Gender Differences in Concussion Symptoms of High School Soccer Players

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Karin E. Thomas

B.S., University of Oklahoma, 1985
M.S., University of Oklahoma 1987

This dissertation, "Gender differences in concussion symptoms of high school soccer players," by Karin E. Thomas, is approved by:

Dissertation Committee Chair

Katherine Lamb, Ph.D.
Professor of Communication Sciences and Disorders

Dissertation Research Member

Mary Gorham-Rowan, Ph.D.
Professor of Communication Sciences and Disorders

Committee Members

Renee Hannibal, Ph.D.
Associate Professor of Communication Sciences and Disorders

William H. Youngs, Ph.D.
Visiting Assistant Professor of Psychology

Associate Provost for Graduate Studies and Research

Becky K. da Cruz, Ph.D., J.D.
Professor of Criminal Justice

Defense Date July 3, 2018

ABSTRACT

Sports-related concussion caused by either direct or indirect force to the head is a form of mild traumatic brain injury (mTBI) that results in a disturbance in brain functioning. This disturbance may affect the athlete's ability to participate in sports, pursue vocations or experience success academically. Because mTBI is a health concern with need for medical and clinical management, it is imperative to determine which features of concussion influence or impact recovery. These features, or prognostic indicators, include gender and may impact recovery and overall outcomes.

The purpose of this study is to determine whether males and females differ in concussive symptoms after sport related injuries. This may ultimately change the way concussions are managed from the sideline, in the emergency department, and during rehabilitation therapies until finally, determination of returning to play. The study design is a retrospective cohort study with data collected from the 2015, 2016, and 2017 soccer seasons from northern Indiana's South Bend school corporation. Data collection methods consisted of concussion symptom information being collected by athletic trainers (AT) from the time a player sustained a sport related mTBI until the player was asymptomatic. The participants consisted of male and female high school soccer athletes injured during practice or during a game. Male and female players were compared for number of symptoms, severity of symptoms and duration of symptom complaints. The results of the study revealed that females reported an increased number and level of severity of concussion symptoms. Females experienced a longer duration of recovery that is becoming asymptomatic when compared to males.

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Chapter I

INTRODUCTION

During the 4th International Conference On Concussion, researchers sought to clarify the term concussion and separate it from mild traumatic brain injury (mTBI). Aconcussion is brain injury defined as a “complex pathophysiological process affecting the brain, induced by biomechanical forces” (McCrory, Meeuwisse, Aubry, Cantu, Dvorak, Echemendia & Turner, 2013, p. 179). The cause of a concussion, according to the authors, may be direct or indirect force and varies in severity, duration and outcome. After a player has suffered a concussive injury, it is important to identify the mechanism of injury, symptoms after injury and severity of trauma prior to returning that player back to the field or academic classroom. There may be a rapid onset of clinical and cognitive symptoms after a concussive injury (Almasi & Wilson, 2012).

The understanding of concussion and professional compliance with current medical evaluations, concussive management protocols and consistency with which protocols are being implemented is critical for the care and outcome of the injured player (King & Kirwilliam, 2013; Scorza, Raleigh, & O’Connor, 2012). The incidence of concussive injuries has increased over recent years despite increased attention to safety equipment and education for the public (McKinlay, Bishop, & McLellan, 2011). As the incidence of injuries increase so does the trend of increasing numbers of individuals with concussive injuries pursuing treatment (Guay, Lebretore, Main, DeFrangesco, Taylor & Amedoro, 2016). Even so, there remain varying viewpoints in clarifying the definition of concussion, its management and protocols for treatment. The general public's understanding is also a key component to reducing the incidence of under-recognizing and under-reporting possible concussive events (King, Brughelli, Hume, & Gissane, 2014; McDonald, Burghart, & Nazir, 2016).

Concussion Issues and Recommendations

Gender and concussive injuries

Cancelliere, Donovan and Cassidy (2016) asserted gender has a role in an individual's health, as biological processes between the genders are different, asserting that concussive injuries would be experienced differently as well. Gender differences in concussive injuries may play an important role in understanding and projecting overall health related quality of life, and improving self-efficacy, and overall outcomes (Moore, Ashman, Cantor, Krinick, & Spielman, 2010; Ono, Burns, Bearden, McManus, King & Reisner, 2016; Tierney, Higgins, Caswell, Brady, McHardy, Driban & Darvish, 2008). These differences encompass the reporting of injuries, symptoms experienced by players, the severity and duration of those symptoms and recommendations for management. An understanding of gender differences in concussive injuries, symptoms and treatment may lead towards gender specific standardized management (McDonald, Burghart & Nazir, 2016; Ono et al., 2016).

According to Putukian, Raftery, Guskiewicz, Herring, Aubry, Cantu and Molloy (2013) the player should be assessed initially at the sideline of the field of play. This assessment is also known as an "on the run" assessment meaning there is limited time to rule out spinal and or brain injuries as officials may be waiting to continue a game or event once the status of an injured player is determined. The sideline assessment is effective in identifying injuries to the cervical spinal as well as a severe brain injury. Shim, Smith and Van Luen (2015) assert the need for a standardized process for identifying signs and symptoms of a concussion injury. That is, identifying the on-field signs and symptoms that should be targeted. This abbreviated assessment may lead to a player being pulled out of the game and evaluated more thoroughly off the field or transported to an emergency department (ED) (Jaebin, Smith, & Van Lunen, 2015; Putukian et al., 2013).

Return to learn and return to play

Return to learn (RTL) and return to play (RTP) recommendations are a part of concussion management (Darling, Freitas, & Leddy, 2015; Wasserman, Bazarian, Mapstone, Block, & van Wijngaarden, 2016). The RTL process focuses on returning the concussed player to the classroom while RTP address a player's readiness after a documented injury to begin reintegrating in sports or physical activities that include a risk of injury. A standardized graded plan assists in supporting sport participation reintegration and reduces the health risk of the player. For both RTP and RTL, post-exertion monitoring of symptoms should be a part of the decision-making protocol (Diaz, 2014; Eastman & Chang, 2015; Echemendia, Giza, & Kutcher, 2015; McGrath, Dinn, Collins, Lovell, Elvin & Kontos, 2013). In conjunction with an RTL accommodation plan for academic support, a player should also be monitored before returning to the field after an injury (Glang, Tois, Thomas, Hood, Bedell & Cockrell, 2008; Schilling & Getch, 2012). By recognizing or identifying medical and neurocognitive consequences of a concussive injury those involved in the treatment of an injured player may provide comprehensive and appropriate care. The timeline for RTL requires understanding symptoms of a concussive injury and the resulting recovery process, which vary per individual case (Carson, Lawrence, Kraft, Garel, Snow, Chatterjee & Frémont, 2014). Thus, it is important that a comprehensive accommodation plan be active for the duration of the player's symptoms or symptom complaints. These accommodations will vary because they are based on the type and severity of the concussive injury as a player and resulting academic needs of the student (Darling et al., 2015; Scorza et al., 2012).

Purpose of study

The purpose of this study is to determine whether there are gender differences in concussion symptoms and if so, what they are in order to advance an understanding of concussion, which may include gender-specific protocols. There is an increased participation of female athletes in a variety of sports including soccer (Raukar et al., 2014). This increase in female soccer player participation may allow for a comparative balance between males and female players. The rules of the game of soccer are the same for each gender. Soccer is a sport in which the player's head is used, known as heading, to advance the ball. In Indiana, heading the ball is prohibited in both younger male and female players before high school. This lack of experience in the younger players leaves them more susceptible to injuries as they enter high school athletics. Concussion protocols from sideline assessments to emergency department (ED) management for male and female players continue with the same protocols. However, the severity, type and duration of symptoms between males and females may vary. A focus to develop standardized protocols for soccer, based on gender, is of prime importance in order to advance in the study of concussion with high school soccer players.

Theoretical Framework

Despite concussive injuries receiving increased attention in recent years resulting in clinical procedures being developed for assisting with injured high school and college athletes, there remain inconsistencies in identification and management of these injuries (Shim et al., 2011). Researchers have sought to determine whether gender differences in these injuries should be addressed differently or, at a minimum used to project recovery in terms of symptom type, symptom resolution time, and decision-making for RTP and RTL (Shim et al., 2011). In other words, diagnosing, recommendations for RTL and RTP and use of exertion protocols are varied.

Failure to recognize concussion symptoms may result in repeated injury and poorer long-term outcomes for RTL and RTP. Several questions arise from the above considerations in the studying concussion symptoms. These include whether or not female players are more at risk for more severe injuries than male players. Other questions consist of whether or not there is a need for more academic support for female players than for male players and if female players recover from concussion faster than male players.

According to Baker, Rieger, McAvoy, Leddy, Master, Lana and Willer (2016) and Tierney et al. (2008) female players may be at a greater risk of sustaining a concussive injury when compared to male players. Variables between the two groups consist of physical differences characterized by smaller neck size and strength and a smaller head-to-ball ratio as well as females experiencing an increased speed of head acceleration because of the smaller size. For female soccer players, the impact of head acceleration is directly related to a brain injury.

With the development of a standardized symptom rating scale, it is possible to compare genders with concussive injuries. In particular, concussive injuries sustained in male and female soccer players between the ages of 14 to 18 years of age as protocols for data collection and symptom tracking are improving. While other assessments are included in the review of concussion management, this study focuses only on the symptom rating scale of the Sport Concussion Assessment Tool-3 (SCAT-3) (McCrory et al., 2013) (see Appendix C) and the Sport Concussion Assessment Tool-5 (SCAT-5) (Echemendia et al., 2017) (see Appendix D).

Chapter II

LITERATURE REVIEW

Medical Definition Of Concussion

Concussions have received more media attention in recent years primarily focusing on sport injuries of well-known individuals (Giza, 2014). Advancements have been made in the clarification of the definition of concussion as well as guidelines for its management. As previously stated, concussion is defined as a direct or indirect force to the head that results in a change in behavior. The term concussion is distinguishable from more severe traumatic brain injury (TBI) as results of conventional neuroimaging are negative for brain injury (Noble & Hesdorffer, 2013). The use of the label mTBI is another definition for concussion; however, the designation of "mild" may be misleading. The use of the term mild must be delineated in reference to brain injury as even a brain injury that is diagnosed as mild may still be present and require medical services (Almasi & Wilson, 2012; Phillipou, Douglas, Krieser, Ayton, & Abel, 2014; Smits, Hunink, Nederkoorn, Dekker, Vos, Kool & Dippel, 2011).

Almasi and Wilson (2012) sought to advance the clarity of defining concussion by categorizing concussion as simple-symptoms resolve within seven to ten days or complex with symptoms persisting beyond ten days. Dominguez and Raparla (2014) also sought to improve the understanding of concussion by interchanging the terms mTBI with concussion. This was accomplished by grouping a concussive event into two phases. Phase one, the initial injury, provides information regarding the mechanism of injury. Phase two, the secondary injury, includes the metabolic reaction, metabolic and ionic changes after impact, and diffuse axonal injury and shearing forces. The presence of a normal computerized (CT) scan or magnetic resonance imaging (MRI) scan of the brain after injury does not rule out brain damage (Smits et al., 2011). Normal medical test results may occur with severe subjective symptom complaints, which add to a post concussive syndrome (PCS) controversy, which is why understanding the symptoms, or "behaviors" of concussion are important.

Symptoms Of Concussion

While there is a benefit to having a system for defining a concussive injury, it is also essential to recognize and understand the symptoms of a concussive injury (Carroll-Alfano, 2017). Schrader, Mickeviciene, Gleizniene, Jakstiene, Surkiene, Stover and Obelieniene (2009) reported that many individuals have complaints of persistent non-specific symptoms following concussive injuries. Hartwell, Spalding, Fletcher, O'Mara, & Karas (2015) reported that many symptoms are immediate post-injury with a rapid, spontaneous resolution. According to Trontel, Hall, Ashendorf, and O'Connor (2013) and Villemure, Nolin, and Le Sage (2011), concussive symptomatology is divided into three separate categories that include cognitive, psychological/emotional and physical. The cognitive symptoms are characterized as problems concentrating, slower thinking speed and memory problems. The psychological/emotional symptoms involve behavioral issues related to increased irritability, frustration, lability and impatience. Villemure et al. (2011) defined the somatosensory symptoms as headaches, dizziness, nausea, fatigue, and noise sensitivity as well as visual changes characterized by double vision and light sensitivity (see Table 1). According to Mansell, Tierney, Higgins, McDevitt, Toone and Glutting (2010) any player exhibiting signs and symptoms of concussion should be diagnosed as having a concussion. Carroll-Alfano (2017) emphasized the importance of concussion education for student athletes to improve their understanding of concussion symptoms in order to recognize and report their occurrence.

Table 1. Concussion symptoms and categories

Concussion Symptoms	Category
Headache	Somatosensory
Pressure in head	Somatosensory
Neck pain	Somatosensory
Nausea or vomiting	Somatosensory
Dizziness	Somatosensory
Blurred vision	Somatosensory
Balance problems	Somatosensory
Sensitivity to light	Somatosensory
Sensitivity to noise	Somatosensory
Feeling slowed down	Cognitive
Feeling like in a fog	Cognitive
Don't feel right	Somatosensory
Difficulty concentrating	Cognitive
Difficulty remembering	Cognitive
Fatigue or low energy	Somatosensory
Confusion	Cognitive
Drowsiness	Somatosensory
More emotional	Behavioral
Irritability	Behavioral
Sadness	Behavioral
Nervous or anxious	Behavioral
Trouble falling asleep	Somatosensory

These symptoms may be observed as specific behaviors or responses following injury, as noted by the Center for Disease Control (see Table 2). It is necessary to recognize these signs and symptoms as those athletes that RTP while still symptomatic increase their risk of repeated injury and greater complications (Haran, Bressan, Oakley, Davis, Anderson & Babl, 2016; Hartwell et al., 2015; Jaebin et al., 2015).

Table 2. Center for Disease Control Heads Up concussion program list of identifying signs of concussion.

Concussion signs
Appears dazed or stunned
Is confused about assignment or position
Forgets sports plays
Is unsure of game, score, or opponent
Moves clumsily
Answers questions slowly
Loses consciousness (even briefly)
Shows behavior or personality changes
Can't recall events prior to hit or fall
Can't recall events after hit or fall

It has been well documented that concussion, caused by direct and indirect forces to the brain, is a common medical problem (Almasi & Wilson, 2012; Baillargeon, Lassonde, Leclerc, & Ellemberg, 2012; Villemure et al., 2011). Unfortunately, the language descriptions for concussions have not been definitive or consistently disseminated to players, their families, and coaches (Leitch, Ayers & Andrews, 2015). McKinlay et al. (2011) state the language of concussion and mTBI is so varied and contradictory with a lack of consistency that creates confusion for the public. The variation in the management of concussion has also lead to limited agreements on clarification in terms of severity scales and classifications (McKinlay et al., 2011; Scorza et al., 2012). Leitch, Ayers and Andrews (2015) assert the education of players in the symptomology of concussion is important for improving recovery and avoiding potential for additional injuries.

The resulting symptoms of concussion may also be misleading. Pieper & Garvan (2014) assert that parents may only be concerned with concussive injury if there are symptoms of headache, difficulty sleeping or persistent problems in school performance. This may result in the concussed child not be identified as having been injured without perceived symptoms or changes in their behavior. Under diagnosing injuries may interfere with a player receiving medical treatment. According to Solomon & Zuckerman (2015) the perception of concussion must be addressed as not all cases resolve completely. Researchers assert cases of concussion without a clear diagnosis are at risk of prolonged, chronic symptom complaints (Jun, Lisa, Brett, Yushi, Jonathan & Jamshid, 2016). Clarifying the definition of concussion and increasing identification and management of symptoms are important steps in avoiding both the short and long-term consequences of concussion and improving recovery (Edwards & Bodle, 2014; Snedden, 2013).

Sport-Related Headache

Posttraumatic headache (PTH) has been classified as a secondary headache disorder according to Lucas and Blume (2017). That is, they are the result of a causal event such as a TBI, as opposed to a primary headache, which has no causal event such as a migraine. PTH is the most commonly reported symptom after concussion and is normally experienced shortly after the injury has occurred (Heyer & Idris, 2014; Miller-Phillips & Reddy, 2016). The headache may be classified as acute or chronic depending on the length of duration of the symptom. Acute recovery of PTH is defined as resolution of this condition within three months while a chronic PTH persists beyond that time frame (Heyer & Idris, 2014). Begasse de Dhaem, Barr, Balcer, Galetta, and Minen (2017) used the symptom of PTH in conjunction with a self-rating symptom scale for prediction of duration of recovery. They demonstrated a correlation between PTH and other somatosensory symptoms of concussion such as blurred vision, sensitivity to light and noise, neck pain and nausea or vomiting. The authors suggested the use of the SCAT-3 symptom scores for measurement of concussion symptoms, specifically headache and its correlated symptoms, is an effective instrument for tracking recovery.

Sport-Related Concussion

According to Noble and Hesdorffer (2013), sport-related concussion (SRC) is a mTBI affecting approximately 300,00 young American adults each year. Even though this is an increasing occurrence, not all injuries are being identified by professionals, reported by athletes or managed appropriately after injury. In an effort to advance clarification of concussion and the forces to the brain, Villemure et al. (2011) suggested that these forces should be divided into two categories, direct and indirect, which provide clarification of the definition and improve identification. The direct force injury is characterized as a blow or shock to the head. An episode of direct force trauma assists with an objective diagnosis of injury due to visible signs to the head, scalp and/or skull. The indirect force of injury, defined as inertia, results from a rapid acceleration and deceleration in the movement of the head. An episode of indirect force jolts the brain violently within the skull and exceeds the mechanical limits of the brain's capacity to move and stretch. This can result in a covert injury of the brain. Both direct and indirect forces contribute to the occurrence of concussion and subsequent symptoms, including headache, dizziness, and cognitive slowing.

Post-Concussive Syndrome

Schrader et al. (2009) reported that many individuals have complaints of persistent non-specific symptoms following concussive injuries. Symptoms of concussion that persist over an extended duration, beyond the acute stage, result in PCS. This encompassing term depicts prolonged neurocognitive, behavioral and somatosensory symptoms (MacFarlane & Glenn, 2015; McCarthy & Kosofsky, 2015). While some individuals may experience more evident symptoms of PCS, others may have milder or fewer symptoms such as sleep disturbances or fatigue. According to Sandel, Schatz, Goldberg and Lazar (2017), the recovery period from concussion is seven to ten days; a longer period of time is indicative of a protracted recovery. PCS has many definitions with researchers seeking to determine what symptoms/factors may result in this condition and may be used for identification, management, and projecting outcomes (Kerr, Zuckerman, Wasserman, Vader Vegt, Yengo-Kahn, Buckley & Dompier, 2018). PCS is essentially the presence of at least one symptom from a concussive injury that persists beyond the acute stage of recovery.

The identification of PCS is not clear-cut as symptoms of concussion may be misdiagnosed. Mild symptoms, lack of awareness within the general public in identifying the occurrence of a concussive injury, and PCS are contributing factors to suboptimal management of these injuries. Dean, O'Neill, and Sterr (2012) demonstrated that the general public, without a history of a head or brain injury, interpreted similar symptom complaints as a concussed group. That is, the presence of symptoms (e.g. headache, drowsiness, anxiety), may be present in a nonconcussed individual and should not be misinterpreted as a concussion symptom. This reinforces the need for clarification of diagnosis and monitoring of recovery. Particularly, improved assessments to distinguish PCS from other sports related injuries or co-morbid conditions not related to concussion are warranted for optimal outcomes.

Concussive Injury and The Brain

Neurophysiology of Concussion

Knowledge of normal neurological structures and functions are important for the understanding of changes brought about by direct or indirect forces according to Livingston (2011). The complexity of the brain makes this difficult as the brain is comprised of multiple systems and networks that may be affected by concussion (Leddy, Baker, Haider, Hinds & Willer, 2017). Jünger, Newell, Grant, Avelinno, Ghatan, Douville and Winn (1997) stated that multiple systems include the vestibular system, autonomic nervous system, cerebral vascular system, and the cardiac system may be involved. According to Zhu, Covassin, Nogle, Doyle, Russell, Pearson and Kaufman (2015), it is hard to predict which areas of the brain will be impacted by a sports-related injury. Livingston (2011) categorized each system by connecting the system to each symptom of concussion. The cerebral cortex categories included the frontal lobe functions consisting of cognitive processes related to attention, memory, reasoning using forethought and planning, and concentration.

