Sport-Related Concussion and the Relationship of Psychological Functioning on Prolonged Recoveries

by

Patricia Arends

A thesis submitted in partial fulfillment of the requirements of the degree of

Master of Education

in

School and Clinical Child Psychology

Department of Educational Psychology
University of Alberta

Abstract

The purpose of this study is to explore potential risk factors of psychological functioning that contribute to the recovery of sport-related concussions (SRC) in professional and collegiate athletes. The current study used prospective reporting from athletes prior to and within 48 hours of sustaining a SRC. Participants included 63 male and female athletes participating in the Canadian Football League and University of Alberta varsity rugby, soccer, football, volleyball, ice hockey, and wrestling teams. Participants ranged in age from 18 to 37 years and sustained a SRC during the 2017 – 2018 athletic seasons. To assess for psychological functioning, the Brief Symptom Inventory (BSI-18) was utilized. The first analysis indicated baseline psychological symptoms of depression to be statistically predictive of prolonged concussion recovery ($F(1,61) = 5.301$, $p = .025$). Furthermore, analysis of athletes' baseline symptoms indicated statistical significance of several symptoms as being predictive of prolonged concussion recovery. Significant somatic symptoms include "numbness or tingling in parts of your body" ($F(1, 60) = 27.773$, $p < .000$, $R^2 = .316$), "faintness or dizziness" ($F(2, 59) = 22.031$, $p < .000$, $R^2 = .428$), "pains in the heart or chest" ($F(4, 57) = 15.615$, $p < .000$, $R^2 = .523$), along with symptoms of "feeling worthlessness" ($F(5, 56) = 15.344$, $p < .000$, $R^2 = .578$) and "feeling so restless you couldn't sit still" ($F(3, 58) = 18.170$, $p < .000$, $R^2 = .484$). The second analysis indicated post-injury psychological symptoms of anxiety to be statistically significant for predicting prolonged recovery from concussion ($F(1, 61) = 27.290$, $p < .000$). Additionally, several somatic and emotional symptoms reported post-injury were found to be predictive of a prolonged recovery. These symptoms include: "feeling no interest in things" ($F(1, 59) = 16.61$, $p < .000$, $R^2 = .220$), "feeling blue" ($F(2, 58) = 14.54$, $p < .000$, $R^2 = .334$), "feeling fearful" ($F(3, 57) = 14.15$, $p < .000$, $R^2 = .427$), and "numbness or tingling in parts of your body" ($F(4, 56) = 14.66$, $p < .000$,

R^2 = .512). These results suggest that both baseline and post-injury psychological functioning influence the recovery of sport-related concussions.

Preface

This thesis is an original work by Patricia Arends. The research is part of the Active Rehabilitation Project approved by the University of Alberta Research Ethics Board (Pro00073481).

Dedications

First of all, this thesis is dedicated to my family for their unconditional support, love, and encouragement. To my mother-in-law for her continual support and encouragement. To my parents for instilling a strong work ethic, with patience, and love. To my mother who always encourages me to continue my educational journey, celebrates my achievements, and listens to my struggles. To my late father who taught me to strive for success in all I do and who is forever in my heart. To my husband, James, who keeps me smiling, laughing, and always keeps me in perspective; you have helped me make my dreams become a reality, and without your support, strength, and sacrifices, I would not be the person I am today.

Additionally, I would like to thank my dearest friends, who have always been my biggest cheerleaders in life. Their continual support, love, and guidance have helped me through all of life's challenges. To my cohort, 10 intelligent, strong, and amazing women who have come along this journey with me. You inspire me to hustle and work hard every day.

Finally, this project is dedicated to all the athletes I have played and worked with in my athletic and academic careers. The struggles that athletes undergo when faced with an injury, especially concussion, is a unique and challenging burden. I will continue to fulfill my passion to contribute to the growing fields of sport-related concussion, athlete psychological challenges, and clinical child psychology.

Acknowledgments

I would like to thank my supervisor, Dr. Martin Mrazik, for his continuous support, patience, guidance, and encouragement that he provided me throughout this project and degree. I am grateful for all the experiences that Dr. Mrazik has provided for me and the opportunities for continual learning and growth. I am fortunate for the opportunity to further develop my skills and knowledge under Dr. Mrazik's supervision for my doctoral studies. Thanks to the University of Carolina and the Active Rehabilitation project for the opportunity to complete my thesis research with this project. I would also like to thank my committee members Dr. Phillip Sevigny and Dr. Okan Bulut for their time, contributions, and feedback on this project.

Table of Contents

Tables

Chapter One: Introduction

Benefits of Physical Activity

The benefits of participation in sports and physical activity for adults, adolescence, and children are well supported within the scientific literature. According to the American College of Sport Medicine and American Heart Association, a physically active lifestyle for healthy adults, involves moderate-intensity aerobic physical activity for 30 minutes five days a week or vigorous-intensity aerobic physical activity for 20 minutes three days a week (Haskell et al., 2007). Distinguishing between moderate-intensity and vigorous-intensity can be explained by changes in heart rate. A moderate-intensity physical activity consists of an acceleration of the heart rate such as during a brisk walk; whereas a vigorous-intensity physical activity involves rapid breathing and a substantial increase in heart rate usually obtained in activities such as jogging (Haskell et al., 2007). Living a physically active lifestyle has shown improvements in cardiometabolic health, and academic performance, and also lowers risks of medical conditions like obesity and type II diabetes (Janssen & LeBlanc, 2010; Strong et al., 2005). In addition to physical health benefits, the psychological benefits of being physically active and sport participation have also been well established. Furthermore, children involved in vigorous physical activity such as running, and participation in sports such as basketball, soccer, football, and hockey several times a week show decreased levels of anxiety and depression, and an increase in overall self-concept and well-being (Janssen & LeBlanc, 2010; McMahon et al. 2017; Strong et al., 2005).

