (95%CI) were calculated to determine whether those entering training with a history of AS were at increased risk of AS during training. **Results:** Twenty-five percent (n=15/60) of SM entering training reported a history of AS. At graduation, 10% (n=6/60) of SM reported sustaining AS during the one-month training course. Among SM who reported an AS history, 33.3% (n=5/15) sustained an AS during training. Among SM who did not report an AS history, 2.2% (n=1/45) sustained an AS during training. There was a significant association between history of AS and AS during training (p=0.003), with those entering with a history of AS at 15 times greater risk of reporting a new AS during the one-month training course compared to those with no AS history (RR=15.0, 95%CI=1.9, 337.5). **Conclusions:** Participants entering a one-month training course with a history of AS were more likely to report sustaining a new AS during training compared to those with no AS history. A limitation of these findings is that the sample size for this study is small and the CI is large. Future research should evaluate a larger sample and investigate whether AS history is associated with lost training

days, delayed graduation, early discharge from service, or prolonged dysfunction/disability due to recurrent injuries during training. Regardless, it may be prudent for injury risk mitigation strategies during military training to account for prior AS. Such strategies may include using ankle braces for training or implementing targeted exercise interventions that are designed to address deficits found in individuals with a history of AS (e.g. proprioceptive or balance training).

Musculoskeletal Injuries During an Overseas Training Exercise: Do Sustainment Brigade Soldiers Seek Care?

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Context: The U.S. Department of Defense (DoD) reports approximately 1.6 million musculoskeletal injuries (MSKIs) annually. Despite the high incidence of known MSKIs, recent evidence suggests that injury reporting rates by Servicemembers (SMs) remain low for various reasons, suggesting a potential underrepresentation of true MSKI prevalence. To date, no studies have investigated MSKI care-seeking trends among SMs deployed in support of non-combat overseas training missions. The purpose of this study was to describe injury reporting behaviors among U.S. Army Soldiers following an overseas training mission to better understand factors influencing a SM's willingness to report MSKIs to medical providers during these types of missions. **Methods:** This cross sectional study utilized an anonymous 55-item electronic survey (NDiV Inc.) to measure injury reporting behaviors among U.S. Army Soldiers. The

survey asked SMs to provide information about potential MSKIs sustained during the previous 12 months and whether their injuries were reported to a medical provider. The survey was completed by a convenience sample of 50 U.S. Army Soldiers returning from a training exercise in Europe. A previously developed survey pertaining to symptom reporting in Army and Air Force SMs was adapted for this study. SMs were predominately male (94%) with a mean age of 27 years ($SD \pm 6.49$ years). To determine if Soldiers are more likely to not report their injuries to a medical provider while in garrison versus while deployed, a McNemar's test was conducted. **Results:** Of 186 total injuries, 49% were reported to a medical provider. SMs who were deployed were more likely to not report their injuries than in garrison, but this difference is not significant, $X^2(1) = 2.29$, $p = 0.13$. Common reasons for not seeking medical care were "I did not want to be prevented from participating in training" and "I did not want to be put on profile". Additionally, a large number of subjects (40%, $N=20$) felt medical providers did not give their injuries the attention they deserved. **Conclusions:** Consistent with previously published research in other military populations, a large number of potential MSKIs sustained by this cohort of Soldiers returning from an overseas training mission were unreported to

medical providers. Not seeking care for MSKIs prevents adequate treatment, which may result in increased risk for re-injury. Strategies to increase Soldier's willingness to report MSKIs to medical providers may improve warfighter health and readiness by mitigating chronic or recurring injuries.

Perceptions, Practices, and Barriers of Military Athletic Trainers' Using Patient-Reported Outcome Measures in Their Clinical Practice

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Context: The vast majority of athletic trainers (ATs) recognize the importance of patient-reported outcomes (PROs) in clinical practice but encounter unique barriers that limit their implementation. Previous studies have examined the use of PROs among ATs in the collegiate and secondary school settings, but no specific studies have determined the use of PROs in the military setting. The purpose of this study was to explore the perceptions, practices, and barriers to implementing PROs in the military setting. **Methods:** We used a cross-sectional design with a survey distributed through the Board of Certification with certified ATs who listed military/government/law enforcement as their employment setting within the last year. We used a previously validated survey, modifying the demographic questions relevant to the military setting and used an expert panel to review. Dependent variables for all participants were endorsements of perception, practice, and barrier statements with PROs. ATs who reported using PROs in clinical practice were asked the criteria they use for

selecting the measures, whereas ATs who reported not using PROs were asked their reasons for not using them. **Results:** Emails were sent to 365 potential participants and 95 responded (access rate=26.0%), of which 67 were eligible to participate (response rate=18.4%). Of those that were eligible, 52 participants completed the tool entirely (completion rate=77.6%, effective response rate: 14.2%) (age=40±10y; years certified=14±9y; years practicing in military setting=6±6y). More ATs in the military setting reported not using PROs (59.6%, n=31/52) than those that do (40.4%, n=21/52). Among participants, the most commonly cited reasons for using PROs were documenting the status, progress, or outcomes of patients (41/52, 79%) and demonstrating effectiveness to administration (40/52, 77%). Improving communication with the patient (54/57, 95%) and helping to direct the plan of care (52/57, 91%) were the most frequently endorsed benefits of PROs (Table). Time for patients to complete (28/54, 52%) and time to score and analyze (26/54, 48%) were the most common problems. For ATs using PROs, the easiness for patients to understand was the most common criterion used to select individual measures (17/21, 81%). For ATs not using PROs, the most frequent reasons were both time for patients to complete (13/31, 42%) and lack of a support structure (13/31, 42%). **Conclusions:** The majority of ATs in the military setting recognize the uses and benefits of

PROs in their clinical practice, yet less than half of them use them. These findings are similar to previous studies, where ATs recognize the beneficial role PROs play in clinical care; however, the barriers remain the same in each setting. Further research should investigate the components of mindset, motivation, and methods for implementation to develop successful strategies for widespread implementation of PROs across practice settings in AT.

Table. Perceived Benefits of Patient-Reported Outcome Measures (Likert Scale)

Benefit	Mode ^a	Frequency of the mode, n (%)	Mean ± SD
Direct plan of care	Agree	33 (49.3)	4.21 ± 0.70
Improve communication; clinician and patient	Agree	28 (41.8)	4.39 ± 0.65
Improve communication; physician and other providers	Agree	32 (47.8)	4.19 ± 0.64
Patient feels evaluation was thorough	Agree	27 (40.3)	4.30 ± 0.71
Increase efficiency of evaluations	Agree	29 (43.3)	4.00 ± 0.78
Focus choice of interventions	Agree	30 (44.8)	4.11 ± 0.72
Better patient outcomes	Agree	27 (40.3)	4.26 ± 0.72
Motivate and encourage patient	Strongly Agree	26 (38.8)	4.33 ± 0.72

^a Level of agreement: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*

The Examination of Access and Experience with Health Care Providers for ROTC Members

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Context: Reserve Officers Training Corps (ROTC) programs prepare student-civilians to become leaders through strenuous physical and leadership training. Unlike their student-athlete counterparts who have direct access to athletic training services, ROTC members may or may not have a healthcare provider during their physical training sessions. Therefore, the purpose of our study was to examine the access to care and reporting behaviors of ROTC members with a secondary aim exploring the quality of those healthcare interactions relative to patient-centered care. **Methods:** We snowball recruited ROTC members from 541 institutions. Overall, 132 members (age=20±3 y; male=89, 67.4%, female=41, 31.1%, missing=2, 1.5%) dispersed between the Army, Navy, Air Force, and Marines completed the cross-sectional survey. The survey assessed access to care using a self-report tool on the type of medical providers available to the ROTC member and their illness/injury history and reporting behaviors. The participants who sought care for an injury/illness also completed the valid and reliable Consultation and Relational Empathy (CARE)

tool to measure the level of patient-centered care by the healthcare provider. The CARE tool uses a 5-point Likert scale with combined scoring from 10 (dissatisfied) to 50 (satisfied). Data were analyzed using descriptive statistics.

Results: Overall, ROTC members reported having access to 2±1 healthcare providers including a designated civilian physician (n=35, 26.5%), athletic trainer (n=31, 23.5%), and ROTC peer first responder (n=19, 14.4%). However, 50.8% of respondents (n=67) stated they were unsure what healthcare providers were available to them. In total, 22.7% (n=30) of members reported being injured and 26.5% (n=35) reported being sick/ill while participating in ROTC activities. Of those who stated they had sustained an injury during ROTC, 59.9% (n=18) seldomly or never reported their injury to someone else. The members who did report their injury mostly did so to another ROTC member (n=7, 5.3%) or a healthcare provider outside of the program (n=7, 5.3%). Of the 35 participants that reported being sick/ill, 37.1% (n=13) stated they almost always reported their illness. The members stated they often reported their illness to the ROTC program leader (n=14, 51.8%). On the CARE tool, an average score for patient-centeredness was 35.96±10.60 for injury treatment and 35.48±13.10 for illness treatment which can be interpreted as satisfied with their care. **Conclusions:** The ROTC members reported a general unfamiliarity with the healthcare providers available to them. We also

identified that illness reporting was higher than injury reporting, however the reporting was often to an ROTC program leader or peer member rather than a healthcare provider. Despite the reporting behaviors, the members reported being satisfied with the care they received. ROTC programs should consider expanding direct access to athletic trainers who can assist with injury and illness reporting and treatment at the point-of-care.

Free Communications, Poster Presentations: Therapeutic Exercise

On Demand: June 22-September 30, 2021

Kinesiology Tape: A Descriptive Survey of Healthcare Professionals in the United States

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Context: The purpose was to survey and document the beliefs and clinical application methods of kinesiology tape (KT) among healthcare professionals in the United States. **Methods:** Members of the National Athletic Trainers Association, Academy of Orthopedic Physical Therapy, and American Academy of Sports Physical Therapy were recruited for this survey study. Professionals were also informed through Facebook. A 30-question online survey was emailed to association members and a notification was posted in private Facebook groups. The survey included one respondent consent question and 29 questions that represented four distinct areas: 1) respondent demographics, 2)

clinical perceptions about KT, 3) clinical application of standard, specialty, infused KT, topicals, and clinical measures, and 4) KT education, and referral. The main outcome measure was participant responses. Statistical analysis included total responses, frequency count, and percentages. **Results:** A total of 51,000 healthcare professionals were recruited. A total of 1083 respondents finished the survey resulting in a 2.1% completion rate. Most respondents used KT for post-injury treatment (74%), pain modulation (67%), and neuro-sensory feedback (60%). Most believed that KT stimulates skin mechanoreceptors (77%), improves local circulation (69%), and modulates pain (60%). Some respondents believed KT only creates a placebo effect (40%) and use it for such therapeutic purposes (58%). Most respondents used a standard uncut roll (67%) in black (71%) or beige (66%). Most did not use any specialty pre-cut tape (83%), infused tape (99.54%), or a topical analgesic with tape (65%). The most common tape tension lengths used by respondents were 50% tension (47%) and 25% (25%) tension. Patient reported outcomes (80%) were the most common clinical measures. Most respondents provided skin prep (64%) and tape removal (77%)

instructions. Some did not provide any skin prep (36%) or tape removal (23%) instruction. The average recommended time to wear KT was two to three days (60%) and maximum time range was from two to five days (81%). **Conclusions:** This survey provides insight into how professionals use KT and highlights the gap between research and practice. Future research should address these gaps to better determine evidence-based guidelines.

