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Examining Fear of Re-Injury in High School Athletes with Sport-Related Concussion

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Examining Fear of Re-Injury in High School Athletes with Sport-Related Concussion

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Abstract

Recent consensus statements have advocated for research on the emotional sequelae that is associated with sport-related concussion (McCrory et al., 2012). However, changes in fear of re-injury throughout SRC recovery are understudied. The purpose of this study was two-fold: 1) to describe fear of re-injury in high school athletes with SRC, and 2) to document changes in fear of re-injury throughout SRC recovery. This study addressed several exploratory questions regarding fear of re-injury in high school athletes with SRC that pertain to identifying predictors of fear of re-injury as well as examining the relationship between fear of re-injury and locus of control and perceptions of recovery in high school athletes with SRC. This study used a prospective, repeated measures research design. A total of twenty-six (20 M/6 F) high school athletes between the ages of 14 and 18 years ($M = 15.6$, SD= 1.5) with a medically diagnosed concussed were recruited and enrolled in the study. Participants completed the Tampa Scale of Kinesiophobia, Levenson Multidimensional Locus of Control Scale, and rated perceived recovery at four time points throughout concussion recovery (1 – 7 days post-injury, start of return to play (RTP), RTP, at least one week after RTP). The main finding of this study was that high school athletes experienced varying degrees of fear of re-injury following SRC. There was an observed significant negative relationship between total TSK scores and external locus of control scores 1 -7 days post-injury ($r = .46$, $n = 26$, $p = .03$). In addition, a significant relationship was observed at 1 -7 days post-injury total TSK scores and self-reported percent back to normal during the first week following injury ($r = -.79$, $n = 26$, $p = .01$)These findings provide preliminary support for the need to further investigate fear of re-injury and length of recovery in athletes following concussion.

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Dedication

For Mom and Dad.

Gracias para todo

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Chapter 1

Introduction

The recovery process for sport-related concussion (SRC) may be a time of uncertainty for both the injured athlete and the sports medicine professional. Recovery following SRC is variable for each athlete and previous research has identified several risk factors that influence recovery time and clinical outcomes. There are two classifications of risk factors for concussion; primary and secondary. Secondary risk factors predispose athletes to poor recovery outcomes (i.e. recovery lasting longer than 21 days) and the identification of secondary risk factors that influence SRC recovery may be useful for informing early intervention to help mitigate poor outcomes. Research has identified several secondary risk factors such as removal from play status (Elbin et al., 2016), on-field dizziness (Lau et al., 2011), mental fogginess (Lau et al., 2010) post-traumatic migraine (Kontos et al., 2013; Mihalik et al., 2013) and post-concussive mood (depression/anxiety) (McCrory et al., 2012). Despite the growing body of literature on concussion, there is a need for further identification of additional risk factors that contribute to worse recovery outcomes as well as barriers that influence readiness for return to play (RTP).

Several researchers have discussed the important role psychological factors play during the SRC recovery process. There is a growing body of literature documenting the emotional responses to concussion, for example, depression and anxiety (Iverson, 2006; Kontos, Covassin, Elbin, & Parker, 2012; Covassin et al., 2014). The diagnostic symptoms of depression often overlap with concussion symptoms (i.e., sadness, fatigue, irritability) and can seriously complicate injury understanding as it makes differential diagnosis difficult (Iverson, 2006). In addition to depression, concussed athletes have been reported to exhibit similar levels of post-injury state and trait anxiety as athletes with orthopedic injuries (Covassin et al., 2014). If this anxiety is not identified and appropriately treated early in the recovery process, it may progress and disrupt the effectiveness of other treatments as well as serving as a hindrance to recovery (Kontos, Deitrick, McAllister, Reynolds, 2016). Despite the recent growth in understanding of the emotional response to concussion, little is currently known about the fear of re-injury a concussed athlete may experience following injury or the influence of fear of re-injury on recovery outcomes (Moss & Slobounov, 2006).

Fear of re-injury has been investigated in musculoskeletal injuries (Covassin, McAllister-Deitrick, Bleecker, Heiden, & Yang, 2015; Reesor & Craig, 1998; Houston, Cross, Saliba, & Hertel, 2013; Tripp, Stanish, Ebel-Lam, Brewer, & Birchard, 2007) and has been shown to delay RTP (Kvist, Sporrstedt, & Good, 2005), therefore, may influence SRC recovery as well. Fear of re-injury is a feeling of vulnerability to painful re-injury that is linked to decreased physical performance and may increase risk of future injury (Vlaeyn, Kole-Snijders, Boeren, & Van Eek, 1995; Kori, Miller, & Todd, 1990). This can be a serious stressor for injured athletes returning to competition that may lead to a lack of concentration, decreased confidence and motivation, as well as interfering with physical and mental preparation for competition (Asano, 2007; Johnston & Carroll, 2000; McCullough et al., 2012). Fear of re-injury is a predictor of returning to sport in ACL injuries (Buer & Linton, 2002; Tripp et al., 2007; McCullough et al., 2012; Asano, 2007) and may negatively influence the recovery process for athletes with SRC. This study will describe fear of re-injury throughout the concussion recovery process in high school athletes.

The emotional fluctuations that occur following a sport-related injury are well-documented and are reported to be the most pronounced immediately following injury and at the time of medical clearance. While it is normal for athletes to experience a wide range of emotions immediately following injury, persistent emotional disturbances can be deleterious to the recovery process (Chan & Grossman, 1988; Macchi & Crossman, 1996; Smith, Scott, O'Fallon

& Yong, 1990; Tracy, 2003; Moss & Sloubonov, 2006). The overall emotional response to injury generally improves over the course of treatment and management, however, fear has been measured to be the most prominent emotion at the time an athlete is returning to sport (Arden et al., 2013). Morrey and colleagues (1999) demonstrated a U-shaped emotional response to injury with negative responses being most pronounced immediately following injury, subsiding as rehabilitation progressed, then becoming pronounced again at the time of medical clearance to return to sport. Returning to play requires an athlete to participate in the exact activity that caused the initial injury which may explain the increase in negative emotions upon returning to sport (Houston, Cross, Saliba, & Hertel, 2013). It is possible that fear of re-injury resulting from SRC may follow a similar trajectory, with fear being most pronounced during the acute period (1 – 7 days post-injury) and at the time of medical clearance (RTP). This study will describe the prevalence of fear of re-injury following concussion and explore the influence of fear of re-injury on recovery outcomes.

The role that fear of re-injury plays in SRC recovery is unclear. Intervening variables that may predict fear of re-injury are understudied, for example, locus of control. Locus of control (LOC) is a construct that refers to the degree to which an individual perceives a sense of personal control over outcomes in his or her life (Koski-Jannes, 1994). Currently, there are no studies examining the relationship between LOC and fear of re-injury following SRC, however, the application of LOC scales in other areas of research is promising. In a population of recreational and competitive-level athletes, those who reported high ratings of external LOC prior to reconstructive orthopedic surgery demonstrated greater mood disturbances following their operation and had less realistic perceptions of recovery outcomes (i.e., length of recovery) (Ardern, Taylor, Feller, Whitehead, & Webster, 2013). Conversely, individuals with high ratings of internal LOC are more likely to take responsibilities for stressors in their lives, adhere to medical treatment and physical therapy (McDonald-Miszczak, Maki, & Gould, 2000; Baranowski et al., 1997; Rosenstock, Streaher, & Becker, 1998). In addition to locus of control, perceptions of recovery may also be related to fear of re-injury. Athletes tend to base their perceptions of recovery from SRC on somatic symptoms (i.e., vomiting, nausea, headache) (Sandel, Lovell, Kegel, Collins, & Kontos, 2013) and symptom reports may be exacerbated by fear of re-injury. This is supported by Reesor and Craig (1998) who reported chronic lower back pain patients with higher levels of fear of re-injury also endorsed more symptoms and experienced greater physical impairment than those with congruent signs and symptoms. Fear of re-injury may influence perceptions of recovery which, in turn, may influence recovery outcomes. This study will explore the relationship between fear of re-injury, locus of control, and perceptions of recovery.

Recent consensus statements have advocated for research on the emotional sequelae that is associated with SRC (McCrory et al., 2012). However, changes in fear of re-injury throughout SRC recovery are understudied. If injury-related fear is not addressed during the recovery process, RTP may be delayed, performance may be hindered, and, risk of re-injury may be increased (Kvist, Sporrstedt, & Good, 2005; Heil, 1993; Ross, 2010). It is important for clinicians who are treating SRC to be able to comprehensively evaluate all facets of the injury and, in order to do this, psychological responses to SRC such as fear of re-injury, internal and external locus of control, and self-reported percent back to normal should be assessed. Early intervention could potentially facilitate better recovery outcomes for athletes who report fear of re-injury following SRC.

Purpose of the Study

The purpose of this study was two-fold: 1) to describe fear of re-injury in high school athletes with SRC and 2) to document changes in fear of re-injury throughout SRC recovery. This study addressed several exploratory questions regarding fear of re-injury in high school athletes with SRC that pertain to identifying predictors of fear of re-injury as well as examining the relationship between fear of re-injury and locus of control and perceptions of recovery in high school athletes with SRC.

Specific Aims and Hypotheses:

Aim 1.) To describe fear of re-injury in high school athletes with SRC

Aim 2.) To compare changes in fear of re-injury over time in high school athletes with SRC

H1: Fear of re-injury scores will be highest 1 -7 days following SRC and at RTP.

Exploratory Questions

EQ1.) Which risk factors predict of fear of re-injury in high school athletes recovering from SRC?

EQ2.) Is fear of re-injury related to locus of control in high school athletes with SRC?

EQ3.) Is fear of re-injury related to perceptions of recovery in high school athletes with SRC?

EQ 4.) Does fear of re-injury influence SRC recovery time for high school athletes?