Injury to the temporal lobes may also affect memory and skills of recognition, the cognitive symptoms of concussion. The parietal lobes process sensory information such as spatial orientation. The occipital lobes process visual information are susceptible to vision disturbances after injury (Livingston, 2011). The vestibular system regulates equilibrium and if injured may contribute to balance difficulties and hearing disorders. The brain stem contributes to consciousness, sleep, respiratory control, and cranial nerve functions (Livingston, 2011). According to Ropper and Gorson (2007), injury to the upper midbrain and thalamus may result in loss of consciousness (LOC). Given the extensive network of connections within the brain, the concussed individual should be monitored for changes in symptomology, such as increased drowsiness, vomiting, or even word retrieval difficulties, as such alterations may be an indicator of possible subdural intracerebral bleeding (Ropper & Gorson, 2007).

Autonomic Dysregulation

The autonomic nervous system (ANS), which is comprised of the sympathetic and parasympathetic systems is normally in balance in terms of excitation and inhibition processes

(LaFountaine, 2017; Leddy et al., 2017). The sympathetic system is involved in the "fight or flight" response, which involves the release of epinephrine and norepinephrine and vasoconstriction in the body (Esterov & Greenwald, 2017). The parasympathetic nervous system returns the body to equilibrium and is the "rest and digest" response. A response to mTBI may include dysfunction of the ANS which is recognized by an increase in concussive symptomology, including cardiac issues such as disrupted heart rate regulation and disturbances in sleep regulation, motor control, and cognitive processes (Esterov & Greenwald, 2017; LaFountaine, 2017; Lagos, Thompson, & Vaschillo, 2013). Regulation of the ANS may be measured by changes in heart rate and responses to controlled exercise in terms of blood pressure and symptom reporting. Leddy et al. (2017) asserted that individuals with autonomic dysregulation following concussion were experiencing a predominance of their sympathetic nervous system response. This phenomenon exacerbated concussive symptoms by reduced blood flow regulation and heart rate regulation.

Cerebral Blood Flow

It has been well established that the circulation of the brain's blood flow adapts to both internal and external environmental changes and demands while maintaining a constant level (Jünger et al., 1997). The ANS assists with cerebrovascular profusion efficiency; changes in cerebrovascular blood flow may be related to concussive symptomology and possibly the prolongation of post-concussion symptoms (Albalawi, Hamner, Lapointe, Meehan, & Tan 2017; DeWitt & Prough, 2003; Pertab, Merkley, Cramond, Cramond, & Wu, 2018). Cerebral blood flow has been shown to change during the acute stages of SRC characterized by an increase in C02 production which leads to reduced vasoreactivity; that is, contraction of blood vessels (Steenerson & Starling, 2017). The supply and demand of oxygen and glucose may out of sync resulting in a metabolic mismatch, which is revealed as concussion symptomology (Wang, Nelson, LaRoche, Pfaller, Nencka, Koch, & McCrea, 2016). Neurocognitive recovery may be restored to baseline levels at rest but cerebral blood flow abnormalities may persist during physical activity and/or cognitively demanding tasks (Churchill, Hutchison, Richards, Leung, Graham & Schweizer, 2017; Wang et al., 2016; Len, Neary, Asmundson, Goodman, Bjornson & Bhambhani, 2011). Constantine, Mihu, Crisan, Sovrea, Susman, Bosca and Jianu (2018) concurred with this stating that during this stage of recovery, the brain may experience a reduction in speed of responsiveness. Researchers also stated that changes and reductions in cerebral flow including velocity of blood flow might persist for weeks after a concussive injury, thus prolonging many symptoms noted after concussion (Constantine et al., 2018).

Axonal Injury

Diffuse axonal injury (DAI) is the result of damage to axons and small vessels by external forces to the brain. DAI may be microscopic but has been determined to be the source of cognitive problems in patients with TBI (Moenninghoff, Kraff, Maderwald, Umutlu, Theysohn, Ringelstein & Schlamann, 2015; Sugiyama, Kondo, Higano, Endo, Watanabe, Shindo & Izumi, 2007). According to Hunea, Damian, David, Diac, Illiescu and Ciocoiu (2017), axons move and stretch during normal head movements. However, rapid acceleration and deceleration forces to the brain, and/or excessive rotation, result in sheering, tearing, and stretching of the white matter. The white matter damage interferes with connectivity of various brain regions, thus contributing to the various cognitive deficits associated with cognitive injuries. Esbjornsson, Skoglund, Mitsis, Hofgren, Larsson and Sunderhagen (2013) and Smits, Houston, Dippel, Wielopolski, Vernooij, Koudstaal and van der Lugt (2011) assert that DAI affects necessary skills for daily life functioning such as working memory capacity and selective attention.

Although DAI may be present post-concussion, it is not always identified on standard neuroimaging such as CT scans and MRI protocols (D'Souza, Trivedi, Singh, Grover, Coudhury, Kaur & Tripathi, 2015). A more effective means of assessing DAI is diffusion tensor imaging (DTI), an advanced neuroimaging technique that reveals white matter integrity by assessing water diffusion along myelin sheaths (Ken, Takeo, Yoshimi, Yutaka, Mari, Hiroshi & Shin-Ichi, 2013). Niogi, Mukherjee, Ghajar, Johnson, Kolster, Sakar and McCandliss (2008) showed a relationship between the extent of DAI and reduced reaction time measures during completion of cognitive tasks; they hypothesized that possible variations in results may be due to normal white matter variations among the population. Similarly, Ken et al. (2013) and Smits et al. (2011) have demonstrated the correlation of concussive symptoms with microstructural injury using DTI.

Neurometabolic Cascade

According to Domínguez and Raparla (2014), the pathophysiology of concussion is not clearly understood primarily because of the neurometabolic events that occur with a concussive injury. At the same moment after the brain experiences a biomechanical injury an immediate release of neurotransmitters occurs. This release evolves into a cascade of neuronal depolarization; increases in glucose demands, widespread changes in cerebral blood flow, and reduced axonal functioning (Chamard, Lassonde, Henry, Tremblay, Boulanger, DeBeaumont & Théoret, 2013; Domínguez & Raparla 2014; Giza & Hovda, 2001). The initial injury results in the efflux and influx of potassium and calcium, which causes the increased activity of the sodium potassium pump in order to reestablish equilibrium. This causes an increase in glucose consumption and reduced energy storage and metabolism (Blennow, Hardy & Zetterberg, (2012). The neurometabolic cascade may result in increased duration of concussive symptom complaints as well as causing the brain to be more susceptible to secondary trauma (MacFarlane

& Glenn, 2015). Repeated concussions during the recovery stage, according to Giza & Hovda (2001), increases the risk of cell death. Choe (2016) and Patterson and Holahan (2012), reported on the neuroinflammatory response to concussion, which is the result of the cascade. The inflammatory cells provide a scavenger service that collects debris while it provides a barrier between damaged and undamaged cells. According to Choe (2016) research has not determined if the neuroinflammation is a protective response or if it promotes neurocognitive decline. To this point, according to Patterson and Holahan (2012), no viable treatment for the neurometabolic cascade of concussion has been identified. However, the treatment of the neuroinflammatory response may be a promising consideration for further research.

Loss of Consciousness

An unconscious episode is one that involves the loss of consciousness, duration of unconsciousness, and the recovery of consciousness (Whinnery & Forster, 2017). Measurement of degree of responsiveness is commonly assessed with use of the Glasgow Coma Scale (GCS). The GCS is comprised of three scales that focus on an aspect of responsiveness that include 1) verbal response, 2) motor response and 3) eye opening (de Sousa, & Woodward, 2016; Kasprowicz, Burzynska, Melcer & Kübler, 2016). Each of the three scales is measured independently using a number rating for a maximum total of 15 points. LOC was once considered a factor for determination of severity of injury but more recent research does not support this premise (Almasi & Wilson, 2012; Hack, Huff, Curley, Naunheim, Ghosh Dastidar, & Prichep, 2017). However, the diagnosis of LOC may assist with determination of whether or not brain scanning is necessary in terms of the medical management of concussion. Smits et al. (2007), assessed the relationship between LOC and posttraumatic amnesia (PTA) as determining factors in the diagnosis of severity or predictive of course of recovery. PTA was defined as the inability to recall the traumatic injury or events following the injury measured in minutes. When LOC is present in conjunction with PTA, those clinical signs may be indicative of serious injury such as a skull fracture. Thus, standard neuroimaging should be considered (Smits et al., 2007). Cripps and Livingstone (2017) asserted that for pediatric cases (aged 0-16 years) LOC is an indicator of possible intracranial injury with neuroimaging being recommended. Overall, LOC is not necessarily correlated with the severity of the injury of severity of neurocognitive functioning but is rather an indicator for brain injury diagnosis (Livingston, 2011).

Gender Differences in Neurophysiology of Concussion

It has been established that females experience a higher rate of concussion and are at risk of a longer duration of recovery. It has not been established however, why this is the case. Possible factors for these differences include anatomical differences between males and females in terms of body size, neck length, and girth; honesty in reporting symptoms, hormonal influences and, neuroanatomical differences (Kwon, 2018; Makin, 2018). These factors may make females more susceptive to concussive injury and prolong the recovery process.

Body mass index (BMI) was also a measure that was comparable between players of the same gender and opposite genders. Researchers determined that regardless of BMI, gender appeared a factor in symptom complaints and reduced performance on cognitive measures. Mansell et al. (2010), stated in terms of anthropometric comparisons, higher statements of signs and symptoms of concussion were reported by females with smaller neck girth and longer head-neck segment length. Males may also present with smaller neck girth and longer head-neck length but frequently have stronger necks and torsos than females that assist in dissipating the direct force of injury. Colvin, Mullen, Lovell, West, Collins and Groh (2009), hypothesized that even more important than BMI for determining risk of concussion is gender.

Hormonal influences regarding concussive injuries have been researched extensively in an effort to determine their role in injury outcomes. Progesterone and estrogen are present in both males and females but at different concentrations (Sollman, Echlin, Schultz, Viher, Lyall, Tripodis & Koerte, 2018). Questions regarding hormonal factors include the relationship of estrogen to progesterone and time of injury relating to time of menstrual cycle. A normal menstrual cycle consists of two phases, the follicular phase and the luteal phase with the average cycle length being 25-38 days (Harber, 2004). During the follicular phase, follicle stimulating hormone (FSH) is released and estrogen levels increase. The luteal phase begins after ovulation; during this phase, progesterone levels rise (Harber, 2004). Mihalik, Ondrak, Guskiewicz, McMurray, Mihalik, Ondrak and McMurray (2009) and Wunderle, Hoeger, Wasserman, and Bazarian (2014) sought to determine if the female menstrual cycle at the time of a concussive injury would impact the duration of symptoms. Snook, Henry, Sanfilippo, Zeleznik, and Kontos (2017) hypothesized that a concussive injury may result in abnormal menstrual cycles because of the disruption in factors that control the cycle. These factors are known as the "heuroendocrine hypothalmalamic-pituitary-ovarian axis" (Snook et al., 2017 p. 790). This reduces the concentrations of estrogen and progesterone. Abnormal menstrual patterns and changes in hormone levels may be an indicator of symptomology of concussion, in other words, a contributor to duration of recovery. It is worth noting, however, that menstrual cycles change in female athletes that are not concussed (Harber, 2004). Athletes that engage in rigorous aerobic training they may experience amenorrhea, the absence of menstrual cycles. This change occurs due to a reduction in estrogen and progesterone levels. Thus, female athletes who exhibit amenorrhea may exhibit a greater number and/or increased severity of symptoms, as well as longer duration of recovery.

Makin (2018) found that there are axonal differences in male and female neuroanatomy as demonstrated through electron microscopy. Specific findings revealed that female axons are thinner when compared to males, which may affect the stability of the white matter structure and make the female axons more susceptible to brain trauma. Diffusion weighted magnetic resonance imaging (dMRI) is an advanced neuroimaging technique designed to measure the molecular diffusion in tissue and provide insight into tissure structure changes. Sollman et al., (2018) used dMRI in order to determine differences in male and female hockey players following subconcussive events. Specifically, they noted that female players experienced reduced white matter diffusion when they experienced repetitive forces to the head below the threshold of concussion. This may result in concussive symptomology including reduced cognitive performance. The most affected areas included the superior longitudinal fasciculus, the internal capsule, and the corona radiata of the right hemisphere. These are important regions of the brain for processing, and language, and cognitive information, and motor, and sensory signals in each hemisphere.

Gender Differences in Concussion and Symptomology

In general, there has been a rapid rise in sports participation resulting in increased injuries and a need for emergency physician involvement for diagnosis, management and counseling related to injuries (Almasi et.al., 2012; Raukar et al., 2014). Beyond the physical injury of concussion there are concussion symptoms that should be considered such as changes in cognitive functioning (attention, memory), behavioral changes (irritability, anxiety) and somatosensory complaints (sleep disturbances, headache). With the potential increase in females participating in sporting events, the odds for female athletes sustaining a concussion also increases. If gender is a key element in the management of sports related concussive injuries this may have the potential to improve recognition, identification and overall outcomes.

According to Tsushima, Lum, & Geling (2009) although males are twice as likely to sustain a TBI, females have a poorer outcome and higher mortality rate in comparison. Multiple factors contribute to this difference and include severity of injuries, and extent of loss of consciousness and amnesia as well as premorbid personality traits and age (Tsushima et al., 2009). Baker et al. (2016) asserted that female concussed players required almost two times as long to become asymptomatic when compared to their male counterparts. As previously noted, the difference in recovery rates may be related to the force of the injury and the smaller size of the female as well as biological differences (hormone levels) between the genders.

Chamard et al. (2013) and Nelson, Guskiewicz, Barr, Hammeke, Randolph, Kwang Woo and McCrea (2016a) assessed the long-term neurometabolic and microstructural variances after concussion in female athletes by use of magnetic resonance spectroscopy (MRS). This is a test that measures biochemical changes in the brain, and DTI scans. They asserted that on the surface, an SRC may appear to result in limited or no functional changes; however, there may be sub-clinical alterations of the function and the structure of the brain. The brain may still be recovering from an injury but the injured individual may not have changes in functioning that are readily apparent. The authors determined this phenomenon is greater for females participating in sports. This may ultimately put them at risk for a neurodegenerative disease as well as reduced healthy aging (Chamard et al., 2013; Nelson, et al., 2016a).

Colvin et al. (2009) analyzed the difference between male and female soccer athletes in terms of the effect of prior concussion on post-concussive testing and post-concussion recovery patterns. Soccer was the sport chosen for analysis due to its equal participants of male versus female and identical rules for each gender. The authors demonstrated that players with at least one prior concussion performed worse on neurocognitive assessments. Females reported more symptoms and performed worse on test measures than males. According to Sandel et al. (2016), female athletes may experience more concussive symptoms when compared to male concussed athletes regardless of the sport. When comparing the sports of soccer and lacrosse, not only were neurocognitive measures worse in females their symptom reporting was also worse (Sandel et al., 2016).

Gender differences in symptomology consist of greater reporting of confusion and amnestic type complaints for males and the somatosensory symptoms of drowsiness and sensitivity to noise for females (Covassin, Drutcher & Wallace, 2013; Frommer, Gurka, Cross, Ingersoll, Comstock & Saliba, 2011). Current research separates male symptoms as being primarily cognitive and female symptoms as being behavioral and somatosensory related.

In sum, neuropathology of concussion results in changes in cerebral blood flow, neurometabolic changes and white matter changes consistent with DAI. Complicating factors include hormonal differences in females and time of concussive injury in terms of menstrual cycle phases. Additional difficulties for clarification of injury severity and projected course of recovery include premorbid history of rigorous exercise and menstrual cycle history. These differences may contribute to females being at risk for increased symptomology and duration of recovery from concussive injuries.

Overall, the complexities of SRC consists of many factors and nuances making it important to be aware of not only the mechanism of injury, the cause and description, but also the pathophysiology resulting from the injury. Changes in cerebral blood flow, axonal injuries, gender differences, microstructural damage, and premorbid histories should all be taken into account when evaluating concussion.

Concussion Management

Future directions for intervention of concussion should include improved educational services for students beginning with communication between the medical community and the school as well as education and planning for school personnel (Ennis, Rivara, Mangione-Smith, Konodi, Mackenzie & Jaffee, 2013; Glang, Tyler, Pearson, Todis, & Morvant, 2004; Schilling & Getch, 2012). Consistency of the care of mTBI players across all stages of recovery is important for the transition back to the academic environment. The school environment and school personnel are responsible for the needs of the student players. Medical personnel who contribute to the identification of the student, education regarding the injury and need for accommodations, as well as management of both symptom analysis and neurocognitive testing guide this transition or reintegration back to the classroom. Without clear guidelines, students are at risk for additional injuries as well as educational, social, and behavioral difficulties. The transition for RTL may need to include several re-entry steps beginning prior to the actual return to the classroom and through the end of the first month post-injury, including monitoring of important milestones (Schilling & Getch, 2012). These milestones are times for review of recovery, such as determining readiness to transition from grade to grade, before beginning a semester, during a midterm-grading period, or when decision making regarding adequacy of services is indicated.

The recovery from concussion encompasses more than just medical recovery and retuning the player to their previous activities. It may impact the long-term perceived quality of health in an injured individual. Trontel et al. (2013) sought to determine the diagnosis threat effect on neuropsychological performance in cases of mTBI. In other words, evaluating whether a subject’s cognitive performance would be negatively affected if given the label of TBI in comparison to those without the label. The researchers demonstrated that those without a TBI diagnosis appeared better at assessing their own ability to perform cognitive skills in their academic environment. This is important to consider in terms of complaints of persistent post-concussive symptoms as even with adequate cognitive ability, perceived difficulty that may impact academic self-efficacy. Comprehensive management of mTBI from the sideline, to the classroom and reintegrating back to the field of play should be standardized and supported until it is determined services of any kind are no longer indicated (Ropper et al., 2007).

Concussion Testing

Dessy, Rasouli, Gometz and Choudhri (2014) concluded that assessment of concussion should be complex or take into account multiple issues such as postural control, neurocognitive performance and the identification of concussive symptoms. Assessment may be completed at baseline, which is pre-season, at the sideline of play, and anytime during recovery.

Common computerized baseline and sideline concussion tools include the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) (http://www.impacttest.com/. accessed June 18, 2018), the CogState (https://www.cogstate.com/. Accessed June 18, 2018) and the SCAT-3. These computerized assessments lend themselves to improved standardized administration and scoring (Allen & Gfeller, 2011; Rahman-Filipiak & Woodard, 2013). Other advantages to computerized testing is the ability to test large groups of athletes at the same time, have immediate scoring, have the ability to store the test results, and have automatic randomization of test forms (Iverson & Schatz, 2015).

The ImPACT battery consists of neurocognitive tests and demographic information with five composite scores including Verbal Memory, Visual Memory, Processing Speed, Reaction Time and Impulse Control. The ImPACT test has been used for baseline measures prior to the sports season, after injury for tracking recovery, and in the emergency department. The

ImPACT is widely used as a reliable and valid concussion-screening tool for management of concussive injuries (Thomas, Collins, Saldino, Frank, Raab & Zuckerbraun, 2011).

Repeated assessment practice effects have been researched in an effort to determine if repetition of cognitive test would result in improved test performance (Falleti, Maruff, Collie, & Darby, 2006). Because of observed practice effects, researchers determined alternative forms, such as those offered with the CogState allowed for standardized repeated assessment of a cognitive change. The CogState focuses on cognitive tasks targeting speed of processing, skills of attention, visual learning, working memory, visual motor ability and executive function ability (Bangirana, Sikorskii, Giordani, Nakasujja, & Boivin, 2015). It consists of four main cognitive tasks characterized as detection (change in a card), identification (color of a card), one back (one card prior) and one card learning (recognition of previously presented card) (Louey, Cromer, Schembri, Darby, Maruff, Makdissi & McCrory, 2014; Nelson, LaRoche, Pfaller, Lerner, Hammeke, Randolph & McCrea, 2016b). Similar to other neurocognitive tests it compares baseline to post-injury levels of cognitive functioning. The CogState also includes a concussion symptom questionnaire consisting of self-ratings of perceived symptoms that contributes to the diagnosis of concussion and tracking of recovery (Louey et al., 2014).

