**Toward Restoring Scapular Position and Motion Through Mapping Muscle Activation in the Trapezius: A Pilot Study**

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**Introduction:** The scapula is a major connection between the arm and thorax allowing full range of motion of the upper extremity. Alterations in scapular position and motion (scapular dyskinesis) are risk factors for shoulder injury and often present clinically in those with shoulder pathology. The trapezius muscle has three distinct regions with differing fiber orientation and is an important scapular stabilizer. Given the multi-directional forces of the muscle, differences in activation within these regions likely influence scapular position.

**Rationale:** Correcting the activation of scapular stabilizers is understood as essential for restoring normal scapular kinematics. However, little evidence exists demonstrating the efficacy of this intervention. This suggests a lack of complete understanding of the neuromuscular mechanisms underlying scapular dyskinesis and the appropriate strategies to correct scapular position. The purpose of this study was to further comprehend the role of the trapezius in scapular dyskinesis.

**Methods:** Fourteen healthy right-handed participants were assessed to determine the presence of scapular dyskinesis using the scapular dyskinesis test: 7 had normal scapular motion (CON: 5 female, 29 ± 11 years) and 7 had subtle dyskinesia (DYS: 5 female, 26 ± 5 years). Participants completed five repetitions of shoulder flexion and abduction while holding a dumbbell determined by body weight (< 150 lb = 3 lb, > 150 lb = 5 lb). High-definition surface electromyography data were collected throughout the movements from each region of the trapezius (upper [UT], middle [MT], lower [LT]) using 32-electrode grids. The ratio of muscle activation between regions of the trapezius (UT:MT, UT:LT, MT:LT) were compared by calculating root mean square (RMS) of each electrode. Comparison of muscle activity during the first 0.5 second of movement (approximately 0° to 30°) between groups (CON and DYS) was performed using independent samples t tests.

**Results:** No significant difference (P > .05) in ratio of mean RMS was determined between groups. Means and standard deviations for each ratio during abduction were: UT:MT = 1.40 ± 0.53 CON, 1.09 ± 0.55 DYS; UT:LT = 2.97 ± 1.84 CON, 2.82 ± 2.4 DYS; MT:LT = 2.10 ± 0.88 CON, 2.21 ± 1.01 DYS; and during flexion: UT:MT = 1.53 ± 0.98 CON, 1.09 ± 0.56 DYS; UT:LT = 1.89 ± 1.89 CON, 1.13 ± 0.65 DYS; MT:LT = 0.71 ± 0.41 CON, 0.12 ± 0.37 DYS.

**Discussion:** Ratio of muscle activation of the three regions of the trapezius was unaffected by the presence of scapular dyskinesis during the initial 30° of concentric motion. A larger sample size and analysis of different concentric/eccentric ranges may reveal greater distinctions between groups. Determining the trapezius’ role in scapular position and motion may help identify strategies to correct altered scapular kinematics, informing shoulder rehabilitation.

**An On-Field Assessment of Cognitive-Motor Integration (HurtSHynes™ Test) in Healthy Varsity Athletes**

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**Introduction:** The current metrics for assessing performance in athletes following concussion and prior to returning to play (RTP) measures cognition followed by movement. However, success in sport performance often requires simultaneous integration of cognition and action, known as cognitive-motor integration.

**Rationale:** The purpose of this study was to develop an on-field cognitive-motor integration task (HurtSHynes™) using healthy athletes that would represent an improved measurement tool for assessing an athlete’s readiness for RTP after sustaining a head injury.

**Methods:** The HurtSHynes™ test involves having athletes respond to four visual directional cues presented by an examiner while running 26 meters in two separate conditions. In the first condition, the response matches the visual cue of the examiner (eg, a raised hand = jump up with both hands in the air). In the second condition, the response is opposite to the visual cue of the examiner (eg, a leftward hand = cut two steps laterally to the right). Athletes were randomly assigned to completing either condition 1 or 2 first. The number
of errors were recorded for an incorrect response to the visual stimulus.

Results: Data were collected from 103 York University varsity athletes (51 females, 52 males) from 13 different teams who had never sustained a head injury. Fifty-three athletes (27 females, 26 males) were assigned to complete condition 1 first, where mean time was 10.80 ± 1.5 and 9.72 ± 1.06 seconds for females and males, respectively, followed by 10.84 ± 1.37 and 9.70 ± 1.17 seconds for condition 2. The remaining athletes, who were assigned to condition 2 first, had a mean time of 11.50 ± 0.99 and 10.58 ± 2.12 seconds, respectively, followed by 10.71 ± 1.01 and 9.36 ± 1.31 seconds for condition 1.

