Morphology and Function of the Lumbar Multifidus Muscle in Collegiate Ice Hockey Players With and Without Low Back Pain

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Introduction: There is a growing body of evidence in spine research suggesting a link between low back pain (LBP) and paraspinal muscle morphology and function. Imaging studies of both athletic and non-athletic populations with LBP have reported degenerative changes including asymmetry, atrophy, and functional deficits of the lumbar multifidus (LM) muscle. Smaller LM was also found to be a strong predictor of lower limb injuries in professional rugby players. However, despite the high prevalence of LBP in ice hockey players, LM muscle morphology and function have not been investigated in this group of athletes.

Rationale: The assessment of LM muscle characteristics may be useful for the identification/prevention of athletes at risk of injuries.

Methods: Ultrasound examination of the LM was performed in 18 female and 14 male ice hockey players from the Concordia University varsity teams. LM muscle cross-sectional area (CSA) measurements were obtained at the L5-S1 level, bilaterally, in a prone and standing position. LM thickness (TK) at rest and during submaximal contraction (eg, contralateral arm lift) in prone and standing positions was also obtained bilaterally at the same level to assess muscle function. The % change in multifidus muscle TK during submaximal contraction was calculated using the following formula: [(TK contracted-TK rest)/TK rest *100]. Self-reported questionnaires were used to acquire demographic information and LBP history data.

Results: Male players had significantly greater LM CSA in prone. LM CSA increased from the prone to standing position. Resting LM CSA and TK in the prone position were significantly smaller in players reporting the presence of LBP in the previous 4 weeks ($P = .004$, $P = .04$, respectively). LM CSA side-to-side asymmetry in the standing position was also significantly greater in players who reported LBP in the previous 3 months (4.77% ± 0.75%) compared to players with no LBP (2.63% ± 0.61%, $P = .03$). There were no significant differences in LM % TK change in prone or standing positions between players with and without a history of LBP.

Discussion: Collegiate ice hockey players with LBP showed specific deficits in resting CSA and TK when compared to those without LBP, as well as greater LM CSA asymmetry. Preseason screening assessment of LM could be useful and incorporated in injury prevention programs.

Importance: The results provide new insights on the LM morphology and activation during movement in prone and standing positions in ice hockey players. LBP had moderate effect on LM morphology in this group of athletes; further research is warranted.

Evaluating the Quality of Care for Patients Presenting With Chronic Rotator Cuff Disorders in Alberta

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Introduction: Chronic rotator cuff disorders (RCD) are among the most prevalent of all musculoskeletal disorders. Chronic RCD has attracted attention due to the commonality and economic burden of the disease.

Rationale: The goal of this study is to measure quality in health care delivery for patients presenting with chronic RCD in Alberta.

Methods: Patients were asked to complete two questionnaires: the Rotator Cuff Quality-of-Life Index (RC-QOL) and the Healthcare Access and Patient Satisfaction Questionnaire (HAPSQ) to collect patient-reported outcome measures that assess quality against six dimensions: acceptability, accessibility, efficiency, effectiveness, appropriateness, and safety.

Results: Patients presenting with chronic RCD were recruited from two tertiary care centers in Edmonton and Calgary, Alberta. One hundred seventy-one patients (65% response rate) completed both
questionnaires. Patient satisfaction (acceptability) was higher for orthopedic surgeons with respect to quality of care received (90%), but low with regard to waiting times (60%). Patient satisfaction was low for emergency room physicians with respect to quality of care (62%) and waiting time (54%). There was a significant difference between patient-suggested waiting times (appropriateness) and actual patient-reported waiting times (accessibility) for emergency room physicians (P < .001), sports medicine physicians (P = .01), and orthopedic surgeons (P < .001). The mean number of physicians (efficiency) seen by patients was 2.5 (SD: 0.77; range: 2 to 7). Seventy-seven patients (45%) received magnetic resonance imaging (MRI) in the public system, and 19 patients (11%) paid out-of-pocket. Fifty-six patients (33%) received an ultrasound and an MRI. The mean RC-QOL score (effectiveness) for all patients was 42 (SD: 22). A comparison of current to ideal clinical standards of care was performed (safety). Only 41 patients (24%) met ideal standards of care.