Management of Osteitis Pubis in the Soccer Athlete: A Case Report

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Background: Osteitis pubis (OP) is a chronic overuse injury characterized by an inflammation of the pubic symphysis. It is common in athletes performing extensive amounts of change in direction and speed, such as soccer and hockey players. This self-debilitating injury presents with pain directly on palpation of the pubic symphysis and in the adductor musculature, however pain in the abdominal region may be noted. OP is often difficult to diagnose due to a gradual onset of symptoms and the complexity of the groin region. It also presents with symptoms similar to athletic pubalgia. OP is a significant injury impairing sport and daily performance. Gia Via and Frizziero found that a rehabilitation program focused on the improvement of lumbo-pelvic muscular imbalances, early isometric core strengthening and eccentric hip strengthening in the functional phase of rehabilitation paired with anti-inflammatory medications resulted in an average return to play (RTP) of three months. In this level 1 CASE report the implications of conservative treatment for OP will be discussed. **Patient:** A male collegiate soccer player suffered from debilitating lower abdominal and adductor musculature pain midway through a three-day soccer tournament. Initial assessment noted decreased hip ROM and adductor musculature weakness. Upon further examination and results of MRI, a diagnosis of OP was made. **Intervention &**

Treatment: The initial phase of rehabilitation lasted for approximately four weeks with a focus on pain management and stretching of the hip musculature. During the secondary phase the patient began concentric core strengthening activities along with continual increases in strength and ROM of the lumbo-pelvic musculature for approximately five weeks. The final functional phase lasted approximately six weeks with a primary focus on concentric strengthening of the core and hip musculature. **Outcomes or Other Comparisons:** Gia Via and Frizziero addressed pairing anti-inflammatories with a rehabilitation program focused on correcting lumbo-pelvic imbalances, early isometric core strengthening and eccentric hip exercises in the functional phase of rehabilitation, which resulted in an average RTP of three months. The rehabilitation of the current patient paired anti-inflammatories and correcting lumbo-pelvic muscular imbalances with a focus on concentric strengthening of the core and hip musculature and resulted in a return to play of approximately three and a half months. Upon full return to sport the patient now is following a strict regimen of proper warm up and maintaining a proficient balance in lumbo-pelvic musculature resulting in a symptom free lifestyle. **Conclusions:** The average RTP period reported in the comparison study was three months. In the current case, the rehabilitation of the patient to return asymptomatic to running and sport specific activities occurred in approximately three and a half months. This extended time could have been due to a number of factors such as; low compliance in taking anti-inflammatories or utilizing concentric core and hip strengthening exercises rather

than isometric core and eccentric hip exercises. A regimen of early anti-inflammatories, correcting lumbo-pelvic imbalances, isometric core strengthening and eccentric hip exercises could lead to an earlier return to sport as reviewed in the comparison study. **Clinical Bottom Line:** OP in an athlete can become a tremendous frustration and psychological burden depending on the amount of playing time missed. An implementation of ROM and strength exercises focusing on a strong balance between the lumbo-pelvic musculature paired with anti-inflammatories, early core isometric strengthening and eccentric hip strengthening in the functional phase of rehabilitation should be a primary focus in the prevention and treatment of OP.

Muscle Activation, Median Frequency, and Perceived Exertion During the Sport Specific Endurance Plank Test
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Context: Shoulder pain is the most commonly reported complaint of overhead throwing athletes. The throwing motion is heavily reliant on the kinetic chain and proper sequencing of the lumbopelvic-hip complex (LPHC) and scapular stabilizers. The Sport Specific Endurance Plank Test (SSEPT) is the only functional test proposed in the literature to link the LPHC and the upper extremity. The SSEPT showed increased LPHC activation in healthy adults; however, the activation of the scapular stabilizers has not been measured. Our objective was to assess the muscle activation and median frequency of the serratus anterior (SA), latissimus dorsi (LD), and LPHC, as well as perceived exertion (RPE), during the SSEPT in healthy, active adults. We hypothesized that the SSEPT would significantly activate and increase the median frequency in the SA, LD, and LPHC, and that RPE would increase. **Methods:** This cross-sectional study was conducted in a university laboratory; 20 healthy adults (7 male, 13 female, age: 20.6±2.7 years, mass: 68.4±13.3kg, height: 170.1±11.0cm, BMI: 23.1±2.5, Godin: 69.1±23.6) participated. Surface EMG recorded SA, LD, rectus abdominus (RA), external oblique (EO), gluteus

maximus (GM), and erector spinae (ES) activity. Mean EMG amplitudes of each muscle were collected from each phase of the SSEPT (Table1). EMG was normalized to participants' muscle-specific maximal voluntary isometric contraction (MVIC). Fatigue was measured as median EMG frequency and RPE. One-way repeated measures ANOVAs with Sidak comparisons were completed to assess muscle activation between phases. Dependent t-tests compared median frequency and RPE between phases 1 and 8. Significance levels were set at p<0.05. Muscle activation was classified as absent to minimal (0-15%MVIC), low (16-30%MVIC), moderate (31-60%MVIC), and high (>60% MVIC) to determine clinical relevance where >60% indicates a training effect. **Results:** Throughout the SSEPT, muscle activation of the 1) SA and EO activation was high, 2) LD and RA activation was moderate-high, 3) GM activation was minimal-moderate, and 4) ES was minimal-low (Table 1). Activation across the SSEPT phases ranged widely depending on position (SA: 129.1±53.4%-214.6±107.2%, LD: 34.1±25.2%-81.7±53.8%, RA: 58.5±34.8%-92.9±66.8%, EO: 93.1±57.0%-227.4±153.5%, GM: 9.6±7.0%-39.3±26.8%, ES: 8.4±4.2%-19.0±12.5%). Significant increases were demonstrated in all muscles from phase 1-8 (SA p=0.02, LD p=0.012, RA p=0.03, EO p=0.003, GM p=0.024, ES p<0.001). Median frequency decreased from phase 1-8, in all muscles (SA: Phase1=44.2±7.1, Phase8=34±7.0, p<0.001; LD: Phase1=38.4±5.9, Phase8=31.5±5.1, p<0.001; RA: Phase1=68.1±12.1, Phase8 = 53.2±12.3, p<0.001; EO: Phase1=57.3±11.8,

Phase8=40.9±11.2, p<0.001; GM: Phase1 =50.8±22.9, Phase8=34.5±11.2, p=.005) except the ES (p=0.428, Phase1= 25.7±8.2, Phase8=26.7±5.7). RPE also increased (p<0.001, Phase1=8.05±2.03, Phase8 =16.3±1.59). **Conclusions:** The SSEPT can be used to highly activate and fatigue the SA, LD, and LPHC in healthy, active adults. These findings should be verified in upper extremity and/or injured athletes. The SSEPT may be an appropriate exercise for training the scapular stabilizers and LPHC simultaneously, both in training and rehabilitation settings.

Table 1: Activation levels across muscles and phases of the Sport Specific Endurance Plank Test

Muscle	High (>60%)	Moderate (31-60%)	Low (16-30%)	Absent-Minimal (0-15%)
Serratus Anterior	1,2,3,4,5,6,7,8			
Latissimus Dorsi	6,7	1,2,3,4,5,8		
Gluteus Maximus		4,7	3,5,6	1,2,8
Erector Spinae			6	1,2,3,4,5,7,8
Rectus Abdominus	2,4,5,6,7,8	1,3		
External Oblique	1,2,3,4,5,6,7,8			

Phases: 1. basic plank (60s), 2. lift right arm (15s), 3. lift left arm (15s), 4. lift right leg (15s), 5. lift left leg (15s), 6. lift right arm and left leg (15s), 7. lift left arm and right leg (15s), 8. basic plank (30s)

Muscle Activation and Reason for Termination in the Lumbopelvic-Hip Complex During the Prone Bridge Plank and V-Sit

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Context: Stabilization of the lumbopelvic-hip complex (LPHC) and maintaining proper form are fundamental during core exercises. Understanding if an individual discontinued a plank exercise due to abdominal pain, shoulder fatigue, or overall neuromuscular dysfunction allows clinicians to make decisions about exercise prescription. The purpose of this study was to measure percentage of activation from the muscles generating the highest activation within the entire LPHC and upper extremity (UE) during the prone bridge plank (PBP) and V-sit, and report reasons subjects terminated exercise. **Methods:** Fifteen healthy participants, 10 males and 5 females (Age: 21.4±3.1years, Height: 179.0±9.2cm, Mass: 75.9±11.5kg) completed this descriptive laboratory study. LPHC muscles (rectus abdominis (RA), external oblique (EO), erector spinae, gluteus medius, latissimus dorsi) and UE muscles (middle deltoid (MD), middle trapezius (MT)), were assessed with surface electromyography on dominant side.

Peak activation was measured during maximum isometric voluntary contraction (MVIC) for normalization. Participants performed 2 trials of the PBP and V-sit. Participants then reported their reason for termination (pain or fatigue) from a list of anatomical regions. %-LPHC activation and %-UE activation were calculated as a percentage of the highest activators to the entire LPHC and UE, respectively. Reason for termination were dichotomized into two groups, LPHC or extremity. Means and standard deviations were calculated for each continuous variable, and frequency for reason for termination. Independent t-tests were used to compare %-activation with an alpha set at $P<0.05$. Cohen's d effect sizes with 95% confidence intervals (CI) were calculated. **Results:** The RA and EO achieved high activation levels during the PBP ($57.87\pm28.99\%$ MVIC; $56.17\pm19.64\%$ MVIC) and V-sit ($43.48\pm19.34\%$ MVIC; $60.09\pm29.30\%$ MVIC). The %-LPHC activation for RA was similar for the PBP ($35.59\pm10.86\%$) and V-sit ($33.94\pm8.99\%$, $P=.65$). Conversely, the %-LPHC activation for the EO was 9.49% higher with a large effect ($P=.01$, $d=-0.9$, CI: -1.65, -0.15) during the V-sit ($46.19\pm10.54\%$, PBP: $36.70\pm10.62\%$). For the extremity, MD reached high activation for PBP ($42.48\pm19.30\%$ MVIC) while both MD and MT were negligible ($<2\%$ MVIC) during the V-sit. %-UE activation for the MD was 36.51% greater during the PBP with a large effect ($P<.001$, $d=2.25$, CI: 1.34,

3.17). Nine of 15 participants terminated the PBP due to extremity fatigue compared to 13 of 15 participants who terminated the V-sit due to LPHC fatigue or pain (Figure). **Conclusions:** The RA and EO achieved high activation during both exercises and increased anterolateral stability for participants to maintain the exercise position. The surrounding muscles of the LPHC should contribute at least a minimal level of activation to perform the exercises. Core exercises relying heavily on the extremities require a greater co-contraction of the surrounding muscles to minimize fatigue and discomfort while improving objectives of the exercise.