The original version of the SCAT was developed during a Concussion in Sport Group (CISG) conference in 2004 (Davis, Purcell, Schneider, Yeates, Gicoia, Anderson & Kutcher, 2017). The SCAT was initially designed as a concussion assessment tool for medical personnel and as an educational reference for the public. The SCAT was revised in 2008 (the Sport Concussion Assessment Tool-2; SCAT-2) for the primary purpose of concussion assessment by medical personnel. In 2012, the SCAT-3 was developed with an additional SCAT-3 child version (Davis et al., 2017). The SCAT-3 assessment includes a clinical exam, symptom reporting, a postural evaluation, and a cognitive test section. Each section includes instructions for administration and rating scales as well as symptoms of concussion and when to activate medical services.

Several studies have been completed to evaluate the SCAT and its various editions. Chin, Nelson, Barr, McCrory, & McCrea (2016) evaluated the psychometric properties of each SCAT-3 component as part of the clinical decision-making process. They sought to determine if baseline testing or use of normative data was the most useful for identification of concussion. The results demonstrated that both approaches are acceptable. According to Guskiewicz, Register-Mihalik, McCrory, McCrea, Johnston, Makdissi and Meeuwisse (2013) the symptom questionnaire section was revealed to be the most sensitive to a concussive injury. Researchers also compared the SCAT-3 with the previous edition, the SCAT-2, and determined that each version allow for independent use of subtests that may be scored independently. Each of the subtests evaluates potential problems that may be affected by concussion in differing degrees allowing for appropriate referrals for medical follow up, RTP recommendations, and academic accommodations. Both the SCAT-2 and SCAT-3 editions are effective concussion screening tools (Dessy et al., 2014).

The most recent sports concussion assessment tool is the SCAT-5 which is a revision of the prior SCAT-3 version (Davis et al., 2017). According to Echemendia, Meeuwisse, McCrory, Davis, Putukian, Leddy and Herring (2017), SCAT-5 modifications consist of the inclusion of an immediate assessment section for signs of concussion, clarified instructions regarding the symptom checklist stating the athlete should be in a resting state during completion, additional questions regarding pre- and post-injury behavior of the athlete, and a return to school progression list. Additional modifications include variations in test stimuli to avoid re-test practice such as options for word lists and digits backwards. The SCAT-5 also includes a neurological screen measure for rapid assessment of suspected concussion (Echemendia et al., 2017).

Neurocognitive Testing

Although a sideline neurocognitive screening is conducted immediately after an injury, a more extensive neurocognitive assessment, the Woodcock Johnson IV (WJ-IV) (Schrank, McGrew, & Mather, 2014a) should be considered. The WJ-IV is a recent revision of its former editions that includes re-norming, additional test batteries, and clusters improved diagnostic capabilities (Schrank, McGrew, & Mather, 2014b). The test includes three batteries consisting of the tests of cognitive abilities, tests of achievement and tests of oral language. The cognitive test battery measures different aspects of cognition such as attention, memory, and executive functioning and includes standard and extended versions. The achievement test battery measures academic abilities to assist with school accommodation recommendations and also includes standard and extended versions. The oral language test battery measures aspects of oral language, such as vocabulary knowledge and comprehension of direction following, and identifies inconsistencies between oral language and achievement levels. These three test batteries are comprehensive, may be used in combination or individually to evaluate individual strengths and weaknesses and may assist with clinical decision-making (Schrank et al., 2014b).

Oculomotor Testing

The addition of an oculomotor test such as the King-Devick Test (K-D) (http://kingdevicktest.com/for-concussions/. accessed June 18, 2018), should be considered as a way to expand the comprehensiveness of sideline concussion testing. The K-D test measures oculomotor movements, which have been identified as an objective measure of the presence of suboptimum brain functioning. According to Ventura, Balcer, Galetta, & Rucker (2016) and Echemendia et al. (2017) the assessment of eye movement such as saccades, fixation, smooth pursuits and vergence provides information regarding visual pathways that are vulnerable to concussion. There are several advantages of saccadic eye movement testing which include the ease of testing, ease of recording results and clearly understood neural substrates (Phillipou et al., 2014). The dorsolateral prefrontal cortex and anterior cingulate cortex are involved in these types of eye movements and have also been identified as contributing to the role of executive functioning. Specific areas of executive function include behavioral control and suppression of responses, attention, decision-making and self-monitoring of error recognition (Phillipou et al., 2014). Schulte and Müller-Oehring (2010) also assert the integration of visuomotor and cognitive processes, focusing on the corpus callosum and its contribution to this interhemispheric process. Thus even in the face of a mild injury, subtle changes in the processing of sensory, cognitive, and motor abilities may be present.

Academic Impact

According to DeMatteo, Stazyk, Giglia, Mahoney, Singh, Hollenberg and Randall (2015) the main occupation of children is to be a student and to participate in and take part in school academically. School experiences are necessary for laying the groundwork for a child's future endeavors. It assists with the development of social skills as well as learning. Injuries from a TBI interfere with school attendance and performance, especially when recovery extends beyond an acute stage. It is recommended that athletes with possible concussion or concussive symptoms be identified so that academic assistance can be provided if services are needed (Gfroerer, Wade, & Wu, 2008; Glang, Todis, Thomas, Hood, Bedell and Cockrell, 2008). Even without clear evidence of concussion incidences, educators should be focused primarily on whether the injury has resulted in deficits impairing a child's ability to learn and develop (Hux et al., 2013). Wasserman et al. (2016) reported that academic dysfunction is a risk of academic challenges is higher if the player has experienced prior concussions.

In the pediatric population, the effects of concussion may not be apparent until academic skills begin to worsen and may be characterized by problems with behavior and cognitive functioning (Garcia-Rodriguez & Thomas, 2014). In addition to behavior problems and difficulty with cognitive functioning, students have reported complaints of somatosensory symptoms including headache, photosensitivity, blurred vision, balance problems and nausea. There may be long term consequences of concussion that are not recognized by school personnel but have detrimental effects on academic performance and behavior (Hux et al., 2013).

Academic accommodations are not uncommon and have been recommended for many years for students with health and/or academic needs. Accommodations or adaptations may be temporary or permanent but all should be individualized with the purpose of providing support to students. Support should reduce barriers and increase support that allows for improved school performance (Lyons, Moore, Guiney, Ayyagari, Thompson, Rivara & Vavilala, 2017). Returning to the classroom after concussion should be addressed as a monitored process. This process begins after a period of cognitive rest, and then proceeds with a gradual increase in cognitive tasks (Baker, Rieger, McAvoy, Leddy, Master, Lana & Willer, 2014; Irvine, Babul & Goldman, 2017). Researchers recommend cognitive tasks remain sub-threshold for symptoms. That is, while increasing the cognitive and environmental demands of a classroom, cognitive activities should not rise to the level of symptom complaints. Examples of accommodations include reduced workload, shortened class day, longer time for taking tests, and communication with school personnel and family members (Baker et al., 2014). (see Appendix F). Figure 1 illustrates a gradual increase in academic demands. It begins with preparation for returning to the classroom to full academic status with each step requiring monitoring. The rate of advancement through each stage depends on the student's rate of recovery. Accommodation recommendations vary and are based on student needs. The goal of RTL is for the student to return to and maintain their prior level of academic performance.

Baker et al. (2014) recommends communication between all members of the team of professionals working with the concussed student. Crawford and Sirmon-Taylor (2014), agree with this and make the point of including the speech language pathologist (SLP) as part of the multidisciplinary team assisting with cognitive communicative issues and recommendations.

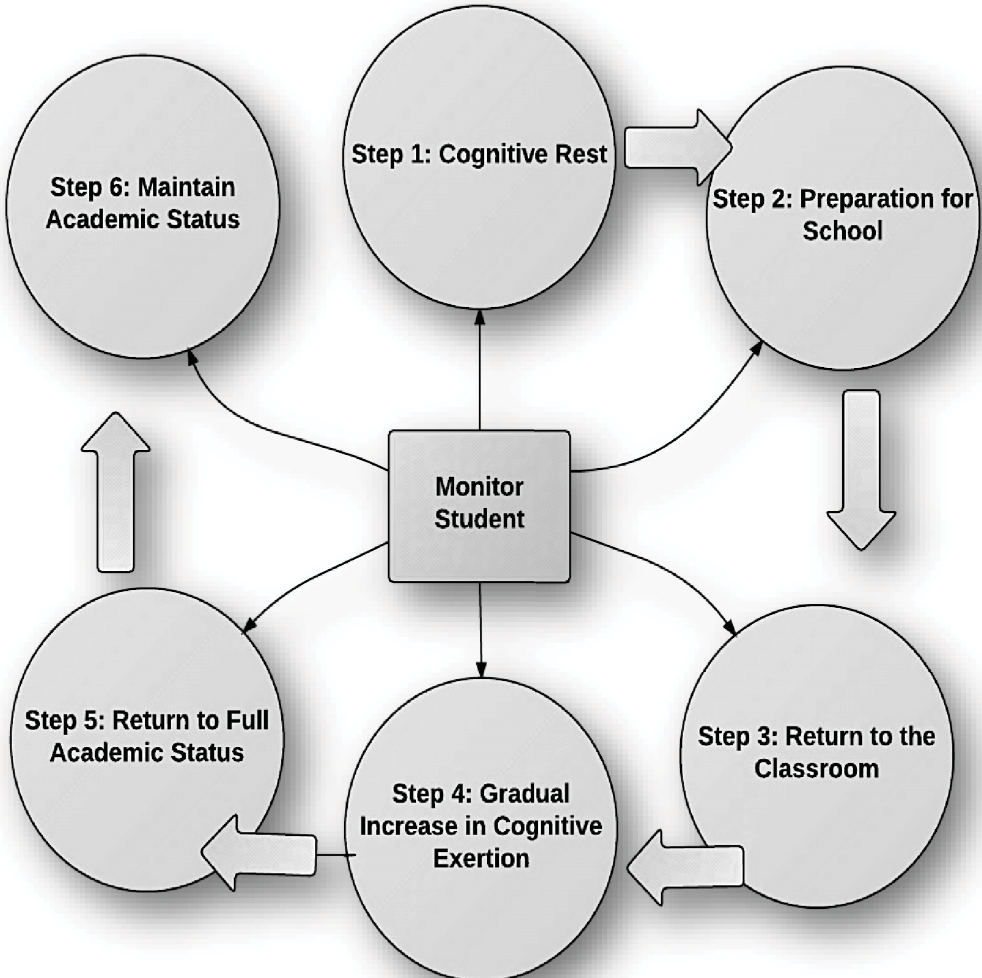

Figure 1: Return to learn figure providing step-by-step reintegration to school monitoring. Step 1 through step 6 requires monitoring of the player's tolerance to increased academic demands.

The Role of Speech Language Pathology in Concussion Evaluation and Management

SLP's have been providing services to individuals with TBI for many years. Because of the history of TBI services, it is important to understand how the SLP might function in terms of concussion management. The role of the SLP is an important component in concussion management as part of a multidisciplinary team (Crawford & Sirmon-Taylor 2014). The authors reviewed the role of SLP throughout the continuum of care, from acute care stage through outpatient rehabilitation. They determined that the initial therapeutic need is limited based on recommendations for brain rest and the use of screening tools; however, the therapeutic need expands during the recovery process. Given the SLP's availability in educational settings as well as medical settings, they are poised to have an important role in the management of concussion across multiple environments (Knollman, Constantinidou & Hutchinson, 2014; Salvatore, 2014). The SLP has expertise in assessment, diagnosing, and management of cognitive disorders related to mTBI, e.g., memory problems, reduced attention skills, and executive dysfunction (Riedeman & Turkstra, 2018). They are also assist with recommendations for accommodations and adaptations in the classroom (Dachtyl & Morales, 2017; Duff & Struck, 2015), as well as an important voice for determination of return to play readiness.

Return to Play

The two main issues necessitating the need for further research include the risk of repeated injury and overuse which complicate the decision-making process regarding RTP (Echemendia et al., 2015; Giza & Hovda, 2001). Premature RTP and premature RTL as defined by Carson et al. (2014), is the recurrence or worsening of symptoms experienced by players participating in sport activities and/or the classroom environment without allowing sufficient time for recovery and symptom resolution. In other words, returning the player to physical and mental exertion tasks that are beyond their tolerance level, which may result in increased symptomology. The question remains as to whether there is a system for monitoring a concussed players tolerance for increased exertion by use of symptom reporting. Carson et al. (2014) sought to determine the proportion of the concussed athlete population that experiences an exacerbation of symptoms as a result of premature RTP and RTL. The authors demonstrated that 43.5% of students RTP too soon and 44.7% of students RTL too quickly. This puts the player at risk of prolonged recovery by not allowing for symptom resolution. Sprouse, Harris, Sprouse, Humerick, & Miller (2016) recommend a standardized protocol for determination of RTP. This process includes the removal of the player from play immediately after a concussive injury has occurred in order to complete a sideline assessment. Guidelines should also stipulate not returning the player to the game in which the player sustained an injury and with RTP following a step-by-step plan (Darling et al., 2015). Along with assessment tasks, a step-wise plan is provided with the SCAT-3 and SCAT-5 tools (see Appendices C & D).

The risk of returning a player to the field before complete recovery has occurred is more than just prolonging the duration of recovery, but actually may reinjure the brain or extend the physical injury. Those risks are second impact syndrome (SIS) and chronic traumatic encephalopathy (CTE). With the condition of SIS, the brain is thought to lose its ability to auto-regulate back to its baseline levels of cerebral blood flow, metabolic levels and intracranial pressures. This condition may result in cerebral edema and cell death (Bey & Ostick, 2009). CTE as a neurodegenerative disease that is associated with head trauma (Guay et al., 2016; Maroon, Winkelman, Bost, Amos, Mathyssek & Meile, 2015; Shively, Egerton, Iacono, Purohit, Qu, Haroutian & Perl, 2017). This condition is relatively difficult to diagnose without autopsy and is characterized by the presence of abnormal tau in neurons of the brain. The abnormal accumulation of tau is historically related to conditions such as Alzheimer's disease (Ling, Neals & Revesz, 2017). Exposure of the brain to contact during an injury or recovery state, may have long term repercussions for the injured player.

Conclusion

The results of this study will be used to answer the following questions:

1) Are there differences in the types of sport concussion symptoms between males and females?
2) Are there differences in the severity of sport concussion symptoms between males and females?
3) Are there differences in the duration of sport concussion symptoms between males and female?

Based on these questions, the following hypotheses were generated:

1) Females will have complaints of cognitive, behavioral and somatosensory symptoms. Males will have complaints of cognitive and somatosensory symptoms.
2) Females with report a higher level of symptom severity when compared to males.
3) Females will report a longer duration of symptom complaints when compared to males.

Chapter III

METHODOLOGY

The primary goal of this study was to answer questions regarding gender differences in concussive injuries of high school soccer athletes. These differences included the type of symptoms and the severity of each symptom reported by the athlete. The instrument used for the study were the SCAT-3 and SCAT-5 with data being collected at baseline and on the field of play or in the Athletic Training Room (ATR) after a concussive event.

Research Design

The research methodology was a retrospective cohort design. Data were collected from the 2015, 2016 and 2017 soccer seasons from northern Indiana's South Bend school corporation, Union North school corporation, and Edwardsburg, Michigan school corporation. The independent variable was gender. The dependent variables included the type and severity of symptoms reported.

Procedure

Data collection focused on symptoms reported by the concussed soccer player that included the player's perception of symptom severity and symptom type rating. Symptoms were grouped into three main categories: cognitive, behavioral, and somatosensory. Data were recorded via an electronic record, SportsWareOnLine (SWOL) (https://www.swol123.net/) by each school's athletic trainers (AT): two ATs were present at the practices and games. The AT's collecting of and recording of data was based on training and an ongoing oversight of the South Bend, Indiana sport medicine clinic; the clinic was part of Beacon Medical Group. The AT's were certified and had met the standards of the medical clinic. They also followed Indiana's Athletic High School Association (IHSSA) (www.ihsaa.org) guidelines. (see Appendix E).

Selection of Participants

This study was approved by the Beacon Health System Institutional Review Board prior to recruitment of participants (see Appendices A and B). Participants for this study included 23 male and 15 female high school student players from the school corporations noted previously. The participants' ages ranged from 14 to 18 years and were comprised of diverse ethnic groups. All participants were soccer players at the varsity and junior varsity levels. The inclusion criteria consisted of all concussive injuries being associated with soccer, either during competitive play or during practice. A self-reported history of no more than two prior concussions and no history of mental health problems or special education services were also required for inclusion in this study. If there were greater than three prior concussions or a history of mental health problems or special education services, the participant(s) was excluded from the study. Additional exclusion criteria included a history of brain injuries associated with an event other than soccer, e.g., motor vehicle accidents, falls, or other sports. Players with suspected concussive injuries in which he/she was removed from the game or from practice for monitoring but not being diagnosed with concussion were excluded.

Instrumentation

The instrument utilized was the SCAT-3 (see Appendix C) and SCAT-5 (see Appendix D). All sections of the instrument were administered at baseline, prior to the beginning of the soccer season, immediately after a concussive injury and at daily intervals, Monday through Friday, after injury. There was variation among the different school corporations to the number and interval with which the protocols were administered; therefore, day one symptom reporting (immediately post-concussion), as well as variable intervals of post-concussion symptoms were collected for this study.

The SCAT-3 and SCAT-5 include a symptom questionnaire, a cognitive assessment, a balance assessment and a coordination assessment. The symptom questionnaire is a Likert-type scale requiring athletes to measure their perception of the severity of each symptom they are experiencing. Severity is rated on a six-point number scale, with "0" meaning no symptoms being rated, "1-2" indicates mild severity, "3-4: indicates moderate severity, and a "5-6" refers to a severe rating (Baker et al., 2016). All self-reported symptoms as well as balance and coordination evaluations were administered by AT's in the ATR. The AT's were trained in the administration of the SCAT-3 and SCAT-5.

Data Collection

The data were collected in the ATR or equivalent if the players were at an away game. The AT's administered the SCAT-3 version of the sport concussion assessment tool if the athlete had been tested with that edition previously; otherwise, the SCAT-5 was administered. The concussed player used an iPad for rating their symptoms with monitoring by the AT. Per the SCAT-5 symptom evaluation, this is noted as self-rated with clinician monitored. This process was followed for all data collection periods; daily evaluations with the AT until cleared by a physician for RTP are required after a player has been diagnosed with a concussion. The AT's transcribed the results on a data collection form (see Appendix G).

In order to determine differences in symptomatic reporting between males and females, a Kruskal Wallis *H* test was completed. The data for males and females were analyzed individually using a Spearman's rho correlation to examine trends in the symptoms reported by each gender.

Chapter IV

RESULTS

The purpose of this study was to describe gender differences in concussion symptoms of high school soccer players. In order to compare the type, severity, days until asymptomatic and number of concussion symptoms, the results of a self-rated concussion questionnaire were utilized. Concussion data were collected by AT's from three school corporations in northern Indiana and southern Michigan. Concussion symptoms include 22 signs and behaviors that were categorized according to cognitive, behavioral, and somatosensory types, as shown in Table 1.

Demographics

Participant demographics are reported in Table 3 and includes the total number of participants for each gender. The ages for all participants ranged from 14 to 18 years.

Table 3: Subject totals by gender

Subjects	Total *n=38*	%
Male	23	60.52
Female	15	39.48

As shown in Table 4, the majority of concussive injuries occurred during a game. Because of the self-reporting nature of symptoms and prior concussions, the full concussive history for each participant is not known. Only 23% of the participants reported a history of prior concussion(s) (see Table 5). For those that reported prior concussive injuries, no specific information regarding circumstances, severity of injury, symptom types, duration or recovery, or time since onset were available.

Table 4: Comparison of concussion injury suffered during a game, practice or unknown/not stated.

Concussion Sustained	Male *n*=23	Female *n*=15
Game	12	8
Practice	2	3
Unknown/Not stated	9	4

Table 5. History of concussion reported by male and female players.

Concussion History	Male *n*=23	Female *n*=15
Prior Concussion	5	2
No History of Concussion	7	4
Unknown/Not reported	11	9

Symptom Comparisons Day 1

For all symptom categories, cognitive, behavioral, and somatosensory, females generally reported increased severity in comparison to males on day one of sustaining a concussive injury (see Table 6). Comparison of cognitive symptoms are shown in Figure 2; the results of the Kruskal-Wallis *H* test revealed no significant difference in severity ratings between males and females (see Appendix H). With regard to behavioral symptoms, females reported significantly higher ratings for "being more emotional" compared to males ($H(1) = .009$, $p < .01$) (see Figure 3). Within the somatosensory category, severity ratings of "don't feel right" ($H(1) = .071$, $p < .05$), neck pain ($H(1) = .012$, $p < .05$), and dizziness ($H(1) = .051$, $p < .05$) were significantly higher for females than males. These data are depicted in Figure 4.