Discussion: Patients are receiving multiple physician visits resulting in the overuse of practitioners at the primary care level. Patients are also experiencing redundancy with ancillary tests. Ultrasound is the most cost-effective investigation for diagnosing RCD, and MRI should only be ordered by a surgeon primarily for surgical planning purposes. Overall, patients are experiencing lengthy waiting times, using too many health care resources, suffering lower levels of satisfaction, and not meeting ideal standards of care.

Importance: Real-time information is critical to determining the quality of care a patient receives, and can provide a complete description of the patient’s clinical pathway. This study is the first step toward collecting waiting time, resource utilization, patient-reported outcome measures, and cost information at a provincial level.

The Effects of a Specific Exercise Program on Shoulder Function for Breast Cancer Survivors, 6 to 9 Months Post-surgery: A Pilot Study
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Introduction: The most common complication following breast cancer intervention surgery is a lack of shoulder function of the affected side, which has been linked to a decrease in quality of life. Presently, few reports are available that examine the benefits of a limited active, rehabilitative shoulder program to assist this population during their recovery period (6 to 9 months).

Hypothesis: Implementing a 9-week specific active exercise program for breast cancer survivors 6 to 9 months post-surgery will improve this population’s perceived quality of life and shoulder function, improve their observational posture, decrease lymphedema, and improve their active shoulder range of motion.

Subjects: Six women (average age of 63.5 years) who were breast cancer survivors, 6 to 9 months post-lumpectomy or post-mastectomy surgery.

Study Design and Methods: The exercise program targeted muscle range of motion, strength, and endurance. Specific exercises included: static pectoralis stretch, active shoulder lateral raises with internal rotation, bent over row, and standing push-ups. The exercise program was progressed at a pace of 5 repetitions per week. All subjects were assessed at baseline and 8 weeks post-baseline. Outcome measures included: Quality of Life questionnaires (EORTC QLQ-C30, QLQ-BR23, and DASH), clinical postural evaluation, lymphedema measures, and shoulder range of motion using a standard manual goniometer.

Results: On completion of the study, subjects found a perceived improvement in social functioning with a mean change from baseline to final assessment of 58.0 to 77.7 (P = .03). In addition, subjects perceived an improvement in their shoulder function (P = .019). Clinically, subjects experienced a decrease in lymphedema above and below their elbow (1.38 ± 0.71 and 0.62 ± 0.34 inches, respectively), as well as mean changes in shoulder flexion (15.33º ± 12.71º), extension (7.67º ± 5.61º), abduction (32.33º ± 23.95º), internal rotation (2.83º ± 6.46º), external rotation (10º ± 9.63º), horizontal abduction (12.50º ± 10.09º), and horizontal adduction (13.83º ± 6.66º).

Conclusion: This pilot study supports the implementation of a daily active exercise program for breast cancer survivors 6 to 9 months post-surgery. More research is required to help establish the most effective exercises during this recovery period to augment improvements in quality of life and shoulder function.
An Exploration of Concussion Knowledge, Attitudes, and Reporting Behaviors in Varsity Athletes

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Introduction/Rationale: Concussions experienced by young adults are most commonly caused by their involvement with sport (Gordon, Dooley, & Wood, 2006). An individual suffering from a concussion can experience a wide range of symptoms, including somatic symptoms, behavioral changes, emotional symptoms, cognitive impairment, and sleep-wake disturbances (McCrory et al., 2017). Proper concussion management is important to avoid long term complications. Unfortunately, many concussions go unreported, untreated, or mismanaged. The purpose of the current study was to examine concussion knowledge in a Canadian varsity athlete population, attitudes toward concussion reporting and actual reporting behaviors.

Methods: Eighty-five varsity athletes participated in an initial questionnaire exploring baseline concussion knowledge, attitudes about concussions, and general reporting behaviors. From this sample, 12 athletes were randomly selected to take part in an individual interview. Subjects included athletes from contact sports (eg, football), limited contact sports (eg, soccer), and non-contact sports (eg, volleyball).