Discussion: Effects of learning (improvement in mean time scores across the conditions) and sex-related differences in our healthy sample (P < .01) were observed when condition 2 was assigned first. Males on average performed faster than females in both conditions and had fewer errors in condition 1 but a greater number of errors compared to females in condition 2, regardless of the condition assigned first. The findings of this study suggest that the HurtSHynes™ test might be a useful and fast measure for assessing an athlete’s performance to assist in guiding RTP decisions.

Are Sporting Organizations Preparing Referees to Recognize Potential Concussions in Youth Sport? Referees’ Experiences and Education With Concussions as Influences on Calling Injury Time-outs

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Introduction: Concerns regarding sports-related concussions (SRCs) have grown steadily in recent years. Public campaigns and legislation have attempted to raise awareness and minimize risks. However, there are still many misconceptions and lack of awareness in important stakeholder groups, especially referees.

Rationale: The role of the referee in SRC recognition and initial management is unclear and has yet to be explored in youth sport populations. Considering referees as important stakeholders in SRC safety may help to mitigate the risk of further injury following an SRC, especially when adequate medical care (eg, athletic therapist) is not present. Through an interpretivist lens, this study sought to investigate the experiences and training undertaken by football, rugby, soccer, and hockey referees to explore whether they were equipped to recognize an SRC during a match.

Methods: Ninety-eight referees (73 males, 24 females, 1 other) completed a questionnaire considering previous experiences with SRCs, SRC knowledge, and the role of the referee in SRC safety. Responses were further analyzed for emerging themes and used to create an interview schedule with 10 participants (8 males, 2 females) to further deconstruct referees’ experiences.

Results: Experience and training varied greatly among referees. A total of 34% of participants had received formal concussion training, but only 60% of these came from national sporting organizations. Participants correctly dispelled common misconceptions of SRC, including one must be unconscious to be diagnosed (98% correct) and one may still have a concussion without visible symptoms (97% correct). However, there were some indiscretions, most notably the recommended treatment of SRC (31% correct), length of recovery in youth SRCs (35% correct), and presence of visible injury on brain imaging after SRC (46% correct). Among the most significant findings were only 41% of referees felt adequately equipped to aid in SRC recognition by calling injury time-outs and 87% believed that more could be done to educate youth sport referees in SRC recognition.

Discussion: SRC knowledge stemmed from personal experiences and professional training that varied greatly among referees. Participants emphasized the importance of annual concussion education moving forward, using a multimodal approach for effective knowledge translation. This study highlights the need for harmonized education from national sporting organizations for referees to contribute to SRC safety in youth sport. Additional support from stakeholders including athletic therapists, coaches, and parents will aid in fostering a sport culture that prioritizes SRC safety.

An Exploration of Intrinsic and Extrinsic Factors Influencing Mental Health of Athletes Recovering From Concussion

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Introduction: Due to an abundance of media coverage within athlete mental health, suicide, and issues following retirement, research surrounding mental health issues among concussed athletes has recently increased. Depression has most often been the focus of these studies, but there continue to be gaps in the literature concerning other mental health issues such as anxiety and irritability.
Rationale: Although correlations have been suggested between abundance/severity of concussions and mental health issues following injury, the specific intrinsic and extrinsic factors that influence mental health states during concussion recovery is currently unknown. The purpose of this study was to identify and further explore various intrinsic and extrinsic factors.

Methods: Seventy-three university-aged students (49 females, 23 males) participated in an online questionnaire exploring their history of sports-related concussions and overall mental health (before and after injury). Responses were further analyzed to find common trends for identifying the abundance of mental health issues following concussion, classification of the management/recovery protocol that was followed, and adequacy of support networks. These themes were further deconstructed during semi-structured interviews with 10 participants (5 females, 5 males).

Results: A total of 43.8% of questionnaire participants indicated experiencing depression or anxiety during their recovery from concussion, whereas only 11% reported experiencing irritability. A total of 31.5% of participants sought out counselling services for at least one of the aforementioned mental health issues. Friends and family were identified as being the most supportive group following a concussion. Various intrinsic and extrinsic factors impacting mental health states following a concussion emerged from the data, including: changes to athlete identity, lack of participation in physical activity (as recommended by health care professionals), lack of sensitivity from coaches and health professionals toward concussed athletes, and need for further education on proper concussion management among primary care health care practitioners.