Sport Participation

Participation in sports provides multiple physical and psychological developmental benefits. Vigorous aerobic activity during sports results in the greatest benefit for cardiovascular

and respiratory health (Janssen & LeBlanc, 2010). Children participating in sport experience team involvement, being mentored by coaches, collaborative activities with others their age, and goal directed activities (McMahon et al., 2017). Involvement in team and individual sports has been shown to support mental health development. Sport participation leads to lower levels of both anxiety and depression and higher levels of well-being in both males and females (McMahon et al., 2017).

Sport-Related Injury

Participating in sports and remaining physically active has significant benefits for a person's overall health, yet participation in sports and recreational activities also comes with a risk of injury. Several studies have shown a positive correlation between the increase of physical activity and increased physical injuries (Janssen & LeBlanc, 2010). Individuals who suffer more significant or prolonged physical injuries have the added burden of dealing with the psychological burden of managing their injuries.

Psychological outcomes as a result of an injury have been extensively researched. Research on competitive athletes has shown that emotions, cognitions, and behaviours are associated with their overall rehabilitation after a physical injury (Forsdyke et al., 2015). In other words, how athletes feel, think, and behave can impact their recovery and should be monitored throughout the rehabilitation of their injury. Physically injured athletes often experience increased anxiety, distorted cognitions about re-injury and self-image, and lack confidence in their athletic abilities (Forsdyke et al., 2015). When provided with appropriate coping strategies and supportive social interactions, an athlete's rehabilitation success rate increases (Forsdyke et al., 2015). Physical injuries are not the only form of injury that sports participation can yield;

sport-related concussions, are a subset of injuries that competitive athletes are at risk of receiving.

Sport-related Concussions: Sport-related concussions (SRC) are increasing in prevalence as awareness, knowledge, research, and diagnostic tools increase (Currie et al., 2017). Studying the effects of SRC is complicated due to unique injury characteristics. Sport-related concussions are often difficult to diagnose and treat, as symptoms of SRC are not always visible to athletes or clinicians and clinicians have to rely on subjective reporting from athletes. Athletes diagnosed with SRC may subjectively report experiencing physical, cognitive, and behavioural symptoms, for example, headaches, confusion, and mood changes which can overlap with other injuries (Sattler & Mrazik, 2014).

The majority of athletes with an SRC recover unremarkably within 10-14 days; however, there is a small subset of athletes who suffer from prolonged symptoms (McCrory et al., 2017; McCrea et al., 2005). As clinicians, athletes, and the public become more knowledgeable in SRC there is need for understanding the long-term effects that SRC can have on athletes. Research has highlighted a number of variables associated with prolonged SRC recovery; however, identifying variables that have the potential to be most predictive of prolonged recovery from SRC continues to evolve.

Some researchers suggest that prolonged symptoms following a SRC may be attributed to undiagnosed and untreated psychological symptoms (Currie et al., 2017). Studies have shown that psychological factors, such as anxiety and depression, may be predictive of prolonged recoveries after mild traumatic brain injuries (mTBI); however, research is still needed to fill in the gaps, specifically within the athletic population (Brooks et al., 2019; Zahniser et al., 2019). Other factors, such as pre-existing mood disorders and variables associated with the athletic

population (i.e. pressure to perform, re-injury, avoidance, motivation), can further impact an athlete's sport rehabilitation (Iverson et al., 2017; Grady, 2010). Providing clinicians with an understanding of potential risk factors that may lead to an athlete's prolonged recovery from a SRC is beneficial to the rehabilitation process.

The Rationale

Research investigating variables associated with prolonged recovery from SRC has mainly focused on injuries sustained in the lay population who are assessed through hospital emergency admissions. There is less research conducted with athletic populations. Furthermore, athletic populations are unique, not only in their ability to perform at a high level of competition but also with multiple variables associated with injury outcomes. When recovering from a physical injury, athletes have unique cognitions such as managing confidence, post-injury competence, and fear of re-injury (Forsdyke et al., 2015). Studies analyzing cognitions and psychological variables related to SRC have not been extensively researched.

The majority of research on SRC has been conducted using an athlete's subjectively-reported recall of previous symptoms and conditions prior to SRC. Select research has shown bias with this method of gathering pre-injury data and self-reported recall may not be a reliable source for pre-injury symptoms in athletic populations (Arends et al., 2019; Gunstad & Suhr, 2001). Instead, in order to eliminate recall bias and provide reliable data for predictive studies, it is important that athletes be assessed prior to participating in competitive sport in order to obtain baseline information.

Finally, the majority of research conducted with SRC has not focused on psychological predictors of complex recovery for athletes (Rice et al., 2018). Previous predictive studies have focused on physical symptoms, pre-injury characteristics, and neuropsychological results, such

as cognitive abilities, memory, and processing speed. Psychological factors, such as anxiety, depression, that are unique to athletic populations are often overlooked in predictive research for complex concussion recovery. Therefore, by obtaining reliable baseline and post-injury assessments of psychological symptoms, researchers can determine their predictive value for prolonged recovery of SRC; which may provide a new perspective and insight into the recovery of SRC within athletic populations.

Research Purpose

The purpose of this study is to explore the recovery of SRC in professional and collegiate athletes ages 18 to 37, including potential risk factors of psychological functioning that contribute to recovery, using the Brief Symptom Inventory-18. Additionally, the study focuses on athletes' psychological functioning at two time periods; baseline and within 48 hours of injury, to determine if psychological functioning at these specific points in time impact an athlete's overall recovery from SRC. Finally, this study investigates psychological variables in the areas of, anxiety, depression, and somatic symptoms, along with symptom items at the two time periods aforementioned.

Chapter Two: Literature Review

The purpose of this chapter is to review the current literature associated with predictive variables of prolonged recovery from concussion and mild traumatic brain injury (mTBI). To provide context, the chapter begins with a brief history and definition of sport-related concussions (SRC), followed by a review of typical pathology and symptomatology after a concussion and mTBI. Next, I review predictive research of concussion and mTBI recovery including psychological risk factors of prolonged recoveries, as well as limitations in athlete specific populations. The chapter concludes with the research study objectives and hypotheses statements supported by the reviewed literature.