Results/Discussion: Athletes in the current study scored highly on the knowledge component of the questionnaire, but this did not reflect in greater reporting behaviors. Several interesting themes emerged from the data with regard to concussion reporting behaviors. Athletes appeared hesitant to report symptoms to those individuals who could limit their playing time (athletic therapists and coaches) and were most likely to tell their friends or teammates about their symptoms. Underreporting behaviors were also most apparent in contact sport athletes during preseason baseline testing, as well as during concussion testing post-injury compared to limited and non-contact athletes. Perceived pressure from coaches and teammates to play was described as a major contributor to not report symptoms. Similarly, the most commonly noted reason for underreporting was wanting to play. Athletes would continue to play if they thought they were the better option for the team (compared to their replacement), and would generally only feel comfortable sitting out if they were presenting physical symptoms or were negatively affecting overall team performance. Many athletes noted a dissatisfaction with current return-to-play protocols, and listed the length of time sitting out as another deterrent to reporting concussions. Athletes noted a willingness to take part in concussion education, with key topics of interest including the effects of playing with a concussion, potential long-term effects, and the rationale behind the RTP protocol.

Importance: Based on these findings, health professionals (especially athletic therapists) need to continue to build trusting relationships with their athletes and educate them on the importance of reporting concussive symptoms.

No Change in Plasma Tau and Serum Neurofilament Light Concentration Following Sport-Related Concussion

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Introduction: Concussion is a worldwide epidemic, and athletes participating in contact sport are at an increased risk. Loss of consciousness does not always occur; however, symptoms such as headache, dizziness, and nausea are commonly reported. Clinical diagnosis can be problematic because it relies heavily on self-reported symptoms.

Rationale: An objective tool to detect sport-related concussion and inform safe return-to-play decisions has the potential to improve precision medicine. Tau and neurofilament light (NF-L) have shown promise as objective markers of concussion, although no study to date has examined pre-injury and post-injury samples within the same subjects.

Methods: This prospective cohort study collected preseason baseline blood samples from 142 junior-level contact sport athletes from 3 teams (2 hockey, 1 football) from 2015 to 2017. Of the 142 athletes, 12 reported a concussion and underwent repeated blood sampling at 6 and 14 days post-injury. Tau (plasma) and NF-L (serum) were quantified using the Simoa HD-1 Analyzer. Data are presented as mean ± standard deviation. Separate one-way repeated measures analyses of variance were conducted to compare differences in tau and NF-L biomarker concentrations across time points.

Results: Concussed athletes were 18.4 ± 1.7 years at
time of injury. Preseason tau and NF-L concentrations were 2.34 ± 0.71 and 8.05 ± 3.03 pg/mL, respectively. Following a concussion, tau concentration showed no change (P = .29) at 6 (2.82 ± 1.11 pg/mL) and 14 (2.82 ± 1.38 pg/mL) days. Similarly, NF-L concentration remained unchanged (P = .51) at 6 (9.05 ± 3.42 pg/mL) and 14 (7.88 ± 3.86 pg/mL) days post-concussion.

Discussion: This is the first study to measure tau and NF-L concentrations in blood at preseason and post-concussion in the same individual. The major findings from this study were that tau and NF-L concentrations are not altered from baseline values at 6 and 14 days following sport-related concussion. More research is needed to investigate the temporal profile of these biomarkers closer to time of injury within subjects.

Importance: SRC is associated with acute axonal and astroglial injury, and functional disturbances in the brain include ionic and energy imbalances. Health care professionals lack an objective test to detect a SRC. Blood-based biomarkers have shown promise, and have the potential to help define injury severity, track recovery, and provide biochemical feedback for treatment interventions. Biomarker research is still in the early stages, although promising data exist. More work is necessary to determine appropriate clinical use.

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Introduction: Recent attention to concussive injuries has led to an increase in the number of people seeking care following injury. Limited evidence exists for how clinicians should manage children who experience prolonged symptoms following concussion.

Rationale: Understanding the types of treatment that clinicians provide to their patients will reveal if evidence-based strategies are being used.

Objective: To estimate the scope of concussion management practices used by Canadian athletic and physical therapists, specifically to estimate the type of treatment services provided. A secondary objective was to estimate the use of aerobic exercise.

Design: Cross-sectional online survey.

Participants: Members of the Canadian Athletic Therapists Association (CATA) and Canadian Physiotherapy Association (CPA) were invited to participate.

Methods: An online survey was developed for the project. Two clinical vignettes were provided with a brief history, including details of an injury, the current symptom score of the patient, and information about school and physical activity. Respondents were asked to answer questions related to the type of treatments they would prescribe each patient.