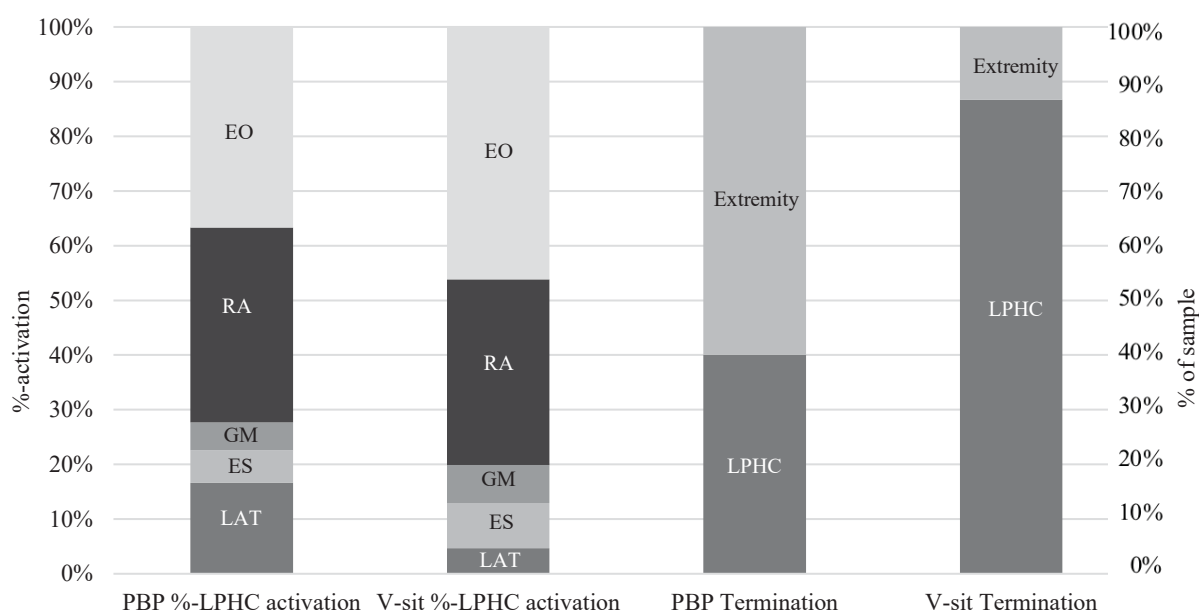


Figure. %-LPHC activation and reasons for termination during prone bridge plank and v-sit exercises

The Usage of Active Video Games among Athletic Trainers in a Clinical Setting, Part 1: Examining the Constructs of the Theory of Planned Behavior

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Rocky Mountain University of Health Professions, Provo, UT

Context: Evidence regarding behavioral intentions of active video game (AVGs) usage as a mode of therapy among physical therapist and occupational therapists in clinical settings is well documented in the literature. However, research regarding the same among athletic trainers (ATs) is limited. The objective was to determine the relationship between the constructs of the Theory of Planned Behavior (TPB): planned behavioral control (PBC), attitude, and social norm; and demographics indicating the usage of AVGs among ATs. **Methods:** A cross-sectional online survey-based design was used to evaluate the behavioral intentions for using active video games (AVGs) such as the Nintendo Wii, Xbox Kinect, and PlayStation Move as a mode of therapy. Content validity and face validity for Assessing the Determinants of Prospective Take-up of Active Videogames (ADOPT-AVG) survey was established based on the original survey, Assessing Determinants of Prospective Take-up of Virtual Reality (ADOPT-VR),

Cronbach alpha = 0.876.1 The survey contained both Likert-scale (1 = strongly disagree, 5 = strongly agree) and open-ended questions that addressed the determinants of TPB. The frequencies of the responses were assessed with Chi-square tabulations. Pearson (r) correlation, linear regression, and binary logistic regression assessed the relationships exhibited between the constructs' demographics and mean scores. Independent t-test and ANOVA assessed differences in responses. Open-ended responses were analyzed inductively. Two hundred seventy-six ATs completed 25 item ADOPT-AVG survey. Of the 276 participants, 65.2% (n = 180) were females and 34.8% (n = 96) males with 88% of the participants employed in secondary/high school (n = 159) and intercollegiate athletic settings (n = 84). **Results:** The greatest relationship for the intent to use AVGs was exhibited between the construct PBC (r = 0.581, P < 0.001). This was followed by Social Norms (r = 0.466, P < 0.001), and Attitude (r = 0.449, P < 0.001), Table 1. The demographics were weakly correlated to the 3 primary constructs of TPB. There was no significant difference between the demographics for the mean scores in the 3 primary constructs of TPB, except between gender (t PBC = 3.327, P < 0.001; t BI = 1.936, P < 0.001); and social norm means scores for clinical settings (F SN = 5.168, P < 0.001): hospital, 2 year college institution, and industrial. **Conclusions:** The intent to implement AVGs

lies specifically in personal beliefs (PBC construct) influenced by attitude and social norms. ATs attitude regarding the usage of AVGs in the clinical setting are favorable. However, barriers such as time management and lack of research decreases the intent to implement AVGs. As the profession continues to grow in evidence-based practice, future research should focus on application and practicality to indicate AVGs effectiveness in providing optimal care for the athletic population.

Table 1. Correlation Matrix for the Constructs of TPB and Demographics.

	Gender	Setting	Degree	Exp.	Attitude	SN	PBC	BI
Gender	1	-0.129*	-0.070	-0.200**	-0.014	-0.012	-0.226**	-0.116
P		0.033	0.245	0.001	0.817	0.849	0.001	0.54
Setting	-0.129	1	0.094	0.049	-0.044	-0.133*	0.026	0.21
P	0.033		0.118	0.421	0.463	0.027	0.711	0.725
Degree	-0.070	0.094	1	0.109	-0.038	0.03	-0.027	0.034
P	0.245	0.118		0.071	0.529	0.959	0.699	0.577
Exp.	-0.200**	0.049	0.109	1	-0.121*	0.001	-0.030	0.021
P	0.001	0.421	0.071		0.045	0.985	0.671	0.734
Attitude	-0.014	-0.044	-0.038	-0.121*	1	0.530**	0.559**	0.449**
P	0.817	0.463	0.529	0.045		0.000	0.000	0.000
SN	-0.012	-0.133*	0.03	0.001	0.530**	1	0.523**	0.466**
P	0.849	0.027	0.959	0.985	0.000		0.000	0.000
PBC	-0.226**	0.026	-0.027	-0.030	0.559**	0.523**	1	0.581**
P	0.001	0.711	0.699	0.671	0.000	0.000		0.000
BI	-0.116	0.021	0.034	0.021	0.449**	0.466**	0.581**	1
P	0.54	0.725	0.577	0.734	0.000	0.000	0.000	

Note. * Correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level. Social Norms (SN). Perceived Behavioral Control (PBC). Behavioral Intentions (BI). Exp. (Years of experience).

Dry Cupping Therapy Application Procedures for Treating Musculoskeletal-Related Pain: A Systematic Review

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VA, and Creighton University, Omaha,
NE

Context: Dry cupping therapy (DCT) has been suggested to alleviate pain and improve quality of life (QOL) in various patient populations. Due to the lack of standardized application protocols, recent studies have demonstrated a wide variety of DCT utilization methods, which may contribute to the conflicting findings regarding the treatment effectiveness. Therefore, the aim of this review was to critically evaluate and summarize the available evidence on DCT study application procedures for treating musculoskeletal-related pain. **Methods:** Electronic databases including PubMed, SPORTDiscus, and the Cochrane Library were comprehensively searched and evaluated by two independent researchers in July 2020 to identify studies evaluating the effect of DCT on musculoskeletal-related pain. Studies were included if: (1) the article was an original research study, (2) DCT was applied as an intervention, (3) musculoskeletal

pain was reported as an outcome variable using a Likert-type scale, (4) DCT treatment time was documented, and (5) the article was written in English. Methodological quality was evaluated using the Modified Downs & Black Checklist, with quality scores categorized as poor (≤ 14), fair (15-19), good (20-25), and excellent (26-28). Application procedures for DCT including style (i.e. static or moving), number of cups and cupping sessions, treatment time, cup material, suction mechanism, and the amount of air extraction were gathered from each study. Where possible, means, standard deviations, and p-values for pain, function, and QOL outcomes were extracted from the included studies. When not provided, within-group mean differences (converted to a 10-point scale) and p-values were interpolated by the researchers. Due to methodological heterogeneity, a meta-analysis was not conducted. **Results:** A total of 10 studies (8 good quality, 2 fair quality) were included in the review. Five studies included participants with neck or shoulder pain, two with back pain, two with plantar pain, and one with fibromyalgia pain. The most common application procedures included 3.4 ± 2.7 sessions of static DCT involving approximately 10 minutes of glass or plastic cup application. The amount of air extraction per cup was not reported in most of these studies. Although pain intensity was

the only outcome measure assessed across all ten studies, results were also evaluated for patient-perceived function and QOL in a subset of reports. Results indicated that DCT may be an effective short-term method for decreasing pain (Table 1) and improving QOL. However, there was conflicting evidence regarding the effectiveness of DCT for improving function as well as long-term (48.3 ± 77.7 days post-treatment) pain and QOL. **Conclusions:** Findings from this review suggest that DCT may be an effective method for reducing musculoskeletal-related pain. Additional high-quality studies are needed to identify evidence-based standardized protocols for DCT including proper treatment time, amount of air extraction, and number of treatment sessions in order to achieve optimal patient-benefits.

Table 1. Pain intensity study results

Author	Quality Score	Outcome Measure	Pain Scale (0-10)	Mean Difference 1	p-value	Mean Difference 2	p-value
Lauche et al.	22	Neck pain intensity (at rest)	VAS	-1.94 (IN)	0.005 (IN)	-	-
		Neck pain intensity (with movement)	VAS	-3.30 (IN)	< 0.001 (IN)	-	-
Kim et al.	23	Neck pain intensity (1-week average)	NRS	-3.07 (IN)	< 0.001 (IN)	-3.05 (IN)	< 0.001 (IN)
Chi et al.	23	Neck pain intensity	VAS	-6.10 (IN)	< 0.001 (IN)	-	-
		Shoulder pain intensity	VAS	-5.90 (IN)	< 0.001 (IN)	-	-
Saha et al.	23	Neck pain intensity	VAS	-1.99 (IN)	0.014 (IN)	-	-
		Neck pain intensity (with movement)	VAS	-1.04 (IN)	0.128 (IN)	-	-
Stephens et al.	21	Neck pain intensity	VAS	-2.00 (PR)	0.001 (PR)	-1.29 (PR)	0.06 (PR)
Markowski et al.	15	Back pain intensity	VAS	-3.00 (IN)	< 0.0001 (PR)	-	-
Volpato et al.	17	Back pain intensity (current)	BPI	-2.56 (IN)	< 0.05 (PR)	-1.84 (IN)	< 0.05 (PR)
		Back pain intensity (at its worst)	BPI	-	-	-1.28 (IN)	< 0.05 (PR)
		Back pain intensity (at its least)	BPI	-	-	-1.16 (IN)	< 0.05 (PR)
		Back pain intensity (average)	BPI	-	-	-2.55 (IN)	< 0.05 (PR)
Ge et al.	20	Plantar pain intensity	VAS	-2.98 (PR)	< 0.05 (PR)	-	-
AlKhadhrawi et al.	24	Plantar pain intensity (current)	VAS	-1.60 (IN)	< 0.05 (PR)	-0.70 (IN)	0.242 (PR)
		Plantar pain intensity (first morning steps)	VAS	-	-	-2.60 (IN)	< 0.05 (PR)
Lauche et al.	25	Pain intensity	VAS	-0.44 (IN)	0.311 (IN)	0.30 (IN)	0.454 (IN)