Operational Definitions

Fear of Re-Injury- A feeling of vulnerability to painful re-injury linked to decreased physical performance and may increase risk of future injury (Vlaeyn, Kole-Snijders, Boeren, & Van Eek, 1995; Kori, Miller, & Todd, 1990)

Operational Definitions

Acute-The first week following an injury (i.e., 1 – 7 days) (Krainin et al., 2011, p. 38)

Return to Play (RTP) - The point in recovery from concussion when an individual is medically cleared to return to previous levels of sports participation. It is important that an athlete demonstrate normal neurological and cognitive evaluations before the start of the RTP process.

Concussion- "A complex pathophysiological process affecting the brain, induced by biomechanical forces to the head" (Aubry et al., 2001, p. 58)

Neurocognitive Performance- Scores on a battery of scientifically-validated computerized tests (ImPACT) for verbal and visual memory, processing speed, and reaction time

Chapter 2

Review of Literature

Introduction

Concussion continues to be the focus of increasing concern from clinicians, researchers, sporting organizations and athletes based off of reported prevalence of the injury and fears over long-term neurological effects (Dekosky, Ikonomovic, & Gandy, 2010; Langois, Rutland-Brown, & Wald, 2006; McCrory et al., 2005; McCrory et al., 2009). Concussion is a type of traumatic brain injury caused by a bump, blow, or jolt to the head of body causing the brain to move rapidly within the skull (CDC, 2017). Sport-related concussion (SRC) is a frequently occurring injury in contact and collision sports (e.g. football, soccer, ice hockey) at all levels of participation including high school and collegiate athletes (Guskiewicz, Weaver, Padua, & Garrett, 2000; Halstead & Walter 2010).

Prevalence and Incidence of Sport-Related Concussion

Concussions account for approximately 5 - 10% of all contact sports-related injuries (McGrath, 2010). Recent estimations report that approximately 1.6 to 3.0 million sport and recreation-related concussions occur every year in the U.S. (Langlois, Rutland-Brown, & Wald, 2006). Additionally, approximately 136,000 sport or recreation related concussions occur in high school-aged individuals alone (Langlois, Ruthland-Brown, & Wald, 2006; Meehan, d’Hemecourt, & Comstock, 2010). A recent epidemiological review on a representative sample of high school athletes reported the incidence and injury rates for the 2005 – 2006 sports seasons (Gessel, Fields, Collins, Dick, & Comstock, 2007). A total of 4,431 injuries occurred, of which 8.9% (n = 396/4,431) were sport related concussion. The majority of concussions occurred in games (n = 259/396; 65%), whereas 35% (n = 137/396) occurred in practice (Gessel, Fields, Collins, Dick, & Comstock, 2007). Moreover, the rates of concussion are reported to be .23 per

1,000 for high school sports which is higher than reported in college levels (Marshall et al., 2015; Gessel, Fields, Collins, Dick, & Comstock, 2007). Based on the national estimate, the majority of concussions at the high school level occurred in football (40.5%) followed by girls' soccer (21.5%), boys' soccer (15.4%) and girls' basketball (9.5%) (Gessel, Fields, Collins, Dick, & Comstock, 2007). A systematic review of 62 articles conducted by Clay and colleagues (2013) reported the overall incidence of concussion in sport ranged from .1 to 21.5 per 1000 AE. The lowest incidence of concussion occurred in swimming and the most elevated rate was reported in football (Clay, 2013). Clay (2013) also reported that younger athletes have the highest incidence of concussion and female incidence rate is greater than males in many comparable sports (i.e. soccer) (Clay, 2013). However, previous epidemiological studies reported a lower injury rate than Gessel et al (2007) and Clay (2013) (Powell & Barber-Foss, 1999; Schluz et al., 2004). This may be due to the recent increase in awareness of concussion, symptoms, diagnosis, and management of the injury. Consequently, rate of concussion is expected to increase as more high school students participate in athletics (Guskiewicz et al., 2006).

Biomechanics of the Concussion

Concussion is an injury caused by the acceleration or deceleration of the brain resulting in biomechanical forces transmitted to the brain (Ommaya & Gennarelli, 1974). These forces are caused by the propagation of applied forces to either the head or torso (McCrory et al., 2013). When the skull makes contact with a stationary object, there is an abrupt deceleration of the skull while the brain remains in motion (Barth et al., 2001). Mechanical energy from the external impact is transferred to the brain and vascular tissue causing the brain to abruptly move within the fluid and collide against the interior surface of the skull (Meaney & Smith, 2014; Dashnaw, Petraglia, Bailes, 2012). Guskiewicz and Mihalik (2011) describe concussion as a "diffuse axonal injury" resulting in functional impairments transient in nature.

Linear and Rotational Injuries

Linear and rotational head accelerations have been hypothesized to be the primary risk factor for concussion during the application of an impact (Guskiewicz & Mihalik, 2011). Barth and colleagues (2001) describe that in a linear impact, sufficient force in the opposite velocity vector can cause the brain to strike against the skull in the direction the force was initially applied (coup injury) (Barth et al., 2001). The brain may also "rebound" in the opposite direction resulting in a contrecoup injury (Ommaya & Gennarelli, 1974; Barth et al., 2001). In addition to linear accelerations, rotational acceleration is also common during impact or impulsive head loading (Meaney & Smith, 2014). Brain tissue deforms more easily in response to rotational (shear) forces compared to other biological tissues which means this movement carries a high potential for damage (Unterharnscheidt &Higgins, 1969; Gennarelli et al., 1982; Adams, Graham, Murray, & Scott, 1982). The combination of linear and rotational head accelerations create patterns of strain in brain tissue which may result in mild traumatic brain injury (Guskiewicz & Mihalik, 2011). Following the collision between the brain and interior of the skull there is a resulting energy crisis causing the brain to work at a less than optimal level (Giza and Hovda, 2014).

Pathophysiology of Concussion

Acute Metabolic and Ionic Changes

Concussion is the result of a complex neurometabolic cascade causing an energy crisis within the brain resulting in functional impairments transient in nature (Giza & Hovda, 2014; Guskiewicz & Mihalik, 2011). Immediately following injury to the brain there is an abrupt release of neurotransmitters and ionic fluxes. There is further neuronal depolarization with efflux of potassium and influx of calcium, which results in acute and subacute changes in cellular physiology (Giza & Hovda, 2014). This massive potassium flux is followed by a wave of neuronal suppression referred to as “spreading depression” and has been shown to manifest as early loss of consciousness, amnesia or other cognitive dysfunction (Giza & Hovda, 2014). A hypermetabolic state occurs compensating for diminished blood flow in effort to return to pre-injury membrane potential (Giza & Hovda, 2014). Energy-requiring membrane pumps are activated immediately after injury and cause an uptake in glucose persisting for up to 30 minutes in the ipsilateral cortex and hippocampus (Bull & Cummings, 1973; Mayevsky & Chance, 1974; Rosenthal et al., 1979; Yoshino et al., 1991). Accelerated glycolysis leads to an increased lactate production and impairs oxidative metabolism (Corbett et al., 1988; Biros & Dimlich, 1987; Richards et al., 1987). Impaired oxidative metabolism results in reduced adenosine triphosphate (ATP) production and, with an increase in lactate anabolism, results in lactate accumulation. Increases in calcium may also impair mitochondrial oxidative metabolism and may lead to cell death (Dominguez & Raparla, 2014). The resulting energy crisis serves as a likely mechanism for post-concussive vulnerability which makes a second injury dangerous and encompassing the potential to lead to longer lasting deficits (Giza & Hovda, 2014).

Signs and Symptoms of Concussion

Concussion is a heterogeneous injury presenting with inconsistent presentation of a myriad of symptoms (McCrory et al., 2013). Post-concussion symptoms can be categorized into four clusters, cognitive-fatigue-migraine (e.g. headache, difficulty concentrating, fatigue, dizziness), affective (e.g. sadness, nervousness), somatic (e.g. nausea, numbness), and sleep (e.g. difficultly sleeping, irregular sleep patterns) (Kontos et al., 2012). These symptoms can be an isolated occurrence or in conjunction with other signs and symptoms of concussion. Traditionally, loss of consciousness (LOC) has often been considered a hallmark of concussion and requires immediate removal from play and medical attention (McCrory et al., 2013). However, Guskiewicz and colleagues (2004) reported that in a sample of 1003 reported concussions, only 8.9% of injured athletes experienced loss of consciousness. On-field signs and symptoms commonly associated with concussion are presented in Table 1.

Table 1.
On-Field Signs and Symptoms (CDC, 2016)

Dizziness	Confusion
Headache	Fatigue
Post-traumatic amnesia	Balance Problems
Retrograde amnesia	Personality Changes
Sensitivity to light/noise	Vomiting
Visual problems	Numbness
Loss of Consciousness	

In the period of time following a concussion, it is common for athletes to experience a variety of physical, cognitive, emotional and sleep-related symptoms. However, athletes may minimize or deny symptoms for a plethora of reasons ranging from a lack of understanding about the injury, fear of losing a spot on the team or wanting to appear tough (McGrath, 2010). In a study by McCrea and colleagues (2004) only 15% of 1532 high school athletes with examined concussions reported any symptoms. Symptom reports are a subjective measure and clinicians depend on athletes truthfully describing their symptoms for the diagnosis and management of their injury. Symptoms are commonly assessed by using the Post-Concussion Symptom Scale

(PCSS), a 22-item survey that explores four types of symptoms. The PCSS addresses the four symptom clusters and can be used a predictor for prolonged recovery (Iverson, 2007).