Results: The survey was completed by 555 clinicians. Approximately two-thirds of respondents were physical therapists (62%) and one-third were athletic therapists (33%). Most therapists worked in a private outpatient setting that was multidisciplinary. The completion rate was 57% (555 of 957). The top five treatment options included: education, sleep recommendations, energy management, goal setting, and manual therapy. Approximately one-third of clinicians prescribed aerobic exercise. Having a high case-load of patients with concussions (75% to 100%) was a significant predictor of prescribing aerobic exercise. Therapists were not more likely to prescribe exercise when patients were inactive for 4 weeks compared to 2 weeks.

Discussion: A variety of treatment options were selected and most were educational in nature (eg, sleep recommendations, goal setting, energy management). Few clinicians use aerobic exercise as part of their concussion management strategy.

Importance: Recent literature has shown the potential benefits of individualized, aerobic exercise for concussion recovery. Knowledge translation efforts are needed to implement evidence-based strategies into practice.

Building a Foundation for Programmatic Assessment in Athletic Therapy
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Introduction: Programmatic assessment (PA) is a robust method for student evaluation in competency-based education (CBE). Numerous assessments from multiple stakeholders at various points throughout a student’s education are used to inform evaluative decisions (van der Vleuten et al., 2012). However, PA is costly because executing workplace-based assessment
and forming committees to make evaluative decisions require substantial financial and time commitments (van der Vleuten & Heeneman, 2016). Furthermore, ensuring evaluators can provide a certain standard of performance feedback is critical for student learning (Heeneman et al., 2015).

**Rationale:** Implementing PA nationally is one of many demands athletic therapy (AT) program directors, professors, and practicum supervisors (herein supervisors) face in the transition to CBE. Understanding previous challenges of facilitating PA and developing a context-specific model may help establish where to focus resources for optimal implementation in AT.

**Methods:** A scoping review of the medical and health professions education literature that discussed PA theory or studied implementation was performed using the MEDLINE and CINAHL Plus databases. Three faculty members from the AT self-study group at Mount Royal University were interviewed to construct a context-specific logic model for implementing PA at Mount Royal University. Member-checking and triangulation were used with the self-study group and they engaged in reflexivity during qualitative data analysis to ensure rigor in logic model development (Denzin, 1978; Janesick, 1994).

**Results:** A common interview theme was concern for how supervisors would adapt to the increased responsibilities associated with PA without a national training standard. The self-study group also recognized the importance of addressing supervisory role strain.

**Discussion:** Conducting a national needs assessment of AT supervisors may alert program directors to potential areas for faculty development to support supervisors with PA responsibilities. It could be beneficial to interview a purposive sample of supervisors with varying experience to understand role conceptualizations and supervisor supports needed in different program contexts (Timmerman & Dijkstra, 2017). A survey based on the interview responses will be used to verify qualitative results among remaining supervisors nationally.

**Importance:** Effective implementation of PA requires preparing supervisors for their central role (Bok et al., 2013). A needs assessment inquiring into role conceptualization and required training is essential to ensure Canadian AT supervisors are equipped with the resources to evaluate students using PA (Hashizume et al., 2016).

**The Relationship Between Cerebellum Volume and Self-reported Symptoms in Females With Post-concussion Syndrome**

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**Introduction:** Post-concussion syndrome (PCS), in which symptoms persist for more than 3 months, occurs in approximately 15% of individuals who sustain a concussion. Females have greater reported rates of persistent symptoms and PCS. Recent evidence demonstrated that mild traumatic brain injury (mTBI or concussion) resulted in general brain atrophy of the cortex over the course of a year when compared to healthy controls. Yet no subcortical regions, including that of the cerebellum, were investigated. The cerebellum is essential for skilled performance through its involvement in sensorimotor integration, coordination, balance, and cognition. Yet the effects of concussion on this structure are not well understood. Cerebellar atrophy has been found in moderate to severe brain injury, even when it is not the location of injury. In addition, atrophy of the cerebellum was noted in those with chronic mTBI; however, the cerebellum was not investigated in detail.

**Rationale:** To investigate structural differences within the cerebellum of females with post-concussion syndrome in relation to self-reported symptoms.