VAS: visual analog scale; NRS: numeric rating scale; BPI: brief pain inventory; Mean Difference 1: post-intervention 1 - baseline; Mean Difference 2: post-intervention 2 - baseline; IN: interpolated; PR: provided; (-): not reported

The Efficacy of Low-Level Laser Therapy in the Treatment of Type I Complex Regional Pain Syndrome
Thompson AJ: Indiana Wesleyan University, Marion, IN

Background: During high school track workouts, a healthy 18-year-old female cross country/track athlete developed non-traumatic pain in her right foot. Mild swelling increased with continuous burning sensations throughout her foot persisting for 5 days post onset of pain. Signs and symptoms were localized to the plantar foot between the 2nd and 3rd distal metatarsals. Initial diagnosis was nerve impingement/Morton's neuroma. Conservative treatment of NWB was achieved through foot immobilization and crutches to limit injury exacerbation. Neurologic abnormalities progressed in the following weeks including sensitivity to touch and cold, varying skin color and temperature, muscle spasm leading to weakness and atrophy, paresthesia, and decreased range of motion throughout the right lower extremity. Initial pain was reported as a 4 of 10 on the numeric pain rating scale (NPRS). Pain was rated 8 of 10 NPRS one month post onset. **Differential Diagnosis:** Nerve impingement, Morton's Neuroma, Stress Fracture **Intervention & Treatment:** Physician referral and diagnostic testing resulted in a diagnosis of Complex Regional Pain Syndrome (CRPS). Unsuccessful interventions over 5 months included alternate workouts leading to discontinuing running activities, prescription NSAIDS, over-the-counter arch supports, prescription orthotics, therapeutic ultrasound, thermotherapy, and cryotherapy. Upon transition into collegiate sport participation, alternate therapeutic interventions were considered. Low Level Laser Therapy (LLLT) was initiated to

address the chronic neurologic signs and symptoms. A super pulsed, multi-wavelength laser emitter by Multi Radiance was used including a 1-905nm 25w Gallium arsenide (GaAs) super pulsed laser diode, 4-875 infrared broadband diodes and 4-640 nm red light LED. Treatments of 3000 HZ for 4 minutes were applied bilaterally to the lumbar spine over the exiting L4-L5 and L5-S1 nerve root origins. 1000 HZ for 3 minutes was applied bilaterally to the Medial Sural Cutaneous nerve between the medial and lateral Gastrocnemius muscles. Lastly, 1000 HZ for 3 minutes was applied bilaterally to the Posterior Tibial nerve posterior to the medial malleolus. Treatments were performed daily over the course of 8 weeks. Prior to the initiation of LLLT, the patient was unable to complete running workouts that were longer the 1 mile at a moderate intensity without a cessation of running activity due to pain and disability. At the conclusion of 8 weeks of LLLT, the patient was running 6-7 mile workouts multiple days per week at moderate to severe intensities without negative signs and symptoms. 12 weeks post initiation of LLLT the patients' negative signs and symptoms from CRPS had resolved. **Uniqueness:** CRPS is a form of chronic neurological pain that typically affects the extremities following trauma. The pain is commonly disproportionate to the severity of the initial injury. The incidence of this syndrome in athletic patients is unknown and its etiology makes it challenging to select ideal therapeutic interventions. CRPS type I is indicated by pathological sensory, motor, sudomotor, vasomotor, and/or trophic changes. LLLT is a somewhat misunderstood therapeutic intervention with a growing body of literature supporting its efficacy for producing positive patient outcomes. LLLT is the application of light to a biological system to promote tissue

regeneration, reduce inflammation, and relieve pain. LLLT does not use a thermal mechanism for treatment. Photobiomodulation occurs with the application of LLLT where the light is absorbed and causes a chemical systemic change in underlying tissues. **Conclusions:** It is suggested that more research and investigation is needed into neurologic treatment protocols for LLLT. Neurologic disorders are a serious, widespread health issue resulting in a large amount of dysfunction and as such have a significant socio-economic impact. Treatment and rehabilitation should be multidisciplinary and focus on regaining function, with sport participation being secondary. Neurologic pathologies are highly problematic as they could cause severe and lifelong disability if mismanaged.

The Effect of Dynamic Compression on Recovery of Performance and Self-Reported Function After an Intense Bout of Plyometric Exercise

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Context: Delayed onset muscle soreness (DOMS) causes pain and dysfunction that can inhibit athletic performance and potentially increase injury risk. Dynamic compression is commonly used to enhance recovery despite the lack of evidence to support its prevalent use. Our purpose was to investigate the effects of dynamic compression on objective and subjective metrics of recovery after a single bout of plyometric exercise. **Methods:** This repeated-measures design included 25 recreationally-active participants (17M, 8F; 1.75±1.0m, 76.4±12.8kg, 22.1±1.9yrs) who completed baseline performance assessments for vertical jump (VJ; m), single-hop (SH; m), triple-hop (TH; m), and 505-agility test for sprint (Sp; s) and cut (Cut; s) time, as well as self-reported muscle soreness (via visual analog scale (VAS)) and function (Disablement in the Physically-Active (DPA)) scale prior to the plyometric protocol (20 repetitions of 5 exercises x2 sets). Then, participants either received a 15-minute lower extremity compression or sham treatment (order was randomized). Identical assessments

were repeated for 3 consecutive days (±2 hrs.) to track recovery. Participants then completed the other condition 1-2 weeks later. 2(condition) x 3(time) repeated-measures ANOVA examined differences in performance outcomes between conditions and days. Non-parametric Wilcoxon signed-rank tests examined ordinal data from the VAS and DPA. Significance was set a priori at P<0.05 and P<0.013 (after Bonferroni correction) for the performance and self-reported data, respectively. **Results:** Descriptives are provided in Table 1. We observed significant main effects of Condition for SH (F1,24= 4.6; P=0.04; sham>compression) and Cut (F1,24= 6.6; P=0.02; compression>sham), but not VJ (F1,24= 0.49; P=0.49), TH (F1,24= 3.1; P=0.09), or Sp (F1,24= 1.8; P=0.13). There was a Condition x Day interaction for SH (F3,72= 3.00; P=0.04; sham>compression on Day 3) but not VJ (F3,72= 0.47; P=0.70), TH (F2.3,56.0= 0.61; P=0.57), Sp (F2.2,53= 1.6; P=0.21), or Cut (F3,72= 1.3; P=0.29). There was a significant effect of Day for all variables: VJ (F3,72= 0.47; P=0.03), SH (F3,72= 4.1; P=0.01), TH (F3,72= 7.7; P<0.01), and Cut (F3, 72= 7.6; P<0.01), except Sp (F3, 72= 1.8; P=0.19). Overall, post-hoc pairwise comparisons showed decrements in performance on the first and second days post-exercise, with recovery back to baseline by Day 3 (Table 1). For self-reported data, there were no differences between the dynamic compression and sham treatments on any day for soreness of the quadriceps (Z-range: -2.1- -0.80;

P-value range: 0.42-0.04), hamstrings (Z-range: -1.0- -0.14; P-value range: 0.89-0.30), or gluteal (Z-range: -1.6- -0.21; P-value range: 0.83-0.12) muscle groups or the DPA scale (Z-range -1.17- 0.47; P-value range: 0.24-0.64). **Conclusions:** Following a single bout of intense plyometric exercise, participants did not experience enhanced recovery of performance after DOMS nor did they perceive differences in pain or function after using dynamic compression. Future work should investigate the effects of dynamic compression after multiple bouts of exercise.

three recovery (D1-3) assessments.

	D0	D1	D2	D3	D0	D1	D2	D3
	Single Hop (m)				Triple Hop (m)			
Compression	2.04 (0.34)	2.01 (0.34)	2.04 (0.37)	2.05 ^c (0.36)	5.80 (1.07)	5.71 (1.07)	5.76 (1.13)	5.88 ^{bc} (1.11)
Sham ^e	2.05 (0.35)	2.07 (0.36)	2.08 (0.36)	2.12 ^c (0.38)	5.85 (1.05)	5.81 (1.04)	5.89 (1.07)	5.94 ^{bc} (1.04)
	Sprint time (s)				Cut time (m)			
Compression	2.03 (0.15)	2.04 (0.16)	2.06 (0.19)	2.02 (0.19)	2.55 (0.27)	2.57 (0.29)	2.56 (0.26)	2.52 ^{bc} (0.29)
Sham	2.03 (0.19)	2.04 (0.19)	2.03 (0.19)	2.01 (0.16)	2.54 (0.28)	2.51 (0.26)	2.50 (0.27)	2.46 ^{bc} (0.26)
	Vertical Jump (m)							
Compression	0.61 (0.13)	0.60 (0.12)	0.61 (0.13)	0.62 (0.14)				
Sham	0.61 (0.13)	0.61 (0.13)	0.61 (0.13)	0.61 (0.13)				

^a ≠Day 0; ^b ≠Day 1; ^c ≠Day 2; ^d ≠Day 3; ^e Sham> Compression

Upper Extremity Injury History Impacts Current Health-Related Quality of Life in Collegiate Baseball and Softball Athletes

Picha KJ, Valovich McLeod TC, Bay RC, Evans CM, Huxel Bliven KC: A.T. Still University, Mesa, AZ

Context: Upper extremity (UE) overuse injury is common in baseball and softball athletes. Prior injury affect one's injury risk, but little is known about its relationship to patient-reported outcomes, specifically health-related quality of life (HRQOL). The Disablement of the Physically Active (DPAS) and Functional Arm Scale for Throwers (FAST) are validated scales that assess function and HRQOL in athletic populations and may provide insight about the impact prior UE overuse injury has on one's perceptions. The purpose of this study was to explore whether prior UE overuse injury is related to function and HRQOL in collegiate baseball and softball athletes. **Methods:** This was a cross-sectional, online survey-based study. A convenience sample of baseball and softball athletes participating on a junior/community college or college/university team were recruited to participate by the institution's athletic trainer. This study was part of a larger project examining sport participation, prior UE overuse injury, HRQOL, and sport specialization. Data

analyzed for this study included UE overuse injury, defined as a prior injury (strain, sprain, tendinitis) to their shoulder, elbow, and/or wrist, and completed the DPAS and FAST scales. Total DPAS (0-64 points) and FAST Total, subscales (pain, throwing, ADLs, psychological, advancement), and Pitcher module (0-100 points) scores were calculated. Higher scores on both scales indicate more dysfunction and diminished HRQOL. Data were analyzed descriptively (percentages, frequencies) and with Spearman's correlations to estimate the association between UE overuse injury and HRQOL. An alpha level of .05 was used for analyses. **Results:** Of the 76% who accessed and completed the survey (n=94/123, 29 partial responses), 81% (n=100/123) endorsed at least one prior UE overuse injury as a baseball (55.3%, n=63/114) or softball (44.7%, n=51/114) athlete. Respondents were 19±1.0 years (male: 42.3%; female: 29.2%, undisclosed: 28.5%), and 42.1% (n=48/114) were pitchers. Most UE overuse injuries endorsed were to the shoulder (30.5%; n=40/131) with similarities between elbow (17.6%; n=23/131) and wrist (18%, n=23/131) injuries. Respondents reported low levels of dysfunction and good HRQOL, indicated by low DPAS (8.4±8.9) and FAST total (11.2±16.8) scores. Table 1 displays correlations between prior UE overuse injuries and HRQOL. Significant weak to moderate correlations were

found between position players and pitchers with prior shoulder and elbow overuse injuries and HRQOL, and accounted for ~20% of the variance in DPAS and FAST Total, subscales, and Pitcher module scores. **Conclusions:** Most baseball and softball players self-reported a prior UE overuse injury during their athletic career. The presence of shoulder and elbow overuse injury history explained a significant amount of variance in DPAS and FAST scale scores, emphasizing the impact of prior injury on current perceptions of function and HRQOL. Our results highlight the important role of injury history on a day-to-day functional basis in managing an athlete's healthcare needs.