Discussion: The results of this study identified several important intrinsic and extrinsic factors that negatively impacted mental health during the recovery from a concussion. Most of these factors demonstrate the need for increased knowledge among general health care practitioners (e.g., family physicians). Increased knowledge may provide primary care health care practitioners the necessary tools to handle each athlete sensitively while outsourcing to appropriate professionals when necessary. Furthermore, knowledge of current recommendations in general concussion recovery may also prompt general practitioners to prescribe earlier exercise, reducing the challenges of removing physical activity and sport for long periods of time.

Comparison of Head Acceleration and Brain Tissue Deformation Between Three Different Times to RTP

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Introduction: The time to return-to-play (RTP) is often used as an indication of concussion severity, but the time an athlete is allowed to RTP involves several factors. This research is designed to better understand the relationship between the biomechanics of Concussive impact and time to RTP. Peak linear and rotational acceleration are commonly used to describe head impact magnitudes but are limited in their ability to describe the tissue injury. Finite element modeling of impacts metrics such as maximum principal strain provide additional information on the relationship between head impacts and tissue injury. Unlike peak head acceleration, maximum principal strain considers the direction of the impact, the duration of the acceleration, and the viscoelastic behavior of the brain.

Rationale: The purpose of this study was to investigate whether peak acceleration and maximum principal strain could differentiate between three groups of different time to RTP (< 14 days, 14 to 28 days, > 28 days) in National Football League (NFL) players to provide a better understanding of the relationship between head impact biomechanics and RTP.

Methods: Laboratory reconstructions of 68 Concussive head impacts in the NFL (2009 to 2013) and using a hybrid III headform and Finite element brain modeling were performed to obtain the magnitudes of head acceleration and maximum principal strain. Confirmation of diagnosis and time to RTP were obtained through media press releases.

Results: A one-way analysis of variance was conducted to investigate differences in peak acceleration and MPS between the three recovery groups. There were no statistically significant differences between the recovery groups for any variables analyzed (P > .05).

Discussion: The results of this study showed that time to RTP was not influenced by the magnitudes of the head impacts. Most players in this study returned to play in fewer than 14 days (40 of 68). Early RTP may be explained by the ability of some athletes to recover faster from brain trauma, but most worrisome is the possibility that factors that are not related to managing the injury including fear of losing a lucrative contract or pressure from the team were deciding factors. The time needed for a full RTP following a concussion was not associated with the magnitude of the head impact. This suggests that understanding...
injury recovery based on RTP data is limited because it is influenced by factors not directly related to tissue injury.

**Student Athletic Therapists’ Knowledge Levels of Opioid Use and Misuse With Athletes**

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**Introduction:** Athletes are known to take pain-relieving medications (PRMs) to prevent and/or alleviate pain. Research has found an increased use of opioids among athletes to relieve pain, enhance performance, and combat stress in collegiate and professional sports. This is alarming because opioid use is known to cause addiction and impair cognition and judgment, resulting in increased injury rates and associated psychological harm.

**Rationale:** Athletes expect student and certified athletic therapists to provide PRM information and assess and manage injuries. Most accredited athletic therapy programs in Canada do not deliver curriculum regarding PRM. This creates a knowledge gap, preventing accurate knowledge transfer between student athletic therapists and athletes and questions the accuracy of assessments, resulting in potential mismangement of injuries. The purpose of this research was to gain an understanding of student athletic therapists’ knowledge of PRM, specifically opioids.

**Methods:** Sheridan College student athletic therapists were individually interviewed to uncover knowledge levels, discover the source of their knowledge, and explore personal and professional viewpoints associated with an athlete’s use of PRM and opioids. Results were used to develop themes via grounded theory to understand student athletic therapists’ knowledge of PRM and opioids.

**Results:** A total of 22 interviews were conducted between March and April 2019 with representations from all 4 years and sexes (1st = 23%, 2nd = 5%, 3rd = 29%, 4th = 43%; male = 14%, female = 86%). Data analysis revealed four major themes: (1) student athletic therapists lacked knowledge of opioids and consequences associated with their lack of knowledge; (2) student athletic therapists’ knowledge stemmed from their personal and professional experience; (3) student athletic therapists’ knowledge was influenced by culture (eg, movies/music), social media (eg, Facebook), and news organizations; and (4) student athletic therapists felt a significant burden to provide accurate information.