Sideline Assessment of Concussion

The Sport Concussion Assessment Tool-3 (SCAT3) is often used as a sideline clinical assessment of concussed athletes. The SCAT3 consists of the symptom checklist, the SAC, and the modified BESS (mBESS). The SAC is a brief cognitive screening tool that assesses orientation, immediate memory, delayed recall, and concentration (score range = 0-30; higher scores indicate better performance). This screening tool is a brief assessment of mental status that has been validated in several studies for use in the diagnosis and treatment of sport-related concussion (Barr & McCrea, 2000; Bell, McCrea, Guskiewicz, Clark & Parda, 2011). The SAC has been shown to be sensitive to concussion within the first 48 hours following injury and provides an objective measure. The mBESS is a measure of postural stability that records stability errors while participants assume 3 positions for 20 seconds each with a maximum of 10 errors per trial. The SAC and mBESS components of the SCAT3 have demonstrated acceptable reliability and validity (Barr & McCrea, 2000; Bell, McCrea, Guskiewicz, Clark, & Parda, 2011). The intra-rater reliability of the BESS ranges from an ICC of .60 to .92 for the total BESS score and .50 to .98 for individual stances (Hunt, Ferrara, Bornstein et al., 2009; Erkmen, Taskin, Kaplan, et al., 2009; Finnoff, Peterson, Hollman et al., 2009; Valovich McLeod, Barr, McCrea et al., 2004). Test-retest reliability is moderate in youth participants aged 9-14 years and young adults (generalizability coefficient=0.64) (Portney & Watkins, 2009).

Assessment and Management Approaches for Concussion

Sports-related concussion is a heterogeneous injury that requires a multifaceted assessment and management approach that includes symptom reporting, neuropsychological assessment, postural stability, and vestibular/ocular motor screening (McCrory et al., 2014; Guskiewicz, Bruce, Cantu, & Ferrara, 2004; Peterson, Ferrara, Mrazik, Piland, & Elliot, 2003). SRC management has evolved in recent years from relying on an athletes self-reported symptoms (e.g. "Tell me how you are feeling") to a more objective assessment. Concussion is a clinical diagnosis based largely on observed mechanism of injury, signs and symptoms (McCrory et al., 2013). The current cornerstone of concussion management is physical and cognitive rest until the cessation of acute symptoms followed by a graded exertion program before RTP (McCrory et al., 2013; Guskiewicz, Bruce, Cantu, & Ferrara, 2004). In a recent consensus statement, concussion was described as an evolving injury with rapidly changing clinical signs and symptoms which may be reflective of underlying physiological injury in the brain (McCrory et al., 2013; Guskiewicz, Bruce, Cantu, & Ferrara, 2004). This multifaceted approach includes neuropsychological assessment, postural stability tests, and vestibular/ocular motor screening.

Neuropsychological Assessment for Concussion

Neuropsychological assessment is considered to be an integral part of comprehensive concussion management programs (Covassin et al., 2010; Iverson, 2006; McCrory et al., 2013). Recent consensus statements recommend that all athletes have a clinical neuropsychological assessment as part of their overall management of a concussion (McCrory et al., 2013). Neuropsychological testing may be used to assist in RTP decisions and may also be used in aspects of management (e.g. return to school in pediatric athletes) (McCrory et al., 2013). Computerized neuropsychological testing is widely recognized as being a sensitive and sophisticated measure of neurocognitive impairment following mTBI (Levin, 1994; Iverson, Lovell, & Collins, 2003; Schatz, 2009; Schatz & Sandel, 2012; Elbin, Schatz, & Covassin, 2011) and can aid the clinical decision making process (McCrory et al., 2013).

The Immediate Post-Concussive Assessment and Cognitive Testing (ImPACT), a computerized neurocognitive test, is considered to be sensitive to concussion and measures a variety of cognitive domains such as attention, memory, processing speed and reaction time (Iverson, Lovell, & Collins, 2003). The ImPACT testing battery consists of three sections: demographics/health history questionnaire, the 22-item Post-Concussion Symptom Scale (PCSS), and six neurocognitive modules assessing memory, attention learning, processing speed, reaction time. Four composite scores are created from the six neurocognitive modules for verbal and visual memory, visual motor processing speed and reaction time in seconds (Henry et al. 2016). The ImPACT testing battery is considered to be sensitive and specific, yielding 91.4% sensitivity and 69.1% specificity for athletes with concussion (Schatz & Sandel, 2012). In addition, in a sample of asymptomatic athletes suspected of hiding their concussion, data from ImPACT yielded 94.6% sensitivity and 97.3% specificity. The ImPACT tool is a valid measure of neurocognitive performance during the acute period following concussion and has demonstrated high levels of sensitivity and specificity.

The validity and reliability of computerized neuropsychological testing is hotly debated in the literature. Invalid baselines are a concern of neuropsychological testing with a recent study reporting that only 52% of athletic trainers (ATC's) verify that baseline scores are a valid representation of each athletes individualized performance (Collie, Darby, & Maruff, 2001). In a study by Covassin and colleagues (2009), 86% of ATC's would not return an asymptomatic athlete to competition if he or she was still clinically impaired on ImPACT and 95% would not return an athlete with baseline ImPACT scores but still reporting symptoms. VanKampen and colleagues (2006) reported that neurocognitive testing increases diagnostic accuracy when used in conjunction with self-reported symptoms.

The ImPACT baseline test is considered to be a stable measure of neurocognitive performance that minimizes practice effects through the use of multiple versions. Previous literature has reported the test-retest reliability of the ImPACT battery (Iverson, Lovell, & Collins, 2003; Broglio, Ferrara, Macciocchi, Baumgartner, & Elliot, 2007; Schatz, 2009; Elbin, Schatz, & Covassin, 2011). Iverson and colleagues (2003) reported reliability coefficients for ImPACT composite scores ranging from .67 to .85 over a 7-day test-retest period (Iverson, Lovell, & Collins, 2003). In addition, Broglio and colleagues (2007) examined ImPACT test-retest reliability over intervals (i.e. 45 days, 50 days) and reported low intraclass correlation coefficients (ICCs) ranging from .23 to .38 and .39 to .61, respectively. It is important to note that the methodology of Broglio et al (2007) is flawed and that test-retest scores were obtained from participants who were required to complete four separate computerized testing batteries which may have resulted in the high amount of variability. A study conducted by Schatz (2009) reported composite scores reflected stability over a 2-year period (i.e., visual memory = .65, processing speed = .74, and reaction time = .68). Only a small percentage of participants' scores exhibiting significant change on the composite scores (0%-6%), or symptom scale scores (5%-10%) (Schatz, 2009). A similar study conducted by Elbin and colleagues (2011) reported that ImPACT appeared to be a stable measure of neurocognitive performance across a 1-year time period for high school athletes (ICC's: motor processing speed = .85; reaction time = .76; visual memory = .70; and verbal memory = .62). Neuropsychological testing is cost-effective, standardized, and focused assessment that provides clinicians with important data (Woodward & Rahman, 2012).

Postural Stability

Approximately 30% of individuals with concussions experience balance disturbances (Murray et al., 2014 and Armstrong, 1994). Balance disturbances have been noted to return to normal within 72 hours of injury (Guskiewicz, 2011), however, prolonged damage may last more than 7 days beyond the initial injury (Marrar et al., 2012). A balance disturbance could place the athlete at greater risk for additional injury through falls or collisions further emphasizing the need to accurately access balance in athletes with concussion (Guskiewicz, 2011). Postural stability assessment is an important component of evaluation after concussion and can be assessed using several different methods (Riemann et al., 2000).

Multiple tests such as the Balance Error Scoring System (BESS) and force-plate measures have been developed to assess balance dysfunction in individuals with concussions. These balance assessments range from simple clinical sideline tests to complex lab testing that requires specialized training (Murray et al., 2014). The BESS is a low-technology, widely accepted assessment of balance that is subjective and relies upon trained rater interpretations of balance assessments (Murray et al., 2014). BESS is a brief, non-instrumented assessment of balance that can be administered on the sideline or in the athletic training room (Broglio et al., 2008). The BESS was developed to provide a low-technology, cost-effective SRC assessment for balance (Murray et al., 2014). It requires a foam platform and a stop watch and can be used as both a sideline and as a clinical test. There are three stances used for the BESS which are double, single, and tandem stance support. Clinical observation of balance lasts for 20 seconds and begins when the participant's eyes are closed. The performance of the participant is assessed and rated by how many errors or deviations from the original position are made. Following an SRC athletes typically commit more errors on the BESS that at baseline or in control subjects which suggests a decrease in postural control and stability occurs after SRC (Broglio, 2008). Psychometrics of the BESS test are widely available and support the use of the BESS test in the evaluation of an athlete with a suspected concussion. Finnolf and colleagues (2009) investigated reliability of the BESS in 30 healthy non-concussed athletes and found the intra-rater and inter-rater reliability to be .74 and .57, respectively. The minimum detectable change scores were found to be 7.3 for intra-rater and 9.4 for inter-rater were calculated as the total BESS scores (Finnolf et al., 2009). In addition to changes in postural stability following SRC, it is also common for athletes to experience disturbances in the vestibular and ocular motor systems.

Vestibular/Ocular Motor Screening (VOMS) Assessment

Vestibular and oculomotor impairments and associated symptoms are common following a concussion and may be associated with delayed recovery from the injury (Hoffer, Gottshall, Moore, Balough, & Wester, 2004; Naguib et al., 2012). The vestibular system is a complex network that provides information regarding head movement and positions to maintain visual and balance control (Mucha et al., 2014). Two suggestions have been proposed that may underlie diminished vestibular function with concussion that would create such disturbances in injured athletes, which are 1.) damage to the peripheral receptors and 2.) inhibited sensory integration in response to structural damage of the central processing structure (Guskiewicz, 2011). Dizziness is reported in 50% of athletes following SRC and may be represent an underlying impairment of the vestibular and/or ocular motor systems (Kontos, 2012; Mucha et al., 2014). In addition to vestibular impairments, changes in the ocular motor system are also common following SRC with nearly 65% of athletes reporting visual problems the first week after injury (Capo-Aponte et al., 2012). Impairments in the ocular motor system may manifest as blurred vision, changes in eye function, double vision, impaired eye movement, dizziness, headaches, and poor visual-based concentration (Ciuffreda, Ludlam, & Thiagarajan, 2011).