Sport-Related Concussions

History and Epidemiology

The prevalence of SRC has increased over the last decade as awareness, knowledge, scientific evidence, and diagnostic tools assessing SRC have advanced (Currier et al., 2017). Historically, severe traumatic brain injuries (TBI) resulting in significant behavioural and emotional changes have been studied extensively while milder forms of TBI received lesser attention due to the lack of visible physical injuries (Zillmer et al., 2008). In the past, concussions have been referred to as a mild form of TBI (mTBI). The term concussion was first coined by an Arabic physician, Rhazes in the 900s. He differentiated a concussion from a traumatic brain injury by defining a concussion as an abnormal physiological state without the occurrence of brain lesions (McCrory & Berkovic, 2001). Due to their lack of amnesia, fractures, or internal bleeding, concussions were not previously considered a medical emergency; however, in the 1980s researchers discovered long term impairment from mTBIs and began to recognize their potential impact on athlete health and performance (Zillmer et al., 2008).

With an increase of participation in competitive sports in the last century, awareness and documentation of concussion have increased (Zillmer et al., 2008). The Government of Canada (2018) reported that 46,000 youth aged 5-19 years old presented to the emergency department and were diagnosed with concussions in 2016-17. Fifty-four percent of male concussions and 45% of female concussions were a result of a sport or recreational injury (Government of Alberta, 2018). In the United States of America, SRC account for 144,000 pediatric hospital visits annually (Meehan & Mannix, 2010). Sport-related concussions occur more frequently in full-contact sports such as football and ice hockey; however, they are still prevalent in moderate-contact sports such as basketball and soccer (Sattler & Mrazik, 2014). Specifically, in Canada, ice hockey, rugby, and ringette account for the highest reported brain injuries for 5-19-year old's (Government of Canada, 2018). Although the knowledge and awareness of SRC has increased over the last decade, reliable and valid research pertaining to the prevalence and detriments of SRC on youth and athletes remains incomplete.

Definition

The terms concussion and mTBI, used interchangeably in the past, make the terms confusing for study and research (McCrory et al., 2017). The American Psychiatric Association (APA; 2013) Diagnostic and Statistical Manual for Mental Disorders (5th ed.; DSM-5) defines a TBI as a trauma to the brain with specific characteristics, such as loss of consciousness, posttraumatic amnesia, disorientation, confusion, and/or neurological signs. Traumatic brain injuries as defined above consist of a range of characteristics, whereas mTBI may have milder versions of these characteristics, (McCrory et al., 2017).

Research involving milder forms of TBI was not conducted until the 1980s; through the work of Jeffrey Barth, the significance of milder forms of mTBI was realized (Zillmer et al.,

2008). McCrory and colleagues (2017) describe concussions as a subset of TBI, focussing on the immediate and transient symptoms of a TBI.

Although interchangeable terms (i.e., TBI, mTBI, concussion, and SRC) can be problematic when comparing and interpreting these terms across studies (McKinlay, 2009), this study will refer to the recent Concussion in Sport Group who provided the most current definition of SRC at their consensus meeting in 2016:

> Sport related concussion is a traumatic brain injury induced by biomechanical forces. Several common features that may be utilized in clinically defining the nature of a concussive head injury include: 1) SRC may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head; 2) SRC typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, signs and symptoms evolve over a number of minutes to hours; 3) SRC may result in neuropathological changes, but the acute clinical signs and symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies; 4) SRC results in a range of clinical signs and symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive features typically follows a sequential course. However, in some cases, symptoms may be prolonged. (McCrory et al., 2017, p. 2)

For the purpose of this thesis the term “concussion” and “sport-related concussion” will be used interchangeably and will follow the definition laid out by McCrory et al. (2017), as stated above. Furthermore, due to the fact that mTBI has been used interchangeably with concussion and SRC, select literature examining these terms will be reviewed and discussed.

Symptomatology and Pathology

Sport-related concussions as defined above include a number of neurological impairments (McCrory et al., 2017). Symptoms for SRC may consist of physical, cognitive, and behavioural loss. Physical symptoms may include; balance problems, blurry vision, dizziness, fatigue, headaches, ringing in the ears, sensitivity to light and/or noise, sleep impairment and vomiting (Sattler & Mrazik, 2014). Cognitive symptoms may include confusion, difficulty concentrating, and memory problems, while behavioural symptoms encompass symptoms such as anxiety, agitation, irritability, mood changes, and sadness (Sattler & Mrazik, 2014). It is important to note that these symptoms may or may not be immediately present after an individual receives a blow to the head or impulsive force, due to the fact that concussions are an evolving injury (McCrory et al., 2017).

Any athlete suspected to have suffered SRC should undergo an evaluation by a qualified medical professional (McCrory et al., 2017). The recent consensus meeting of the Concussion in Sport Group, McCrory and colleagues (2017) noted that range of symptoms used in diagnosing an athlete with a SRC includes somatic, emotional, and cognitive symptoms, physical signs of a concussion (e.g. loss of consciousness), balance impairment, behavioural changes, cognitive impairment, and sleep/wake disturbances. If an athlete experiences any one of these symptoms, a SRC may have occurred and the athlete should be removed from play until they have completed recommended steps and their symptoms have resolved. (McCrory et al., 2017). The recovery process and return to sport protocols after receiving a SRC consist of monitoring symptoms until an athlete presents as asymptomatic (McCrory et al., 2017; Sattler & Mrazik, 2014).