**Discussion:** Results from this study highlighted a general lack of PRM knowledge, specifically opioids, among student athletic therapists. Student athletic therapists reported increased anxiety related to their lack of knowledge and their inability to source accurate information to provide to their athletes. As a result of or due to their lack of knowledge, student athletic therapists developed negative stigma and a bias toward athletes using PRMs. Student athletic therapists are placed in difficult positions regarding an athlete’s use of PRM. The expectation of being the primary health care provider for teams creates anxiety and a false sense of omniscience, potentially creating opportunities of great harm occurring to athletes, especially in light of the rise in opioid use. Accredited programs should therefore institute a formalized pharmacology curriculum to assist student athletic therapists in their understanding of PRM, particularly opioids.

**Cervical Muscle Strength and Kinematics During an Unanticipated Perturbation in University-Aged Male and Female Rugby Athletes**

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**Introduction:** Concussions are an inevitable risk posed to all athletes, especially those within contact sports. Female athletes participating in contact sports demonstrate a concussion injury risk factor that is two times greater than their skill- and age-matched male counterparts. Recent literature has outlined the importance of neck muscle strength and neuromuscular characteristics in the mitigation of excessive head kinematics resulting in such brain injuries.

**Rationale:** Rugby is a contact sport in which tackles comprise the mechanism for concussion, which is caused by inertial impacts rather than direct impact to the head. Females exhibit higher measurements of acceleration and investigating potential gender differences in dynamic stabilization of the head is warranted in rugby.

**Methods:** Twenty-three (15 female, 8 male) university-aged rugby athletes participated in an unanticipated perturbation and a series of clinical tests of the cervical musculature. Anthropometrics of the head and neck were obtained. Maximal isometric neck strength was measured in all planes using handheld dynamometry. Endurance of the neck musculature was determined using the isometric endurance test. Electromyography and accelerometers were used to analyze activity of the sternocleidomastoid, upper trapezius, and external and internal oblique muscles, as well as to quantify head, neck, and trunk change in velocity during a simulated unexpected
dynamic task. One-way multivariate analysis of variance tests were used to determine gender differences in anthropometrics, muscle activation, and head kinematics. Independent t-tests were used to compare neck muscle endurance.

**Results:** Males demonstrated significantly greater neck girth, head girth, and head-neck segment mass. Isometric strength was significantly different with the exception of the left upper trapezius muscle, with males demonstrating 40% to 60% greater strength. Males demonstrated 43% greater muscle endurance than females. No statistical significance in neuromuscular activation was found between genders; however, female participants exhibited a muscle activation strategy of bilateral co-contraction of the cervical musculature, whereas males used contralateral muscles to the diving direction to stabilize the head. Males had statistically significant greater change in velocity of the head in the sagittal plane.

**Discussion:** In agreement with current literature, males and females demonstrate differences in their ability to stabilize the head in dynamic situations. These data suggest that even female competitive rugby players demonstrate significant clinical factors that increase risk of concussion. Determining injury risk predictors between male and female rugby athletes can help to design specific injury prevention interventions.

**A Comparison of Craniocervical Posture, Anthropometrics, Strength, and Endurance Between Healthy Male and Female University Students**

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**Introduction:** Sports-related concussions (SRCs) arise from the biomechanical forces subjected to the head and neck segment, resulting in pathophysiologic changes in the tissues of the brain. Displacement of the head can be attenuated by neuromuscular control of the cervical musculature. Evidence has suggested clinical considerations that could reduce risk of SRCs are neck strength and girth, neck muscle endurance, strength imbalances, and posture. A forward head posture alters the normal mechanics of the neck and leads to muscle imbalances. Forward head posture is more common in females. Females also experience higher rates of SRCs, more severe symptoms, and longer recovery.

**Rationale:** Along with increasing strength of the cervical muscles, greater muscular endurance could influence the stability of the head and neck. Evaluation of isometric strength in the cervical musculature may help identify those at risk of concussions in sport. Neck strengthening has been identified as a concussion injury prevention intervention. Normative values for strength and posture in this population are sparse.