The Vestibular/Ocular Motor Screening (VOMS) Assessment examines vestibular and ocular motor impairments with patient-reported symptom provocation after each assessment (Mucha et al., 2014). The VOMS assessment briefly tests 5 domains: 1.) smooth pursuit, 2.) horizontal and vertical saccades, 3.) near point convergence (NPC), 4.) horizontal and vertical vestibular ocular reflex (VOR), and 5.) visual motion sensitivity (Mucha et al., 2014). Mucha and colleagues (2014) found the VOMS to be highly sensitive (Cronbach's α=0.92; interim correlations ranging from .44 to .88), indicating that a positive test result is highly accurate in the identification of SRC with a positive prediction rate of .89. The internal consistency of the VOMS is high (α= .92) and is able to distinguish concussed from non-concussed athletes making the VOMS assessment a clinically useful tool (Mucha et al., 2014).

Management of Concussion and Return-to-Play Decisions

Current consensus statements on the management of SRC recommend a multi-faceted approach that includes balance assessments, symptom inventories and computerized neurocognitive testing (McCrory et al., 2009). It is important that an athlete be completely asymptomatic and demonstrate normal neurological and cognitive evaluations before the start of the RTP process (McCrory et al., 2013; Guskiewicz et al., 2003). Returning an athlete to play should follow a stepwise progression that begins when an athlete is completely symptom free (McCrory et al., 2013; Guskiewicz et al., 2003). The stepwise process that an athlete should complete prior to returning to play is outlined in six steps. This process is outlined in Table 2. However, it is not always possible for an athlete to be completely symptom free. At any given point in time, a non-concussed individual may report a range of symptom similar to those associated with a concussion (Alla, Sullivan, & McCrory, 2014).

Table 2.
Stepwise Return to Play Progression (McCrory et al., 2013)

Step	Description
1	No activity, complete rest, once asymptomatic proceed to level two
2	Light aerobic exercise such as walking or stationary cycling
3	Sport specific training (e.g. skating in hockey, running in soccer.)
4	Non-contact training drills
5	Full contact training after medical clearance
6	Full RTP

Signs and symptoms should be evaluated both at rest and following exertion to see if symptom provocation occurs during each step of the RTP progression Guskiewicz et al., 2003). Athletes can then continue onto the next step of RTP progression if asymptomatic at the current level. (Guskiewicz et al., 2003). However, if any symptoms do occur, the athlete reverts back to the previous level and try to progress again 24 hours later (McCrory et al., 2013).

Predictors of Prolonged Recovery

Sport-related concussions are typically reported to have a relatively short recovery time with athlete's recovery most commonly falling between 21 and 28 days (Henry et al., 2016). However, there is an increasing body of literature that suggests certain demographic groups experience a longer recovery such as age, female gender, and history of concussion (Lau, Collins, & Lovell, 2012; Eisenberg, Meehan, & Mannix, 2014; Meehan, Zhang, Mannix, & Whalen, 2012; Covassin & Bay, 2012). Persistent symptoms lasting longer than 10 days are reported in 10-15% of athletes with concussion (McCrory et al., 2013). Iverson (2007) reported that athletes who had a higher summed score for the PCSS took longer to recover than athletes who scored lower on the assessment. Lau and colleagues (2011) reported that the assessment of on-field dizziness may help identify high school athletes at increased risk for a protracted recovery. In addition, athletes who indicated they experienced post-traumatic migraine and cognitive symptoms took longer to recover.

There are two types of risk factors in the SRC literature; primary risk factors such as previous concussion history and secondary risk factors (e.g., post-traumatic migraine) that predispose an athlete to poor recovery outcomes (McCrory et al., 2012). Some risk factors can be considered modifiable through prevention or intervention or non-modifiable (i.e. cannot be changed such as female gender, genetic predisposition). Primary risk factors increase the likelihood for a SRC. Examples of primary risk factors include sport type and setting (Covassin, Swanik, & Sachs, 2003; Gessel, Fields, Collins, Dick & Comstock, 2007; Hootman, Dick, Agel, 2007) age/level of competition (Field, Collins, Lovell. Maroon, 2003; Kontos et al., 2013), and gender (Covassin, Ryan, & Elbin, 2016; Gessel et al., 2007). Secondary risk factors predispose an athlete for poor recovery outcomes following SRC. Examples of secondary risk factors include removal from play status (Elbin et al., 2016), on-field dizziness (Lau, Kontos, Collins, Mucha, & Lovell, 2011), post-traumatic headache/migraine (Kontos et al., 2013), and post-concussive mood (depression/anxiety) (Kontos, McAllister-Deitrick, & Reynolds, 2016). None of the secondary risk factors are considered modifiable; however, by understanding which of these factors predict prolonged recovery and can facilitate interventions and management approaches (Elbin, Covassin, Gallion & Kontos. 2015). Henry and colleagues (2016) recently reported in a mixed-sex cohort study of adolescent and young adult athletes that recovery outcomes most commonly fell between 21 and 28 days, which is longer than the frequently reported time window of 7 to 14 days. Symptoms improved the greatest during the first 2 weeks however, neurocognitive impairment lingered in certain domains for up to 28 days after SRC (Henry et al., 2016). This study also reported a heterogeneous pattern of recovery across domains that emphasizes the importance of a multifaceted approach to management (Henry et al., 2016). However, there may be other predictors of protracted recovery that have been understudied.

Psychological Issues and Concussion Recovery

The pressure to return to full participation before a complete recovery from a musculoskeletal injury may have dire consequences for an athlete (Moss & Slobounov, 2006). Conversely, there are instances in which athletes may fabricate or exaggerate their symptoms in order to stay out sport participation or to gain attention from others (Rotella, Ogilvie, & Perrin, 1999). Emotional reactions to an injury can have a negative impact on performance and athletes who return to play too early from any injury may play with less intensity, comfort, and confidence (Williams & Roepke, 1993). In some cases, athletes who report lingering symptoms may also exhibit emotional distress such as anxiety and mood disturbances (Arden et al., 2013; Evans & Hardy, 1995; Larson, Starkey, & Zaichkowsky, 1996, Gasquoine, 1997). The overall emotional responses of an athlete generally improves over the course of treatment and management, however, fear has been measured to be the most prominent emotion at the time an athlete is returning to sport (Arden et al., 2013). While there are several formal epidemiological studies done on the emotional responses of concussion, there is limited research on fear of re-injury being a predictor of prolonged recovery in athletes. Recent consensus statements have advocated for research on the emotional sequence (e.g. depression and anxiety) that accompany

SRC (McCrory et al., 2005), and currently little is known about the fear of re-injury an athlete may experience throughout recovery and before RTP (Moss & Slobounov, 2006).

Fear Catastrophizing Following Concussion

Returning to play following concussion may be influenced by several psychological barriers including fear of re-injury (Schilaty, Nagelli, & Hewett, 2015). Fear of re-injury can lead to avoidance behavior, disuse, disability, and depression (Severeijns et al., 2001). Previous studies have been conducted on orthopedic populations regarding fear catastrophizing specifically in patients with chronic lower back pain (Ressor & Craig, 1998), ACL tears (Kvist, Sporrstedt, & Good, 2005; Ardern, Kvist, & Webster, 2016; Tripp, Stanish, Lam, & Brewer 2007) and Achilles tendon strains (Ardern, Glasgow, Schneiders, Withvrouw, Clarsen, et al., 2016). Reesor and Craig (1998) reported patients with chronic lower back pain that exhibited symptoms not typical to the injury had greater physical impairment and pain catastrophizing than patients with congruent signs and symptoms. These findings support a previously proposed cognitive–behavioral conceptualization of chronic pain which assumes that catastrophizing pain promotes fear of movement and a fear of re-injury injury (Vlaeyen, 1995). Athletes self-reported symptoms are relied on by sports medicine professionals for the management of concussion and, based off of the aforementioned Reesor and Craig (1998) study, fear of re-injury may exacerbate symptom reports following SRC and lead to protracted recovery.

Injury outcomes depend largely on how an individual appraises they will perform in given situations and are heavily rooted on perceived efficacy (Moss & Slobounov, 2006; Kirsch, 1992). There are two potential pathways described in the literature that athletes will follow after injury: avoidance and confrontation (Tripp, Stanish, Lam, & Brewer 2007). Confrontation refers to an athlete seeing his or her injury as temporary, allowing an acceptance of injury and increasing likelihood of recovery while avoidance includes catastrophizing, fear of movement and avoidance which all contribute to facilitating negative psychological outcomes (Tripp, Stanish, Lam, & Brewer 2007). Negative psychological reactions include denial, mild depression, anxiety, worry, anger, diminished vigor, loneliness, and general overall negativity (Weinberg & Gould, 2007). Psychological responses that are maladaptive may be detrimental to the athletes' ability to return to previous levels of sports participation, decrease quality of sports performance, and increase risk of re-injury (Hanson, McCallagh, & Tonymon, 1992; Kontos, Feltz, & Malina, 2000; Reuter & Short, 2005; Short et al., 2004; Williams, 2006; Podlug & Eklund, 2007).

Stages of coping with a sport-related injury have been demonstrated to behave similarly to the stages of grieving with the distress of being removed from play initiating emotional turmoil (Weinberg & Gould, 2007). These stages are coupled with one's self-concept, self-efficacy, physical and social well-being creating the overall psychological effect of the injury (Moss & Slobounov, 2006). These psychological effects typically underlie normal post-concussive symptoms especially when there is a prolonged recovery (i.e. more than 2 weeks) (Moss & Sloubounov, 2006). Considering these results, athletes who avoid the reintegration to sport, despite being medically cleared, may have underlying psychological issues (Arden et al., 2012). Behavior that is guided by fear has the potential to impact outcomes negatively for patients with musculoskeletal pain (Mintken, Cleland, Whitman, & George, 2010) and, fear of re-injury may also carry negative implications for athletes following SRC.