**Methods:** 26 female participants were included in this study; 13 with PCS for more than 6 months and 13 age-matched controls. T1-weighted anatomical brain images (3T Siemens Tim Trio) were acquired. The cerebellum and cerebellum lobules were segmented using SUIT within SPM12, and the percentage relative to the total intracranial volume was calculated. In addition, both the number and severity of symptoms were self-reported using the Post-Concussion Symptom Scale as part of the SCAT3.

**Results:** The number of symptoms reported by those with PCS (Mdn = 11.0) was significantly higher than controls (Mdn = 2.0) (U = 13.5, \(P < .001\)). Similarly, the symptom severity was significantly greater in those with PCS (Mdn = 21.0) compared to controls (Mdn = 2.0) (U = 16.0, \(P < .001\)). Volume (%) of the left VIIIb cerebellar lobule was significantly lower in those with PCS (Mdn = 0.426) versus controls (Mdn = 0.472) (U =
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44.0, \( P = .038 \)). Those with PCS also had significantly smaller volume of the left VIIIa lobule (Mdn = 0.519) versus controls (Mdn = 0.566) (\( U = 46.0, P = .048 \)). Similarly, those with PCS had lower volume in both the left (\( U = 43.0, P = .034 \)) and right (\( U = 41.0, P = .026 \)) lobule X compared to healthy controls. Finally, these lobules were significantly correlated with both the number and severity of reported symptoms (\( P < .001 \)), with lower volume % associated with greater number and severity of symptoms.

**Discussion:** Both lobule VIIIa and VIIIb serve cognitive and sensorimotor functions. Lobule X (the floculonodular lobe) is associated with vestibular function, with direct associations to the vestibulo-ocular reflex.

**Importance:** These findings highlight potential structural correlates for PCS.

**How Does the Athletic Therapy Competency Framework Compare to Medical and Allied Health Educational Frameworks?**

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**Introduction:** Competency-based education (CBE) is ubiquitous in medical and allied health professional education (Gruppen et al., 2017). In CBE, accredited educational programs must account for developing student competence and certifying bodies must evaluate these competencies through examinations (Frank & Danoff, 2007). An effective approach must coordinate the education of future professionals with assessment for professional certification (Iobst & Holmboe, 2015). The Canadian Athletic Therapists Association (CATA) is currently employing different frameworks: one for program accreditation (Self-Study/Competencies, 2007) and one for professional certification (Role Delineation Study, 2015). Therefore, a new competency framework that covers both CATA program accreditation and certification needs to be established.

**Rationale:** Understanding how medical education and allied health professions have organized current framework domains will aid development of an evidence-based framework for athletic therapy (AT) in Canada.

**Return to Play After Grade I Splenic Laceration in an Elite Hockey Player: Case Report**

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**Introduction:** In the practice of contact sport, splenic injuries have a high incidence with an increasing need for return-to-play strategies that are safe and time efficient when opting for a conservative approach. Current management after splenic preservation suggests that athletes restrain from physical activity in the first 3 weeks following the injury, and competition for 3 months. The lack of appropriate and time efficient approaches to conservative measures has been raised in previous literature, with athletes often opting for surgical methods to enhance their recovery time regardless of potential long-term risks. There is a need for new contributing literature covering return-to-play strategies that are safe and time efficient when opting for a conservative approach.

**Rationale:** This report proposes a successful graded on- and off-ice return to sports activities in an elite hockey player. This case report aims to contribute to the literature on conservative management of splenic injuries in the elite athletic population to better assist athletic therapists when facing this type of injury.

**Methods:** Case report of a graded return to play protocol over 6 weeks on a 18 years old elite hockey player with grade I splenic laceration, treated conservatively.

**Results:** After 2 weeks of rest, the athlete progressively integrated light off-ice aerobic exercise (eg, bike) avoiding any physical contact and Valsalva maneuver. He skated for the first time 3 weeks after the trauma. At week 4, he started supervised weight lifting and skating drills, progressing toward full practice without contact (weeks 4 to 6). A control CT scan was performed at 5 weeks post-injury, at which time point the athlete could sustain high levels of exercise. The athlete played his first game 6 weeks after the injury without complications. He successfully finished the season and still practices hockey at an elite level.