Typical Recovery: In the last decade, understanding the variables associated with the amount of time it takes for an athlete to recover from a SRC has evolved due to more rigorous

research findings. Research prior to 2005 reported that the majority of athletes with SRC recovered within 10 days of the injury (McCrory et al., 2017). However, a review of previous research suggests that studies were conducted with large group data and lacked a focus on individuals or stratified data by age cohorts; additionally, there is reason to suspect that athletes returned to sport prior to being asymptomatic (McCrory et al., 2017). Research conducted in the last decade suggests that an athlete's recovery time from a SRC may be longer than the initial 10 day findings (McCrory et al., 2017). In fact, some studies suggest that recovery time may be between 21-28 days post-injury (Henry et al., 2015) but variables like biological sex, age, history of learning and attention disorders moderate recovery longevity.

In the most recent consensus reported by the Concussion in Sport Group, the typical recovery time for adult athletes suffering from SRC is recorded as 10-14 days (McCrory et al., 2017). Although new research findings are suggesting that perhaps the current recovery time outlined in the consensus statement may not be an accurate recovery period for athletes suffering from SRC, this research has yet to be deliberated and validated.

Prolonged Recoveries

In this section, I begin by reviewing the most common variables that are predictive of prolonged concussion recovery. Following the prolonged recovery section, I narrow my focus to overall psychological variables of concussion or mTBI, including symptom scores on measures of psychological distress. I then address the specific psychological conditions of anxiety, depression, and somatization, and conclude with psychological symptom items as predictors of prolonged recovery from concussion and mTBI.

Many factors contribute to a prolonged recovery from a concussion. Zuckerman et al. (2016) conducted a prospective case control study investigating risk factors that impact post-

concussive symptoms in 1507 collegiate athletes who received a SRC. Of the 1507 collegiate athletes, 112 developed prolonged symptoms lasting longer than 4 weeks and were identified as the post-concussive symptom group, while athletes who recovered within 2 weeks were identified as the non-post-concussive symptom group. An odds ratio was estimated using a logistic regression model to compare the two groups. Results found that retrograde amnesia, difficulty concentrating, light sensitivity, and insomnia were identified as risk factors in the post-concussive symptom group. Additionally, multiple concussions were also associated with increased odds of post-concussive symptoms, which is consistent with previous studies (Corbin-Berrigan & Gagnon, 2017; McCrory et al., 2017; Morgan et al., 2015; Zuckerman et al., 2016).

A study conducted by Meehan and colleagues (2013) examined potential risk factors that may contribute to prolonged symptoms for athletes (ages 7.6 to 26.7 years) suffering from a SRC. This study utilized prospective data by breaking athletes into two groups, one group showing symptom resolution within 28 days, and the other group with persistent symptoms after 28 days. Using a logistic regression model, the two groups were compared on a number of demographic variables, self-report measures, and neuropsychological examinations to determine their predictability. The results showed that total concussion symptoms were predictive of a prolonged recovery; while alone, no specific symptoms were predictive risk factors. Furthermore, the researchers discovered younger athletes took a longer time to recover from SRC.

Cognitive deficits and symptoms have additionally shown to be potential risk factors for prolonged recovery from concussion. One study investigated adult emergency department patients diagnosed with mTBI and discovered that psychological symptoms were predictive of cognitive deficits over time after a mTBI (Nelson et al., 2018). Additionally, poor cognitive

performance also predicted an increase of symptoms over time (Nelson et al., 2018). Other emergency department results conducted with children and adolescents suggest that acute cognitive deficits in orientation at the time of injury to be a significant predictor of psychological distress at 12 weeks post-injury (Brooks et al., 2019). Further studies on emergency department admission of children and adults have identified cognitive symptoms to be present post-injury when compared to baseline scores (Cunningham et al., 2008).

In addition to cognitive deficits, pre-injury demographics have also been found to be predictive of prolonged recoveries. Researchers have discovered the following demographic variables to be predictive of prolonged symptom recovery from mTBI: a history of brain injury, living alone, non-Caucasian, psychotropic medication, high levels of alcohol consumption, as well as females (Theadom et al., 2016). These variables showed statistical significance as being predictive of poor recovery outcomes at 12-months post-injury (Theadom et al., 2016). Pre-existing demographic variables such as premorbid mood disorder, psychiatric illness, significant life stress during recovery, and family history of mood disorders or migraines are additional risk factors of prolonged concussion recovery for high school athletes (Morgan et al., 2015). These results suggest that pre-existing psychological functioning is associated with the recovery from SRC.

Psychological Implications

A history of mood disorders, psychological illness, family history of mood disorders, and stress during the recovery of a SRC have been shown to be predictors of prolonged recovery (Morgan et al., 2015). Therefore, further investigations, researching the impact of psychological variables on the recovery of concussions, are warranted.

Brooks et al. (2019) investigated a number of predictors of psychological distress following a concussion in pediatric emergency department patients (ages 6 to 17 years). Psychological distress was measured at 4- and 12-weeks post-injury. Findings showed psychological distress increased from 4 to 12 weeks with children who had no previous pre-injury psychological distress. Additionally, 23% of the youth reported psychological distress at 4 and 12-weeks post-injury. It is important to note that Brooks et al. (2019) and other researchers often collect baseline scores retrospectively. There is a cause for concern of validity when collecting retrospective baseline scores as self-reported recall has the potential to be biased (Arends et al., 2019; Brooks et al., 2014; Cunningham et al., 2008; Gunstad & Suhr, 2001; Iverson et al., 2010; Yang et al., 2014). Regardless, these results from Brooks and colleagues study suggest that psychological variables play a considerable role in the recovery from concussion for pediatric populations. These studies indicate an area of interest for researchers; specifically, psychological variables may have implications on recovery from concussion.

Self-Report Measures. Research findings support the importance of utilizing self-report measures that incorporate symptoms, including psychological, psychosocial, and physiological considerations, relevant to concussions. Several studies examined the usefulness of self-report measures, including specific symptoms and total symptom scores.