**Methods:** Twenty-three healthy females (mean age: 21.2 ± 1.3 years) and 17 healthy males (mean age: 21.2 ± 1.9 years) attended one data collection session. Anthropometric measures included height, weight, head-neck segment length, head circumference, and neck girth. Cervical range of motion was assessed using a goniometer. Peak strength measures were collected using a handheld dynamometer during isometric neck flexion, extension, lateral flexion, and rotation. Measurement involved self-applied resistance to the handheld dynamometer. An isometric endurance test was performed in the supine position and the participant performed craniocervical flexion. Postural measurements included angulations and head translation in the sagittal plane using a reliable posture screen application. Separate one-way multivariate analysis of variance tests were used to test sex differences in anthropometrics, posture, and muscle strength. Independent sample t-tests were used to analyze endurance and flexion/extension ratios.

**Results:** Analysis revealed females had significantly decreased anthropometric measures and increased anterior head angulation. Males had higher flexion extension ratios and increased strength in all ranges.

**Discussion:** These results indicate that in a healthy sample of students, females demonstrated cervical spine factors that increase the risk of SRC. These preliminary data could highlight a potential screening protocol for athletic therapists to identify individuals with a higher risk of SRCs and to develop a specific injury prevention intervention.

**Sex Differences in Lower Extremity Kinematics During Dynamic Jump Landing Tasks Following Neuromuscular Fatigue of the Hip Extensors and Knee Flexors**

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**Introduction:** Anterior cruciate ligament (ACL) injuries often occur during deceleration when landing in single leg stance with the knee close to full extension. In the sagittal plane, females tend to land with greater hip and knee extension. Neuromuscular fatigue has been hypothesized to cause injury to the lower extremity. A common observation during fatiguing contractions is that activation of antagonist muscles increases progressively, which reduces the net torque the agonist can pro-
duce. During the deceleration phase of stance, hip extensor and knee flexor muscles contract eccentrically to counteract the external hip and knee flexion moments.

**Rationale:** Weakness of the hip extensors results in altered landing strategies where females rely on the quadriceps muscle to help with joint stability. Decreased hip flexion has been associated with higher knee extensor moments and females tend to have greater knee extensor moments and decreased hip extensor moments compared to males. Decreased torque-producing ability of the hip extensors and knee flexors could further highlight sex differences. The purpose of this study was to investigate kinematics following neuromuscular fatigue and determine whether sex differences exist in sagittal plane joint postures.

**Methods:** Nine females (mean age: 22.3 ± 3.4 years) and 7 males (mean age: 21.3 ± 2.6 years) completed single-leg hop and drop jumps before and after a fatigue protocol. A motion capture system was used to measure hip, knee, and ankle kinematics. The fatigue protocol consisted of consecutive efforts to failure of eccentric knee extension and eccentric and concentric hip extension. Separate two-way repeated measure analyses of variance were used to identify sex and fatigue differences in lower extremity kinematics.

**Results:** During the hop test, there was a significant effect of time (fatigue) on hip and knee flexion, with both males and females having decreased flexion angles after fatigue. There was also a significant effect of time on peak knee moment, where flexion moments increased by 21% in males and 48% in females after fatigue. During the jump task, there was a sex effect for hip flexion at contact, with females having 18% less hip flexion before fatigue and 27% less hip flexion after fatigue compared to males.

**Discussion:** Fatigue of the hip extensors and knee flexors resulted in more erect landing postures and increased knee flexion moments, and the differences were greater in females after fatigue. Fatigue had a larger impact on female landing kinematics compared to males, highlighting fatigue as a risk factor for lower extremity injury.

**Assessing Movement Competence and Screening for Injury Risk in 8- to 12-Year-Old Children: Reliability of the Child Focused Injury Risk Screening Tool (ChildFIRST)**

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**Introduction:** Childhood obesity is a serious public health challenge leading to sedentary lifestyles and decreasing participation in physical activity and sport. Promoting physical activity helps to reduce obesity, but increasing physical activity increases musculoskeletal injury risk. Poor movement competence is also linked to increased rates of injury, so assessing movement competence from an early age can help clinicians, educators, and other stakeholders identify movement errors that may contribute to injury. Reducing injury risk and enhancing movement competence will help children participate in lifelong physical activity. Using a modified Delphi method, the Child Focused Injury Risk Screening Tool (ChildFIRST) was created to assess movement competence and injury risk in the 8- to 12-year-old population. The ChildFIRST includes 10 movement skills with four associated evaluation criteria. The movements are: bodyweight squat, vertical jump, single-leg sideways hop and hold, walking lunge, two-to-one foot hop and hold, 90° hop and hold, leaping, horizontal jump, running, and single-leg hop.