Cognitive appraisals influence emotional responses, which in turn affect behavioral responses (Moss & Slobounov, 2006; Wiese-Bjornstal, 1998). Evans and Hardy (1995) described the process to which athletes respond emotionally to a perceived loss following an injury is a process characterized by behavioral and psychological manifestations. Physical and psychological readiness to return to sport do not necessarily coincide and need to be investigated separately (Podlog & Eklund, 2007). This could possibly affect an athlete's technique which exposes them to an increased risk of repeat concussion. Connelly (1991) examined the footwork skills efficacy in high school football players before and after experiencing a sports-related injury and found that there was a dramatic loss of skills efficacy as a result of injury. It is possible that a SRC would have a similar effect which would alter an athlete's technique following RTP that could be responsible in part to the increased risk of repeat mTBI.

Newcomer and colleagues (2003) found that adolescents with recent injury history exhibited a higher frequency of intrusive thoughts and exhibited more avoidance behavior than those who were not recently injured. Athletes experiencing trauma-related distress reported heightened reactivity and exaggerated distress when exposed to environmental cues similar to their original trauma (Newcomer et al., 2003). Newcomer (2003) reported that healthy adolescents who had sustained a prior injury appeared to be emotionally reactive upon their return to sport and continued to remain reactive throughout the competitive season. In addition, the study found that children may have an increased sensitivity to injury-related stimuli (Newcomer et al., 2003).

Emotional Response to Injury

It is normal for athletes to experience a wide range of emotions, including a level of fear and anxiety, immediately following injury (Chan & Grossman, 1988; Macchi & Crossman, 1996; Smith, Scott, O'Fallon & Yong, 1990; Tracy, 2003; Moss & Sloubonov, 2006; Morrey, Stuart, Smith, & Wiese-Bjornstal, 1999). Morrey and colleagues (1999) demonstrated a U-shaped emotional response to injury with negative responses being most pronounced immediately following injury, subsiding as rehabilitation progressed, then becoming pronounced again at the time of medical clearance to return to sport (Morrey, Stuart, Smith, & Wiese-Bjornstal, 1999). Returning to play requires an athlete to participate in the exact activity that caused the initial injury (Houston, Cross, Saliba, & Hertel, 2013). If injury-related fear is not addressed, an athlete's performance may be hindered, limit functional progression, and lead to delayed RTP, increase risk of repeat injury and increase negative psychological reaction (i.e., denial, mild depression, anxiety, worry, anger, diminished vigor, loneliness, and general overall negativity) (Kvist, Sporrstedt, & Good, 2005; Heil, 1993; Ross, 2010; Weinberg & Gould, 2007). However, it is important to explore whether or not fear of re-injury influences recovery outcomes and is able to predict a prolonged recovery in high school-aged athletes.

Subjective questionnaires are the current standard for treating clinicians measuring cognitive and/or emotional response to an injury (Schilaty et al., 2015). Psychological states following injury are limited by personal interpretations of life experience and can differ between individuals (Schilaty et al., 2015). Fear of re-injury has been measured in previous studies on musculoskeletal injuries using the Tampa Scale of Kinesiophobia (Kori et al., 1990). The Tampa Scale of Kinesiophobia (TSK) is a 17 item questionnaire developed by Kori and colleagues (1990). This measure includes questions based on fear and movement and has been validated in other sport-related injuries with a majority conducted on orthopedic injuries. The questions are based on a 4-point Likert scale (1=strongly disagree, 4=strongly agree). Quantification of the scale ranges between a minimum total score of 17 and a maximum total score of 68. Responses for item numbers 4, 8, 12, and 16 are reverse scored. Reliability of the TSK has been established as moderate to substantial in patients with acute lower back pain (Cronbach α= .70 and α= .76; Pearsons r= .78) (Swinkles-Meewisse et al., 2003).

Locus of Control

Additional psychological factors that may positively influence recovery outcomes for athletes with SRC are internal and external locus of control. Locus of control refers to the degree to which an individual reports a sense of personal control over the outcomes in his or her life (Gretchen & Gross, 1997). This scale was developed to help investigators understand behaviors and outcomes and has been applied to athletic populations extensively. The Levenson Multidimensional Locus of Control scale is a 6-point Likert scale and includes twenty-four items measuring Internal Locus of Control, Powerful Others, and Chance. This scale scores participants into two simplified groups 1.) the belief in the basic unordered and random nature of the world and 2.) the belief in the basic order of the world coupled with the expectancy that powerful others are in control. The validity of the Levenson Multidimensional Locus of Control scale has been reported as .57 ($p \leq .001$), .49 ($p \leq .01$). One of the first studies to utilize the IPC in a sample of athletes reported that fewer injuries were associated with high school football players who had a high internal IPC (Dahlhauser & Thomas, 1979). The authors also suggested that athletes who accept personal responsibility of sports performance experience a lower rate of injury that athletes who place responsibility on external factors (e.g., coaches, physical environment, fate, bad luck) (Dahlhauser & Thomas, 1979). In addition, Pargman and Lunt (1988) reported that there was a significant positive correlation between locus of control and severity of injury in a population of freshman collegiate athletes. However, in a similar study conducted using a sample of 60 national-level male and female basketball players, researchers reported that the locus of control subscales (Internal, Powerful Others, Chance) did not predict frequency or severity of injury (McLeod & Kirkby, 1994). In contrast, athletes with higher ratings of external locus of control were more likely to place responsibilities on external factors (e.g., coaches, physical environment, fate, chance, bad luck) for the outcomes in their life (Dahlhauser & Thomas, 1979). To the author's knowledge, there are currently no studies that examine the relationship between locus of control ratings and fear of re-injury. External locus of control may serve as a predictor of fear of re-injury following SRC and requires further investigation.

Chapter 3

Method

Design

This study used a prospective, repeated measures research design.

Participants

High school athletes with an SRC that was medically diagnosed by a physician or certified athletic trainer (ATC) were recruited to participate in this study. As a participant of this program, all concussed athletes completed a comprehensive battery of concussion assessments that evaluated symptom reports and neurocognitive, vestibular/oculomotor, and postural stability functioning. These assessments were administered at baseline (i.e. preseason), 1 - 7 days, 8 - 14 days, 15 - 21 days, and 22 - 30 days following concussion. Participants were recruited for this study during their first surveillance visit following injury (approximately 1 - 7 days post-injury).

Inclusion Criteria: Concussed male and female high school athletes between the ages of 14-18 and currently participating in the sports of football, boys' and girls' soccer, boys' and girls' basketball, wrestling, and cheerleading at high schools participating in the concussion surveillance program at the University of Arkansas were included in this study.

Exclusion Criteria: Any concussed athlete that endorsed English as a second language, sustained a non-sport related concussion (e.g., motor vehicle accident), or exhibited any signs of a more severe brain injury (e.g., positive neuroimaging) were excluded from participation.

Measures/Instrumentation

Demographics:

Demographic data including age, sex, grade level, history of migraine/headache, ADHD, LD, and previous concussion history were obtained from the demographics/health history portion of the neurocognitive battery (See Appendix A).

Definition of Concussion

Concussions were assessed by certified athletic trainers or sports medicine physicians using the following criteria: 1) observed and/or reported mechanism of injury; and 2) the presence of at least one or more of the following: a) on-field signs (e.g., disorientation/confusion, loss of consciousness, balance difficulties, amnesia), b) symptoms (dizziness, nausea, headache), and/or c) any impairment on sideline assessments (e.g., Sport Concussion Assessment Tool: SCAT3).

Measures Used for Aims 1 and 2:

The following measures will be used to evaluate the primary Aims 1 and 2:

Modified Tampa Scale of Kinesiophobia (TSK)

Fear of re-injury was measured using the Tampa Scale of Kinesiophobia (Miller, Kori, & Todd, 1991). This measure includes questions based on fear of movement and has been validated in other sport-related injuries with a majority conducted on orthopedic injuries (Ressor & Craig, 1998; Buer & Linton, 2002; Tripp et al., 2007). The Tampa Scale of Kinesiophobia (TSK) is a 17-item questionnaire based on a 4-point Likert scale ranging from 1=strongly disagree to 4=strongly agree (Miller, Kori, & Todd, 1991). The TSK is scored by summing all of the items into a total fear score that ranges from a minimum of 17 to a maximum of 68 with a high value on the TSK indicating a high degree of fear of re-injury. Responses for item numbers 4, 8, 12, and 16 are reverse scored. A cutoff developed by Vlaeyn (1995) determined a score of 37 or greater to be considered as a high score classification and indicating a high degree of fear of re-injury. There are currently four proposed TSK severity ranges created from a sample of chronic musculoskeletal pain disorder patients (Neblett, Hartzell, Mayer, Bradford, & Gatchel, 2016). Scores were grouped into either subclinical, mild, moderate, or severe fear of re-injury groups based off of total TSK scores (Neblett, Hartzell, Mayer, Bradford, & Gatchel, 2016). Severity range information is provided in Table 3.

Table 3.
The Four Proposed TSK Severity Ranges (Neblett et al., 2016)

	Subclinical	Mild	Moderate	Severe
TSK Score Range	13 - 22	23 - 32	33 - 42	43 - 52

Use of a total score which includes all 17 items is recommended, although practitioners may wish to interpret results using two subscales, the activity avoidance and somatic focus (Vlaeyn, 1995). The activity avoidance subscale reflects the belief that the activity may result in re-injury or increased pain (Vlaeyn, 1995). In contrast, the somatic focus subscale reflects the belief in an underlying and serious medical problem (Vlaeyn, 1995). The total score for the TSK will be used in the current study as well as high fear (total score ≥ 37) and low fear (total score < 37) classifications.