Table 6: Frequency of reported symptom averaged and compared by gender.

Symptoms *n=22*	Males *n*=23	Females *n*=15
Headache	17 (74%)	11 (73%)
Pressure in head	13 (56.52%)	7 (46.47%)
Neck pain	1 (.04%)	6 (40%)
Nausea or vomiting	3 (13.04%)	6 (40%)
Dizziness	8 (34.78%)	10 (66.67%)
Blurred vision	6 (26.08%)	6 (40%)
Balance problems	7 (30.34%)	6 (40%)
Sensitivity to light	11 (47.82%)	7 (46.67%)
Sensitivity to noise	8 (34.78%)	8 (53.33%)
Feeling slowed down	10 (43.47%)	6 (40%)
Feeling like in a fog	6 (26.08%)	8 (53.33%)
Don't feel right	9 (39.19%)	9 (60%)
Difficulty concentrating	7 (30.34%)	6 (40%)
Difficulty remembering	8 (34.78%)	5 (33.33%)
Fatigue or low energy	8 (34.78%)	8 (53.33%)
Confusion	4 (17.39%)	5 (33.33%)
Drowsiness	6 (26.08%)	8 (53.33%)
More emotional	0 (0%)	5 (33.33%)
Irritability	5 (21.73%)	4 (26.66%)
Sadness	1 (.04%)	3 (20%)
Nervous or anxious	3 (13.04%)	4 (26.66%)
Trouble falling asleep	1 (.04%)	2 (13.33%)

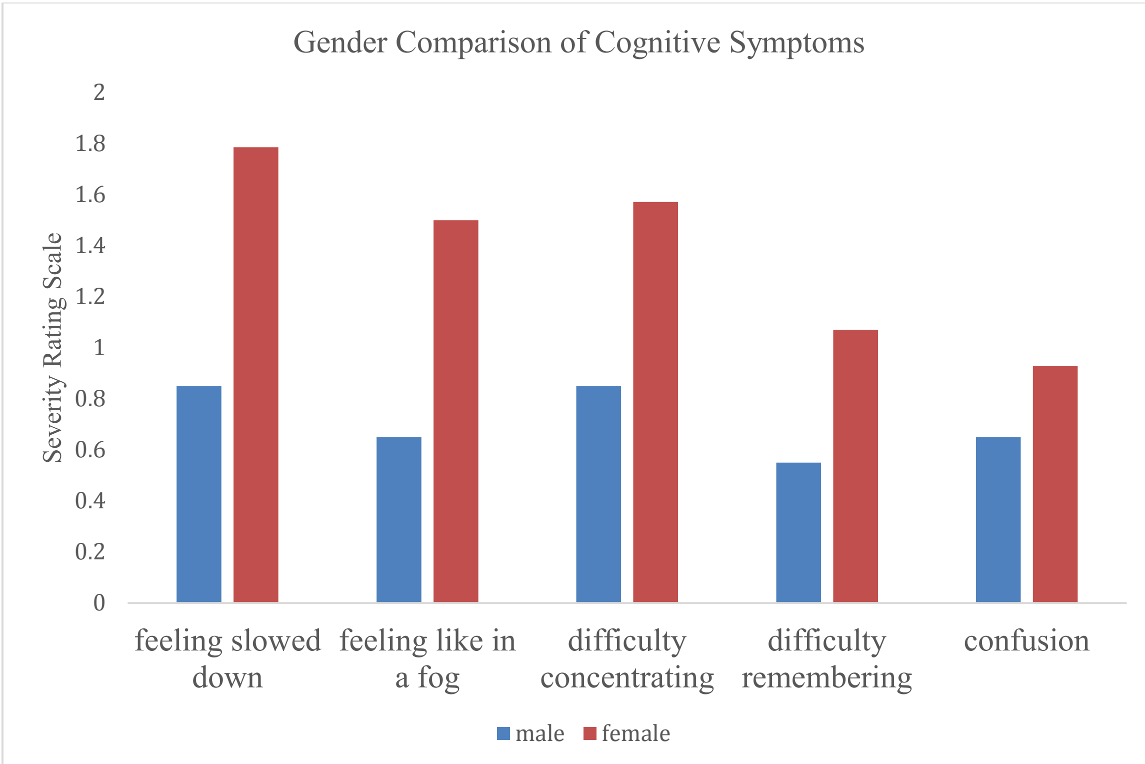

Figure 2: Gender comparison of cognitive symptoms

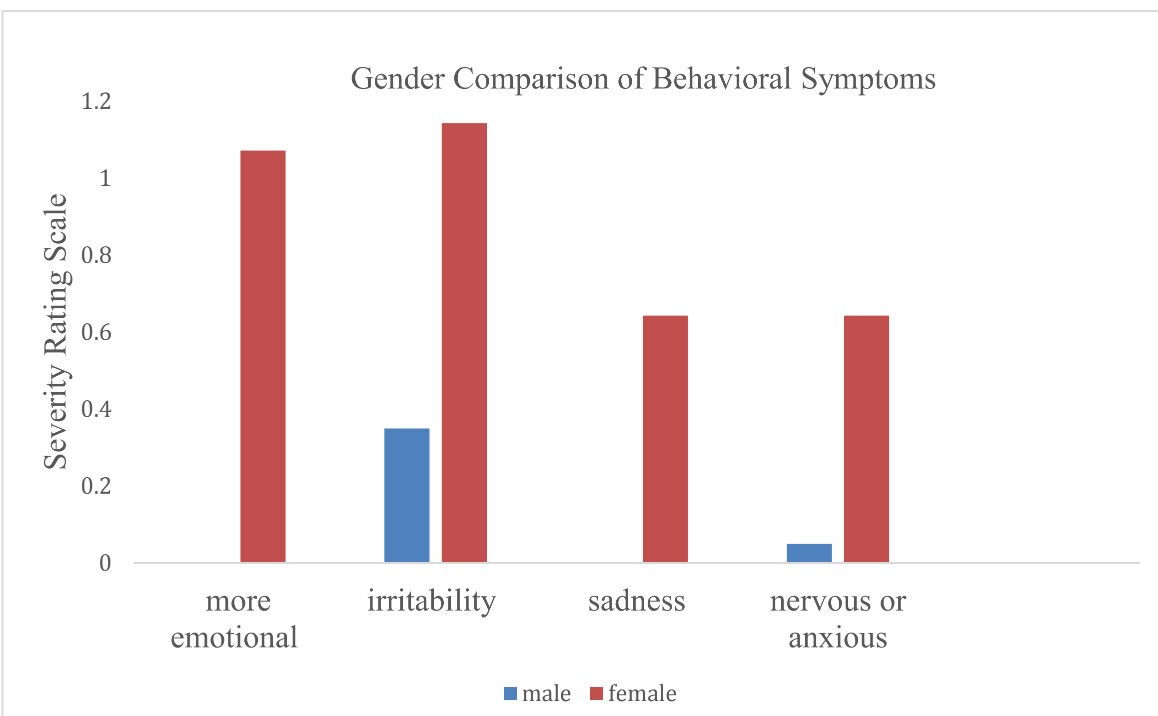

Figure 3: Gender comparison of behavioral symptoms

The behavioral symptoms of more emotional and irritability reflected the majority of ratings for female players. Consistent with the previous categories of symptoms (cognitive and behavioral) females reported higher levels of severity for all symptoms.

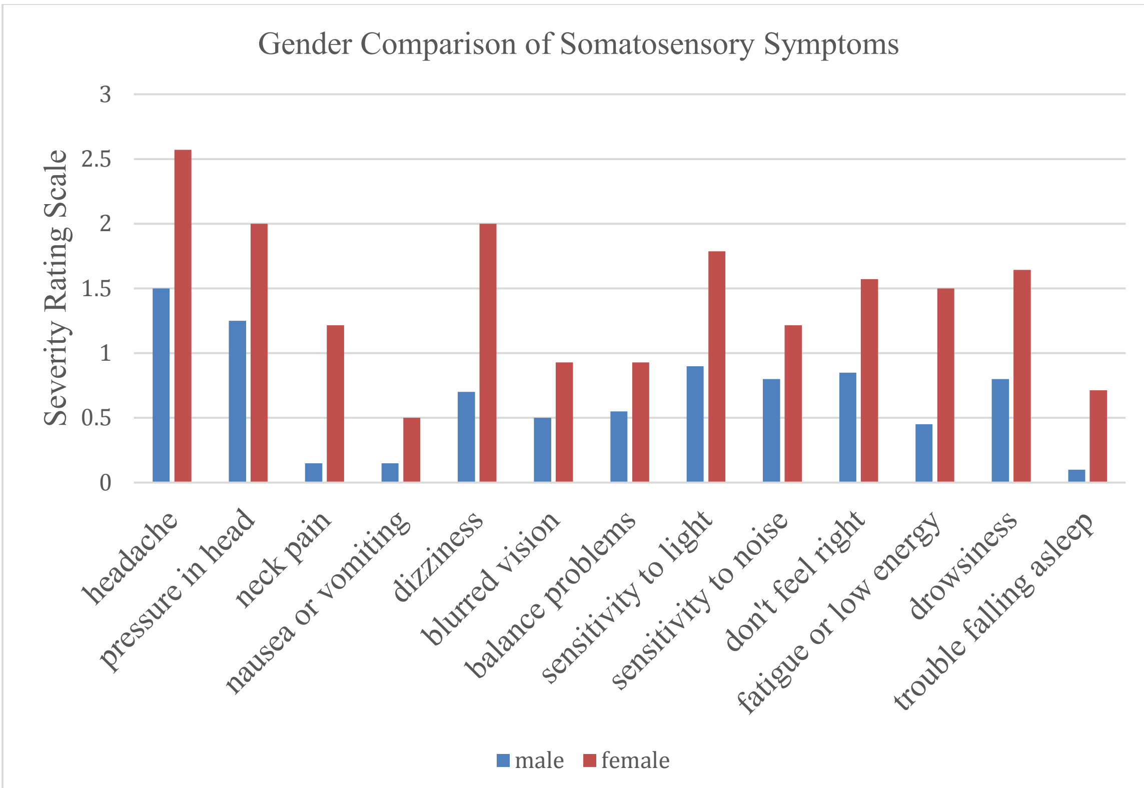

Figure 4: Gender comparison of somatosensory symptoms

As shown in Table 5, the most frequently reported symptom for both males (73.9%) and females (73%) was headache. The pressure in head was the next most frequently reported symptom for male players (56.52%), while dizziness (67.7%) and "don't feel right" were the second and third most common symptoms among females. The remaining symptoms were reported by half or less than half of the players. Individual female players also reported a greater number of symptoms than male players.

Correlation of Male Symptomology

The relationship between symptoms was analyzed by gender using a Spearman's rho (r_s) correlation procedure for each gender. Male cognitive symptom correlations revealed five symptoms that correlated significantly with difficulty concentrating; these included "feeling slowed down" ($r_s = .572$, $p < .01$), feeling like "in a fog" ($r_s = .518$, $p < .05$), don't feel right ($r_s = .862$, $p < .01$), difficulty remembering ($r_s = .849$, $p < .01$) and confusion ($r_s = .784$ $p < .01$). The symptom of feeling slowed down was correlated significantly with three other cognitive symptoms, feeling like "in a fog" ($r_s = .638$, $p < .01$,) don't feel right ($r_s = .594$, $p < .01$), and difficulty concentrating ($r_s = .572$, $p < .01$).

Male behavioral symptoms correlations revealed that no male players reported the symptom of being more emotional. The behavioral symptom that correlated significantly with the symptom of sadness was nervous or anxious ($r_s = .725$, $p < .01$).

Several male somatosensory symptoms showed significant correlations were identified with the symptom of headache for nine other somatosensory symptoms; these symptoms included pressure in head ($r_s = .655$, $p < .01$), nausea or vomiting ($r_s = .487$ $p < .05$), dizziness ($r_s = .472$, $p < .05$). Sensitivity to light ($r_s = .489$, $p < .05$), sensitivity to noise ($r_s = .699$, $p < .01$), don't feel right ($r_s = .647$, $p < .01$), fatigue or low energy ($r_s = .505$, $p < .05$), and irritability ($r_s = .443$, $p < .05$). Balance problems were significantly correlated with six other symptoms including pressure in head ($r_s = .751$, $p < .01$), dizziness ($r_s = .853$, $p < .01$), blurred vision ($r_s =$. 512, $p < .05$), sensitivity to light ($r_s = .696$, $p < .01$), don't feel right ($r_s = .600$, $p < .01$), fatigue or low energy ($r_s = .478$, $p < .05$), and drowsiness ($r_s = .658$, $p < .01$). The symptom of light sensitivity was significantly correlated to nine other somatosensory symptoms including headache ($r_s = .489$, $p < .05$), pressure in head ($r_s = .484$, $p < .05$), dizziness ($r_s = .659$, $p < .01$), blurred vision (r_s = .555, $p < .01$), balance problems (r_s = .696, $p < .01$), don't feel right (r_s = .667, $p < .01$), fatigue or low energy (r_s = .751, $p < .01$), drowsiness (r_s = .829, $p < .01$) and irritability (r_s = .691, $p < .01$).

Correlation of Female Symptomology

Spearman's rho (r_s) ranking for female cognitive symptoms revealed the symptom of difficulty concentrating correlates significantly with four other cognitive symptoms including: feeling slowed down (r_s = .841, $p < .01$), feeling like "in a fog" (r_s = .527, $p < .05$), difficulty remembering (r_s = .687, p <. 01) and confusion (r_s = .764, $p < .01$). The symptom of feeling slowed down correlated significantly to four other cognitive symptoms including feeling like "in a fog" (r_s = .574, $p < .01$), difficulty concentrating (r_s = .841, $p < .01$), difficulty remembering (r_s = .563, $p < .01$), and confusion (r_s = .809, $p < .01$).

The correlation of female behavioral symptoms is showed the symptom of sadness was correlated significantly to two other behavioral symptoms, including being more emotional (r_s = .788, $p < .01$), irritability (r_s = .758, $p < .01$), and nervous or anxious (r_s = .687, $p < .01$).

The correlations of female somatosensory symptoms revealed four somatosensory symptoms were correlated significantly to the symptom of headache; these included, pressure in head (r_s = .589, $p < .01$), dizziness (r_s = .500, $p < .05$), blurred vision (r_s = .464, $p < .05$), and sensitivity to light (r_s = .480, $p < .05$). Dizziness correlated significantly with nine other symptoms including headache (r_s = .500, $p < .05$), pressure in head (r_s = .711, $p < .01$), blurred vision (r_s = .489, $p < .05$), balance (r_s = .633, $p < .01$), sensitivity to light (r_s = .668, $p < .01$), sensitivity to noise (r_s = .453, $p < .05$), don't feel right (r_s = .720, $p < .01$), fatigue or low energy (r_s = .795, $p < .01$), and drowsiness (r_s = .744, $p < .01$). Sensitivity to light correlated significantly to the other somatosensory symptoms of headache (r_s = .480, $p < .05$), pressure in head (r_s = .810, p < .01), dizziness (r_s = .668, p < .01), blurred vision (r_s = .444, p < .05), balance problems (r_s = .776, p < .01), don't feel right (r_s = .692, p < .01), fatigue or low energy (r_s = .878, p <. 01), confusion (r_s = .567, p < .01), and drowsiness (r_s = .773, p < .01).

The results of the Kruskal Wallis *H* test revealed significant differences in specific symptoms of all three category types. Females reported the cognitive symptom of "don't feel right" ($H(1)$ = .071, p < .05) and the behavioral symptoms of "being more emotional" ($H(1)$ = .009, p < .01) more frequently than males. Females were also more likely to report the somatosensory symptoms of neck pain ($H(1)$ = .012, p < .05) and dizziness ($H(1)$ = .051, p < .05). Complete Kruskal Wallis *H* results are provided in Appendix I-J.

Duration of Symptoms

For both male and female concussed players, symptom ratings were collected in order to track recovery for RTL and RTP. For males, symptoms were reported for 18 days and for females, 34 days. According to the policy for tracking and recording symptoms (see Appendix E), these should have been daily recordings. It is not known why this was not the case.

Male Symptom Duration

Male symptoms were recorded for 18 days. The tracking of symptoms appeared less standardized; symptoms were recorded for various participants for the first nine days post-concussion, with days 1-9 being reported, as well as day 18. Not all male players were recorded each day; number of symptoms, days recorded, percentages, and averages severity rating scale numbers are shown in Table 7. For all male concussed players, they were recorded as being asymptomatic by day 18.

Table 7. Male duration and severity of symptom recording, days recorded and percentages

Day of symptom recording for males	Number of players rating symptoms	Percentage recorded	Severity rating average
Day 1	23	100%	0.58
Day 2	6	26.08%	0.61
Day 3	6	26.08%	0.36
Day 4	2	11.50%	0.75
Day 5	1	0.04%	0.91
Day 6	3	13.04%	0.38
Day 7	2	11.50%	0.30
Day 8	1	0.04%	0.45
Day 9	1	0.04%	0.18
Day 18	1	0.04%	0.00

For all symptoms recorded, after day one there was inconsistency with number of players being recorded and frequency of recording. Cognitive and somatosensory symptoms persisted for a longer duration of time when compared to behavioral symptoms. Although all symptoms (cognitive, behavioral, and somatosensory) were resolved by day 18, it is not known if some of the symptoms were resolved before 18 days as there were 11 days between the two final days of recording.

Female Symptom Duration

As stated previously with the male players, female players were not tracked consistently for the duration of their concussion recoveries. It is also important to note that although the female players were recorded for 32 days post-concussion, not all players were asymptomatic. At no point during reporting of somatosensory symptoms did female players report being asymptomatic. That is, somatosensory symptoms were consistently being reported. The female player that was tracked until day 32 reported somatosensory data for days 1, 5, 30, 31 and day 32 only. It is not known why this information was not available. Table 8 shows number of symptoms, days recorded, percentages, and averages severity rating scale numbers.

Table 8. Female duration and severity of symptom recording, days recorded and percentages

Days of female symptom recording	Number of players rating symptoms	Percentages recorded	Severity rating average
Day1	15	100%	1.31
Day 2	7	46.47%	0.75
Day 3	4	26.66%	0.44
Day 4	2	13.33%	1.39
Day 5	4	26.66%	1.26
Day 6	1	0.06%	0.05
Day 7	1	0.06%	0.18
Day 8	2	13.33%	0.27
Day 9	2	13.33%	0.09
Day 10	3	0.20%	0.02
Day 11	1	0.06%	0.00
Day 12	2	13.33%	0.02
Day 14	1	0.06%	0.00
Day 22	1	0.06%	0.77
Day 25	1	0.06%	0.00
Day 30	1	0.06%	4.41
Day 31	1	0.06%	3.45
Day 32	1	0.06%	3.18

Chapter V

DISCUSSION

Current Research

Many studies have sought to address the issue of gender differences in concussive injuries and symptomology with the expectation of clarifying identification and management of these differences. Comparisons of sport-related concussive injuries are not always possible due to lack availability of female players in high contact sports such as football. Because the mechanism of injury is different among different sports such as rotational forces and velocity of impact as well as different protective equipment per sport, comparisons and generalizations are difficult (Covassin et al., 2013). By choosing the sport of soccer, comparisons of gender differences in concussion symptoms were possible. Covassin et al. (2013) and Colvin et al. (2009) compared gender differences in soccer-related concussions, including concussive histories and neurocognitive performances. The researchers were able to demonstrate increased symptom reporting by females related to number, and severity as well as a longer duration of recovery. There were inconsistencies in the type of symptoms reported by each gender. According to Preiss-Farzanegan, Chapman, Wong, Wu, and Bazarian (2009) differences in concussive injuries between genders does not appear to be related to age, concussion history, type of symptom reporting, LOC, or type of sport. Additional research to determine why females are at a higher risk of PCS needs to be pursued in an effort to improve treatment and outcomes.