**Rationale:** Assessment tools require psychometric evaluation prior to use in the field. The purpose of this study was to evaluate inter-rater and intra-rater reliability of the movement skills and evaluation criteria in the ChildFIRST.

**Methods:** Twelve college-aged participants attended a 1-hour training session and subsequently rated 60 counterbalanced videos of children performing the movements in the ChildFIRST. The participants returned in a minimum of 7 days to rate the same 60 videos in a different counterbalanced order.

**Results:** The ChildFIRST demonstrates good to excellent inter-rater reliability (ICC < 0.75 to 1.00) for eight movement skills, single-leg hop achieved moderate reliability (ICC = 0.727), and two-to-one foot hop and hold achieved poor reliability (ICC = -0.306). Intra-rater reliability ranged from ICC = -0.386 to 0.881. Inter-rater reliability, using Krippendorf’s alpha for the evaluation criteria, ranged from -0.04 to 0.835, with 52% to 100% agreement. Intra-rater reliability, using Cohen’s kappa for the evaluation criteria, ranged from -0.328 to 0.303, with 45.8% to 98.6% agreement.

**Discussion:** The ChildFIRST demonstrates moderate to excellent inter-rater reliability (ICC < 0.50 to 1.00) in 9 of 10 movements. Despite demonstrating overall reliability of the movement skills, inter-rater and intra-rater reliability of the individual evaluation criteria is poor. Users can confidently evaluate 9 movements in the ChildFIRST, but scores from individual evaluation
criteria and repeated measures should be interpreted with caution. The ChildFIRST can help users evaluate movement in 8- to 12-year-old children. Evaluators can use the ChildFIRST to inform interventions aimed at enhancing movement competence, reducing injury risk, and promoting lifelong physical activity. Follow-up results from those interventions/studies will improve validation of the tool.

Sex-Related Differences in Oculomotor and Cognitive Abilities in Asymptomatic Varsity Athletes

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Introduction: Recent research has shown that oculomotor and cognitive functions in athletes are imperative to performance. Although it has been shown that males and females recover differently from sports-related concussions, varsity athletes who receive a concussion during play are subject to a variety of protocols and treatment options that do not typically differ based on sex. This study aims to fill the existing gap when comparing sex-related differences in oculomotor and cognitive measures in asymptomatic varsity athletes.

Rationale: New insights in concussion research demonstrate the need for a more in-depth look into sex-related differences in athletes, specifically on the oculomotor and cognitive measures.

Methods: Data were collected from 134 varsity athletes (70 males, 64 females), including a concussion history questionnaire during their preseason baseline testing (54 athletes reported > 1 concussion; 26 males, 28 females). Oculomotor (2D saccades) and cognitive tests (Stroop) were administered using the Saccade Analytics© system. These tests were performed using virtual reality goggles in a stationary seated position. SPSS Statistics 26 (SPSS, Inc.) was used to conduct an independent samples t tests to analyze the results.

Results: The independent samples t test showed a significant difference between males and females for the cognitive test, particularly in combined errors (df = 132, t = 2.18, P = .01). Males demonstrated a combined error greater than females (1.17 ± 1.26 and 0.77 ± 0.83, respectively). It is important to note that there were no significant differences found for oculomotor errors between males and females.

Discussion: This study demonstrates that asymptomatic males made more errors in the Stroop test at baseline before sports-related injuries, regardless of concussion history. These errors could be due to the nature of the test, in which males tended to perform faster. Finding no sex differences in oculomotor function suggests that both males and females have similar abilities in oculomotor reaction time and accuracy. Future research should compare results before and after injury to determine the differences in recovery from concussion-related oculomotor and cognitive deficits. This research may aid in the development of more objective testing protocols when assessing oculomotor and cognitive skills between males and females, as well as provide a better understanding of sex-related differences.

A Cross-sectional Study of Functional Performance Across Maturity, Sex, and Sport

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Introduction: Little is known about normative fitness performance in male and female youth athletes from a variety of sports, relative to peak height velocity (PHV).

Rationale: Long-term athlete development models focus on training relative to PHV; understanding the impact of PHV, sex, and sport on fitness assessments is important. The purpose of this study was to analyze the effect of age from PHV, sex, and sport on fitness assessments in adolescents.