The Post-Concussion Symptom Scale (PCSS) is a self-report measure applied in neurocognitive, sport-concussion, and mTBI assessments. When compared to neurocognitive and vestibular changes in weeks following a SRC, symptoms as reported on the PCSS display the greatest significance in change across time periods (Henry et al., 2015). As an athlete recovers from a SRC, the total symptom score on the PCSS also significantly improves (Henry et al., 2015). Symptoms on self-report measures reflect the biggest change over time for athletes

recovering from SRC. The PCSS symptom severity score is predictive of prolonged recovery of SRC at acute (24-hours) post-injury assessment (Nelson et al., 2016). Additionally, the PCSS has been utilized to investigate concussion recovery with children, resulting in the total symptoms score being predictive of prolonged recovery (Corbin-Berrigan & Gagnon, 2017). Of note, the emotional category within the PCSS and the item, irritability, displays a strong tendency for predicting prolonged recovery for children diagnosed with a concussion (Corbin-Berrigan & Gagnon, 2017).

The Rivermead Post Concussion Symptoms Questionnaire is another self-report measure used for diagnosing and tracking symptoms of concussion recovery. Upon initial evaluation, overall scores on the Rivermead Post Concussion Symptoms Questionnaire show promising results at predicting prolong recovery in a mTBI group (Rabinowitz et al., 2015). Furthermore, the Rivermead Post Concussion Symptoms Questionnaire has shown similar results as studies on the PCSS, with emotional symptoms persistent at 1-month post-injury (Cunningham et al., 2008; Corbin-Berrigan & Gagnon, 2017).

Predictive research conducted on athletic populations has shown total symptom score on self-report measures to be predictive of prolonged recovery. One study examined high school and collegiate athletes' baseline and post-injury scores on the Graded Symptom Checklist (GSC; McCrea et al., 2012). The results indicated that an increase of 20 points on the GSC were predictive of prolonged SRC symptoms (McCrea et al., 2012). A second study found similar results with athletes' (ages 7 to 26) post-injury total symptoms on the PCSS to be predictive of prolonged recovery, which is similar to previous research (Corbin-Berrigan & Gagnon, 2017; Henry et al., 2015; Meehan et al., 2013; Meehan et al., 2014). These studies however, focused on demographic variables such as previous concussions, retrograde amnesia, in addition to

neurocognitive functioning and balance, and did not investigate psychological variables. The results from these studies of athletic populations support the need for predictive research of psychological functioning and prolonged SRC recovery of athletes. Furthermore, for clinicians, these results suggest the utility of self-report measures as tools for predicting and screening potential prolonged recoveries. Further investigation of the following psychological variables on self-report measures may assist clinicians with a better understanding of an athlete's recovery process.

Anxiety Symptoms. Anxiety disorders after a mTBI are the most common psychological diagnosis at one-year post-injury (Mallya et al., 2015). This finding leads to understanding how anxiety can influence the recovery process from concussion at the early stages of rehabilitation.

Investigating anxiety within elite athletes is important. Studies have shown that athletes who sustained a SRC often report high anxiety in the acute stages of their injury, compared to healthy controls (Rice et al., 2018; Singh et al., 2015). Although high levels of anxiety symptoms have been found with concussed elite athletes, other studies have found no differences between athletes suffering from either SRC or orthopedic injuries (Covassin et al., 2014; Rice et al., 2018). Predictive research on anxiety variables may provide additional information to contribute to teasing out differences between concussion and orthopedic injuries for elite athletes.

Brooks et al. (2019) investigated anxiety as a variable in prolonged psychological distress from concussion. Significant results of psychological distress were found in children who reported a pre-existing anxiety disorder prior to injury. The authors concluded that anxiety may contribute to a prolonged recovery from concussion. It is worthy to note that this study collected parent self-report estimates of their child's functioning prior to their concussion. Pre-injury estimates of demographic information, for the most part, is a reliable way to gather information;

however, parents in this study were also asked to provide pre-injury functioning for post-concussive symptoms, which may not be an accurate or valid measure of a child's functioning (Brooks et al., 2014).

Although anxiety is a psychological variable to be considered during prolonged recovery from concussion, there is a lack of research as to the specific contributions and impact anxiety has on the recovery of concussions and mTBI (Mallya et al., 215). Some results show promising outcomes for anxiety as a predictive variable as adjusted odds ratio results suggest a strong trend towards delayed recovery, while increased symptoms of anxiety immediately after a concussion nears significance (Grubenhoff et al., 2016). Similar findings were found with scales correlated to anxiety and depression, with a higher prevalence in delayed recovery groups approaching significance. One factor which may be attributed to the lack of significant findings is the age of the population. The population in Grubenhoff et al. (2016) study used pediatric patients within emergency departments, who may provide different results than athletic populations, or patients who report to physicians outside of the emergency department.

Anxiety and depression may at times be comorbid and often have similar presentations and/or features that are important to consider as psychological variables impacting the recovery of concussion (APA, 2013). The relationship between anxiety and depression variables within elite athlete populations warrants investigation. In fact, studies have found that elite athletes who report pre-injury depression are more likely to suffer from post-injury anxiety after sustaining a SRC (Rice et al., 2018; Yang et al., 2015).

Depressive Symptoms. As the process of recovery from a concussion or TBI can be isolating and slow, an increase in depressive symptom report is common for an individual recovering from a concussion or TBI. Depressive symptoms are often reported by elite athletes

after sustaining a SRC (Rice et al., 2018). Rice and colleagues conducted a meta-analysis on elite athletes reporting symptoms of depression after a concussion. The results from the meta-analysis concluded that retired NFL players often reported depression after sustaining a SRC. However, these studies were collected retrospectively and have the potential to be biased or mediated by other factors such as life stressors. In addition to retired athletes, Rice and colleagues reviewed studies of current competing elite athletes and discovered that athletes often reported symptoms of depression 4-weeks post-injury. As depressive symptoms are reflected in samples of elite athletes, investigating depression as a predictive variable for prolonged symptoms of SRC is warranted.