The findings of this study are significant in that they describe gender differences in concussion symptoms in high school soccer players as reported via a self-rated symptom questionnaire. The two populations are not the same in terms of perceived concussive injuries. Differences include number of symptoms, types of symptoms and level of severity of symptoms with female reporting a greater number and increased severity for each symptom type in comparison to males.

Player Understanding of Concussion

The understanding of concussion and subsequent concussive symptoms is important for players as they may be putting themselves at risk for additional injury otherwise. Lack of understanding of concussions and its sequela may lead to players not recognizing concussive symptoms or even reporting symptoms, subsequently putting themselves at risk by continuing to play while they are symptomatic (Register-Mihalik, Guskiewicz, Valovich, Linnan, Mueller & Marshall, 2013). Ideally this would increase their reporting and compliance with academic and sporting recommendations. Education of concussive injuries and symptomology to players as well as coaches and school personnel will increase awareness, identification of concussion and compliance of recommendations for improved outcomes.

Comorbid Conditions

Comorbid conditions should be included when assessing the concussed adolescent (Albanese, Boffa, Macatee, & Schmidt, 2017; Grady, 2010; Stewman, Liebman, Fink & Sandello, 2018). These symptoms may be caused by the concussion or event but not necessarily the brain injury itself. Comorbid conditions are described as attention deficit hyperactivity disorder (ADHD), migraine headaches, sleep disturbances, mood disorders including but not limited to anxiety and depression. According to Silver (2012) and Sprouse et al. (2016)

comorbid conditions may influence symptom reporting. The symptoms may be caused by the concussion or event but not necessarily the brain injury itself. These researches demonstrated the influencing role of psychological factors, specifically anxiety which indirectly impacted concussive symptom reporting. Stewman et al. (2018) asserted that ADHD, if present, has symptomology that is also associated with symptoms of concussion. The approach to diagnosis and management of concussion may benefit from awareness of ADHD as this may affect decision-making regarding RTP and RTL.

Debate and study of the obsessive and compulsive personality traits in the athletic population is not new to researchers (Hauck & Blumenthal, 1992). While it is well accepted that exercise improves psychological health, more information is needed to understand the negative implications of exercise, that is the addiction to it (Lichtenstein, Nielsen, Gudex, Hinze, & Jørgensen, 2018; Landolfi, 2013). That is, the continuing to participate in exercise even in the presence of injury as well as other aspects in life e.g. family issues, time constraints or work demands. Researchers have considered the need for control in this area of the athlete's life (exercise) while other areas are out of their control (Landolfi, 2013). According to Lichtenstein et al. (2018) and Weinstein, Maayan, and Weinstein (2015), exercise addition that is, compulsive exercise is related to emotions such as depression and anxiety. Compulsive exercise is differentiated from a "normal" level of exercise in that it goes beyond recreation or health purposes. Researchers state that for some, exercise helps to alleviate anxiety, for others exercise may not be effective for this to occur (Rex and Metzler, 2016; Weinstein et al., 2015). This raises a concern that those experiencing higher levels of anxiety may be more prone to injuries (Rex and Metzler, 2016).

An athlete's mental health should be considered when managing concussive injuries as this may be a factor in symptom recognition, reporting as well as compliance with recommendations towards RTP and RTL.

Influence of Method on Symptom Reporting

Symptoms that are reported after a concussive injury may be varied based on the method implemented for gathering that information: thus care should be taken to ensure a consistent method of collecting symptom information (Cripps & Bohman 2015; Krol, Mrazik, Naidu, Brooks & Iverson, 2011). If a pre-injury assessment is completed with a written survey or a face-to-face interview, the post injury assessment information should be collected the same way. The authors further assert that method of reporting should be considered in information gathering. Cripps and Bohman (2015) concluded that electronically based symptom reporting results in a higher number of symptoms in comparison to verbal and paper-based self-rating scales. Villemire et al. (2011) expanded this topic comparing self-reported symptoms versus those that were reported in an interview format. That is the spontaneous reporting versus suggested reporting of concussive symptoms. Consistently subjects reported more symptoms during the interview (suggested) format although their reported symptoms were not the same for each method type. This is important to note as it supports the concept of a self-rated symptom checklist. By allowing a player to rate symptoms consistent with concussion, they are able to determine the presence and level of severity they may be experiencing after injury.

Gender Differences in Reporting

Although little is known regarding the consistency of concussion symptom or concussion history reporting in the high school population, researchers have determined that self-reporting is relatively reliable between males and females in this population (Wojtowicz, Iverson, Silverberg, Mannix, Zafonte, Maxwell & Berkner, 2017). Sandel et al. (2016) cautioned against using male-based research outcomes for female concussed adolescents asserting that regardless of the sport played, males reported fewer concussive symptoms when compared to females. This was also the case with this study. Females reported more symptoms than males at a higher level of severity for a longer duration of time.

Other considerations, according to Léveillé, Guay, Blais, Scherzer and De Beaumont (2017) and Williams and Wood (2010) relate to emotional recognition of the behavioral symptoms of concussion when males are reporting symptoms. For both concussed and non-concussed subjects, Léveillé et al. (2017) asserted better emotional recognition in females as opposed to males. This was found to be the case with this study as well. Males reported fewer behavioral symptoms than females, reporting no symptoms of more emotional and only .04% reported sadness.

The question regarding the differences in symptom reporting between males and female after concussion remains. The neurophysiology between genders may play a role in these differences as hormonal responses to trauma are varied. Other issues that may explain the differences relate to physical size and strength of the players. Even with subconcussive forces, females may perceive more symptoms of concussion based on size and speed of head acceleration. It should be noted that the psychological backgrounds of the players in this study were unknown. Because of that, it is not clear as to whether anxiety, depression or obsessive compulsive behaviors played a role in reporting or at minimum, discernment of prior issues compared to acute change.

Limitations

By limiting the study to high school soccer players, the external validity does not allow for generalization to other players with sport related concussions. Another limitation to the study is the small sample size, which also limits generalization. The ATs in this study all held Master's degrees in kinesiology and psychology and were working in a sports medicine clinic at the time of this study. Therefore, their knowledge of concussion and compliance with sport medicine and school corporation protocols may not be generalized to smaller athletic programs. The compliance of the players following through with recommendations after their injuries and their motivation for underreporting symptoms due to unawareness or personal pressures not to report.

The study utilized self-reported data in a retrospective format. This design limited control of additional questions and clarification of concussion history. It is not clear whether the concussed players were involved in other sporting activities or if they had academic accommodations post-concussion. The inconsistency of data collection was also an issue with this study. Given that the data were collected from different school corporations, there were inconsistencies in terms of frequency of data collection for both male and female players as well as the duration of symptom recording. The reason for these differences is not known, this was true for both males and females.

Another limitation is the small sample group. Even though the data were collected from three school corporations for a total of six high schools, the total number of concussed players for three soccer seasons was 38. Because of the small number of athletes as well as focusing only on high school soccer players, results cannot be generalized to concussions sustained during other sports or by athletes of different age ranges. The results of the study do support the need for additional research on this topic as the questions still remain as to whether or not there are differences in symptoms and if this pattern may lead to gender specific concussion protocols.

Delimitations

The delimitations in this study were selected in order to gain an understanding of concussive sport-related injury differences between males and female soccer players in order to improve standardized protocols. The study focuses on high school aged soccer players in a northern Indiana school, limiting generalization to private school players, players in other locations in the state, and other sports or concussive etiologies. The school corporation was selected based on convenience, the AT's history of compliance with school protocols and the use of a reliable and valid sport concussion-screening tool.

Unexpected Results

It is unclear as to why the symptom of trouble falling asleep was included during the initial symptom rating. Question as to whether these were players that had experienced prior concussions and may have residual unresolved symptoms of a sleep disturbance related to that. It is also not clear if whether these players were reporting a symptom related to comorbid issues not related to the concussive injury.

Two other issues need to be considered as well, the involvement of the ATs and sports medicine physicians and the nacebo effect. As noted previously, AT oversight for the players with their advanced education and involvement of sports medicine physicians may have influenced the reporting by the players. That is, the concussed players may have reported more accurately their injuries based on their own knowledge and athletic support. The players may have over-reported their symptom ranking because of the interest, discussion, and daily follow-up by the AT's and sports medicine physicians.

The nacebo effect is the occurrence of adverse reactions that appear to result from a benign stimulus. According to Silver (2015), the injured player may be expecting to have problems. This assumption, the nocebo effect results in increased perception of severity, which results in symptom amplification or possibly the reporting of symptoms not caused by the concussive injury.

Future Directions

Concussive injuries are a part of daily life whether the injury results from car accidents, falls or sporting event participation. Clarifying terminology, management protocols, RTL and RTP procedures continue to require additional research. Based on this study, ongoing research should focus on sex differences in concussions in terms of type and severity of symptoms, duration of recovery, and standardization of program management.

Other areas of study should include follow-up evaluations to monitor long-term recovery and health-related quality of life. This may be most important for adolescents as they continue to develop through school, social relationships, and vocational pursuits.

In addition, improvement of athletic training, management of contact during practice in terms of reducing frequency, focus on sub-concussive events and ongoing research into protective equipment and adherence to player restrictions after being removed from play is recommended.

As the population increases their activities and participation in sports, researchers will continue to study injuries, protective equipment and protocols for the best prevention and management of concussions. In recent years, advances have been made in the identification of concussions and development of protocols for returning to the classroom and returning to the field of play. There are concerns regarding long term repercussions of concussion and whether this results in chronic neurological and cognitive deficits and reduced overall quality of life. Improvements need to continue to be made regarding standardization of emergency department treatment for mTBI cases that include acute treatment as well as clear follow-up recommendations. Increased awareness of comorbid conditions and possible sex differences in type, frequency, and severity of symptoms as well as duration of recovery will improve the outcome of this population.

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Appendix A

Memorial Hospital Internal Review Board

Appendix A

Memorial Hospital Internal Review Board

MEMORIAL HOSPITAL
Institutional Review Board

Expedited Date: November 21, 2017

Investigator: Karin Thomas
56750 Mulberry Road
Lakeville, IN 46536

Protocol Title: **Gender Differences in Concussion Symptoms in High School Soccer Players**

The Memorial Hospital IRB conducted an expedited review of the above mentioned protocol.

As Chair, it is my pleasure to inform you that your research Protocol (Dated 11/20/17), has been approved by the Board for an initial one year period commencing on 11/20/2017 and continuing until 11/19/2018.

Memorial Hospital operates in accordance with federal regulations; our assurance number is FWA 00005819.

The board determined that the above study is in compliance with 21 CFR part 50, subpart D (Additional Safeguards for Children in Clinical Investigations)

Section 50.51- Clinical investigation does not involve greater than minimal risk

Section 50.55 Requirements for permission by parents or guardians and for assent by children.

- Informed consent will be done by the parents or guardians. Assent by children is not applicable.

Section 50.56 Wards

- Not applicable

Please be advised that an annual progress report will be required. The IRB must also be notified of significant adverse events that are felt to be protocol related. Thank you for your interest in conducting research in our community. If you are in need of additional information, please feel free to contact me at (574) 647-7370 or adombkowski@beaconhealthsystem.org with any questions.

☐ **Full Board IRB Approval**

☑ **Expedited IRB Approval**

Sincerely,

Alicia Dombkowski
Alicia Dombkowski
IRB Chair

11/20/17
Date

615 N. Michigan St. | South Bend, IN 46601 | qualityoflife.org

Appendix B

Memorial Hospital Internal Review Board Revision

Appendix B

Memorial Hospital Internal Review Board Revision

MEMORIAL HOSPITAL

Institutional Review Board

Meeting Date: February 28, 2018

Investigator: Karin Thomas
56750 Mulberry Road
Lakeville, IN 46536

Protocol Title: **Gender Differences in Concussion Symptoms in High School Soccer Players**

The Memorial Hospital IRB acknowledges receipt and approval of the attached **Amendment dated January 23, 2018**.

Memorial Hospital operates in accordance with federal regulations; our assurance number is FWA 00005819.

The board determined that the above study is in compliance with 21 CFR part 50, subpart D (Additional Safeguards for Children in Clinical Investigations)

Section 50.51- Clinical investigation does not involve greater than minimal risk

Section 50.55 Requirements for permission by parents or guardians and for assent by children.

- Informed consent will be done by the parents or guardians. Assent by children is not applicable.

Section 50.56 Wards

- Not applicable

Feel free to contact me at (574) 647-7370 or adombkowski@beaconhealthsystem.org with any questions.

☑**Full Board IRB Approval**

☐ **Expedited IRB Approval**

Sincerely,

Alicia Dombkowski — 2/28/18

Alicia Dombkowski
IRB Chair

Date

615 N. Michigan St. | South Bend, IN 46601 | qualityoflife.org

Appendix C

Sports Concussion Assessment Tool-3rd Edition

Appendix C

Sports Concussion Assessment Tool-3rd Edition

SCAT3™

FIFA® IIHF FEI

Sport Concussion Assessment Tool – 3rd Edition

For use by medical professionals only

Name

Date/Time of Injury:
Date of Assessment:

Examiner:

What is the SCAT3?[1]

The SCAT3 is a standardized tool for evaluating injured athletes for concussion and can be used in athletes aged from 13 years and older. It supersedes the original SCAT and the SCAT2 published in 2005 and 2009, respectively[2]. For younger persons, ages 12 and under, please use the Child SCAT3. The SCAT3 is designed for use by medical professionals. If you are not qualified, please use the Sport Concussion Recognition Tool[1]. Preseason baseline testing with the SCAT3 can be helpful for interpreting post-injury test scores.

Specific instructions for use of the SCAT3 are provided on page 3. If you are not familiar with the SCAT3, please read through these instructions carefully. This tool may be freely copied in its current form for distribution to individuals, teams, groups and organizations. Any revision or any reproduction in a digital form requires approval by the Concussion in Sport Group.

NOTE: The diagnosis of a concussion is a clinical judgment, ideally made by a medical professional. The SCAT3 should not be used solely to make, or exclude, the diagnosis of concussion in the absence of clinical judgement. An athlete may have a concussion even if their SCAT3 is "normal".

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific signs and/or symptoms (some examples listed below) and most often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (e.g., headache), or
- Physical signs (e.g., unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour (e.g., change in personality).

SIDELINE ASSESSMENT

Indications for Emergency Management

NOTE: A hit to the head can sometimes be associated with a more serious brain injury. Any of the following warrants consideration of activating emergency procedures and urgent transportation to the nearest hospital:

- Glasgow Coma score less than 15
- Deteriorating mental status
- Potential spinal injury
- Progressive, worsening symptoms or new neurologic signs

Potential signs of concussion?

If any of the following signs are observed after a direct or indirect blow to the head, the athlete should stop participation, be evaluated by a medical professional and **should not be permitted to return to sport the same day** if a concussion is suspected.

Any loss of consciousness?	Y N
"If so, how long?" ________	
Balance or motor incoordination (stumbles, slow/laboured movements, etc.)?	Y N
Disorientation or confusion (inability to respond appropriately to questions)?	Y N
Loss of memory:	Y N
"If so, how long?" ________	
"Before or after the injury?" ________	
Blank or vacant look:	Y N
Visible facial injury in combination with any of the above:	Y N

1 Glasgow coma scale (GCS)

Best eye response (E)	
No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4
Best verbal response (V)	
No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5
Best motor response (M)	
No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion/Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6
Glasgow Coma score (E + V + M)	of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

2 Maddocks Score[3]

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

What venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week/game?	0	1
Did your team win the last game?	0	1
Maddocks score		of 5

Maddocks score is validated for sideline diagnosis of concussion only and is not used for serial testing.

Notes: Mechanism of Injury ("tell me what happened"?):

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle until cleared to do so by a medical professional. No athlete diagnosed with concussion should be returned to sports participation on the day of Injury.

BACKGROUND

Name: ______________________ Date: ________________

Examiner: ____

Sport/team/school: ______________ Date/time of injury: __________

Age: ______________ Gender: M F

Years of education completed: ____________________

Dominant hand: right left neither

How many concussions do you think you have had in the past? __________

When was the most recent concussion? ______________

How long was your recovery from the most recent concussion? __________

Have you ever been hospitalized or had medical imaging done for a head injury? Y N

Have you ever been diagnosed with headaches or migraines? Y N

Do you have a learning disability, dyslexia, ADD/ADHD? Y N

Have you ever been diagnosed with depression, anxiety or other psychiatric disorder? Y N

Has anyone in your family ever been diagnosed with any of these problems? Y N

Are you on any medications? If yes, please list: Y N

SCAT3 to be done in resting state. Best done 10 or more minutes post excercise.

SYMPTOM EVALUATION

3 How do you feel?

"You should score yourself on the following symptoms, based on how you feel now".

	none	mild		moderate		severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22)

Symptom severity score (Maximum possible 132)

Do the symptoms get worse with physical activity? Y N

Do the symptoms get worse with mental activity? Y N

self rated · self rated and clinician monitored

clinician interview · self rated with parent input

Overall rating: If you know the athlete well prior to the injury, how different is the athlete acting compared to his/her usual self?

Please circle one response:

no different	very different	unsure	N/A

Scoring on the SCAT3 should not be used as a stand-alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion. Since signs and symptoms may evolve over time, it is important to consider repeat evaluation in the acute assessment of concussion.

COGNITIVE & PHYSICAL EVALUATION

4 Cognitive assessment

Standardized Assessment of Concussion (SAC)[4]

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score		of 5

Immediate memory

List	Trial 1		Trial 2		Trial 3		Alternative word list		
elbow	0	1	0	1	0	1	candle	baby	finger
apple	0	1	0	1	0	1	paper	monkey	penny
carpet	0	1	0	1	0	1	sugar	perfume	blanket
saddle	0	1	0	1	0	1	sandwich	sunset	lemon
bubble	0	1	0	1	0	1	wagon	iron	insect
Total									

Immediate memory score total of 15

Concentration: Digits Backward

List	Trial 1		Alternative digit list		
4-9-3	0	1	6-2-9	5-2-6	4-1-5
3-8-1-4	0	1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0	1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0	1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6
Total of 4					

Concentration: Month in Reverse Order (1 pt. for entire sequence correct)

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan	0	1
Concentration score		of 5

5 Neck Examination:

Range of motion · Tenderness · Upper and lower limb sensation & strength

Findings: ________________________________

6 Balance examination

Do one or both of the following tests.

Footwear (shoes, barefoot, braces, tape, etc.) ______________

Modified Balance Error Scoring System (BESS) testing[5]

Which foot was tested (i.e. which is the **non-dominant** foot) Left Right

Testing surface (hard floor, field, etc.) ______________

Condition	
Double leg stance:	Errors
Single leg stance (non-dominant foot):	Errors
Tandem stance (non-dominant foot at back):	Errors

And/Or

Tandem gait[6,7]

Time (best of 4 trials): ________ seconds

7 Coordination examination

Upper limb coordination

Which arm was tested: Left Right

Coordination score of 1

8 SAC Delayed Recall[4]

Delayed recall score of 5

INSTRUCTIONS

Words in *Italics* throughout the SCAT3 are the instructions given to the athlete by the tester.

Symptom Scale

"You should score yourself on the following symptoms, based on how you feel now".

To be completed by the athlete. In situations where the symptom scale is being completed after exercise, it should still be done in a resting state, at least 10 minutes post exercise.
For total number of symptoms, maximum possible is 22.
For Symptom severity score, add all scores in table, maximum possible is 22 x 6 = 132.

SAC[4]

Immediate Memory

"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order."

Trials 2 & 3:

"I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before."

Complete all 3 trials regardless of score on trial 1 & 2. Read the words at a rate of one per second. **Score 1 pt. for each correct response.** Total score equals sum across all 3 trials. Do not inform the athlete that delayed recall will be tested.

Concentration

Digits backward

"I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7."

If correct, go to next string length. If incorrect, read trial 2. **One point possible for each string length**. Stop after incorrect on both trials. The digits should be read at the rate of one per second.

Months in reverse order

"Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November ... Go ahead"

1 pt. for entire sequence correct

Delayed Recall

The delayed recall should be performed after completion of the Balance and Coordination Examination.

"Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."

Score 1 pt. for each correct response

Balance Examination

Modified Balance Error Scoring System (BESS) testing[5]

This balance testing is based on a modified version of the Balance Error Scoring System (BESS)[5]. A stopwatch or watch with a second hand is required for this testing.

"I am now going to test your balance. Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of three twenty second tests with different stances."

(a) Double leg stance:

"The first stance is standing with your feet together with your hands on your hips and with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. I will start timing when you are set and have closed your eyes."