Psychometrics for the TSK is well documented in the literature. Reliability of the TSK has been established in patients with acute lower back pain (Pearsons $r = 0.78$ ($p \leq .01$)) (Swinkles-Meewisse et al., 2003). The internal consistency for the TSK has been reported as moderate (Cronbach $\alpha = 0.70$) (Swinkles-Meewisse et al., 2003). The TSK has also been applied to chronic musculoskeletal injuries including neck and upper extremity pain and was found to have a high internal consistency (Cronbach's $\alpha = 0.86$) (Tkachuk & Harris, 2012). Modifications to the TSK were made to make this measure specific to the concussion the athlete recently sustained and the word "injury" was changed to "concussion" when applicable (e.g., "People are not taking my concussion seriously enough"). A modified version of the TSK used for this study can be found in Appendix B.

Measures Used for Exploratory Questions

The following measures will be used to evaluate exploratory questions 1 through 4:

Neurocognitive Assessment: The Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT)

The ImPACT testing battery consists of three sections: demographics/health history questionnaire, the 22-item Post-Concussion Symptom Scale (PCSS), and six neurocognitive modules assessing memory, attention learning, processing speed, and reaction time. Scores were created from the six neurocognitive modules that yield four composite scores; verbal memory, visual memory, visual motor processing speed, and reaction time in seconds (Iverson, Lovell, & Collins, 2003). The ImPACT baseline test is considered to be a stable measure of neurocognitive performance and minimizes practice effects through the use of multiple versions. Previous literature has reported the test-retest reliability of the ImPACT battery (Iverson, Lovell, & Collins, 2003; Broglio, Ferrara, Macciocchi, Baumgartner, & Elliot, 2007; Schatz, 2009; Elbin, Schatz, & Covassin, 2011). Iverson and colleagues (2003) reported reliability coefficients for ImPACT composite scores ranging from .67 to .85 over a 7-day test-retest period (Iverson, Lovell, & Collins, 2003). In addition, Broglio and colleagues examined ImPACT test-retest reliability over intervals (i.e., 45 days, 50 days) and reported low intraclass correlation coefficients (ICCs) ranging from .23 to .38 and .39 to .61, respectively. It is important to note that the methodology of Broglio et al., (2007) is flawed and that test-retest scores were obtained from participants who were required to complete four separate computerized testing batteries which may have resulted in the high amount of variability In a study by Schatz (2009), composite scores reflected stability over a 2-year period (i.e., visual memory = .65, processing speed = .74, and reaction time = .68). Only a small percentage of participants' scores exhibiting significant change on the composite scores (0%-6%), or symptom scale scores (5%-10%) (Schatz, 2009). A similar study conducted by Elbin and colleagues (2011) reported that ImPACT appeared to be a stable measure of neurocognitive performance across a 1-year time period for high school athletes (ICC's: motor processing speed = 085; reaction time = .76; visual memory = .70; and verbal memory = .62).

Post-Concussion Symptom Scale (PCSS)

The PCSS is designed to measure the presence and severity of symptoms following concussion (Lovell, 1996, 1999; Lovell & Collins, 1998). The 22-item PCSS includes headache, dizziness, vomiting, balance problems, trouble falling asleep, sleeping more than usual, fatigue, drowsiness, sensitivity to light, sensitivity to noise, irritability, sadness, nervousness, feeling more emotional, numbness or tingling, feeling slowed down, feeling mentally "foggy", difficulty concentrating, difficulty remembering, and visual problems. The PCSS is self-reported and uses a seven-point Likert scale with 0 indicating not experiencing that symptom and symptom reporting of 1 - 6 representing mild-to-severe difficulty with the symptom. The reliability and validity of the PCSS are well documented with the internal consistency ranging from .88 to .94 across various samples of healthy high school and college students (Lovell et al., 2006).

Recently, Kontos and colleagues (2012) examined the factor structure of the 22-item PCSS and identified baseline and post-concussion symptom clusters (See Table 4).

Table 4.
Post-Concussion Symptom Clusters in Athletes (Kontos et al., 2012)

Cluster	Symptom
Cognitive-Fatigue-Migraine	Headache, dizziness, difficulty concentrating, fatigue, drowsiness, sensitivity to light, sensitivity to noise, feeling slowed down, mentally foggy, difficultly remembering
Affective	Sadness, nervousness, feeling more emotional
Somatic	Nausea, numbness, vomiting
Sleep	Trouble sleeping, sleeping less than usual

Self-Reported Percent Back to Normal

Athletes rated their self-perceived percent back to normal by indicating how recovered they believe they are on a visual analog scale. The visual analog scale was adapted from Sandel et al (2012). This is a single-item, self-report regarding athletes "percent back to normal" (i.e., perceived recovery). Athletes rated their perceived recovery from SRC on a semantic differential scale from 0% ("I do not feel at all recovered") to 100% ("I feel fully recovered").

Levenson Multidimensional Locus of Control.

Internal-external control construct was measured using the Levenson Multidimensional Locus of Control scales (IPC). The Levenson's IPC scale is a 6-point Likert scale and includes twenty-four items which measures internal control, powerful others, and chance. This scale scores participants into two simplified groups 1.) the belief in the basic unordered and random nature of the world and 2.) the belief in the basic order of the world coupled with the expectancy that powerful others are in control. There are three subscales derived from the IPC; Internal Locus of Control, Powerful Others, and Chance. Scores are calculated by adding up responses for specific items (Internal Locus of Control: total responses for items 1, 4, 5, 9, 18, 19, 21 and 23; then add +24; Powerful Others: total responses for items 3, 8, 11, 13, 15, 17, 20, and 22, then add +24; Chance: total responses for items 2, 6, 7, 10, 12, 14, 16, and 24; then add +24). Total scores for each subscales should be between 0 and 48. A high rating on the Internal Locus of Control scale indicates that an individual has a strong internal locus of control. An internal locus of control can be helpful for successful behavior change. Inversely, high ratings on either the Powerful Others scale or the Chance scale indicate a strong external locus of control. A person who scores high on the Powerful Others scale typically believes that his or her fate is controlled by other people. In addition, a person who scores high on the Chance scale believes their fate is controlled by chance The validity of the questionnaire, as measured by Levenson's IPC scale was .57 ($p < .001$), .49 ($p < .01$).

Procedures

After obtaining University IRB approval, researchers recruited concussed high school student-athletes currently participating in University of Arkansas Sport Concussion Surveillance Program in Northwest Arkansas. Parental consent and child assent were obtained during the first week following the diagnosis of a SRC. Athletes individually completed the TSK in a designated room at their respective data collection site (i.e., high school) during their first surveillance visit following injury (1-7 days). The testing battery for the current study (TSK, Levenson’s IPC, self-reported percent back to normal) was administered at four time points during the recovery process and administration occurred before any concussion assessment measures (ImPACT/PCSS, KD, SCAT3, and VOMS) in order to control for any perceptions of impairment and/or recovery that may have occurred from completing these assessments (e.g., the realization of poor performance when taking ImPACT due to feedback from the actual assessment). Surveys were first completed within one week of SRC. Athletes completed the testing battery again immediately before beginning the stepwise RTP progression, and a third time when the last step of the RTP stepwise progression is completed. Participating athletes completed the final testing battery at least one week after returning to full-contact practice. Athletes completed a stepwise RTP process prior to full medical clearance from the injury under the supervision of a sports medicine professional.

Data Analysis

Sample Demographics

Demographic and health history information were obtained from the neurocognitive battery. Descriptive statistics (e.g., means, standard deviations, frequency) were performed for age, sex, history of migraine/headache, ADHD, LD, sport endorsement and previous concussion history. Data collection timelines were described by calculating mean days between each testing battery administration.

Data Analyses for Aim 1.) To describe fear of re-injury in high school athletes with SRC

Descriptive statistics (e.g., mean, standard deviation, frequency) were used to describe fear of re-injury for the total TSK scores at 1 – 7 days, start of the RTP progression, date of full medical clearance (RTP), and at least one week after full RTP. Total TSK scores were also dichotomized into high fear of re-injury and low fear of re-injury groups for each time point.

Athletes who had a total TSK score greater or equal to 37 were classified as having high levels of fear of re-injury while athletes who had a total TSK score of less than 37 were classified as having low fear of re-injury as per Vlaeyn (1995).

Data Analysis for Aim 2.) To compare changes in fear of re-injury in high school athletes with SRC

Evaluation of H1: Fear of re-injury scores will be highest at 1 -7 days following SRC and at RTP.

A repeated measures ANOVA was conducted to detect any overall differences in the mean fear of re-injury scores throughout concussion recovery. The independent variable was time (i.e., 1-7 days post-injury, start of RTP progression, RTP, at least one week after RTP). The dependent variable was total TSK scores. Statistical significance was set at a Bonferroni corrected $p \leq .01$.

Data Analysis for EQ1.) What risk factors predict of fear of re-injury at 1 -7 days post-injury in high school athletes recovering from SRC?

A logistic regression was conducted to predict high fear of re-injury following SRC. The independent variables were sex, migraine/headache history, previous concussion history, ADHD, LD and on-field dizziness. The dependent variable was fear of re-injury classification (i.e., high fear of re-injury, low fear of re-injury). Statistical significance was set at Bonferroni corrected $p \leq .05$.

Data Analysis for EQ2.) Is fear of re-injury related to locus of control in high school athletes with SRC?

A series of Pearson product-moment correlations were computed to assess the relationship between the internal and external locus of control subscales calculated from the Levenson Multidimensional Locus of Control and fear of re-injury total scores. Statistical significance was set to $p \leq .05$.

Data Analysis for EQ3.) Is fear of re-injury related to perceptions of recovery in high school athletes with SRC?

A series of Pearson product-moment correlations were computed to assess the relationship between self-reported percent back to normal and total TSK scores. A series of correlations were conducted for each of the four time points (i.e., 1-7 days post-injury, start of RTP progression, RTP, at least one week after RTP). Statistical significance was set to $p \leq .05$.

Data Analysis for EQ4.) Does fear of re-injury influence recovery time?

An independent samples t-test was used to examine differences in recovery time (i.e., days elapsed from injury date to medical clearance) between high fear and low fear groups. Statistical significance was set to $p \leq .05$.