Table 1. Spearman Rho Correlation Summaries for all Respondents

	DPAS Total	FAST Total	FAST Pain	FAST Throwing	FAST ADL	FAST Psychological	FAST Advancement	FAST Pitcher
Shoulder Injury (Yes/No)	.253*	.430*	.409*	.425*	.404*	.315*	.393*	.529*
Elbow Injury (Yes/No)	.344*	.446*	.472*	.462*	.401*	.278*	.393*	.540*
Wrist Injury (Yes/No)	.143	.011	.106	-.004	.068	-.007	.105	.007

DPAS- Disablement of the Physically Active patient reported outcome measure, FAST- Functional Arm Scale for Throwers patient reported outcome, ADL- Activities of Daily Living, *Significant at the .01 level (2-tailed)

Muscle Synergy Adaptations in Overhead Athletes

Wambold MR, Taylor C, Tucker C, Thomas SJ: Germantown Friends School, Philadelphia PA; Temple University, Philadelphia PA; Thomas Jefferson University, Philadelphia, PA

Context: Neuromuscular adaptations are common in overhead athletes and have been thought to contribute to upper extremity injuries. However, previous research relied on simple muscle ratios (interactions of only two muscles) and ignored the overall interactions between muscles. A more robust way to explore neuromuscular control is through muscle synergy analysis of a large group of muscles. Muscle synergies are defined as the central nervous systems organizational structure for movement. Previous research has demonstrated that synergy structure can adapt due to training and injury. Therefore, the purpose of this study was to identify bilateral adaptations to glenohumeral and scapular muscle synergies of experienced baseball players. **Methods:** A cross-sectional design with fourteen healthy competitive baseball players (age: 20 ± 1.1 yrs, height: 70.5 ± 1.5 inches, weight: 175 ± 27.5 lbs). Participants were tested bilaterally during a center-out planar reaching task using the KINARM robot (BKIN Technologies, Ontario,

Canada), where kinematic data and surface electromyography data from 14 glenohumeral and scapular muscles were synchronized together. Participants moved the KINARM handle to 4 different targets that were projected in the 2-D workspace of the KINARM, and 10 trials were recorded. Principal Component Analysis (PCA) was used to extract muscle synergies, the Variance Accounted For (VAF) of each synergy, and muscle coefficients. The dominant arm was compared to the non-dominant arm using paired t-tests for all dependent variables.

Results: The same number of muscle synergies were extracted on the dominant (DOM) and non-dominant (NDOM) arms, along with no differences in VAF. In the 1st synergy, the infraspinatus (DOM: 0.798, NDOM: 0.587, $p = .038$) and lower trapezius (DOM: 0.872, NDOM: 0.480, $p = .005$) muscle coefficients significantly increased on the DOM arm (Table 1). The 2nd synergy had a significantly increased anterior deltoid (DOM: 0.764, NDOM: 0.374, $p = .003$) and a significantly decreased posterior deltoid (DOM: -0.069, NDOM: 0.197, $p = .041$) muscle coefficient on the DOM arm. The 3rd synergy had a significantly decreased serratus anterior (DOM: -0.013, NDOM: 0.379, $p = .033$) and pectoralis major (PM) (DOM: -0.271, NDOM: 0.335, $p = .003$) muscle coefficient on the DOM arm. The 4th synergy had a significantly increased PM (DOM: 0.420, NDOM: 0.085, $p = .047$) muscle coefficient on the DOM

arm. **Conclusions:** While we observed a similar number of muscle synergies between tasks, the components of these synergies varied between handedness in both glenohumeral and scapular muscles. These muscles have previously been shown to be important in acceleration and stabilizing the shoulder in overhead athletes, and due to the increased reliance may put them at risk for fatigue or overuse. By further exploring these neuromuscular adaptations, the improved understanding of muscle synergy adaptations in baseball players will help to optimize injury prevention and rehabilitation techniques.

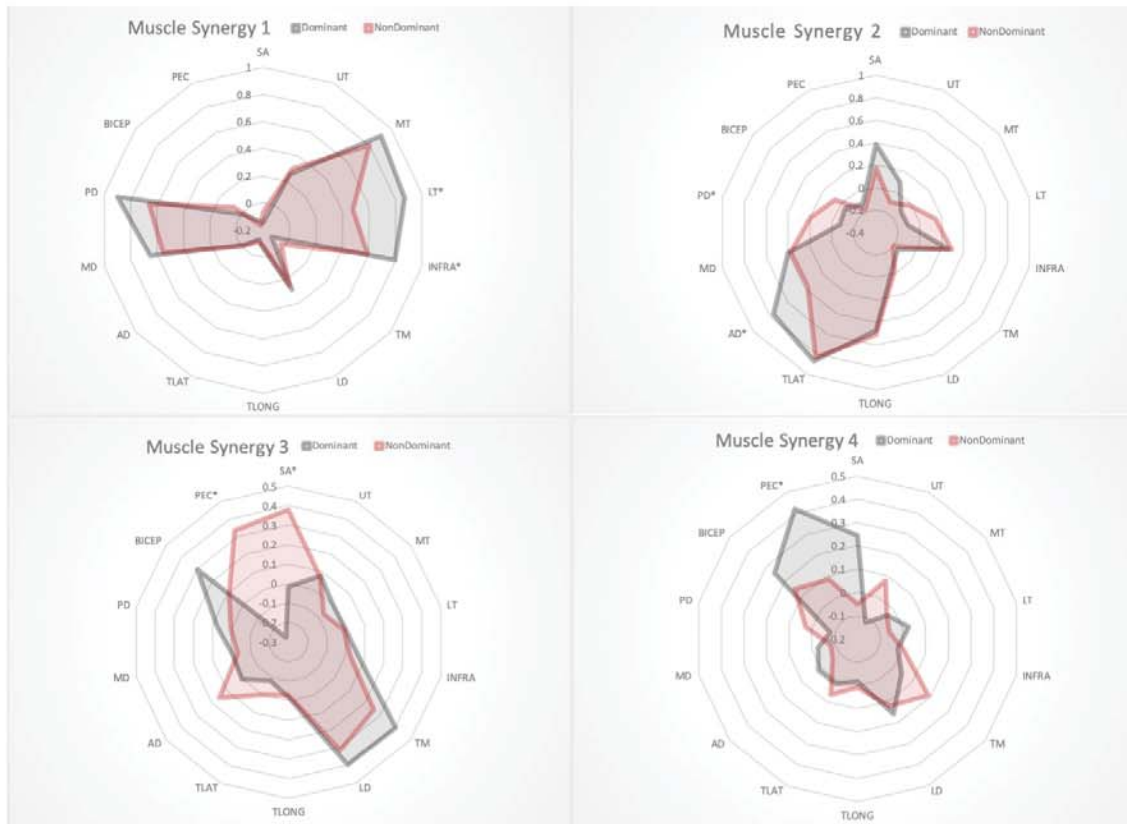


Figure 1. Differences in muscular coefficients between dominant and non-dominant arms within each muscle synergy. Closest to 1 = primary movers, closest to 0 = stabilizers, closest to -1 = antagonists.

SA = Serratus Anterior; **MT** = Middle Trapezius; **LT** = Lower Trapezius; **IN** = Infraspinatus; **TM** = Teres Major; **LD** = Latissimus Dorsi; **TLong** = Triceps Brachii Long Head; **TLat** = Triceps Brachii Lateral Head; **BI** = Biceps Brachii; **AD** = Anterior Deltoid; **MD** = Middle Deltoid; **PD** = Posterior Deltoid; **UT** = Upper Trapezius; **PEC** = Pectoralis Major Clavicular Fibers

The Effects of Fatigue on Muscle Synergies in the Shoulders of Baseball Players

Paul RW, Castillo GC, Topley M, Thomas SJ: Temple University Department of Kinesiology, Philadelphia, PA; Rothman Orthopaedic Institute, Bryn Mawr, PA; Thomas Jefferson University, Philadelphia, PA

Context: The external rotation (ER) muscles of baseball players often become fatigued following acute throwing. When these muscles become fatigued, the body must compensate by using other muscles to maintain the throwing motion. Muscle synergies are defined as the central nervous systems organizational structure for movement. A muscle's role within a synergy may be either eliminated or reduced due to fatigue, which forces the remaining muscles to become more involved. However, the neuromuscular compensation strategies of baseball players in response to fatigue are currently unknown. Therefore, the purpose of this study is to determine the effects of isolated ER fatigue on the adaptation of muscle synergies in the shoulders of college-aged baseball players. **Methods:** Nine players from a university club baseball team (height: 70.1 ± 1.6 inches, weight: 162.2 ± 10.6 lbs, age: 20.1 ± 1.1 years, playing experience: 14.3 ± 2.5 years) voluntarily participated in this cross-sectional controlled laboratory

study. Surface electromyography (EMG) was used on 14 muscles of the glenohumeral and scapulothoracic joints during a reaching protocol. Players completed a baseline reaching protocol (pre-fatigue), then an ER fatigue protocol, and then repeated the same reaching protocol (post-fatigue). Participants moved the KINARM handle to 4 different targets that were projected in the 2-D workspace of the KINARM, and 10 trials were recorded. ER fatigue was induced using a Biodex dynamometer, and a player was considered fatigued once maximum concentric ER force reduced by 40%. Principal Component Analysis (PCA) was used to extract muscle synergies, the Variance Accounted For (VAF) of each synergy, and muscle coefficients. Pre-fatigue was compared to post-fatigue using paired t-tests for all dependent variables. **Results:** Four muscle synergies were extracted for both pre- and post-fatigue. The VAF for the ER/abduction synergy decreased significantly (PRE: 34.6%, POST: 32.4%, $p=0.032$). Furthermore, muscle coefficients decreased for the pectoralis major in the ER/abduction synergy (PRE: -0.49, POST: -0.55, $p=0.014$). For the internal rotation (IR) synergy muscle coefficients increased for the serratus anterior (PRE: 0.15, POST: 0.43, $p=0.022$) and middle deltoid (PRE: -0.06, POST: 0.10, $p=0.011$), while additional differences in the pectoralis major (PRE: 0.50, POST: -0.20, $p=0.014$), teres major (PRE: -0.04, POST: 0.40, $p=0.011$), and biceps brachii (PRE: 0.20, POST: 0.40, $p=0.046$) muscle

coefficients were observed in the cross-body synergy (fig. 1). **Conclusions:** The decreased VAF of the ER/abduction synergy after fatigue, indicated that other muscles within that synergy cannot fully compensate to maintain function. Interestingly, the changes in muscle coefficients suggest the switching of the IR and cross-body synergy following fatigue. This may be due to imbalances between ER and IR while maintaining balance between cross abduction and adduction. Clinicians may consider rehabilitative methods that involve intentional fatigue of the posterior cuff to focus on compensatory muscle strategies.