(b) Single leg stance:

"If you were to kick a ball, which foot would you use? [This will be the dominant foot] Now stand on your non-dominant foot. The dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

(c) Tandem stance:

"Now stand heel-to-toe with your non-dominant foot in back. Your weight should be evenly distributed across both feet. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

Balance testing – types of errors

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

Each of the 20-second trials is scored by counting the errors, or deviations from the proper stance, accumulated by the athlete. The examiner will begin counting errors only after the individual has assumed the proper start position. **The modified BESS is calculated by adding one error point for each error during the three 20-second tests. The maximum total number of errors for any single condition is 10.** If a athlete commits multiple errors simultaneously, only one error is recorded but the athlete should quickly return to the testing position, and counting should resume once subject is set. Subjects that are unable to maintain the testing procedure for a minimum of **five seconds** at the start are assigned the highest possible score, ten, for that testing condition.

OPTION: For further assessment, the same 3 stances can be performed on a surface of medium density foam (e.g., approximately 50 cm x 40 cm x 6 cm).

Tandem Gait[6,7]

Participants are instructed to stand with their feet together behind a starting line (the test is best done with footwear removed). Then, they walk in a forward direction as quickly and as accurately as possible along a 38mm wide (sports tape), 3 meter line with an alternate foot heel-to-toe gait ensuring that they approximate their heel and toe on each step. Once they cross the end of the 3m line, they turn 180 degrees and return to the starting point using the same gait. A total of 4 trials are done and the best time is retained. Athletes should complete the test in 14 seconds. Athletes fail the test if they step off the line, have a separation between their heel and toe, or if they touch or grab the examiner or an object. In this case, the time is not recorded and the trial repeated, if appropriate.

Coordination Examination

Upper limb coordination

Finger-to-nose (FTN) task:

"I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm (either right or left) outstretched (shoulder flexed to 90 degrees and elbow and fingers extended), pointing in front of you. When I give a start signal, I would like you to perform five successive finger to nose repetitions using your index finger to touch the tip of the nose, and then return to the starting position, as quickly and as accurately as possible."

Scoring: 5 correct repetitions in < 4 seconds = 1

Note for testers: Athletes fail the test if they do not touch their nose, do not fully extend their elbow or do not perform five repetitions. **Failure should be scored as 0.**

References & Footnotes

1. This tool has been developed by a group of international experts at the 4th International Consensus meeting on Concussion in Sport held in Zurich, Switzerland in November 2012. The full details of the conference outcomes and the authors of the tool are published in The BJSM Injury Prevention and Health Protection, 2013, Volume 47, Issue 5. The outcome paper will also be simultaneously co-published in other leading biomedical journals with the copyright held by the Concussion in Sport Group, to allow unrestricted distribution, providing no alterations are made.

2. McCrory P et al., Consensus Statement on Concussion in Sport – the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. British Journal of Sports Medicine 2009; 43: i76-89.

3. Maddocks, DL; Dicker, GD; Saling, MM. The assessment of orientation following concussion in athletes. Clinical Journal of Sport Medicine. 1995; 5(1): 32–3.

4. McCrea M. Standardized mental status testing of acute concussion. Clinical Journal of Sport Medicine. 2001; 11: 176–181.

5. Guskiewicz KM. Assessment of postural stability following sport-related concussion. Current Sports Medicine Reports. 2003; 2: 24–30.

6. Schneiders, A.G., Sullivan, S.J., Gray, A., Hammond-Tooke, G. & McCrory, P. Normative values for 16-37 year old subjects for three clinical measures of motor performance used in the assessment of sports concussions. Journal of Science and Medicine in Sport. 2010; 13(2): 196–201.

7. Schneiders, A.G., Sullivan, S.J., Kvarnstrom. J.K., Olsson, M., Yden. T. & Marshall, S.W. The effect of footwear and sports-surface on dynamic neurological screening in sport-related concussion. Journal of Science and Medicine in Sport. 2010; 13(4): 382–386

ATHLETE INFORMATION

Any athlete suspected of having a concussion should be removed from play, and then seek medical evaluation.

Signs to watch for

Problems could arise over the first 24–48 hours. The athlete should not be left alone and must go to a hospital at once if they:

- Have a headache that gets worse
- Are very drowsy or can't be awakened
- Can't recognize people or places
- Have repeated vomiting
- Behave unusually or seem confused; are very irritable
- Have seizures (arms and legs jerk uncontrollably)
- Have weak or numb arms or legs
- Are unsteady on their feet; have slurred speech

Remember, it is better to be safe.
Consult your doctor after a suspected concussion.

Return to play

Athletes should not be returned to play the same day of injury.
When returning athletes to play, they should be **medically cleared and then follow a stepwise supervised program,** with stages of progression.

For example:

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
No activity	Physical and cognitive rest	Recovery
Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity, 70 % maximum predicted heart rate. No resistance training	Increase heart rate
Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
Non-contact training drills	Progression to more complex training drills, eg passing drills in football and ice hockey. May start progressive resistance training	Exercise, coordination, and cognitive load
Full contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
Return to play	Normal game play	

There should be at least 24 hours (or longer) for each stage and if symptoms recur the athlete should rest until they resolve once again and then resume the program at the previous asymptomatic stage. Resistance training should only be added in the later stages.

If the athlete is symptomatic for more than 10 days, then consultation by a medical practitioner who is expert in the management of concussion, is recommended.

Medical clearance should be given before return to play.

Scoring Summary:

Test Domain	Score		
	Date: ______	Date: ______	Date: ______
Number of Symptoms of 22			
Symptom Severity Score of 132			
Orientation of 5			
Immediate Memory of 15			
Concentration of 5			
Delayed Recall of 5			
SAC Total			
BESS (total errors)			
Tandem Gait (seconds)			
Coordination of 1			

Notes:

CONCUSSION INJURY ADVICE

(To be given to the **person monitoring** the concussed athlete)

This patient has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. Recovery time is variable across individuals and the patient will need monitoring for a further period by a responsible adult. Your treating physician will provide guidance as to this timeframe.

If you notice any change in behaviour, vomiting, dizziness, worsening headache, double vision or excessive drowsiness, please contact your doctor or the nearest hospital emergency department immediately.

Other important points:

- Rest (physically and mentally), including training or playing sports until symptoms resolve and you are medically cleared
- No alcohol
- No prescription or non-prescription drugs without medical supervision. Specifically:
  - No sleeping tablets
  - Do not use aspirin, anti-inflammatory medication or sedating pain killers
- Do not drive until medically cleared
- Do not train or play sport until medically cleared

Clinic phone number

Patient's name ______

Date/time of injury ______

Date/time of medical review ______

Treating physician ______

Contact details or stamp

Appendix D

Sports Concussion Assessment Tool-5th Edition

Appendix D

Sports Concussion Assessment Tool-5th Edition

SCAT5©

SPORT CONCUSSION ASSESSMENT TOOL — 5TH EDITION
DEVELOPED BY THE CONCUSSION IN SPORT GROUP
FOR USE BY MEDICAL PROFESSIONALS ONLY

supported by

FIFA® FEI

Patient details

Name: ______________________________

DOB: ______________________________

Address: ______________________________

ID number: ______________________________

Examiner: ______________________________

Date of Injury: ____________________ Time: ____________________

WHAT IS THE SCAT5?

The SCAT5 is a standardized tool for evaluating concussions designed for use by physicians and licensed healthcare professionals[1]. The SCAT5 cannot be performed correctly in less than 10 minutes.

If you are not a physician or licensed healthcare professional, please use the Concussion Recognition Tool 5 (CRT5). The SCAT5 is to be used for evaluating athletes aged 13 years and older. For children aged 12 years or younger, please use the Child SCAT5.

Preseason SCAT5 baseline testing can be useful for interpreting post-injury test scores, but is not required for that purpose.Detailed instructions for use of the SCAT5 are provided on page 7. Please read through these instructions carefully before testing the athlete. Brief verbal instructions for each test are given in italics. The only equipment required for the tester is a watch or timer.

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Recognise and Remove

A head impact by either a direct blow or indirect transmission of force can be associated with a serious and potentially fatal brain injury. If there are significant concerns, including any of the red flags listed in Box 1, then activation of emergency procedures and urgent transport to the nearest hospital should be arranged.

Key points

- Any athlete with suspected concussion should be REMOVED FROM PLAY, medically assessed and monitored for deterioration. No athlete diagnosed with concussion should be returned to play on the day of injury.
- If an athlete is suspected of having a concussion and medical personnel are not immediately available, the athlete should be referred to a medical facility for urgent assessment.
- Athletes with suspected concussion should not drink alcohol, use recreational drugs and should not drive a motor vehicle until cleared to do so by a medical professional.
- Concussion signs and symptoms evolve over time and it is important to consider repeat evaluation in the assessment of concussion.
- The diagnosis of a concussion is a clinical judgment, made by a medical professional. The SCAT5 should NOT be used by itself to make, or exclude, the diagnosis of concussion. An athlete may have a concussion even if their SCAT5 is "normal".

Remember:

- The basic principles of first aid (danger, response, airway, breathing, circulation) should be followed.
- Do not attempt to move the athlete (other than that required for airway management) unless trained to do so.
- Assessment for a spinal cord injury is a critical part of the initial on-field assessment.
- Do not remove a helmet or any other equipment unless trained to do so safely.

Davis GA, *et al. Br J Sports Med* 2017;**51**:851–858. doi:10.1136/bjsports-2017-097506SCAT5 851

1

IMMEDIATE OR ON-FIELD ASSESSMENT

The following elements should be assessed for all athletes who are suspected of having a concussion prior to proceeding to the neurocognitive assessment and ideally should be done on-field after the first first aid / emergency care priorities are completed.

If any of the "Red Flags" or observable signs are noted after a direct or indirect blow to the head, the athlete should be immediately and safely removed from participation and evaluated by a physician or licensed healthcare professional.

Consideration of transportation to a medical facility should be at the discretion of the physician or licensed healthcare professional.

The GCS is important as a standard measure for all patients and can be done serially if necessary in the event of deterioration in conscious state. The Maddocks questions and cervical spine exam are critical steps of the immediate assessment; however, these do not need to be done serially.

STEP 1: RED FLAGS

RED FLAGS:

- **Neck pain or tenderness**
- **Double vision**
- **Weakness or tingling/ burning in arms or legs**
- **Severe or increasing headache**
- **Seizure or convulsion**
- **Loss of consciousness**
- **Deteriorating conscious state**
- **Vomiting**
- **Increasingly restless, agitated or combative**

STEP 2: OBSERVABLE SIGNS

Witnessed ☐ Observed on Video ☐

Lying motionless on the playing surface	Y	N
Balance / gait difficulties / motor incoordination: stumbling, slow / laboured movements	Y	N
Disorientation or confusion, or an inability to respond appropriately to questions	Y	N
Blank or vacant look	Y	N
Facial injury after head trauma	Y	N

STEP 3: MEMORY ASSESSMENT MADDOCKS QUESTIONS[2]

"I am going to ask you a few questions, please listen carefully and give your best effort. First, tell me what happened?"

____

____

Mark Y for correct answer / N for incorrect

What venue are we at today?	Y	N
Which half is it now?	Y	N
Who scored last in this match?	Y	N
What team did you play last week / game?	Y	N
Did your team win the last game?	Y	N

Note: Appropriate sport-specific questions may be substituted.

Name: ______________________

DOB: ______________________

Address: ______________________

ID number: ______________________

Examiner: ______________________

Date: ______________________

STEP 4: EXAMINATION GLASGOW COMA SCALE (GCS)[3]

Time of assessment			
Date of assessment			
Best eye response (E)			
No eye opening	1	1	1
Eye opening in response to pain	2	2	2
Eye opening to speech	3	3	3
Eyes opening spontaneously	4	4	4
Best verbal response (V)			
No verbal response	1	1	1
Incomprehensible sounds	2	2	2
Inappropriate words	3	3	3
Confused	4	4	4
Oriented	5	5	5
Best motor response (M)			
No motor response	1	1	1
Extension to pain	2	2	2
Abnormal flexion to pain	3	3	3
Flexion / Withdrawal to pain	4	4	4
Localizes to pain	5	5	5
Obeys commands	6	6	6
Glasgow Coma score (E + V + M)			

CERVICAL SPINE ASSESSMENT

Does the athlete report that their neck is pain free at rest?	Y	N
If there is NO neck pain at rest, does the athlete have a full range of ACTIVE pain free movement?	Y	N
Is the limb strength and sensation normal?	Y	N

In a patient who is not lucid or fully conscious, a cervical spine injury should be assumed until proven otherwise.

OFFICE OR OFF-FIELD ASSESSMENT

Please note that the neurocognitive assessment should be done in a distraction-free environment with the athlete in a resting state.

STEP 1: ATHLETE BACKGROUND

Sport / team / school: ______

Date / time of injury: ______

Years of education completed: ______

Age: ______

Gender: M / F / Other

Dominant hand: left / neither / right

How many diagnosed concussions has the athlete had in the past?: ______

When was the most recent concussion?: ______

How long was the recovery (time to being cleared to play) from the most recent concussion?: ______ (days)

Has the athlete ever been:

Hospitalized for a head injury?	Yes	No
Diagnosed / treated for headache disorder or migraines?	Yes	No
Diagnosed with a learning disability / dyslexia?	Yes	No
Diagnosed with ADD / ADHD?	Yes	No
Diagnosed with depression, anxiety or other psychiatric disorder?	Yes	No

Current medications? If yes, please list:

______

______

______

______

______

______

Name: ______

DOB: ______

Address: ______

ID number: ______

Examiner: ______

Date: ______

2

STEP 2: SYMPTOM EVALUATION

The athlete should be given the symptom form and asked to read this instruction paragraph out loud then complete the symptom scale. For the baseline assessment, the athlete should rate his/her symptoms based on how he/she typically feels and for the post injury assessment the athlete should rate their symptoms at this point in time.

Please Check: ☐ **Baseline** ☐ **Post-Injury**

Please hand the form to the athlete

	none	mild		moderate		severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6
Trouble falling asleep (if applicable)	0	1	2	3	4	5	6

Total number of symptoms:	of 22
Symptom severity score:	of 132
Do your symptoms get worse with physical activity?	Y N
Do your symptoms get worse with mental activity?	Y N
If 100% is feeling perfectly normal, what percent of normal do you feel?	

If not 100%, why?

______

______

______

Please hand form back to examiner

3

STEP 3: COGNITIVE SCREENING

Standardised Assessment of Concussion (SAC)[4]

Name: ______________________

DOB: ______________________

Address: ______________________

ID number: ______________________

Examiner: ______________________

Date: ______________________

ORIENTATION

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score		of 5

IMMEDIATE MEMORY

The Immediate Memory component can be completed using the traditional 5-word per trial list or optionally using 10-words per trial to minimise any ceiling effect. All 3 trials must be administered irrespective of the number correct on the first trial. Administer at the rate of one word per second.

Please choose EITHER the 5 or 10 word list groups and circle the specific word list chosen for this test.

I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order. For Trials 2 & 3: I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before.

List	Alternate 5 word lists					Score (of 5)		
						Trial 1	Trial 2	Trial 3
A	Finger	Penny	Blanket	Lemon	Insect			
B	Candle	Paper	Sugar	Sandwich	Wagon			
C	Baby	Monkey	Perfume	Sunset	Iron			
D	Elbow	Apple	Carpet	Saddle	Bubble			
E	Jacket	Arrow	Pepper	Cotton	Movie			
F	Dollar	Honey	Mirror	Saddle	Anchor			
					Immediate Memory Score			of 15
					Time that last trial was completed			

List	Alternate 10 word lists					Score (of 10)		
						Trial 1	Trial 2	Trial 3
G	Finger	Penny	Blanket	Lemon	Insect			
	Candle	Paper	Sugar	Sandwich	Wagon			
H	Baby	Monkey	Perfume	Sunset	Iron			
	Elbow	Apple	Carpet	Saddle	Bubble			
I	Jacket	Arrow	Pepper	Cotton	Movie			
	Dollar	Honey	Mirror	Saddle	Anchor			
					Immediate Memory Score			of 30
					Time that last trial was completed			

CONCENTRATION

DIGITS BACKWARDS

Please circle the Digit list chosen (A, B, C, D, E, F). Administer at the rate of one digit per second reading DOWN the selected column.

I am going to read a string of numbers and when I am done, you repeat them back to me in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7.

Concentration Number Lists (circle one)					
List A	List B	List C			
4-9-3	5-2-6	1-4-2	Y	N	0
6-2-9	4-1-5	6-5-8	Y	N	1
3-8-1-4	1-7-9-5	6-8-3-1	Y	N	0
3-2-7-9	4-9-6-8	3-4-8-1	Y	N	1
6-2-9-7-1	4-8-5-2-7	4-9-1-5-3	Y	N	0
1-5-2-8-6	6-1-8-4-3	6-8-2-5-1	Y	N	1
7-1-8-4-6-2	8-3-1-9-6-4	3-7-6-5-1-9	Y	N	0
5-3-9-1-4-8	7-2-4-8-5-6	9-2-6-5-1-4	Y	N	1
List D	List E	List F			
7-8-2	3-8-2	2-7-1	Y	N	0
9-2-6	5-1-8	4-7-9	Y	N	1
4-1-8-3	2-7-9-3	1-6-8-3	Y	N	0
9-7-2-3	2-1-6-9	3-9-2-4	Y	N	1
1-7-9-2-6	4-1-8-6-9	2-4-7-5-8	Y	N	0
4-1-7-5-2	9-4-1-7-5	8-3-9-6-4	Y	N	1
2-6-4-8-1-7	6-9-7-3-8-2	5-8-6-2-4-9	Y	N	0
8-4-1-9-3-5	4-2-7-9-3-8	3-1-7-8-2-6	Y	N	1
		Digits Score:			of 4

MONTHS IN REVERSE ORDER

Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November. Go ahead.

Dec - Nov - Oct - Sept - Aug - Jul - Jun - May - Apr - Mar - Feb - Jan	0 1
Months Score	of 1
Concentration Total Score (Digits + Months)	of 5

4

STEP 4: NEUROLOGICAL SCREEN

See the instruction sheet (page 7) for details of test administration and scoring of the tests.

Can the patient read aloud (e.g. symptom check-list) and follow instructions without difficulty?	Y	N
Does the patient have a full range of pain-free PASSIVE cervical spine movement?	Y	N
Without moving their head or neck, can the patient look side-to-side and up-and-down without double vision?	Y	N
Can the patient perform the finger nose coordination test normally?	Y	N
Can the patient perform tandem gait normally?	Y	N

BALANCE EXAMINATION

Modified Balance Error Scoring System (mBESS) testing[5]

Which foot was tested (i.e. which is the non-dominant foot) ☐ Left ☐ Right

Testing surface (hard floor, field, etc.) ______

Footwear (shoes, barefoot, braces, tape, etc.) ______

Condition	Errors
Double leg stance	of 10
Single leg stance (non-dominant foot)	of 10
Tandem stance (non-dominant foot at the back)	of 10
Total Errors	of 30

Name: ______

DOB: ______

Address: ______

ID number: ______

Examiner: ______

Date: ______

5

STEP 5: DELAYED RECALL:

The delayed recall should be performed after 5 minutes have elapsed since the end of the Immediate Recall section. Score 1 pt. for each correct response.

Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order.

Time Started ______

Please record each word correctly recalled. Total score equals number of words recalled.

______

______

______

Total number of words recalled accurately: of 5 or of 10

6

STEP 6: DECISION

	Date & time of assessment:		
Domain			
Symptom number (of 22)			
Symptom severity score (of 132)			
Orientation (of 5)			
Immediate memory	of 15 of 30	of 15 of 30	of 15 of 30
Concentration (of 5)			
Neuro exam	Normal Abnormal	Normal Abnormal	Normal Abnormal
Balance errors (of 30)			
Delayed Recall	of 5 of 10	of 5 of 10	of 5 of 10

Date and time of injury: ______

If the athlete is known to you prior to their injury, are they different from their usual self?
☐ **Yes** ☐ **No** ☐ **Unsure** ☐ **Not Applicable**
(If different, describe why in the clinical notes section)

Concussion Diagnosed?
☐ **Yes** ☐ **No** ☐ **Unsure** ☐ **Not Applicable**

If re-testing, has the athlete improved?
☐ **Yes** ☐ **No** ☐ **Unsure** ☐ **Not Applicable**

I am a physician or licensed healthcare professional and I have personally administered or supervised the administration of this SCAT5.