Chapter 4

Results

Demographic Information

A total of 26 high school athletes (*M* = 15.5, *SD* = .86 years) with medically diagnosed concussion were enrolled in the study. There were 20 males and 6 females in this sample. Three athletes (3/26, 11%) reported a previous concussion history (n = 3/26; 11%), two athletes reported a history of migraine (2/26, 7%), and two athletes reported being diagnosed with ADHD (2/26, 7%). A variety of contact sports were represented in the sample with football being the most frequently endorsed sport (9/26, 34%). The representation of sports included in the study is provided in Table 5.

Table 5.
Frequency of Sport Representation for Total Sample (*N* = 26)

Sport	Frequency	Percent
Football	9	34.6
Basketball	7	26.9
Wrestling	5	19.2
Cheer	4	15.4
Soccer	1	3.8

Evaluation of Hypotheses

Aim 1.) To describe fear of re-injury in high school athletes with SRC

The average TSK score for athletes at time point 1 (1 – 7 days post-injury) was 37.96 (SD = 6.39). During the first week following concussion, 53.8% (14/26) of athletes were classified as having high levels of fear of re-injury (TSK score $\geq$ 37) and 46.2% (12/26) were classified as having low levels of fear of re-injury. Fear of re-injury scores did change throughout the recovery process from SRC. The average TSK score at the start of RTP and at RTP were slightly lower (M = 34.27, SD = 6.34; M = 29.33, SD = 4.93, respectively) and increased remotely at least one week following RTP (M = 31.95, SD = 5.45). Fear of re-injury classifications for the sample at each time point can be found on Table 6.

Table 6.
High (≥ 37) and Low (<37) Fear of Re-Injury Classifications At Each Time Point

	1 - 7 Days Post-Injury		Start RTP		End RTP		At Least 1 Week After Full RTP	
Fear Classification	High	Low	High	Low	High	Low	High	Low
	53.84% (14/26)	46.15% (12/26)	26.67% (4/15)	73.33% (11/15)	0% (0/15)	100% (15/15)	13.63% (3/22)	86.3% (19/22)

Aim 2.) To compare changes in fear of re-injury in high school athletes with SRC

Evaluation of H1: Fear of re-injury scores will be highest 1 -7 days following SRC and at RTP.

The results of a repeated measures ANOVA did not reveal a significant main effect for time (*Wilks* λ = .40, F (3, 7) = 3.47, p = .08, η^2 = .59). Means and standard deviations for total TSK scores at the four time points are presented in Table 7.

Table 7.
Analysis of TSK scores across four time points (N = 15).

	1 – 7 days post-injury		Start RTP		End RTP		≥ 1 week after RTP	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Total TSK Scores	37.1	4.43	31.9	3.98	29.8	5.71	31.3	5.05

*$p \leq .01$

EQ1.) What risk factors predict of fear of re-injury at 1 -7 days post-injury in high school athletes recovering from SRC?

Due to little variability and small sample size, a logistic regression could not be conducted for the independent variables sex, migraine/headache history, previous concussion history, ADHD, LD and on-field dizziness. See Aim 1 for description of the sample.

EQ2.) Is fear of re-injury related to locus of control in high school athletes with SRC?

The results of a series of Pearson product-moment correlations revealed a significant relationship between fear of re-injury scores and the external locus of control subscale. There was an observed significant negative relationship between total TSK scores and external locus of control scores 1 -7 days post-injury (r = .46, n = 26, p = .03). Results are presented in Table 8.

Table 8.
The Relationship Between Locus of Control Subscales and Total Fear of Re-Injury Scores

Time Point	Internal Locus of Control	External Locus of Control
1 - 7 Days Post-Injury (n = 26)	-0.07	-0.46*
Start RTP (n = 17)	0.28	-0.21
End RTP (n = 15)	-0.01	0.29
At Least 1 Week After Full RTP (n = 22)	-0.35	0.38

* p < .05

EQ3.) Is fear of re-injury related to perceptions of recovery in high school athletes with SRC?

Perceptions of recovery were available at all four time points (i.e. 1 – 7 days post-injury, RTP, RTP, and at least one week after following RTP) for 58% of the sample (15/26). The average self-reported percent back to normal 1 – 7 days following SRC was 69% (N = 26; SD = 24.08). Four athletes (15%) reported being completed recovered during the first week following

SRC. At the start of RTP progression, 71% (12/17) of athletes reported being fully recovered and at the time of medical clearance 100% of the sample reported being fully recovered from their concussion. However, two athletes (9%; 2/22) reported feeling slightly less recovered (i.e., "I feel 90% recovered from my concussion") one week after full medical clearance to return to sport. Means and standard deviations are provided on Table 9.

Table 9.
Average Self-Reported Percent Back to Normal Throughout SRC Recovery

	1 - 7 Days Post-Injury (n = 26)		Start RTP (n = 17)		RTP (n = 15)		At Least 1 Week After Full RTP (n = 22)	
	M	SD	M	SD	M	SD	M	SD
Self-Reported % Back to Normal	69.04	24.08	96.18	6.93	100	0	99.09	2.94

A series of correlations were conducted to determine if there was a relationship between self-reported percent back to normal and fear of re-injury throughout recovery. A significant relationship was observed at time point 1 (1 -7 days post-injury) total TSK scores and self-reported percent back to normal during the first week following injury (r = -.79, n = 26, p = .01) Results of these analyses are presented in Table 10.

Table 10.
The Relationship Between Self-Reported Percent Back to Normal and Total Fear of Re-Injury Scores

Time Point	Self-Reported % Back to Normal
1 - 7 Days Post-Injury (n = 26)	-.79*
Start RTP (n = 17)	-.86
End RTP (n = 15)	-
At Least 1 Week After Full RTP (n = 22)	-

* p < .01

EQ 4.) Does fear of re-injury influence SRC recovery time?

Recovery data were available for 22 (84%) of 26 athletes. An independent samples *t* test was used to examine differences in recovery time in days (i.e., days elapsed from injury to RTP) between total fear of re-injury (TSK) scores for high fear and low fear groups at time point 1 (1 – 7 days). Independent samples *t* tests revealed no significant differences in the length of recovery between high fear of re-injury (*M* = 23.92; *SD* = 9.41) and low fear of re-injury (*M* = 16.80; *SD* = 9.41) (t (20) = -1.99, *p* = .06). Means and standard deviations are presented in Table 11.

Table11.
Independent Samples t Test Comparing Recovery Length Between High Fear (n = 12) and Low Fear (n = 10) Groups

	Average Length of Time from SRC to RTP (days)	Std. Deviation (days)	Std. Error Mean (days)
High Fear Group (≥ 37)	22.92	9.41	2.72
Low Fear Group (< 37)	16.80	6.73	2.13

Chapter 5

Discussion

General Discussion of Findings

This study described fear of re-injury in high school athletes with SRC and documented changes in fear of re-injury throughout SRC recovery. This study also addressed several exploratory questions regarding fear of re-injury in high school athletes with SRC that pertain to identifying predictors of fear of re-injury as well as examining the relationship between fear of re-injury, locus of control, and perceptions of recovery in high school athletes with SRC. The main finding of this study is that high school athletes do experience varying degrees of fear of re-injury following SRC. This finding suggests that fear of re-injury may influence recovery outcomes and that locus of control and perceptions of recovery are related to levels of fear of re-injury.

Describing Fear of Re-Injury Following SRC

Based on previous literature, it was hypothesized that fear of re-injury would be most pronounced during the first week following concussion and at the time of medical clearance (RTP). This hypothesis was founded on Morrey and colleagues (1999) report on the U-shaped emotional response to musculoskeletal injuries. Morrey described the emotional disturbances following injury as being most pronounced during the acute period and at the time of medical clearance. It was hypothesized that high school athletes with SRC would follow a similar trajectory. However, results from the current study do not reflect the aforementioned U-shaped model. Instead, fear of re-injury was most pronounced during the first week following SRC and improved throughout SRC recovery. This finding is supported by Arden and colleagues (2013) report that overall emotional response to injury generally improves over the course of treatment and management. Athletes in the current study exhibited higher ratings of fear of re-injury during the first week following SRC and this rating was, on average, significantly higher than fear of re-injury ratings at the time of medical clearance (RTP).

Locus of Control Ratings and Fear of Re-Injury Following SRC

Athletes who reported higher ratings of external locus of control demonstrated lower levels of fear of re-injury during the first week following injury. This finding is novel and is not well supported by the current literature on locus of control and emotional response to injury. Previous reports on this topic reported people with greater ratings of external locus of control are less likely to take responsibility for their own actions and blame others for stressors in their lives. Ardern (2013) reported that recreational and competition-level athletes who reported high ratings of external LOC prior to reconstructive orthopedic surgery demonstrated greater mood disturbances following their operation and had less realistic perceptions of recovery outcomes (i.e., length of recovery) (Ardern, Taylor, Feller, Whitehead, & Webster, 2013). The current study's findings did not support literature on this topic which may be due to small sample size and requires further investigation to establish the extent of this relationship.

Perceptions of Recovery and Fear of Re-Injury Following SRC

Fear of re-injury was positively related to perceptions of recovery. Athletes largely base their perceptions of recovery following SRC off of somatic symptoms (e.g., vomiting, nausea, headache) (Sandel et al., 2013) and the current study hypothesized that symptom reports may be exacerbated by fear of re-injury as well. Athletes in the current study who were more fearful of re-injury reported feeling "less recovered" than athletes with low levels of fear of re-injury. These findings reflect a study conducted by Reesor and Craig (1998) that reported patients with chronic lower back pain who exhibited high levels of fear of re-injury were more symptomatic than patients with congruent signs and symptoms. Further investigation should be considered in order to determine if there is a significant relationship between total symptom burden following SRC and fear of re-injury levels.