Methods: In this cross-sectional study, independent variables were age from PHV (> 1 year pre-PHV, within ±1-year PHV, > 1 year post-PHV), sport, and sex; dependent variables were FMS deep squat (DS), active straight leg raise (ALSR), push up (PU), shoulder mobility (SM), vertical jump height (CMJ), standing broad jump distance (SBJ), and ankle dorsiflexion range of motion (DF). Fitness assessment data were collected in a pre-participation assessment protocol. Data analysis included descriptive means and standard deviations and three-way analysis of variance (CMJ); for nonparametric data (DS, ALSR, PU, SM) or data that violated assumptions (SBJ), Kruskal–Wallace and Mann–Whitney U tests were used for analysis with SPSS software (version 25; SPSS, Inc.) (P < .05).

Results: A total of 71 male and 100 female participants included 5 pre-PHV, 60 ±1-year PHV, 106 post-PHV; 10 baseball, 44 basketball, 8 fencing, 49 ice hockey, and 60 volleyball. PHV significantly affected PU (H =
11.855; \( P = .001 \)), ±1-year PHV significantly better than post-PHV (\( U = 51.00; \ P = .001 \)) and SBJ (\( H = 11.147; \ P = .004 \)), and ±1-year PHV significantly better than post-PHV (\( U = 2236.50; \ P = .002 \)). There was a significant effect of sport on PU (\( H = 8.405; \ P = .015 \)), with baseball significantly better than basketball (\( U = 41.00; \ P = .025 \)), fencing (\( U = 12.00; \ P = .006 \)), and SM (\( H = 11.00; \ P = .027 \)), basketball significantly better than volleyball (\( U = 1090.00; \ P = .019 \)), and ice hockey significantly better than fencing (\( U = 94.50; \ P = .044 \)) and volleyball (\( U = 780.00; \ P = .020 \)). There were significant main effects for sport (\( F = 4.651; \ P = .001 \)) and sex (\( F = 10.20; \ P = .002 \)) on DF; volleyball was significantly higher than basketball (4.37 vs 3.64 inches; \( P = .003 \)), with females significantly greater than males (4.09 vs 3.99 inches). There were significant main effects for sport (\( F = 9.604; \ P < .001 \)) and sex (\( F = 39.056; \ P < .001 \)) on CMJ. Baseball was significantly better than basketball (18.15 ± 15.32; \( P = .007 \)) and fencing (13.75; \( P = .001 \)). Basketball was significantly worse than ice hockey (17.57; \( P < .001 \)) and volleyball (19.68; \( P < .001 \)). Ice hockey was significantly better than fencing (\( P < .001 \)), but worse than volleyball (\( P < .001 \)). Volleyball was significantly better than fencing (\( P < .001 \)). Males had significantly higher CMJ than females (19.98 vs 15.89 inches). Females performed significantly better in ASLR (\( U = 2241.50; \ P = .021 \)) and SM (\( U = 2,340.50; \ P = .018 \)), but worse in PU (\( U = 80.00; \ P = .027 \)).

**Discussion:** In a large group of adolescents, fitness assessment results were impacted by PHV, sport, or sex. Clinicians should consider these factors when developing training programs. Future research is needed with pre-PHV participants to determine the impact on fitness measures. Providing data to which clinicians can compare their athletes may allow for a better understanding of how PHV, sex, and sport impact fitness assessments and training program development.

**Sex Differences in Movement Competence in Children Aged 8-12 Using the ChildFIRST**

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**Introduction:** Approximately 3.5 million children aged 14 and younger get hurt every year participating in sports and recreational activities, with females experiencing a higher incidence of non-contact anterior cruciate ligament (ACL) injuries. Movement competence is described as proficiency in motor skills and their underlying processes. Good movement competence has been linked to reduced injury risk, yet children demonstrate various levels of competence in the 8 to 12 year age range. Many tools exist to assess movement competency, but they are often product based (ie, evaluating speed or distance). The Child Focused Injury Risk Screening Tool (ChildFIRST) is a process-based assessment tool (ie, evaluating movement quality and body position) created to assess movement competence in 8- to 12-year-old children. The skills in the ChildFIRST include: bodyweight squat, vertical jump (VERT), single-leg sideways hop and hold (H&H), walking lunge, two-to-one foot hop and hold (2-1), 90° hop and hold, leaping, horizontal jump, running, and single-leg hop. The ChildFIRST is designed to evaluate lower body movement competence using movements needed for physical activity with the goal of determining lower extremity injury risk in this population.