Pre-injury depression has the potential to impact psychological symptoms in concussed elite athletes. Yang et al. (2015) investigated the relationship between psychological symptoms collected prospectively and post-concussion symptoms of elite collegiate athletes. Depression was the only psychological variable to be predictive of post-concussive symptoms of anxiety and depression.

Similar results have been found in pediatric populations. Ho and colleagues (2020) conducted a single site cross sectional study investigating post-concussion depression symptoms and how it relates to post-concussion symptoms in youth (ages 10 to 17 years). Youth, after being formally diagnosed with a concussion, were split into a post-concussive depression group and a non-depression group. Comparisons between the two groups resulted in the post-concussive depression group endorsing a heightened number of symptoms on the PCSS. Upon further review of items on self-report measures, researchers discovered that the post-concussive depression group presented with more severe depression symptoms compared to the non-depressed group. These findings were from youth recruited to an emergency department in

Ontario, Canada. Further research needs to be conducted to see if there are similarities in pediatric athletic populations.

The research of depression symptoms after injury as a variable in prolonged recovery from concussions has shown mixed results. When a mTBI group with persistent symptoms was compared to the general population, clinical levels of anxiety, depression, and quality of life did not significantly differ (Theadom et al., 2016). However, it is difficult to differentiate symptoms that are unique to prolonged recovery from a mTBI from symptoms of general anxiety and depression found in the general population. Additional studies have shown pre-injury depression to be predictive of prolonged recovery in athletic populations (Iverson et al., 2017). These results are suggestive of future studies on depression specificities as predictive factors of prolonged recovery from mTBI.

Somatic Symptoms. It is not uncommon for individuals suffering from concussions to report somatic physical symptoms. The rating of somatic and bodily symptoms is important to consider as higher ratings of these symptoms can predict prolonged recovery from concussion. Therefore, somatic symptoms need to be considered in the research of SRC.

Nelson et al. (2016) conducted a longitudinal study investigating pre-injury variables and injury-related variables as predictors of symptom duration following a SRC. The researchers evaluated baseline assessments of high school and collegiate student athletes prior to receiving a SRC, along with psychological, neurocognitive, and balance assessments at days 8, 15, and 45 post-injury. This study provides unique insight into pre-injury evaluations (i.e., baseline assessment) of psychological and neurocognitive scores from athletes during normal everyday functioning. One of the measures for gathering psychological information was the Brief Symptom Inventory-18 (BSI-18), a self-report measure that evaluates symptoms of anxiety,

depression, and somatization, in addition to overall psychological functioning. Baseline predictive results showed the somatic symptom score on the BSI-18 as the only predictive variable of a prolonged recovery. Mediation analysis, also considered in this study, provided significant results showing post-concussive symptoms mediating and influencing the relationship between preinjury somatic symptoms and symptom duration. These results suggest that preinjury somatic symptoms are not only predictive of prolonged recovery from SRC, but additional post-concussive symptoms may be influencing this relationship.

It can be inferred that somatic symptoms tend to be high at the time of injury and decrease over time. Studies conducted on somatic symptoms show mixed results across populations. Somatic symptoms have been found to decrease over time on self-report measures with pediatric populations (Cunningham et al., 2008). However, groups of pediatric populations with delayed recoveries continue to report higher somatic symptoms on self-report measures (Grubenhoff et al., 2016). Studies conducted on pediatric and young adult athletic populations suggest that acute somatic symptoms including headaches and dizziness are predictive of prolonged recovery (Iverson et al., 2017). The results from these studies suggest supporting the concept that somatic symptoms may influence the recovery of adult athletes with SRC.

An additional study conducted by Nelson et al. (2018) examined several predictive variables (i.e. demographic, injury characteristics, and neuropsychological assessments, including psychological measures such as the BSI-18 and PCSS) with emergency department patients (ages 18 to 45 years). Nelson and colleagues assessed patients within 72 hours of the injury and again at days 8, 15, and 45 post-injury. Using multivariate analysis, their findings showed somatic symptom scores on the BSI-18 collected within 72 hours of the injury to be a predictive variable of prolonged recovery from mTBI. Additionally, the PCSS symptom severity

score, within 72 hours of the time of injury, resulted in being a significant predictor of prolonged recovery from mTBI. The authors acknowledged that potential pre-injury somatic symptoms, which were not measured in this study, may contribute to the recovery of mTBI,

Symptom Items: Understanding overall psychological functioning in the areas of anxiety, depression, and somatization is important to research as these variables may impact the recovery process of concussion. Additionally, it is important to investigate psychological symptoms at an item level to determine if individuals suffering from specific symptoms may be at risk of prolonged recovery from concussion.

There are mixed results when looking at specific items on self-report measures as predictors of prolonged recovery from concussion. One study compared pediatric athletes with prolonged recovery to those whose symptoms resolved within 28 days (Meehan et al., 2013). Meehan and colleagues (2013) discovered that there were no differences in symptom report at an item level between the two groups. These results were consistent with another study conducted on athletes (ages 7 to 26 years) investigating predictive variables (Meehan et al., 2014). Psychological symptom items were not found to be predictive in the group of athletes with prolonged concussion symptoms lasting longer than 28 days (Meehan et al., 2014). Although symptom items were not predictive in the two studies, the measures that were utilized in the studies were not measures of psychological functioning and may not be an accurate measure of psychological symptom items. Additionally, it is important to note that the number of days used in these studies to determine prolonged recovery was 28 days, which is significantly longer than the 14-days suggested by the Concussion in Sport Group's current consensus report (McCrory et al., 2017; Meehan et al., 2013; Meehan et al., 2014).