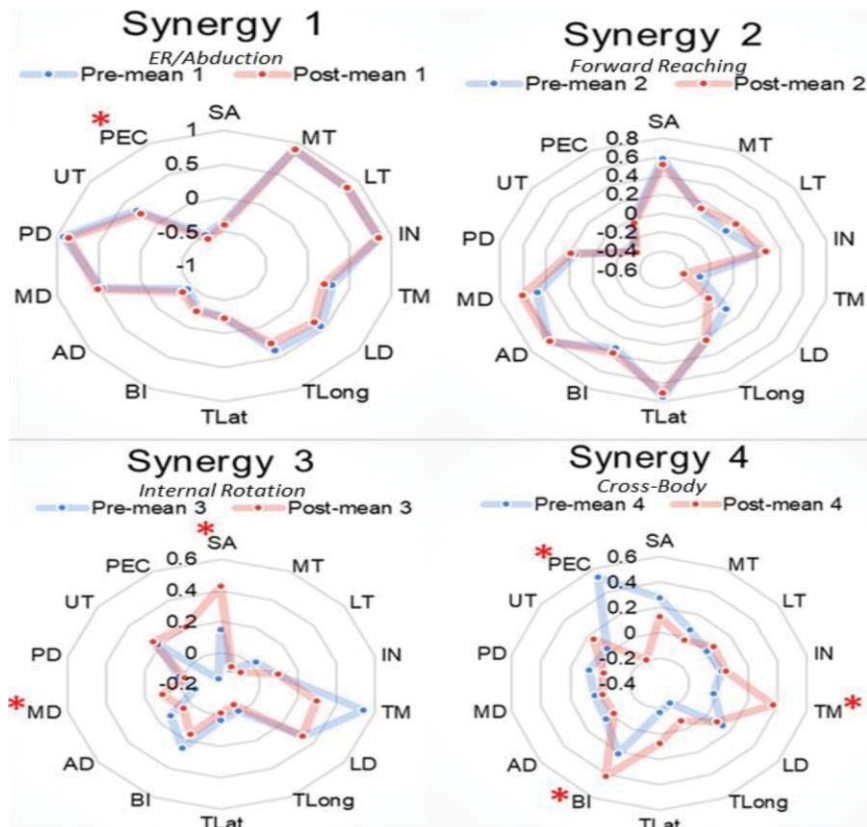


Figure 1. Differences in muscular coefficients between pre- and post-fatigue within each muscle synergy. Closest to 1 = primary movers, closest to 0 = stabilizers, and closest to -1 = antagonists.

SA = serratus anterior; MT = middle trapezius; LT = lower trapezius; IN = infraspinatus; TM = teres major; LD = latissimus dorsi; TLong = triceps brachii long head; TLat = triceps brachii lateral head; BI = biceps brachii; AD = anterior deltoid; MD = middle deltoid; PD = posterior deltoid; UT = upper trapezius; PEC = pectoralis major clavicula fibers.

* $p < 0.05$

Demographics and Associated Comorbidities of Patients Presenting to an Outpatient Sports Medicine Clinic With Calcific Tendinitis of the Shoulder
Mateer JM, Cade WH, Greif DN, Best TM: University of Miami Sports Medicine Institute, Coral Gables, FL

Context: Calcific tendinitis (CT) of the shoulder is a common condition caused by the presence of calcific deposits in the rotator cuff or in the subacromial-subdeltoid bursa [1]. Treatment typically consists of NSAIDs, physical therapy, and ultrasound-guided corticosteroid injections/irrigation. Surgical management is an option when conservative measures fail. Athletic trainers (ATs) are educated in comprehensive health care services. They specialize in 6 domains of clinical practice including clinical evaluation and diagnosis and treatment, rehabilitation and reconditioning [2]. Their value in the outpatient clinic setting continues to grow. Thus, it is important for ATs to have an understanding of demographics and pre-existing health conditions that can predispose patients to conditions such as CT. Therefore, the purpose of this study is to provide a profile of demographic variables and associated comorbidities in patients diagnosed with CT of the shoulder thereby providing ATs with a detailed knowledge base for CT and potential opportunities management. **Methods:** A retrospective chart review was performed on

subjects identified by ICD-10 codes M65.20, M75.30, M75.31, and M75.32 from Dec 1, 2018 to March 25, 2020. Each chart was reviewed by the AT (JM) for age, gender, ethnicity, location of pathology, treatment and specific comorbidities at the time of diagnosis. Descriptive statistical methods were applied to the data set. **Results:** Seventy-six patients were identified; 39 male; 37 female. Participant ages ranged from 28 to 77 with a mean of 54.8 +/- 10.4 years. Of the participants 71% were Hispanic. The remainder were non-Hispanic (Caucasian and African American). Sixty-six reported no known mechanism of injury, while 10 reported an injury. Seventeen participants had a BMI between 18.5-24.9, 27 had a BMI between 25.0-29.9, and 31 had a BMI of 30 and above. One participant did not have a height and weight listed. Three patients reported they were smokers, 10 were diabetic, and 4 self-reported a thyroid disorder. The CT presented in the dominant shoulder of 45 participants and in the non-dominant shoulder of 28 participants. Three did not list extremity dominance. Location of the pathology was identified for all subjects by review of x-ray images. The condition was isolated to the supraspinatus tendon for 71% of participants with the remainder distributed between the infraspinatus, subscapularis, and deltoid tendons. All participants were prescribed treatment consisting of physical therapy, injection/irrigation, NSAIDs, or other medications. **Conclusions:** In conclusion, as ATs increase their presence in

the orthopedic and sports medicine outpatient settings, it is important to have a thorough understanding of the injuries they will encounter. In addition, understanding clinical presentation and response to treatment provides important clues for both diagnosis and management. Follow up studies will aim to determine variables predicting response to treatment that can better guide ATs and physicians in cost effective management of CT.

A Case of a Galeazzi Fracture in a High School Soccer Athlete: A Level 4 Rare Events Case Study

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Background: The patient was a 16-year-old male high school soccer player. He was kicking around a soccer ball with a friend while the football team was practicing on the same field. The patient was standing still when he was knocked to the ground by a football player running to make a catch; he fell on his left outstretched hand. The athletic trainer was immediately called over to evaluate the patient's injury. There was a gross deformity of the distal 1/3 of the left radial shaft a small contusion on his head, but no open wounds. The patient complained of sharp pain on the left forearm (10/10), but denied shoulder and elbow pain. Additionally, his head hurt (3/10) and he felt dizzy and light-headed. The athletic trainer noted that the patient had a strong distal pulse, normal skin turgor, and skin that was warm and moist. To assess the potential head injury, the athletic trainer assessed cervical spine palpation, cranial nerves, and balance; there was no evidence of a brain injury or concussion. The patient's forearm was splinted and referred to his preferred clinic. **Differential Diagnosis:** Radial fracture, ulnar fracture,

interosseous membrane injury, contusion, Colles fracture, Reverse Colles fracture (Smith's fracture), dislocation. **Intervention & Treatment:** Patient was diagnosed with a Galeazzi fracture, which is a fracture of the distal radius with a distal radioulnar joint dislocation. The patient had the same fracture on the same forearm one year earlier. The patient underwent open reduction surgery with plate fixation of the fracture. Adolescent patients are typically treated conservatively, but this patient had surgical intervention because of his past medical history. Patient was immobilized for 6 weeks in a hard cast that went above the elbow and removed from activity. Radiographs were taken at six weeks that showed healing with the presence of a plate and he returned to play. **Uniqueness:** The incidence rate of a Galeazzi fracture in children is less than 3% which is a rare occurrence. The patient had previously been diagnosed with a Galeazzi fracture in the same radius. The occurrence of two Galeazzi fractures in the same person is so low that there is not a recorded incidence rate. Additionally, adolescent patients that suffer from a Galeazzi fracture are usually treated conservatively with a closed reduction and immobilization in supinated with a cast that goes above the elbow. Research on Galeazzi fractures found that conservative treatment has been successful because of the remodeling capacity of the joint. This patient was treated conservatively with the previous Galeazzi fracture, and was treated surgically, which is the common treatment for

adults. **Conclusions:** Athletic trainers should be aware of the chance of a refracture in the youth population. There is a 4.9% chance of a refracture with any displaced forearm fracture. There are also various treatment options and factors that influence the fracture healing process. Athletic trainers should be mindful of how this can affect patients and their return to play/activity after a fracture.

Parsonage-Turner Syndrome in a Female Middle/High School Cheerleader

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Background: Our subject is a 13 year-old female cheerleader with no previous history of health issues. Shortly after our subject's exposure to an influenza virus that resulted in bilateral ear infections, she began experiencing moderate tenderness and pain in her right shoulder extending distally to her wrist. These symptoms were initially diagnosed as tendinitis. The pain progressively increased, prompting the patient to seek further medical evaluation. Her practitioners ruled out tumors and disk pathology through a negative CT scan. An electromyographic evaluation and nerve conduction test revealed widespread denervation of her shoulder. After these tests, a diagnosis of Parsonage-Turner Syndrome (PTS), also referred to as idiopathic brachial plexopathy or neuralgic amyotrophy, was made. PTS is a rare disorder consisting of a complex network of symptoms with an acute onset of shoulder pain, usually unilaterally, often followed by progressive neurologic deficits of motor weakness and dysesthesias. Since PTS is axonal, the nerve conduction study did not reveal any abnormalities. Only the EMG (needle) portion of the exam confirmed her denervation. **Differential Diagnosis:** rotator cuff tear, adhesive capsulitis, Parsonage-Turner syndrome, discogenic nerve root compression, amyotrophic lateral sclerosis, tumor of nerve root, infection. **Intervention & Treatment:** The patient was prescribed corticosteroids, analgesics, muscle relaxers in an

attempt to manage pain. Regular rehabilitation visits were utilized to regain strength and nerve function the shoulder girdle. Despite treatments, moderate to severe shoulder pain continued long-term following her diagnosis, resulting in continued loss of function and muscle atrophy of the area. She had to use her uninvolved left arm at times to assist the involved right side. Her physician prescribed rehabilitative exercises to restore range of motion and function for the right upper extremity. Transcutaneous Electrical Nerve Stimulation (TENS) was also utilized in the treatment. She has had constant pain and dysfunction for several years that limited her activity level to the point she was unable to participate as a cheerleader. Finally, five years later as an 18 year old, her symptoms had improved to the point that she could return to cheerleading. However, our subject did need to occasionally suspend her activities after a flare up of her symptoms. She continues to cheer but does require interferential stimulation and massage from her high school athletic trainer for pain relief. She also continues to have occasional electrodiagnostic evaluations and continues her rehabilitative exercise regime. **Uniqueness:** The exact cause of PTS is idiopathic. Researchers suspect that most cases are due to an autoimmune response following exposure to an illness or environmental factor. The onset of PTS has also been linked to various possible triggers, such as infections, surgery/medical procedures, vaccinations, childbirth or strenuous exercise. One study shows 25% of PTS patients had a viral illness before PTS symptoms occurred, and 15% of PTS patients had recently received an immunization. PTS seems to affect men at a slightly higher rate than women. One study indicates a ratio of 11:9, while another concludes that the ratio may be as high as 11:5. One unique

feature of this case is the reinnervation typically occurs 6-12 months following onset. However, in our subject's case, her symptoms have lasted for over five years. **Conclusions:** Parsonage-Turner syndrome's rare nature and lack of research and clinical studies has revealed many unknowns and unanswered questions about the disease. The prognosis for PTS varies greatly. Our subject's residual complications have lasted longer than the norm. However, newer literature suggests that these complications are more common than previously believed. PTS is a rare and often disabling problem that athletic trainers need to consider when evaluating unique upper extremity conditions.