**Rationale:** The ChildFIRST is the first assessment of movement competence with an injury risk focus in children aged 8 to 12 years. Because competence varies in this age group, the purpose of the study was to evaluate sex differences in movement skills using the ChildFIRST.

**Methods:** The study assessed 46 children (24 females, 22 males) using the ChildFIRST. The children were split into groups of four to five and positioned at stations. They completed a skill and then proceeded to the next station until all children had been evaluated on each skill.

**Results:** Independent sample t-tests were used to analyze the data. Females (\( \text{VERT} = 2.25 \pm 1.28, \ H&H = 3.25 \pm 0.79, 2-1 = 2.16 \pm 0.76 \)) performed significantly better than males (\( \text{VERT} = 1.91 \pm 1.01, \ H&H = 2.68 \pm 0.89, 2-1 = 1.55 \pm 1.14 \)) on the VERT [\( t(44) = 2.46, \ P = .02 \)], H&H [\( t(44) = 2.28, \ P = .02 \)], and 2-1 [\( t(44) = 2.19, \ P = .01 \)]. There were no significant sex differences for any other movement skill.

**Discussion:** The H&H and 2-1 are classified as both locomotor and balance skills. In these results, females performed better than males on the VERT, H&H, and 2-1 movements. These results are consistent with the literature suggesting that females perform better on balance skills, yet there is a discrepancy between females having better balance and increased incidence of ACL injury. Despite females performing better on balance skills, they are at higher risk for non-contact ACL injuries. The results support future research to explain this discrepancy.
Concussed Adolescents Do Not Increase Toe Clearance During Treadmill Walking Following Random Obstacle Stepping and Cognitive Task Exposure

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Introduction: Sports-related concussion (SRC) is a multifaceted injury that affects athletes on several levels. Symptom resolution is the most commonly used criterion when deciding on return-to-play (RTP). However, even when symptom recovery has occurred, sensorimotor deficits may remain. These deficits can adversely affect athletes after RTP. Greater risk of lower extremity injury has been associated with RTP following a concussion.

Rationale: Neurocognitive and motor control alterations might be present following a concussion. Clinical tests should aim to identify these deficits adequately prior to RTP. Reduced toe clearance during gait is associated with increased risk of tripping and could provide insight on the increased risk of lower extremity injury.

Methods: A total of 13 adolescents (7 control [14.9 ± 1.3 years, 62.4 ± 13.7 kg, 1.66 ± 0.06 m] and 6 concussion [13.5 ± 2.0 years, 61.3 ± 11.6 kg, 1.69 ± 0.14 m]) completed two treadmill walking sessions with three-dimensional motion capture. The baseline session was 7.5 ± 4.9 days after sustaining a concussion and the follow-up session was 14.5 ± 3 days following the baseline session. Participants experienced five repetitions of four walking conditions, occurring in random order to reduce habituation effects. The walking conditions included normal walking, a cognitive task, an obstacle stepping task, and obstacle stepping combined with a cognitive task. Kinematic data collected during the normal walking condition were used for analysis. A two-way repeated measure analysis of variance was performed on the mean values of maximal toe clearance.

Results: The maximal toe clearance was smaller ($F = 11.36, P = .006$) for the concussion group with an effect of time ($F = 50.42, P < .001$) and an interaction between time and group ($F = 17.94, P = .001$). During baseline, maximal toe clearance was not different ($F = 1.23, P = .29$) between concussion (95.7 ± 11.2 mm) and control (88.3 ± 12.6 mm) groups but was smaller ($F = 15.69, P = .002$) during follow-up for the concussion (127.6 ± 47.3 mm) compared with the control (214.5 ± 31.3 mm) group.

Discussion: The competition for attentional resources seems to affect concussed adolescents while walking in a challenging environment. Executive function of the individuals might allocate more resources to preparing for upcoming conditions and less to walking. Concussed individuals maintaining smaller toe clearance over time might indicate a lack of adaptation due to the environment being too demanding for their attentional resources, or that they are not recognizing the challenge as well as healthy participants. Diminished toe clearance during gait in challenging environments can be one of the reasons concussed individuals experience an increase in lower extremity injury following concussion. Future studies should examine whether a training program would be beneficial to improve toe clearance adaptation in concussed individuals.

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