Signature: ______

Name: ______

Title: ______

Registration number (if applicable): ______

Date: ______

SCORING ON THE SCAT5 SHOULD NOT BE USED AS A STAND-ALONE METHOD TO DIAGNOSE CONCUSSION, MEASURE RECOVERY OR MAKE DECISIONS ABOUT AN ATHLETE'S READINESS TO RETURN TO COMPETITION AFTER CONCUSSION.

CLINICAL NOTES:

Name: ______
DOB: ______
Address: ______
ID number: ______
Examiner: ______
Date: ______

CONCUSSION INJURY ADVICE

(To be given to the person monitoring the concussed athlete)

This patient has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. Recovery time is variable across individuals and the patient will need monitoring for a further period by a responsible adult. Your treating physician will provide guidance as to this timeframe.

If you notice any change in behaviour, vomiting, worsening headache, double vision or excessive drowsiness, please telephone your doctor or the nearest hospital emergency department immediately.

Other important points:

Initial rest: Limit physical activity to routine daily activities (avoid exercise, training, sports) and limit activities such as school, work, and screen time to a level that does not worsen symptoms.

1) Avoid alcohol

2) Avoid prescription or non-prescription drugs without medical supervision. Specifically:

   a) Avoid sleeping tablets

   b) Do not use aspirin, anti-inflammatory medication or stronger pain medications such as narcotics

3) Do not drive until cleared by a healthcare professional.

4) Return to play/sport requires clearance by a healthcare professional.

Clinic phone number: ______

Patient's name: ______

Date / time of injury: ______

Date / time of medical review: ______

Healthcare Provider: ______

Contact details or stamp

Davis GA, *et al. Br J Sports Med* 2017;**51**:851–858. doi:10.1136/bjsports-2017-097506SCAT5

INSTRUCTIONS

Words in *Italics* throughout the SCAT5 are the instructions given to the athlete by the clinician

Symptom Scale

The time frame for symptoms should be based on the type of test being administered. At baseline it is advantageous to assess how an athlete "typically" feels whereas during the acute/post-acute stage it is best to ask how the athlete feels at the time of testing.

The symptom scale should be completed by the athlete, not by the examiner. In situations where the symptom scale is being completed after exercise, it should be done in a resting state, generally by approximating his/her resting heart rate.

For total number of symptoms, maximum possible is 22 except immediately post injury, if sleep item is omitted, which then creates a maximum of 21.

For Symptom severity score, add all scores in table, maximum possible is 22 x 6 = 132, except immediately post injury if sleep item is omitted, which then creates a maximum of 21x6=126.

Immediate Memory

The Immediate Memory component can be completed using the traditional 5-word per trial list or, optionally, using 10-words per trial. The literature suggests that the Immediate Memory has a notable ceiling effect when a 5-word list is used. In settings where this ceiling is prominent, the examiner may wish to make the task more difficult by incorporating two 5–word groups for a total of 10 words per trial. In this case, the maximum score per trial is 10 with a total trial maximum of 30.

Choose one of the word lists (either 5 or 10). Then perform 3 trials of immediate memory using this list.

Complete all 3 trials regardless of score on previous trials.

"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order." The words must be read at a rate of one word per second.

Trials 2 & 3 MUST be completed regardless of score on trial 1 & 2.

Trials 2 & 3:

"I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before."

Score 1 pt. for each correct response. Total score equals sum across all 3 trials. Do NOT inform the athlete that delayed recall will be tested.

Concentration

Digits backward

Choose one column of digits from lists A, B, C, D, E or F and administer those digits as follows:

Say: *"I am going to read a string of numbers and when I am done, you repeat them back to me in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7."*

Begin with first 3 digit string.

If correct, circle "Y" for correct and go to next string length. If incorrect, circle "N" for the first string length and read trial 2 in the same string length. One point possible for each string length. Stop after incorrect on both trials (2 N's) in a string length. The digits should be read at the rate of one per second.

Months in reverse order

"Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November ... Go ahead"

1 pt. for entire sequence correct

Delayed Recall

The delayed recall should be performed after 5 minutes have elapsed since the end of the Immediate Recall section.

"Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."

Score 1 pt. for each correct response

Modified Balance Error Scoring System (mBESS)[5] testing

This balance testing is based on a modified version of the Balance Error Scoring System (BESS)[5]. A timing device is required for this testing.

Each of 20-second trial/stance is scored by counting the number of errors. The examiner will begin counting errors only after the athlete has assumed the proper start position. The modified BESS is calculated by adding one error point for each error during the three 20-second tests. The maximum number of errors for any single condition is 10. If the athlete commits multiple errors simultaneously, only one error is recorded but the athlete should quickly return to the testing position, and counting should resume once the athlete is set. Athletes that are unable to maintain the testing procedure for a minimum of five seconds at the start are assigned the highest possible score, ten, for that testing condition.

OPTION: For further assessment, the same 3 stances can be performed on a surface of medium density foam (e.g., approximately 50cm x 40cm x 6cm).

Balance testing – types of errors

1. Hands lifted off iliac crest	3. Step, stumble, or fall	5. Lifting forefoot or heel
2. Opening eyes	4. Moving hip into > 30 degrees abduction	6. Remaining out of test position > 5 sec

"I am now going to test your balance. Please take your shoes off (if applicable), roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of three twenty second tests with different stances."

(a) Double leg stance:

"The first stance is standing with your feet together with your hands on your hips and with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. I will start timing when you are set and have closed your eyes."

(b) Single leg stance:

"If you were to kick a ball, which foot would you use? [This will be the dominant foot] *Now stand on your non-dominant foot. The dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

(c) Tandem stance:

"Now stand heel-to-toe with your non-dominant foot in back. Your weight should be evenly distributed across both feet. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

Tandem Gait

Participants are instructed to stand with their feet together behind a starting line (the test is best done with footwear removed). Then, they walk in a forward direction as quickly and as accurately as possible along a 38mm wide (sports tape), 3 metre line with an alternate foot heel-to-toe gait ensuring that they approximate their heel and toe on each step. Once they cross the end of the 3m line, they turn 180 degrees and return to the starting point using the same gait. Athletes fail the test if they step off the line, have a separation between their heel and toe, or if they touch or grab the examiner or an object.

Finger to Nose

"I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm (either right or left) outstretched (shoulder flexed to 90 degrees and elbow and fingers extended), pointing in front of you. When I give a start signal, I would like you to perform five successive finger to nose repetitions using your index finger to touch the tip of the nose, and then return to the starting position, as quickly and as accurately as possible."

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5. Guskiewicz KM. Assessment of postural stability following sport-related concussion. Current Sports Medicine Reports. 2003; 2: 24-30

CONCUSSION INFORMATION

Any athlete suspected of having a concussion should be removed from play and seek medical evaluation.

Signs to watch for

Problems could arise over the first 24-48 hours. The athlete should not be left alone and must go to a hospital at once if they experience:

- Worsening headache
- Drowsiness or inability to be awakened
- Inability to recognize people or places
- Repeated vomiting
- Unusual behaviour or confusion or irritable
- Seizures (arms and legs jerk uncontrollably)
- Weakness or numbness in arms or legs
- Unsteadiness on their feet.
- Slurred speech

Consult your physician or licensed healthcare professional after a suspected concussion. Remember, it is better to be safe.

Rest & Rehabilitation

After a concussion, the athlete should have physical rest and relative cognitive rest for a few days to allow their symptoms to improve. In most cases, after no more than a few days of rest, the athlete should gradually increase their daily activity level as long as their symptoms do not worsen. Once the athlete is able to complete their usual daily activities without concussion-related symptoms, the second step of the return to play/sport progression can be started. The athlete should not return to play/sport until their concussion-related symptoms have resolved and the athlete has successfully returned to full school/learning activities.

When returning to play/sport, the athlete should follow a stepwise, **medically managed exercise progression, with increasing amounts of exercise.** For example:

Graduated Return to Sport Strategy

Exercise step	Functional exercise at each step	Goal of each step
1. Symptom-limited activity	Daily activities that do not provoke symptoms.	Gradual reintroduction of work/school activities.
2. Light aerobic exercise	Walking or stationary cycling at slow to medium pace. No resistance training.	Increase heart rate.
3. Sport-specific exercise	Running or skating drills. No head impact activities.	Add movement.
4. Non-contact training drills	Harder training drills, e.g., passing drills. May start progressive resistance training.	Exercise, coordination, and increased thinking.
5. Full contact practice	Following medical clearance, participate in normal training activities.	Restore confidence and assess functional skills by coaching staff.
6. Return to play/sport	Normal game play.	

In this example, it would be typical to have 24 hours (or longer) for each step of the progression. If any symptoms worsen while exercising, the athlete should go back to the previous step. Resistance training should be added only in the later stages (Stage 3 or 4 at the earliest).

Written clearance should be provided by a healthcare professional before return to play/sport as directed by local laws and regulations.

Graduated Return to School Strategy

Concussion may affect the ability to learn at school. The athlete may need to miss a few days of school after a concussion. When going back to school, some athletes may need to go back gradually and may need to have some changes made to their schedule so that concussion symptoms do not get worse. If a particular activity makes symptoms worse, then the athlete should stop that activity and rest until symptoms get better. To make sure that the athlete can get back to school without problems, it is important that the healthcare provider, parents, caregivers and teachers talk to each other so that everyone knows what the plan is for the athlete to go back to school.

Note: If mental activity does not cause any symptoms, the athlete may be able to skip step 2 and return to school part-time before doing school activities at home first.

Mental Activity	Activity at each step	Goal of each step
1. Daily activities that do not give the athlete symptoms	Typical activities that the athlete does during the day as long as they do not increase symptoms (e.g. reading, texting, screen time). Start with 5-15 minutes at a time and gradually build up.	Gradual return to typical activities.
2. School activities	Homework, reading or other cognitive activities outside of the classroom.	Increase tolerance to cognitive work.
3. Return to school part-time	Gradual introduction of schoolwork. May need to start with a partial school day or with increased breaks during the day.	Increase academic activities.
4. Return to school full-time	Gradually progress school activities until a full day can be tolerated.	Return to full academic activities and catch up on missed work.

If the athlete continues to have symptoms with mental activity, some other accomodations that can help with return to school may include:

- Starting school later, only going for half days, or going only to certain classes
- More time to finish assignments/tests
- Quiet room to finish assignments/tests
- Not going to noisy areas like the cafeteria, assembly halls, sporting events, music class, shop class, etc.
- Taking lots of breaks during class, homework, tests
- No more than one exam/day
- Shorter assignments
- Repetition/memory cues
- Use of a student helper/tutor
- Reassurance from teachers that the child will be supported while getting better

The athlete should not go back to sports until they are back to school/learning, without symptoms getting significantly worse and no longer needing any changes to their schedule.

Appendix E

Concussion Policy and Procedure Document Beacon Medical Group Sports Medicine

Appendix E

Concussion Policy and Procedure Document Beacon Medical Group Sports Medicine

Beacon Medical Group Sports Medicine | POLICY / PROCEDURE DOCUMENT | Effective Date 08/19/2010

TITLE:	Concussion Assessment, Management, and Return to Play Guidelines

Document of (Entity) Beacon Medical Group Sports Medicine Athletic Trainers

POLICY:

The following policy and procedures on neurocognitive baseline testing and subsequent assessment and management of concussions as well as return to play guidelines has been developed in accordance with the goal of the Beacon Medical Group Sports Medicine athletic trainers to provide quality healthcare services and assure the well-being of each athlete treated by the athletic trainers employed by the Beacon Medical Group Sports Medicine.

PATIENT POPULATION:

Any patient thought to have a concussion.

PURPOSE:

The Beacon Medical Group Sports Medicine Clinic recognizes that sport related concussion pose a significant health risk for student-athletes. Therefore the Sports Medicine Athletic Trainers have implemented policies and procedures to deal with the assessment, management, and return to play (RTP) considerations for athletes who have sustained a concussive episode. In addition the Sports Medicine Athletic Trainers also recognize the importance of baseline testing on athletes who participate in sports which are recognized as contact or collision and/or who have a history of concussions upon entering athletic participation at their designated schools. Baseline concussion testing will consist of CogState Sport Computer Cognitive Assessment Tool (CCAT) testing; this information will be extremely useful in RTP decisions. The baseline data along with physical exam, diagnostic testing, symptom scaling, follow up testing and a gradual RTP protocol will all be used in conjunction with sound clinical judgment and on an individualized basis to determine when it is safe for an athlete to return to competition.

DEFINITION:

Concussion- A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.

- Direct blow or impulsive forces transmitted to the head
- Typically results in rapid onset of neurological impairments
- Functional injury: Not structural injury
- May or may no include loss of consciousness (LOC)
- Not always Identifiable on standard imaging (CT, MRI)

Mild Traumatic Brain Injury (mTBI)- All concussions are a form of mTBI, however not all mTBI's are concussions. The term mTBI and concussion should NOT be used interchangeably.

Post Concussion Syndrome- A set of symptoms which may last for weeks, months, or years following a concussion.

Second Impact Syndrome- Rare condition when an athlete sustains a second head injury before symptoms from the first have resolved, often fatal.

SIGNS and SYMPTOMS of CONCUSSION:

Certified athletic trainers need to be aware of the potential signs and symptoms of concussion in order to properly asses the injury and begin formal management. Symptoms can take seconds to hours to develop following a concussive injury.

Physical:	Cognitive:	Emotional:	Sleep:
Headache	Difficulty remembering	Behavioral changes	Sleep more than usual
LOC			
Fatigue	Difficulty concentrating	Irritability	Sleep less than usual
Dizziness			
Photophobia	Feeling slowed down	Sadness	Drowsiness
Nausea	Feeling in a fog	Feeling emotional	Trouble falling asleep
Sensitivity to Noise			
Vision difficulty	Slowed reaction times	Nervousness	
Balance Problems	Altered attention	Anxiety	
	Amnesia		

BASELINE ASSESMENT:

All athletes who are participating in those sports identified as collision or contact and/or who have had previous concussions identified by their health history should have a baseline neurocognitive test performed as a part of their athletic medical screening. Currently the Beacon Medical Group Sports Medicine utilizes the CogState Sport CCAT. The CogState Sport CCAT is a user friendly computer based program which has 4 modules which are designed to test multiple aspects of cognitive functioning. Some Beacon Medical Group Sports Medicine certified athletic trainers may also use the Standard Assessment of Concussion (SAC) cards along with the CogState Sport CCAT program as a baseline test.

Testing all High school and Collegiate athletes is the prerogative of each individual institution, but Beacon's minimal recommendations are listed below:

Football	M&W Soccer	M&W Basketball
Wrestling	College Hockey	College Lacrosse

MANAGEMENT:

In any circumstance where a concussion is suspected, the first priority is to remove the athlete from further participation until a thorough sideline exam can be performed. Furthermore if there is a concern of the mental state of clearing, the certified athletic trainer should err on the side of conservative assessment until the athlete can be examined by a physician. According to Senate Bill 222 any athlete suspected of a concussion is unable to return to play for 24 hours after the incident. If the athlete is diagnosed with a concussion they may NOT return to play until after 24 hours, a medical reevaluation and clearance by a physician. Athletic Directors and coaches will be apprised of the athlete's condition.

The recommendations in this documents for the management of concussion are based on the review of medical literature including but not limited to, Consensus Statement on Concussion in Sport – The IHSAA Protocol for Implementation of NFHS Sports Playing Rules for Concussions, The 3rd International Conference on Concussion in Sport held in Zurich, The National Athletic Trainers' Association Position Statement: Management of Sport-related Concussion, The 6th Annual Sports-Related Conference on Concussion and Spine Injury and NCAA Sports Medicine Handbook.

On Field/ Sideline Evaluation

1. In all cases in which a concussion is suspected the athlete should be removed from the athletic participation and a formal evaluation should take place.
   a) Athlete removed from field utilizing c-spine precautions and transported to emergency department (911 and Ambulance) if presents with:
      i) Prolonged LOC and/ or
      ii)Focal neurologic defect and/or
      iii) Significant alteration or deterioration in mental status.
   b) Athlete conscious and alert will be removed to the sideline for evaluation.

2. Sideline Evaluation
   a) Injury History (Hx), Date/time, previous concussion Hx recorded, etc.
   b) Verbal Symptom checklist
   c) Neurologic exam
      i) Cranial Nerve Assessment
      ii) Upper and lower quarter screen
   d) Neurocognitive test- (possibly the SAC/SCAT 2/SCAT 3, may vary by ATC)
   e) Coordination examination
      i)Finger to nose task
   f) Gait Coordination
      i) Tandem walk

3. Following the sideline evaluation, continue serial monitoring every 5 minutes Until released to responsible adult or further medical care.
   (Hold football helmet if needed to keep athlete from participation)

4. At the 15 min mark repeat examination.
   a) If the athlete is thought to have a concussion, has any symptoms and/or does not pass any portion of the sideline evaluation, the athlete is to remain out from participation.
   b) If athlete reports and increase and/ or prolonged altered mental status and/or focal neurological deficit emergency care and neuroimaging may be warranted.

Athletic Training Room (ATR) Clinic Evaluation

1. Any athlete who is suspected to have sustained a concussion will be required to report to the school's athletic training room (ATR) or equivalent if traveling, for a more formal evaluation.

2. Clinic evaluation will consist of:
   a) Graded symptoms check list
   b) Neurologic exam
   c) Coordination test
   d) SCAT 2 or 3 Test (on a regular basis until asymptomatic)

3. A physician evaluation will also be scheduled (varies by institution) or the athlete will need to schedule a physician evaluation.

4. Prior to leaving the ATR the athlete or athlete's parents will be given a home instructions sheet, and given instruction on what to do should their condition deteriorate.

Level 3 – Non-contact drills (complex training drills, passing, catching, resistance training)

Level 4 – Full contact practice (full medical clearance)

Level 5 – Return to play (game)

Continued post-concussive symptoms, prior concussion history and any diagnostic testing results along with neurocognitive testing and physical exam, will be utilized by the physician and athletic trainer in establishing a timeline for an athlete's return to activity. It is important to note that this timeline could last over a period of days to weeks or months, or potential medical disqualification from athletics. All cases will be handled on an individualized basis. The decision by the Physician for all cases of an athlete's return to activity is final.

SUMMARY:

The Beacon Medical Group Sports Medicine athletic trainers are proactive in the prevention, reorganization, and management of concussion in order to limit the risks of concussions associated with athletics. As well as to limit the potential catastrophic and long term risks associated with sustaining a concussion. Therefore the management and return to play decisions will remain in the realm of clinical judgment on the individualized bases by both the certified athletic trainer and the team physician.

Document History:

Date:	Author:	Summary:	Approval Date:	Approval Person or Group:
08/19/2010	Kara Werner	Revised 07/02/2015	07/15/15	Dr. Linda Mansfield

Appendix F

Academic Concussion Recommendations Beacon Medical Group

Appendix F

Academic Concussion Recommendations Beacon Medical Group

BEACON
MEDICAL GROUP
SPORTS MEDICINE

Academic Concession Recommendations

Student Name:____

The above student/athlete has sustained a concussion.

Academic Relief after Concussion

Current recommendations includes cognitive rest in addition to physical rest for the treatment of concussions. Scholastic work may make symptoms of a concussion worse as well as prolong recovery. Typically, athletes can return to school after resting for a day or two. If problems continue once the athlete returns to school, the following accommodations may be helpful.

Please allow for the following academic accommodations:

_______ Please excuse from school for _____________ days
_______ ½ day school for _____________ days
_______ Excuse/time extensions for tests, homework, or projects until further notice
_______ Un-timed tests, when able to take them
_______ Preprinted class notes by either the teacher or copy those of a fellow student
_______ Allow to participate in class only by listening with no active note taking
_______ Reduced workload whenever possible
_______ Allow unrestricted pass to the nurses office if headaches or symptoms increase
_______ Allow to go home if headaches don't subside after resting for 15 minutes
_______ Tutoring Start Date: _______________Duration: _________________
_______ Use of elevator
_______Other____
____

The student/athlete has the following activity restrictions: No physical education, no sports, no running or jumping, no weight lifting, no aggressive play, no recess.