Possible Prediction of Throwing Arm Injuries With the Scapular Dyskinesis Test During the Course of Collegiate Baseball Seasons

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Context: A unilateral scapular dyskinesis pattern on the dominant side has been demonstrated to decrease throwing arm conditions measured with the Kerlan-Jobe Orthopaedic Clinic (KJOC) score in collegiate baseball pitchers during the course of a single season while no difference in the KJOC score for position players was found regardless of scapular dyskinesis. The purpose of this study was to investigate collegiate baseball pitchers with and without the presence of scapular dyskinesis on both the throwing and non-throwing arm sides in relation to throwing-related injuries during each respective course of 4 subsequent seasons. **Methods:** Design: Cohort prospective. Setting: University field. Participants: A total of 59 collegiate baseball pitchers (height: 184.9 ± 5.8 cm, weight: 88.4 ± 7.9 kg, age: 20.0 ± 1.5 years) from a

NCAA Division I conference team participated in this study over a 4 year-period. This study included 19 pitchers who remained with the team for more than 1 year and those who were subsequently tested each year as they were active on the roster. The scapular dyskinesis test was conducted in the 2nd week of January each year. The subjects were asked to simultaneously lower both arms from full flexion with a 3.2 kg wrist cuff worn on both extremities for 5 seconds constantly following a metronome set at 60 beats per minute in the standing position. **Results:** This study found 6 throwing-related shoulder injuries diagnosed by an official team physician, including 3 subacromial impingement syndromes, 1 superior labrum lesion, 1 thoracic outlet syndrome, and 1 general shoulder pain. The incidence rate of throwing-related shoulder injury for the pitchers was 1.25 per 1,000 athlete-exposures during the course of the season including both practices and games for an average of 81 active days from February to May each season. Twenty-eight out of the 59 pitchers (47.5%) were classified as having scapular dyskinesis most evident around 90° of shoulder flexion on the throwing side. Five out of the 6 pitchers with throwing-related shoulder injuries were classified with the presence of scapular dyskinesis on the throwing side. Subsequently, the odds ratio was 6.52 [95% confidence interval: 4.31-8.74].

Furthermore, for those 19 pitchers who remained with the team for more than 1 year, the percentage of the same results in the scapular dyskinesis test was 89.5% (17 of the 19 scapular dyskinesis) between the previous and following year for the throwing side regardless of whether or not the subjects showed the presence of scapular dyskinesis. **Conclusions:** Collegiate pitchers with the presence of scapular dyskinesis on their throwing side were 6.5 times more likely to suffer throwing-related shoulder injuries than those without scapular dyskinesis. The presence of scapular dyskinesis was nearly consistent on the throwing side between the previous and following year.

**Posterior Shoulder and Upper Back
Pain in a Competitive Tennis Player**
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Background: This level 4 clinical case study examines a patient seen in our sports medicine center. This case involves a 15-year-old, right hand dominant, competitive male tennis player with a two-month history of right posterior shoulder and upper back pain. He reports that this pain was acute in nature after he attempted to perform a hard serve during a tennis match earlier that year. During this serve, he reported feeling a sharp pain and pop in the posterior portion of his shoulder. He was able to finish that match and competed the remainder of the year. Following his season, he continued competing in a club tennis. Prior to presenting in clinic, he performed four sessions of physical therapy (PT) that included strengthening exercises, stretching, and dry needling of the shoulder, with no decreases in pain. He reported to the sports medicine center due to continued pain in his shoulder. He is otherwise a healthy teenager with no significant past medical or surgical history. Upon initial examination, he had no deformity to his scapula or back musculature. No redness, warmth, or swelling was noted. He was tender to palpation over the medial and inferior borders of his scapula, along with minor tenderness to the T6-T7 paraspinal musculature. No tenderness noted over the thoracic/cervical spine, anterior shoulder, or upper arm. He had 5/5 strength in all shoulder planes of motion but had weakness and pain noted

with lift-off testing. All other special testing of the shoulder was normal. He had a normal neurological and neurovascular examination. **Differential Diagnosis:** Based on his presentation, differential diagnoses of muscular strain, scapular dyskinesis, scapular fracture, cervical radiculopathy or oncologic process were all initially considered. **Intervention & Treatment:** The physician's examination agreed with AT's examination. Standard shoulder/thoracic spine x-rays were performed and demonstrated no obvious bony deformities. He was advised to continue with his PT and tennis as tolerated under PT guidance. Due to lack of improvement from PT, a non-contrast MRI was ordered of the shoulder which demonstrated a right sided T7 transverse process fracture. At this visit, he was asked to completely rest from all activities for six weeks. Upon follow up examination, he was pain free. Follow up CT scan demonstrated persistent fracture without evidence of bony bridging. He restarted PT at that time for six weeks. At 12 weeks from diagnosis, he was progressing well in PT and had returned to tennis fully. **Uniqueness:** Sports related thoracic spine process fractures are uncommon. Most cases within the literature are related to significant traumas and MVAs, with few studies describing lumbar transverse process fractures in football. To our knowledge, there are no other case reports of thoracic spine transverse process fractures in tennis or any other sports. The tennis serve is a ballistic movement, and creates significant forces throughout the shoulder, which likely caused this unique injury. **Conclusions:** This study examined a 15-year-old, highly competitive tennis

player who had immediate posterior shoulder and upper back pain following a tennis serve. This pain did not diminish with PT and needed advanced imaging to determine final diagnosis. We are unaware of any other cases of thoracic transverse process fractures in tennis players. This case should be used as a teaching tool for sports medicine providers who have patients with posterior shoulder and upper back pain, that are not improving with conservative treatment. In conclusion, this injury is uncommon, but needs to be ruled out when physical examination and early imaging do not yield any positive results.

Relationships Between Hip, Thoracolumbar and Glenohumeral Ranges of Motion in Division I Collegiate Baseball Players

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Context: Baseball players generate forces in the legs that are transferred through the kinetic chain to the hips, trunk, and eventually the upper extremity. Baseball players may develop compensatory joint hypermobility and hypomobility anywhere along the kinetic chain. Compensations can affect performance and increase risk of injury. Limited research describes how hip range of motion (ROM) relates to thoracolumbar and glenohumeral ROM in collegiate baseball players despite the significant force production role of the hip and thoracolumbar joints necessary for throwing motions. The

purpose of this study was to examine the hip's relationships with thoracolumbar ROM and throwing side glenohumeral ROM in Division I collegiate baseball players. **Methods:** This prospective study included a convenience sampling of 101 NCAA Division I baseball players (47 pitchers, 54 position players, age: 20.0±1.4years, height: 183.8±6.1cm, mass: 89.1±10.2kgs, years of play: 13.2±3.0) from three universities who were measured during the preseason. Measurements consisted of prone passive stance hip (SH) and lead hip (LH) internal rotation (IR), external rotation (ER), and total ROM (IR+ER); standing active-assisted thoracolumbar rotation to the throwing and non-throwing sides; and supine passive throwing and non-throwing side glenohumeral IR, ER, total rotation ROM and horizontal adduction (HAdd) ROM. Hip and glenohumeral ROM were measured using a digital inclinometer and thoracolumbar rotation ROM was measured using two bubble inclinometers positioned at the C7 and S2 vertebrae, with all measurements reported in degrees. The same investigators took all measurements and a-priori testing showed strong intra-rater reliability (ICC>0.75). Pearson Product Moment Correlations (r) were used to identify relationships between hip, thoracolumbar, and glenohumeral ROM (p<0.05). **Results:** Descriptive

results of measurements are presented in Table 1. Thoracolumbar rotation to the throwing (r=0.21, p=0.04) and non-throwing (r=0.25, p=0.01) sides were weakly correlated to LH total ROM. Hip ROM was weakly correlated with glenohumeral ER according to SH IR ROM (r=0.35, p=0.001), SH ER ROM (r=0.20, p=0.04), SH total ROM (r=0.38, p=0.001), LH IR ROM (r=0.38, p=0.001), LH ER ROM (r=0.22, p=0.02), and LH total ROM (r=0.36, p=0.001). Glenohumeral total ROM was weakly correlated to SH IR ROM (r=0.31, p=0.001), SH total ROM (r=0.21, p=0.001), LH IR ROM (r=0.25, p=0.01), and LH total ROM (r=0.26, p=0.01). SH total ROM (r=-0.21, p=0.04), LH IR ROM (r=-0.28, p=0.01), and LH total ROM (r=-0.27, p=0.01) were weakly correlated with glenohumeral HAdd ROM. There were no other significant correlations (r<0.20, p>0.05). **Conclusions:** Our results demonstrate that several significant relationships exist between hip ROM, and ROM of the thoracolumbar and glenohumeral joints among Division I collegiate baseball players. While these correlations are weak, they should be studied further given the high force translation through the kinetic chain. Future research is warranted to determine if these relationships are linked to baseball-related injuries.

Table 1. Hip, Thoracolumbar, and Glenohumeral Ranges of Motion (Degrees) in Division I Collegiate Baseball Players.

Measurement		Mean ±SD	95% Confidence Interval	
Range of Motion (degrees)			Lower	Upper
Hip				
	Stance leg IR	26.5±7.6	25.0	28.0
	Stance leg ER	34.7±6.6	33.4	36.1
	Stance leg total ROM	61.2±10.7	59.0	63.4
	Lead leg IR	26.2±7.1	24.7	27.6
	Lead leg ER	34.1±6.7	32.8	35.5
	Lead leg total ROM	60.3±10.5	58.2	62.4
Thoracolumbar				
	Rotation to throwing side	41.1±9.7	39.1	43.1
	Rotation to non-throwing side	43.0±10.0	41.0	45.0
Glenohumeral Joint				
	Throwing IR	36.4±11.2	34.1	38.7
	Throwing ER	107.7±10.3	105.6	109.8
	Throwing total ROM	144.1±12.8	141.5	146.7
	Throwing HAdd	12.4±9.9	10.4	14.4
	Non-throwing IR	50.2±10.2	48.2	52.3
	Non-throwing ER	101.8±12.1	99.4	104.3
	Non-throwing total ROM	152.1±16.0	148.8	155.3

Footnotes: Internal Rotation, IR, External rotation, ER, Range of motion, ROM, HAdd, Horizontal adduction, SD, standard deviation.