A study conducted by Ho and colleagues (2020) investigated the items of the PCSS as predictive of prolonged recovery in youth populations. Significant results were shown for specific items of the PCSS including, irritability, nervousness, and emotionality to be present in the depressive group (Ho et al., 2020). In a study by Corbin-Berrigan & Gagnon (2017), the item of irritability on the PCSS has been found to show a strong tendency of predicting prolonged recovery of children. Irritability is a common behavioural symptom for individuals suffering from a concussion and the severity of this symptom shows potential of being predictive of prolonged recovery from concussion (Sattler & Mrazik, 2014). It is difficult to tease apart specific items as a result of a concussion from outside factors that may be contributing to an individual's recovery; however, understanding the significance of these items can assist clinicians in the recovery process of concussion for individuals.

The above sections were a review of variables that may be contributing to prolonged recoveries of mTBI and concussion. By evaluating psychological implications including, but not limited to, anxiety, depression, somatic symptoms, and symptom items in the recovery of concussion, clinicians have the opportunity to improve individuals' psychological functioning. This offers the potential to improve overall functioning and improvements in all areas of life, for individuals recovering from a concussion (Zahniser et al., 2019). Although the literature reviewed above supports the need for further evaluation of psychological variables in studies of prolonged concussion recovery, there continues to be a lack of research investigating these variables within athletic populations and SRCs.

Athletic Populations

The research reviewed above shows a lack of predictive concussion research conducted with athletic populations, as the majority of studies have been conducted on emergency

department patients. Student athletes are a unique population in and of themselves because they have a number of factors that they deal with on a daily basis such as academics, personal stressors, physical health, and athletic performance (Broughton & Neyer, 2001). Student athletes are privy to a number of demands and stressors from their respected competitive sports along with the regular demands of student life (Broughton & Neyer, 2001). Professional athletes also experience unique demands, including career dissatisfaction, performance expectations, and career ending injuries (Gouttebarge et al., 2018). Due to their uniqueness, elite athletes may handle rehabilitation and injury with SRC differently than the general population.

Mental Health of Athletes

Athletes are subject to psychological stressors, although there is a stigma that may influence them admitting to these stressors (Moreland et al., 2018). Student athletes in college populations have been found to experience depression, along with other mental health disorders, as often as the general student body (Reardon & Factor, 2010). However, athletes including student athletes, are less willing to use mental health services due to gender, stigma, athletic norms, and influences from coaches (Moreland et al., 2018). The willingness of student athletes to come forward and acknowledge psychological concerns may impact their self-reporting of mental health concerns, as student athletes have been shown to report fewer depressive symptoms than other students (Proctor & Boan-Lenzo, 2010). It is important to note that although student athletes reported fewer depressive symptoms compared to the student body, they may still report symptoms of depression. Studies have shown that student athletes do in fact report depression, with 15.6% of these student athletes meeting the criteria for clinical depression (Proctor & Boan-Lenzo, 2010). Additionally, elite athletes have been found to report lower levels of anxiety to their coaches and athletic staff compared to athletes' self-report

measures of anxiety collected confidentially (Meier et al., 2015; Rice et al., 2018). These findings present the significance of understanding and providing supports and mental health interventions for student athletes.

Athlete Concussion Outcomes

Athletic populations are at a higher risk of receiving a brain injury, as SRC are the second most common cause of head injuries, next to motor vehicle accidents (Zillmer et al., 2008). In the United States, SRC account for 144,000 pediatric hospital visits annually (Meehan & Mannix, 2010). The prevalence and increased risk for athletes make the research of SRC of great significance to ensure that clinicians understand the uniqueness of the athletic population to ensure safe and full recoveries. The research reviewed above considers a link between psychological variables and the recovery of concussions and mTBI; there is now a need to transition this research to athletic populations. Athletes are prone to mental health disorders and these variables may have implications on their recovery from SRC. Therefore, it is important for research to determine if there are potential psychological risk factors that may be predictive of prolonged recovery from SRC, in order for these risks to be addressed and supported through an athlete's recovery from a SRC.

Research Objectives

The main objective of this study is to investigate psychological functioning as a predictive variable of a prolonged recovery for SRC at two different time periods; baseline and within 48 hours of the injury.

Objective 1A

To assess the number of athletes at baseline who fall into the At-Risk level on the scales of the BSI-18 as predictive of prolonged recovery from a SRC. The scales included in the BSI-18 are anxiety, depression, and somatization subscales.

IV: Athlete baseline scores on the 3 BSI-18 scales.

DV: Athlete recovery time in days.

Hypothesis: *Athletes who report At-Risk levels on the anxiety, depression, and/or somatization subscales will have a prolonged recovery from their SRC, with the somatization scale showing the greatest significance.* Research shows that individuals with increased levels of psychological symptoms and somatic symptoms at baseline are at risk of experiencing a longer recovery from concussion and mTBI (Neslon et al., 2016).

Objective 1B

To assess athletes baseline scores on the BSI-18 at an item level, to determine if specific symptoms as reported through items on the BSI-18 are predictive of prolonged recovery form a SRC.

IV: Items on the BSI-18 for athlete at baseline.

DV: Athlete recovery time in days.

Hypothesis: *Athletes who report concerns on items related to somatic symptoms will experience a prolonged recovery from SRC.* Early research on baseline studies indicates there is a potential relationship between pre-injury symptoms of somatization and symptom recovery from concussion and mTBI (Nelson et al., 2016).

Objective 2A

To assess athletes psychological scores within 48 hours of a SRC and fall within an At-Risk level on the scales of the BSI-18 as predictive variables of prolonged recovery for athletes. The scales included in the BSI-18 are anxiety, depression, and somatization subscales.

IV: Athlete scores on the 3 BSI-18 scales collected within 48 hours of a SRC.

DV: Athlete recovery time in days.

Hypothesis: *Athletes who report At-Risk levels on the anxiety, depression, and/or somatization scale will have a prolonged recovery from their SRC.* Research shows that psychological variables and stressors after a concussion or mTBI can have implications on an individual's recovery and be at risk of experiencing a prolonged recovery from their injury (Nelson et al., 2018, Nelson et al., 2016; Rabinowitz et al., 2015; Rice et al., 2018).