Physician Signature: ____________________________________

Printed Name: ____

Phone Number: _______________________________________

Appendix G

Data Collection Form

Appendix G

Data Collection Form

Date: ____________
Gender: Male/Female
Case # __________
Game/Practice
History of concussion ____
School ________________

Days since onset of concussion: __________________

AT comments:

	none	mild		moderate		severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6
Trouble falling asleep (if applicable)	0	1	2	3	4	5	6
Total number of symptoms:						of 22	
Symptom severity score:						of 132	
Do your symptoms get worse with physical activity?						Y N	
Do your symptoms get worse with mental activity?						Y N	
If 100% is feeling perfectly normal, what percent of normal do you feel?							

Appendix H

Appendix H

Kruskal-Wallis *H* Ranking of Symptoms Comparing Male and Female Self-reported Concussion Symptoms

Appendix H

Kruskal-Wallis *H* rankings of symptom information comparing male and female self-reported concussion symptoms.

Symptoms	*H* value	*P* value
headache	18.38	.093
pressure in head	20.21	.473
neck pain	18.1	.012
nausea or vomiting	20.55	.462
dizziness	18.10	.051
blurred vision	20.10	.364
balance problems	20.50	.507
sensitivity to light	19.81	.333
sensitivity to noise	20.57	.585
feeling slowed down	19.00	.142
feeling like in a fog	18.67	.086
don't feel right	18.38	.071
difficulty concentrating	19.71	.300
difficulty remembering	20.76	.633
fatigue or low energy	17.98	.029
confusion	20.17	.362
drowsiness	19.17	.150
more emotional	18.50	.009
irritability	20.17	.345
sadness	19.07	.048
nervous or anxious	19.48	.118
trouble falling asleep	20.48	.288

Appendix I

Spearman's rho Male Symptom Correlations

Appendix I

Spearman's rho Male Symptom Correlations

Correlations

			headache	head_pressu	neck_pain	nausea	dizziness	blurred_visio	balance	light_sens	noise_sens	feel_slow	feel_fog	not_right	diff_conc	diff_remem	fatigue	confusion	drowsiness	emotional	irritability	sadness	nervous	not_sleep
Spearman's rho	headache	Correlation Coefficient	1.000	.655**	.095	.487*	.472*	.333	.389	.489*	.699**	.341	.322	.647**	.753**	.765**	.505*	.637**	.371	.	.443*	.342	.325	.342
		Sig. (2-tailed)	.	.001	.682	.025	.031	.141	.081	.025	.000	.131	.155	.002	.000	.000	.020	.002	.098	.	.044	.129	.150	.129
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	head_pressu	Correlation Coefficient	.655**	1.000	.039	.202	.725**	.448*	.751**	.484*	.293	.524*	.534*	.500*	.533*	.533*	.334	.646**	.455*	.	.095	.177	-.015	.335
		Sig. (2-tailed)	.001	.	.865	.380	.000	.042	.000	.026	.197	.015	.013	.021	.013	.013	.139	.002	.038	.	.682	.442	.949	.138
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	neck_pain	Correlation Coefficient	.095	.039	1.000	-.091	-.154	-.124	-.124	-.185	.275	.198	-.124	.301	.191	-.139	-.108	-.108	-.124	.	-.108	-.050	-.072	-.050
		Sig. (2-tailed)	.682	.865	.	.695	.504	.593	.593	.422	.227	.389	.593	.185	.407	.548	.642	.642	.593	.	.642	.830	.755	.830
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	nausea	Correlation Coefficient	.487*	.202	-.091	1.000	.262	.683**	.045	.318	.689**	.040	.464*	.354	.489*	.749**	.521*	.196	.462*	.	.477*	.606**	.795**	.546*
		Sig. (2-tailed)	.025	.380	.695	.	.250	.001	.846	.160	.001	.863	.034	.116	.024	.000	.015	.394	.035	.	.029	.004	.000	.010
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	dizziness	Correlation Coefficient	.472*	.725**	-.154	.262	1.000	.564**	.853**	.659**	.254	.680**	.814**	.506*	.708**	.628**	.429	.709**	.580**	.	.178	.221	.061	.331
		Sig. (2-tailed)	.031	.000	.504	.250	.	.008	.000	.001	.266	.001	.000	.019	.000	.002	.053	.000	.006	.	.441	.337	.793	.143
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	blurred_visio	Correlation Coefficient	.333	.448*	-.124	.683**	.564**	1.000	.512*	.555**	.353	.376	.533*	.356	.420	.621**	.516*	.279	.693**	.	.522*	.445*	.543*	.371
		Sig. (2-tailed)	.141	.042	.593	.001	.008	.	.018	.009	.117	.093	.013	.113	.058	.003	.017	.220	.000	.	.015	.043	.011	.098
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	balance	Correlation Coefficient	.389	.751**	-.124	.045	.853**	.512*	1.000	.696**	.142	.616**	.489*	.600**	.578**	.537*	.478*	.789**	.658**	.	.301	-.124	-.179	.321
		Sig. (2-tailed)	.081	.000	.593	.846	.000	.018	.	.000	.540	.003	.025	.004	.006	.012	.028	.000	.001	.	.185	.593	.437	.155
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	light_sens	Correlation Coefficient	.489*	.484*	-.185	.318	.659**	.555**	.696**	1.000	.379	.583**	.480*	.667**	.636**	.598**	.751**	.645**	.829**	.	.691**	-.185	.101	.411
		Sig. (2-tailed)	.025	.026	.422	.160	.001	.009	.000	.	.090	.006	.028	.001	.002	.004	.000	.002	.000	.	.001	.422	.664	.064
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	noise_sens	Correlation Coefficient	.699**	.293	.275	.689**	.254	.353	.142	.379	1.000	.210	.323	.579**	.610**	.673**	.474*	.330	.386	.	.480*	.339	.549**	.381
		Sig. (2-tailed)	.000	.197	.227	.001	.266	.117	.540	.090	.	.362	.153	.006	.003	.001	.030	.144	.084	.	.028	.133	.010	.088
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	feel_slow	Correlation Coefficient	.341	.524*	.198	.040	.680**	.376	.616**	.583**	.210	1.000	.638**	.594**	.572**	.296	.541*	.587**	.635**	.	.292	-.154	-.223	.374
		Sig. (2-tailed)	.131	.015	.389	.863	.001	.093	.003	.006	.362	.	.002	.005	.007	.193	.011	.005	.002	.	.199	.505	.330	.094
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	feel_fog	Correlation Coefficient	.322	.534*	-.124	.464*	.814**	.533*	.489*	.480*	.323	.638**	1.000	.311	.518*	.481*	.389	.434*	.521*	.	.099	.371	.196	.470*
		Sig. (2-tailed)	.155	.013	.593	.034	.000	.013	.025	.028	.153	.002	.	.170	.016	.027	.082	.049	.015	.	.669	.098	.394	.032
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	not_right	Correlation Coefficient	.647**	.500*	.301	.354	.506*	.356	.600**	.667**	.579**	.594**	.311	1.000	.862**	.734**	.839**	.814**	.751**	.	.574**	-.139	.102	.463*
		Sig. (2-tailed)	.002	.021	.185	.116	.019	.113	.004	.001	.006	.005	.170	.	.000	.000	.000	.000	.000	.	.007	.548	.659	.034
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	diff_conc	Correlation Coefficient	.753**	.533*	.191	.489*	.708**	.420	.578**	.636**	.610**	.572**	.518*	.862**	1.000	.849**	.680**	.784**	.585**	.	.439*	.191	.277	.424
		Sig. (2-tailed)	.000	.013	.407	.024	.000	.058	.006	.002	.003	.007	.016	.000	.	.000	.001	.000	.005	.	.046	.407	.225	.055
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	diff_remem	Correlation Coefficient	.765**	.533*	-.139	.749**	.628**	.621**	.537*	.598**	.673**	.296	.481*	.734**	.849**	1.000	.730**	.723**	.645**	.	.531*	.417	.556**	.463*
		Sig. (2-tailed)	.000	.013	.548	.000	.002	.003	.012	.004	.001	.193	.027	.000	.000	.	.000	.000	.002	.	.013	.060	.009	.034
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	fatigue	Correlation Coefficient	.505*	.334	-.108	.521*	.429	.516*	.478*	.751**	.474*	.541*	.389	.839**	.680**	.730**	1.000	.705**	.917**	.	.744**	-.108	.253	.539*
		Sig. (2-tailed)	.020	.139	.642	.015	.053	.017	.028	.000	.030	.011	.082	.000	.001	.000	.	.000	.000	.	.000	.642	.269	.012
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	confusion	Correlation Coefficient	.637**	.646**	-.108	.196	.709**	.279	.789**	.645**	.330	.587**	.434*	.814**	.784**	.723**	.705**	1.000	.634**	.	.455*	-.108	-.156	.539*
		Sig. (2-tailed)	.002	.002	.642	.394	.000	.220	.000	.002	.144	.005	.049	.000	.000	.000	.000	.	.002	.	.038	.642	.499	.012
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	drowsiness	Correlation Coefficient	.371	.455*	-.124	.462*	.580**	.693**	.658**	.829**	.386	.635**	.521*	.751**	.585**	.645**	.917**	.634**	1.000	.	.671**	-.124	.213	.494*
		Sig. (2-tailed)	.098	.038	.593	.035	.006	.000	.001	.000	.084	.002	.015	.000	.005	.002	.000	.002	.	.	.001	.593	.353	.023
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	emotional	Correlation Coefficient	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Sig. (2-tailed)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	irritability	Correlation Coefficient	.443*	.095	-.108	.477*	.178	.522*	.301	.691**	.480*	.292	.099	.574**	.439*	.531*	.744**	.455*	.671**	.	1.000	-.108	.197	.539*

Appendix J

Spearman's rho Female Symptom Correlations

Appendix J

Spearman's rho Female Symptom Correlations

			headache	head_pressu	neck_pain	nausea	dizziness	blurred_visio	balance	light_sens	noise_sens	feel_slow	feel_fog	not_right	diff_conc	diff_remem	fatigue	confusion	drowsiness	emotional	irritability	sadness	nervous	not_sleep
Spearman's rho	headache	Correlation Coefficient	1.000	.569**	.350	.363	.500*	.464*	.366	.480*	.364	.488*	.417	.374	.524*	.486*	.381	.409	.402	.383	.446*	.529*	.180	-.056
		Sig. (2-tailed)	.	.007	.120	.106	.021	.034	.103	.028	.105	.025	.060	.095	.015	.025	.088	.065	.071	.087	.043	.014	.436	.811
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	head_pressu	Correlation Coefficient	.569**	1.000	.362	.391	.711**	.577**	.778**	.810**	.505*	.742**	.842**	.786**	.677**	.704**	.733**	.728**	.657**	.668**	.609**	.585**	.261	.247
		Sig. (2-tailed)	.007	.	.107	.080	.000	.006	.000	.000	.020	.000	.000	.000	.001	.000	.000	.000	.001	.001	.003	.005	.253	.281
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	neck_pain	Correlation Coefficient	.350	.362	1.000	.335	.361	.313	.358	.262	.664**	.388	.391	.466*	.458*	.432	.494*	.373	.367	.632**	.611**	.554**	.454*	.552**
		Sig. (2-tailed)	.120	.107	.	.138	.108	.168	.111	.251	.001	.082	.079	.033	.037	.051	.023	.095	.101	.002	.003	.009	.039	.010
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	nausea	Correlation Coefficient	.363	.391	.335	1.000	.377	.833**	.370	.179	.562**	.300	.376	.316	.414	.666**	.269	.379	.218	.466*	.470*	.728**	.415	.455*
		Sig. (2-tailed)	.106	.080	.138	.	.092	.000	.099	.437	.008	.186	.093	.162	.062	.001	.238	.090	.341	.033	.032	.000	.061	.038
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	dizziness	Correlation Coefficient	.500*	.711**	.361	.377	1.000	.499*	.633**	.668**	.453*	.769**	.788**	.720**	.618**	.580**	.795**	.723**	.744**	.450*	.518*	.491*	.378	.417
		Sig. (2-tailed)	.021	.000	.108	.092	.	.021	.002	.001	.039	.000	.000	.000	.003	.006	.000	.000	.000	.040	.016	.024	.091	.060
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	blurred_visio	Correlation Coefficient	.464*	.577**	.313	.833**	.499*	1.000	.681**	.444*	.437*	.431	.445*	.564**	.443*	.789**	.506*	.531*	.517*	.482*	.629**	.692**	.378	.343
		Sig. (2-tailed)	.034	.006	.168	.000	.021	.	.001	.044	.048	.051	.043	.008	.044	.000	.019	.013	.016	.027	.002	.001	.091	.128
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	balance	Correlation Coefficient	.366	.778**	.358	.370	.633**	.681**	1.000	.776**	.361	.692**	.604**	.788**	.572**	.753**	.793**	.799**	.755**	.525*	.702**	.478*	.185	.449*
		Sig. (2-tailed)	.103	.000	.111	.099	.002	.001	.	.000	.108	.001	.004	.000	.007	.000	.000	.000	.000	.015	.000	.028	.422	.041
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	light_sens	Correlation Coefficient	.480*	.810**	.262	.179	.668**	.444*	.776**	1.000	.401	.801**	.592**	.692**	.735**	.501*	.878**	.667**	.773**	.612**	.714**	.477*	.169	.297
		Sig. (2-tailed)	.028	.000	.251	.437	.001	.044	.000	.	.071	.000	.005	.001	.000	.021	.000	.001	.000	.003	.000	.029	.463	.191
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	noise_sens	Correlation Coefficient	.364	.505*	.664**	.562**	.453*	.437*	.361	.401	1.000	.486*	.574**	.413	.757**	.640**	.548*	.403	.403	.599**	.597**	.812**	.654**	.516*
		Sig. (2-tailed)	.105	.020	.001	.008	.039	.048	.108	.071	.	.025	.007	.063	.000	.002	.010	.070	.070	.004	.004	.000	.001	.017
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	feel_slow	Correlation Coefficient	.488*	.742**	.388	.300	.769**	.431	.692**	.801**	.486*	1.000	.574**	.836**	.841**	.563**	.739**	.809**	.710**	.524*	.666**	.467*	.173	.296
		Sig. (2-tailed)	.025	.000	.082	.186	.000	.051	.001	.000	.025	.	.007	.000	.000	.008	.000	.000	.000	.015	.001	.033	.454	.193
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	feel_fog	Correlation Coefficient	.417	.842**	.391	.376	.788**	.445*	.604**	.592**	.574**	.574**	1.000	.653**	.527*	.679**	.695**	.623**	.622**	.612**	.448*	.603**	.502*	.404
		Sig. (2-tailed)	.060	.000	.079	.093	.000	.043	.004	.005	.007	.007	.	.001	.014	.001	.000	.003	.003	.003	.042	.004	.021	.069
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	not_right	Correlation Coefficient	.374	.786**	.466*	.316	.720**	.564**	.788**	.692**	.413	.836**	.653**	1.000	.622**	.619**	.701**	.779**	.792**	.514*	.609**	.359	.146	.325
		Sig. (2-tailed)	.095	.000	.033	.162	.000	.008	.000	.001	.063	.000	.001	.	.003	.003	.000	.000	.000	.017	.003	.110	.527	.150
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	diff_conc	Correlation Coefficient	.524*	.677**	.458*	.414	.618**	.443*	.572**	.735**	.757**	.841**	.527*	.622**	1.000	.687**	.698**	.764**	.515*	.602**	.757**	.675**	.366	.333
		Sig. (2-tailed)	.015	.001	.037	.062	.003	.044	.007	.000	.000	.000	.014	.003	.	.001	.000	.000	.017	.004	.000	.001	.103	.141
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	diff_remem	Correlation Coefficient	.486*	.704**	.432	.666**	.580**	.789**	.753**	.501*	.640**	.563**	.679**	.619**	.687**	1.000	.589**	.796**	.489*	.603**	.714**	.793**	.483*	.410
		Sig. (2-tailed)	.025	.000	.051	.001	.006	.000	.000	.021	.002	.008	.001	.003	.001	.	.005	.000	.025	.004	.000	.000	.027	.065
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	fatigue	Correlation Coefficient	.381	.733**	.494*	.269	.795**	.506*	.793**	.878**	.548*	.739**	.695**	.701**	.698**	.589**	1.000	.691**	.811**	.651**	.747**	.570**	.414	.486*
		Sig. (2-tailed)	.088	.000	.023	.238	.000	.019	.000	.000	.010	.000	.000	.000	.000	.005	.	.001	.000	.001	.000	.007	.062	.026
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	confusion	Correlation Coefficient	.409	.728**	.373	.379	.723**	.531*	.799**	.667**	.403	.809**	.623**	.779**	.764**	.796**	.691**	1.000	.548*	.535*	.688**	.468*	.165	.381
		Sig. (2-tailed)	.065	.000	.095	.090	.000	.013	.000	.001	.070	.000	.003	.000	.000	.000	.001	.	.010	.012	.001	.032	.474	.088
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	drowsiness	Correlation Coefficient	.402	.657**	.367	.218	.744**	.517*	.755**	.773**	.403	.710**	.622**	.792**	.515*	.489*	.811**	.548*	1.000	.468*	.629**	.420	.282	.366
		Sig. (2-tailed)	.071	.001	.101	.341	.000	.016	.000	.000	.070	.000	.003	.000	.017	.025	.000	.010	.	.033	.002	.058	.215	.103
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	emotional	Correlation Coefficient	.383	.668**	.632**	.466*	.450*	.482*	.525*	.612**	.599**	.524*	.612**	.514*	.602**	.603**	.651**	.535*	.468*	1.000	.847**	.768**	.509*	.424
		Sig. (2-tailed)	.087	.001	.002	.033	.040	.027	.015	.003	.004	.015	.003	.017	.004	.004	.001	.012	.033	.	.000	.000	.018	.055
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	irritability	Correlation Coefficient	.446*	.609**	.611**	.470*	.518*	.629**	.702**	.714**	.597**	.666**	.448*	.609**	.757**	.714**	.747**	.688**	.629**	.847**	1.000	.756**	.486*	.454*
		Sig. (2-tailed)	.043	.003	.003	.032	.016	.002	.000	.000	.004	.001	.042	.003	.000	.000	.000	.001	.002	.000	.	.000	.026	.039
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	sadness	Correlation Coefficient	.529*	.585**	.554**	.728**	.491*	.692**	.478*	.477*	.812**	.467*	.603**	.359	.675**	.793**	.570**	.468*	.420	.768**	.756**	1.000	.687**	.457*
		Sig. (2-tailed)	.014	.005	.009	.000	.024	.001	.028	.029	.000	.033	.004	.110	.001	.000	.007	.032	.058	.000	.000	.	.001	.037
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	nervous	Correlation Coefficient	.180	.261	.454*	.415	.378	.378	.185	.169	.654**	.173	.502*	.146	.366	.483*	.414	.165	.282	.509*	.486*	.687**	1.000	.405
		Sig. (2-tailed)	.436	.253	.039	.061	.091	.091	.422	.463	.001	.454	.021	.527	.103	.027	.062	.474	.215	.018	.026	.001	.	.068
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	not_sleep	Correlation Coefficient	-.056	.247	.552**	.455*	.417	.343	.449*	.297	.516*	.296	.404	.325	.333	.410	.486*	.381	.366	.424	.454*	.457*	.405	1.000
		Sig. (2-tailed)	.811	.281	.010	.038	.060	.128	.041	.191	.017	.193	.069	.150	.141	.065	.026	.088	.103	.055	.039	.037	.068	.
		N	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21

Final Approval of Dissertation

Karin E. Thomas
Student

870 509674
ID Number

Education+Human Services
Department

Doctor of Speech Language Pathology
Major

Gender differences in Concussion Symptoms of High School Soccer Players
Title of Dissertation

July 3, 2018
Date of Defense

Committee Approval (Check committee member(s) role where appropriate.)

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Katherine Lamb PhD Dissertation Committee ☑ Chair ☐ Co-Chair	Katherine Lamb PhD	7/3/2018
Dissertation ☐ Co-Chair ☐ Member	Signature	Date
Mary Gorham-Rowan Dissertation Research Member	Mary Gorham	7/3 2018
William H. Youngs, Ph.D. Dissertation Committee Member	William H. Youngs, Ph.D.	7/3/2018
Ruth Renee Hannibal Dissertation Committee Member	Ruth Renee Hannibal, Ph.D.	7/3/2018

This form must accompany the dissertation and both must be submitted to the Graduate School no later than 2 weeks prior to anticipated graduation.

Accepted by the Graduate School Becky K. da Cruz (Signature) 7/19/2018 (Date)

Copies to be filed in the major department and the Graduate Dean's Office.