**Discussion:** Previous literature demonstrates that the course of treatment (preservative versus operative), when it comes to splenic injuries, greatly affect time before activities can safely be resumed by athletes. This case report demonstrates it is possible to return athletes to sports safely and efficiently through a conservative approach. This case report contributes to enhance the currently available literature on such treatment when it comes to splenic injuries.
Methods: A scoping review of the medical education and allied health professions literature (athletic training, physiotherapy, chiropractic, and nursing) related to existing competency frameworks in Canada, the U.S., Europe, and Australia was performed by searching the MEDLINE and CINAHL Plus databases, and the grey literature.

Results: Medical education and the allied health professions in the U.S. vary greatly in structure (Council on Chiropractic Education 2018; Swing, 2007). Some frameworks organize competence by discipline content areas and some by performance domains or by professional roles. CanMEDS Roles are widely recognized and applied as competency framework domains in Canada (medical education, physiotherapy, and chiropractic) and in health professions education globally (Frank, Snell, & Sherbino, 2015).

Discussion: The new Canadian AT competency framework should support the CATA’s strategic objectives of enhancing public awareness and perceptions of AT in the medical and allied health care disciplines (CATA, 2017). Additionally, the new framework must facilitate programmatic teaching and assessment of competencies in preparation for professional certification. Finally, validation of a new framework must conceptually represent the scope of practice while also being able to accommodate the detailed competencies or task statements that currently comprise the multiple frameworks being employed by the CATA.

Importance: There have been two key developments with the CATA recently: the cancellation of the national practical examination and implementation of CBE. Both changes require a valid competency framework as a guiding document to ensure future professional athletic therapists are equipped to evaluate, manage and treat patients.

Athletic Therapy Student Perceptions of Their Internship Experience at a Canadian University

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Introduction: Practical student learning environments are an integral part of any athletic therapy curriculum. Through the internship experience, students develop in many ways, including practical skill refinement, organization of skills into refined protocols, and the acquisition of valuable networking opportunities. Each internship supervisor has a responsibility regarding the students’ experience to create varied learning environments. As a result, the academic program should obtain feedback about learning opportunities and student perceptions of these experiences.

Rationale: To determine if the clinical and mixed (field and clinic) internships provide students with: (1) direct supervision by a certified athletic therapist (CAT(C)), (2) exposure to a variety of injuries, and (3) learning opportunities in the form of seminars and hands on experience that contribute towards skill development and integration for real-world situations.

Methods: One hundred ten students from 2002 to 2017 were surveyed. Surveys were designed by the internship coordinator, and given to students at their end of their internship. The survey included 14 questions (including questions about hours of field vs clinic work, hands-on experience, assessments, charting, injury type, and learning seminars). Analysis involved averaging responses from each question and grouping responses by internship type: mixed (field and clinic) internship (MI) vs clinical only internship (CI).

Results: A total of 41% of the respondents in the MI group performed 20 or more assessments (highest possible rating) under direct supervision, whereas 26% of respondents in the CI group performed 1 to 5 assessments (second to lowest rating) under direct supervision. The MI group performed 64% of their assessments on acute injuries, whereas the CI group rate was 39%. Rates for chronic injury assessments was 59% for the CI group, and 34% for the MI group. A total of 85% of respondents indicated they learned some form of manual therapy technique and 58% of respondents indicated that learning seminars occurred ‘sometimes’ (less than weekly).

Discussion: The results show a difference between the MI and CI experience in both the amount of supervision and injury exposure. Students are directly supervised through more assessments in the MI experience, with greater exposure to acute injuries than chronic injuries, whereas the students in the CI experience were exposed to more chronic injuries than acute injuries.

Importance: Both CI and MI are necessary for exposure to a wide variety of injuries, and this research is valuable in making curriculum decisions and placement selections.
Factors Related to the Diagnosis and Treatment of Exertional Rhabdomyolysis

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Introduction: Exertional rhabdomyolysis (ER), or the breakdown of skeletal muscle following intense physical activity that results in the release of intracellular contents into the bloodstream, has become more prevalent in the athletic population over the past 15 years.

Rationale: Conclusive information regarding diagnosis, treatment, and return to activity following ER is lacking. This study aims to synthesize the published evidence regarding Creatine Kinase (CK) levels at diagnosis, types of treatment, length of hospital stay, and return to activity.