Shoulder Muscle Activation Before and After a Lumbopelvic-Hip Complex Fatigue Protocol

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Context: The lumbopelvic hip complex (LPHC) is essential to transfer energy from the lower body to the upper extremities during functional tasks, and fatigue to the LPHC may increase the risk for musculoskeletal injuries. Isometric shoulder strength is reduced following LPHC fatigue, however there is little research examining LPHC fatigue on muscle activity or isokinetic shoulder torque. Our objective was to compare shoulder muscle activation and peak isokinetic torque before and after a LPHC fatigue protocol. We hypothesized decreased shoulder abduction torque, decreased lower trapezius activity and increased upper trapezius activity would occur following fatigue. **Methods:** Eight physically active, healthy participants (5 females; age: 20.4 ± 1.9 years; mass: 72.0 ± 8.2 kg; height: 169.9 ± 8.2 cm) participated in this descriptive laboratory study. Peak isokinetic torque, normalized to mass, of the dominant shoulder was assessed in sagittal (flexion, extension) and frontal (abduction, adduction) planes during five concentric-concentric contractions at $60^\circ/\text{sec}$. Mean surface electromyography of the anterior deltoid, middle deltoid, upper trapezius,

lower trapezius, pectoralis major, latissimus dorsi, rectus abdominus, external oblique, and erector spinae were recorded during strength assessment and normalized to the maximal voluntary isometric contractions of each muscle (%MVIC). LPHC fatigue was induced through the McGill Core Fatigue protocol and subjectively assessed using the rating of perceived exertion (RPE) scale. Wilcoxon Signed Rank tests were conducted to determine differences in muscle activity, torque, and self-reported RPE from pre- to post-fatigue. The alpha level was set a priori at $p \leq 0.05$. Effect sizes (ES) were calculated with the Z-score divided by the square root of the sample size. **Results:** Participants reported an increase in RPE following the fatigue protocol (Pre: 8.0 [IQR: 6.25, 10.0], Post: 14.0 [IQR: 13.0, 16.75], $p = .017$). The fatigue protocol decreased the anterior deltoid (Pre: 0.59 %MVIC [IQR: 0.45, 0.68], Post: 0.46 %MVIC [IQR: 0.38, 0.61], $p = .012$, ES = -0.89), middle deltoid (Pre: 0.53 %MVIC [IQR: 0.37, 0.76], Post: 0.49 %MVIC [IQR: 0.33, 0.65], $p = .025$, ES = -0.79), and rectus abdominus (Pre: 0.35 %MVIC [IQR: 0.25, 0.84], Post: 0.28 %MVIC [IQR: 0.23, 0.63], $p = .05$, ES = -0.69) muscle activity during strength assessment in the sagittal plane. Pectoralis major muscle activation decreased following fatigue during strength assessment in the frontal plane (Pre: 0.59 %MVIC [IQR: 0.45, 0.68], Post: 0.46 %MVIC [IQR: 0.38, 0.61], $p = .05$, ES = -0.69). Shoulder extension torque decreased following fatigue (Pre: 0.85 Nm/kg [IQR: 0.82, 0.93], Post: 0.78

Nm/kg [IQR: 0.75, 0.82], $p = .02$, ES = -0.84). There were no differences in shoulder flexion, adduction, or abduction torque (all $p > .05$). **Conclusions:** LPHC fatigue reduced shoulder muscle activity and extension torque production during sagittal plane assessment. LPHC fatigue resulted in minimal changes in shoulder muscle activity during frontal plane assessment. Clinicians should be aware that LPHC fatigue affects upper extremity muscle function, which may suggest integrating therapeutic exercises to the shoulder in a LPHC fatigued state.

Strength and Range of Motion Differences at the Hip, Thoracolumbar, and Glenohumeral Joints Between Division I and Division III Baseball Players

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Context: Range of motion (ROM) and strength of the hip, spine and glenohumeral joints are measurable variables that have been linked to risk of injury. Level of play may result in increases in training intensity that cause players in some divisions to incur more risk of injury than others. These variables have not been examined between the different NCAA divisions in collegiate baseball players and may reveal risk factors for injuries specific to these similar yet unique populations. The purpose of this study was to explore hip, thoracolumbar, and glenohumeral (GH) ROM, and hip and GH strength between NCAA Division I (DI) and Division III (DIII) collegiate baseball players. **Methods:** This prospective study included 169 collegiate baseball players from four universities. Division

I (n=101, age: 20 ± 1.4 , height: 183.8 ± 6.1 cm, weight: 89.1 ± 10.2 kg, years played: 13.2 ± 3.0) and Division III (n=68, age: 20 ± 1.6 , height: 182.3 ± 6.5 , weight: 85.3 ± 11.2 kg, years played: 13.8 ± 2.8) players from a sample of convenience were tested during the preseason. Throwing (dominant) and non-throwing ROM were obtained using digital and bubble inclinometers (± 1 degree) for the following measurements: passive prone hip internal rotation (IR), external rotation (ER), and total (IR+ER) ROM; thoracolumbar rotation using two bubble inclinometers placed at C7 and S2; and passive GH IR, ER, total ROM, and horizontal adduction (HAdd) on throwing side only. Bilateral strength using a hand-held dynamometer was measured for resisted side-lying hip abduction (Abd) strength and resisted supine GH IR and prone ER strength. Strength measures were normalized to bodyweight (%BW). Four investigators performed the same measurements on all participants (ICC>.75). One-way ANOVAs were used to analyze differences in ROM and strength between groups ($p < 0.05$). **Results:** Means (\pm standard deviation) of measurements are presented in Table 1. Division III players displayed greater ROM than Division I players for stance hip ER ($p < 0.001$) and total ROM ($p < 0.001$), lead hip ER ($p < 0.001$) and total ROM ($p < 0.001$), throwing GH ER ($p = 0.001$) and total ROM ($p = 0.001$). Division I players displayed greater thoracolumbar rotation ROM

toward the dominant side ($p = 0.016$) and greater GH strength than Division III players for throwing GH IR ($p < 0.001$) and ER ($p < 0.001$), and non-throwing GH IR ($p < 0.001$) and ER ($p < 0.001$). **Conclusions:** Differences exist in thoracolumbar rotation, and hip and GH ROM and strength between collegiate DI and DIII baseball players. These results provide insight into the different physical characteristics between collegiate players, which should be considered in the prevention, diagnosis and rehabilitation of baseball related injuries. Further research should explore whether these ROM and strength differences impact the risk of injury of athletes playing in different divisions.

Table 1. Range of motion and strength at the hip, glenohumeral joint, and thoracolumbar region between NCAA Division I and Division III baseball players (mean \pm standard deviation)

Measurement		NCAA Collegiate Level	
Range of Motion (degrees)		Division I	Division III
Hip			
	Stance leg IR	26.5 \pm 7.6	28.2 \pm 8.4
	Stance leg ER	34.8 \pm 6.9	42.0 \pm 10.6**
	Stance leg total ROM	61.3 \pm 10.5	70.2 \pm 11.7**
	Lead leg IR	26.2 \pm 7.0	27.5 \pm 7.3
	Lead leg ER	34.1 \pm 6.6	40.8 \pm 9.0**
	Lead leg total ROM	59.6 \pm 11.9	68.3 \pm 10.4**
Glenohumeral Joint			
	Throwing IR	36.3 \pm 11.0	38.9 \pm 11.8
	Throwing ER	107.3 \pm 10.3	112.6 \pm 9.7**
	Throwing total ROM	142.1 \pm 19.1	151.4 \pm 14.3**
	Throwing HAdd	12.8 \pm 9.8	10.9 \pm 10.7
		50.1 \pm 10.1	51.9 \pm 10.2
	Non-throwing IR	101.8 \pm 11.9	104.1 \pm 13.0
	Non-throwing ER	150.4 \pm 21.8	156.0 \pm 12.8
	Non-throwing total ROM		
Thoracolumbar			
	Rotation to throwing side	36.4 \pm 9.8*	33.0 \pm 6.8
	Rotation to non-throwing side	37.6 \pm 9.2	37.4 \pm 7.6
Strength (%BW)			
Hip			
	Stance leg ABD	0.35 \pm 0.12	0.43 \pm 0.06**
	Lead leg ABD	0.36 \pm 0.12	0.45 \pm 0.06**
Glenohumeral Joint			
	Throwing IR	0.25 \pm 0.04**	0.21 \pm 0.05
	Throwing ER	0.23 \pm 0.05**	0.19 \pm 0.04
	Non-throwing IR	0.23 \pm 0.05**	0.18 \pm 0.04
	Non-throwing ER	0.21 \pm 0.05**	0.16 \pm 0.03

Footnotes: Internal Rotation, IR, External rotation, ER, Range of motion, ROM, HAdd, Horizontal adduction, Abduction, Abd.

* indicates $p \leq 0.05$, ** indicates $p \leq 0.001$.

Coracoid Stress Fracture Secondary to Biceps Tenodesis: A Level 4 CASE Study

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Background: This case involves a 48-year-old female who presented with right anterior shoulder pain after bathing her dog. The patient described feeling a pop accompanied by extreme pain while she quickly adjusted her grip on her 100lb dog. Examination by an orthopedic physician 1 day post-injury revealed no deformity of the shoulder and ROM that was greatly limited by pain. The patient was tender over the anterior shoulder and refused to perform shoulder flexion. Due to the level of pain, no special tests were performed. No neurological symptoms were reported, and the use of ice did not help to reduce pain. The patient was placed in a sling and sent for x-ray and MRI imaging. **Differential Diagnosis:** Biceps Tendon Tear, Rotator Cuff Tear, Labral Tear. **Intervention & Treatment:** X-ray showed no fracture however MRI imaging revealed a medially dislocated and partially torn biceps long head tendon and a partially torn subscapularis. The decision was made to proceed with surgery consisting of an arthroscopic subscapularis repair and a biceps tenodesis in which the biceps long head tendon would be fixed to the humerus. Following surgery, the patient was instructed to remain in a sling at all times and to begin elbow and wrist ROM exercises. She began physical therapy 3 weeks after surgery with a Penn Shoulder Score (PSS) of 26/80 and pain at 6/10. After approximately 2 months of physical therapy,

the patient had an improved PSS of 67/100 and had made considerable progress with shoulder AROM. She was able to demonstrate 145° of flexion, 70° of 90/90 external rotation, and functional internal rotation to her waistline. She continued to have mild tenderness and occasional soreness over the anterior shoulder as well as decreased strength (3+/5). The patient self-discharged from physical therapy and was instructed to maintain her home exercise program. Five months later, the patient returned to her surgeon complaining of increasing anterior shoulder pain with overhead activities and active motion. Her exam revealed limited AROM, pain with passive abduction, and tenderness over the bicipital groove and subacromial space. X-ray and MRI was ordered to evaluate the integrity of the surgical repair and demonstrated a non-displaced coracoid stress fracture. This was managed conservatively with a sling and instructions to restrict motion and lifting for 3 weeks. At her last follow-up appointment, the patient's x-rays showed callus formation and optimal alignment of the coracoid process. With continued conservative management, the patient was able to make a gradual, full return to pain-free ROM and activity. **Uniqueness:** Although biceps tenodesis and rotator cuff repairs are not unique procedures, a coracoid stress fracture certainly is a rare occurrence. Coracoid process fractures are difficult to discern on radiographs and account for an estimated 3-13% of all scapular fractures. Scapular fractures themselves only account for less than 1% of all skeletal fractures and are most often caused by a traumatic event such as a motor vehicle accident or a high fall. Because of this patient's previous recent shoulder surgery, anterior shoulder pain was not considered abnormal. No suspicion of a

coracoid fracture was raised. **Conclusions:** This case highlighted a common surgical technique utilized to repair the rotator cuff and biceps tendon followed by a unique coracoid process stress fracture. A biceps tenodesis procedure results in the biceps short head being relied on more heavily for shoulder flexion than the biceps long head which consequently places increased amounts of stress on the coracoid process. For this reason, clinicians should consider coracoid stress fractures a possibility when treating patients with biceps tenodesis that continue to have anterior shoulder pain.

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