The Influence of Fear of Re-Injury on Recovery Length

Although the majority of SRCs resolves within about three weeks, a small percentage will experience a protracted recovery. Previous literature has identified several risk factors that assist in predicting protracted recovery including removal from play status (Elbin et al., 2016), on-field dizziness (Lau et al., 2011), and post-traumatic migraine (Kontos et al., 2013; Mihalik et al., 2013). The present study provides evidence suggesting that psychological factors (i.e., fear of re-injury) may play a role in recovery outcomes. Although these findings were not significant, athletes who had high levels of fear of re-injury (total TSK scores ≥ 37) during the first week following SRC on average took nearly a week longer to RTP than athletes with low levels of fear of re-injury (total TSK scores < 37). These findings support previous reports on the influence of fear of re-injury has on recovery outcomes (i.e., delay RTP) in musculoskeletal injuries (Covassin et al., 2015; Reesor & Craig, 1998; Houston et al., 2013; Tripp et al., 2007) and yields further research.

Implications of Findings

As the body of literature on the emotional response to SRC continues to grow, team medical staff needs to be aware of new information and findings regarding SRC. These data serve as preliminary support of the need to further investigate fear of re-injury and length of recovery in athletes following concussion. Sports medicine professionals who are managing concussion may benefit from identifying athletes with high levels of fear of re-injury early in the

SRC recovery process. The early identification of this emotional response may allow clinicians managing SRC to offer intervention

Sport medicine support staff may want to consider administering pre-season inventories in order to identify athletes who are at risk for a more severe emotional upheaval following SRC. The current study provided evidence of a relationship between external locus of control ratings and fear of re-injury. A preseason measure of locus of control is a quick way to determine which athletes are at greater risk for increased levels of fear of re-injury and may experience a longer recovery form SRC. In addition, internal locus of control rating have been shown to predict adherence to rehabilitation and may benefit positively influence recovery outcomes of other sport-related injuries (McDonald-Miszczak, Maki, & Gould, 2000).

Limitations

This study has several limitations. First, these results are based on a small sample of 26 high school athletes in Northwest Arkansas and may not serve as a representative sample of this demographic group. Due to the small sample size, not all planned data analyses were able to be conducted, for example, a logistic regression. A larger sample size could possibly assist in illuminating non-significant trends observed in the current study regarding length of recovery in days and fear of re-injury scores. Second, fear of re-injury, locus of control, and recovery perception reports were based on the athletes self-report. Third, the current study experienced participant attrition. Only 15 athletes completed the testing battery at each of the four time times which resulted in an incomplete dataset.

Suggestions for Future Research

Further investigation is needed to determine the extent of the relationships proposed in the discussion, especially the relationship between fear of re-injury and length of recovery. Baseline measures of the external and internal locus of control subscales should be included and investigated as a risk factor for high fear of re-injury following SRC. In addition, future studies may want to consider using additional measures, for example, social support, to investigate the relationship between coping resources and fear of re-injury following SRC as well as a history of previous sports-related injuries.

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Appendices

Appendix A

Table 7.

A List of Items on the ImPACT Demographics/Health History Section

Age	Sex
Grade level	History of headache/migraine
LD/ADHD	Previous history of concussion

Appendix B

Modified Tampa Scale of Kinesiophobia

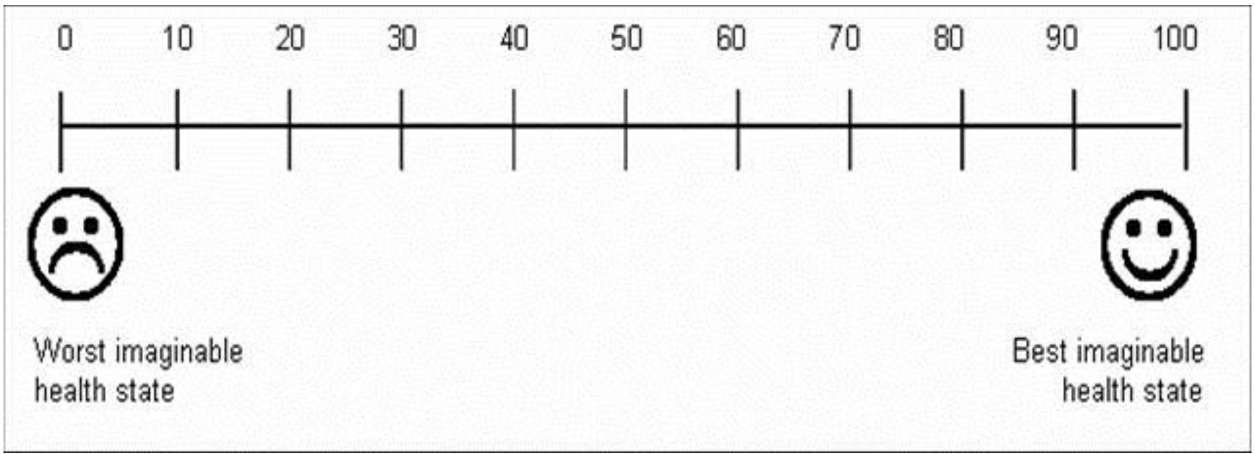
1 = strongly disagree
2 = disagree
3 = agree
4 = strongly agree

Appendix C

1. I'm afraid that I might hurt myself if I exercise	1	2	3	4
2. If I were to try to overcome it, my symptoms would increase	1	2	3	4
3. My body is telling me I have something dangerously wrong	1	2	3	4
4. My symptoms would probably be relieved if I were to exercise	1	2	3	4
5. People aren't taking my concussion seriously enough	1	2	3	4
6. My concussion has put my body at risk for the rest of my life	1	2	3	4
7. Pain always means I have injured my body	1	2	3	4
8. Just because something aggravates my symptoms does not mean it is dangerous	1	2	3	4
9. I am afraid that I might injure myself accidentally	1	2	3	4
10. Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my symptoms from worsening	1	2	3	4
11. I wouldn't have this much pain if there weren't something potentially dangerous going on in my body	1	2	3	4
12. Although my concussion is painful, I would be better off if I were physically active	1	2	3	4
13. Pain lets me know when to stop exercising so that I don't injure myself	1	2	3	4
14. It's really not safe for a person with a condition like mine to be physically active	1	2	3	4
15. I can't do all the things normal people do because it's too easy for me to get injured	1	2	3	4
16. Even though something is causing me a lot of pain, I don't think it's actually dangerous	1	2	3	4
17. No one should have to exercise when he/she is in pain	1	2	3	4

Self-reported Percent Back to Normal

Please rate your percent back to normal right now from 0% (no improvement in recovery since concussion) to 100% (fully recovered since concussion). Please mark on the scale the percent back to normal you feel right now.



Appendix D

Levenson's Multidimensional Locus of Control Scale

For each of the following statements, indicate the extent to which you agree or disagree by circling the appropriate number.

	Strongly Disagree	Disagree Somewhat	Slightly Disagree	Slightly Agree	Agree Somewhat	Strongly Agree
1. Whether or not I get to be a leader depends mostly on my ability.	1	2	3	4	5	6
2. To a great extent my life is controlled by accidental happenings.	1	2	3	4	5	6
3. I feel like what happens in my life is mostly determined by powerful people.	1	2	3	4	5	6
4. Whether or not I get into a car accident depends mostly on how good a driver I am.	1	2	3	4	5	6
5. When I make plans, I am almost certain to make them work.	1	2	3	4	5	6
6. Often there is no chance of protecting my personal interests from bad luck.	1	2	3	4	5	6
7. When I get what I want, it's usually because I'm lucky.	1	2	3	4	5	6
8. Although I might have a good ability, I will not be given leadership responsibility without appealing to those in positions of power.	1	2	3	4	5	6
9. How many friends I have depends on how nice a person I am.	1	2	3	4	5	6
10. I have often found that what is going to happen will happen.	1	2	3	4	5	6
11. My life is chiefly controlled by powerful others.	1	2	3	4	5	6
12. Whether or not I get into a car accident is mostly a matter of luck.	1	2	3	4	5	6

13. People like myself have very little chance of protecting our personal interests when they conflict with those of strong pressure groups.	1	2	3	4	5	6
14. It's not always wise for me to plan too far ahead because many things turn out to be a matter of good or bad fortune.	1	2	3	4	5	6
15. Getting what I want requires pleasing those people above me.	1	2	3	4	5	6
16. Whether or not I get to be a leader depends on whether I'm lucky enough to be in the right place at the right time.	1	2	3	4	5	6
17. If important people were to decide they didn't like me, I probably wouldn't make many friends.	1	2	3	4	5	6
18. I can pretty much determine what will happen in my life.	1	2	3	4	5	6
19. I am usually able to protect my personal interests.	1	2	3	4	5	6
20. Whether or not I get into a car accident depends mostly on the other driver.	1	2	3	4	5	6
21. When I get what I want, it's usually because I worked hard for it.	1	2	3	4	5	6
22. In order to have my plans work, I make sure that they fit in with the desires of people who have power over me.	1	2	3	4	5	6
23. My life is determined by my own actions.	1	2	3	4	5	6
24. It's chiefly a matter of fate whether or not I have a few friends or many friends.	1	2	3	4	5	6

Appendix E

UNIVERSITY OF ARKANSAS

Office of Research Compliance
Institutional Review Board

MEMORANDUM

TO:	Melissa Anderson Morgan Anderson Katie Stephenson Natalie Sherwood	Mallory McElroy Samantha Mohler Nathan D'Amico R.J. Elbin
FROM:	Ro Windwalker IRB Coordinator	
RE:	New Protocol Approval	
IRB Protocol #:	16-07-015	
Protocol Title:	*Examining the Effects and Recovery Time Following Sport-Related Concussion*	
Review Type:	☐ EXEMPT ☒ EXPEDITED ☐ FULL IRB	
Approved Project Period:	Start Date: 09/21/2016 Expiration Date: 09/18/2017	

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (https://vpred.uark.edu/units/rscp/index.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 150 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 109 MLKG Building, 5-2208, or irb@uark.edu.