Methods: A quantitative systematic review of studies including athletes age 15 years and older was conducted. Exclusionary criteria were established to non-athletes, recent history of illness, confirmed drug use, end result of death, and lack of clear treatment method. Fourteen studies were included in the review for a total of 53 athletes (50 males, 3 females, age 21 ± 3.79 years). Following data extraction, descriptive statistics were assessed for pertinent variables; however, all variables were not present in all studies. A Pearson product-moment correlation was calculated to assess the relationship between the CK levels at admission and days of hospitalization, and between length of hospital stay and time to return to activity.

Results: CK levels at admission ranged from 561 to 157,700 IU/L (n = 17; 57, 979 ± 50030). Fluid resuscitation via intravenous (IV) saline at a rate of 120 to 300 mL/hr was the most commonly reported treatment method; 8% of cases reported the addition of compounds such as sodium bicarbonate. Length of hospital stay ranged from 24 hours to 17 days (5 ± 3.7 days). There was no significant correlation (r = .055, n = 18, P > .05) between CK levels at admission and hospitalization time. Return to activity ranged from 7 to 90 days. There was no significant correlation (r = -0.087, n = 12, P > .05) between length of hospital stay and time to return to activity.

Discussion: Early recognition and intervention via fluid replacement with normal saline currently appears to provide the best outcome for athletes diagnosed with ER. Although definitive information is not available, return to activity will vary by individual and should be based on the resolution of signs and symptoms and other personal factors.

Importance: Health care professionals should be cognizant of the factors that influence an athlete’s diagnosis, treatment, and ability to return to activity in relation to diagnosis of ER. There is a need for more research in regard to all facets of ER.

Analysis of Female University Soccer Players’ Performance in Games Using GPS and Heart Rate Measures

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Introduction: Evaluating athlete performance in soccer games is challenging. No drill or physical test can measure all technical and physical aspects of soccer and predict on-field performance. Non-invasive but accurate determinants of in-game performance are needed.

Rationale: The purpose of this study was to measure in-game performance of soccer players using global positioning system (GPS) and heart rate (HR) technologies.

Methods: Fourteen female university soccer players participated in the study. During 14 regular season games, each player wore a Polar Team Pro sensor. Each sensor contained a GPS device that recorded distance. Measures included total distance and distance covered at 5 different speed intervals: standing, walking, jogging, running, and sprinting. A HR monitor recorded peak HR, average HR, and time spent in different percent maximal HR zones, including 50% to 59%, 60% to 69%, 70% to 79%, 80% to 89%, and 90% to 100%.

Player data were analyzed only if they competed for 90 minutes during a game. Paired t tests were used to compare total distance covered, peak HR, and average HR during different periods. Repeated measures ANOVAs were used to compare total distance covered at each speed interval and time spent in each HR zone during games.

Results: Players covered an average of 8613.4 ± 758.5 m per game. Players covered significantly less distance in the second half (4,028 ± 489 m) compared to the first half (4,585 ± 455 m, P = .003). The athletes com-
peted with a significantly lower average HR during the second half (166 ± 9 beats/min) compared to the first half (172 ± 6 beats/min, \( P = .005 \)). Athletes obtained a higher peak HR during the second half (192 ± 7 beats/min) compared to the first half (182 ± 13 beats/min) of the game (\( P = .010 \)). During the game, players covered more distance walking (3,535.4 ± 357.9 m) and jogging (3,385.6 ± 564.9 m) compared to standing (122.1 ± 30.9 m), running (1,312.1 ± 531.9 m), and sprinting (258.2 ± 130.0 m). Finally, players spent the most time competing in the 80% to 90% (45.7±11.7 min) and the second most time in the 90% to 100% (28.0 ± 16.1 min) of their maximal HR compared to the other categories.

**Discussion:** The decrease in distance and HR in the second half may be due to player fatigue or the need to conserve energy. Interestingly, players covered a significantly larger distance walking and jogging during the game but spent a significantly longer time in the 80% to 100% maximal HR zone (73.8 ± 13.9 min).

**Importance:** GPS and HR can be used to evaluate performance of soccer players, including the important strength and conditioning principles of volume and intensity. Training benefits are maximized when the training stimulus matches the demands of the competition.

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