Objective 2B

To assess athlete scores within 48 hours of a SRC at an item level on the BSI-18, as a predictive variable of prolonged recovery from SRC.

IV: Items on the BSI-18 of athlete collected within 48 hours of injury.

DV: Athlete recovery time in days.

Hypothesis: *Athletes who report a concern on items related to irritability, nervousness, and emotionality will experience a prolonged recovery from SRC.* Research suggests that symptoms of irritability, nervousness, and emotionality may result in a prolonged recovery from concussion and mTBI (Corbin-Berrigan & Gagnon, 2017; Ho et al., 2020).

Chapter Three: Methods

This chapter contains five subsections. The first subsection is a review of the study design and key terms, followed by an explanation of the measurements used. The other subsections include the data collection procedure managed in the study and a description of the participants. The final two subsections discuss the statistical analysis conducted; concluding with ethical considerations and the study ethics obtained.

Research Design and Key Terms

The study data used a prospective, quasi-experimental design. As the participants selected were formed naturally with no random selection taking place, the study qualifies as a quasi-experimental design. The quasi-experimental study design poses a threat to the internal validity of the study, as we cannot conclude that the participants were equivalent to each other in areas such as pre-injury mood disorders, years of education, and age, along with overall psychological function or adjustment (Creswell, 2014; Evans, 2008). Although the quasi-experimental design allows for criteria selection, the threats to internal validity need to be considered (i.e. controlling for extraneous factors).

Inclusion and Exclusion Criteria

Data was collected in the 2017 – 2018 athletic seasons, as part of the Active Rehabilitation project. Inclusion criteria for the study were as follows:

a) rostered professional Canadian Football League athletes;
b) rostered student athletes enrolled at the University of Alberta;
    a. rostered athletes participating in either a contact or non-contact varsity team including: basketball, rugby, soccer, football, volleyball, and ice hockey.

Exclusion criteria included:

a) rostered athletes under the age of 18;

b) rostered athletes over the age of 40;

These exclusion criteria were selected to minimize influences on the variables that are not related to current psychological functioning. The exclusions allowed the selection of rostered athletes performing at a high level of sport within a specific age range. It is important to note that participants with a history of psychological disorders were not excluded from the study, as they were medically cleared to play by team physicians.

Key Terms

For the purpose of this study, the term "concussion" will be defined by McCrory and colleagues (2017) as stated at the Concussion in Sport Group's most recent consensus meeting. Furthermore, the term "psychological functioning" will refer to an athlete's psychological, behavioural, social, and overall mental health functioning during the study. Additionally, "athlete" will refer to athletes of both professional and collegiate levels ranging from the ages of 18 to 40 years old.

Measures

One measure, the Brief Symptom Inventory-18 (BSI-18), was utilized in the study to evaluate psychological functioning and outcomes.

BSI-18

The BSI-18 was selected to measure psychological functioning and outcomes (see Appendix A). This measure is used to evaluate psychological functioning in predictive research of both SRC and TBI studies of athletes, inpatient, and outpatient populations (Nelson et al., 2018; Nelson et al., 2016; Rabinowitz et al., 2015; Zahniser et al., 2019). Previous studies

investigating the reliability and validity of the BSI-18 show significant correlations across a number of measures of psychological adjustment (Meachen et al., 2008). In one particular study, the BSI-18 has shown excellent reliability and validity with inpatient and follow-up patient populations (Meachen et al., 2008).

The BSI-18 consists of 18-items measured on a 5-point Likert scale assessing psychological distress in the past 7 days (Lancaster et al., 2016). Scores are summed into total scores, the Global Severity Index (GSI), along with three subscales: anxiety, depression, and somatization. Each subscale consists of 6 items with higher scores signifying greater levels of psychological distress.

Several validation studies support the use of the BSI-18 in TBI patient populations. Lancaster and colleagues (2016) conducted a study to investigate the BSI-18's reliability and validity in student athletic populations of high school and collegiate athletes. Results indicated high levels of internal consistency of the GSI (.83) and on all three subscales of the BSI-18 (.66 to .76). Test-retest reliability estimates demonstrated fair to poor results. Fair results were demonstrated when participants were retested at 7-days (.56 to .70), whereas poor results were found at 30-days (.31 to .40) and 165-days (.28 to .52). These test-retest results suggest difficulties measuring a change of psychological functioning over time, which may be cause for concern when using the BSI-18. With respect to criterion validity, the GSI showed high levels of correlation compared to other psychological measures (.74 to .81), while the subscales displayed moderate results (.36 to .49). All scales and the GSI of the BSI-18 resulted in a significant moderate negative correlation when compared to a life satisfaction scale (-.20 to -.36), suggesting that an increase in BSI-18 scores results in a decreased level of life satisfaction.

The results of Lancaster et al. (2016) study show similar results with previous studies on TBI inpatient and follow-up patient results; however, there is a variation in the results between athletic, TBI inpatient, and follow-up patient populations (Meachen et al., 2008). With respect to an athletic population, the GSI provides the strongest reliability and validity results for measuring emotional adjustment, but the subscales should be interpreted with caution (Lancaster et al., 2016). It is important to note that the use of the BSI-18 is for the screening of psychological functioning and not for a formal psychological diagnosis, which is supported by the results described above (Lancaster et al., 2016). These results suggest the BSI-18 to be an appropriate tool to measure psychological functioning in athletic populations.

Data Collection

The population of interest for this study was professional and collegiate athletes. Participants were collected from a larger project involving a cluster-randomized pragmatic trial utilizing male and female athletes from several sites across three countries (Canada, United States, and New Zealand), multiple sports, levels of play, and levels of contact. However, due to feasibility and accessibility, participants were recruited from a convenience sample extracted from the population. The study participants were gathered from the Canadian Football League (CFL) and the University of Alberta varsity athletic teams as these were the sites that Dr. Martin Mrazik was the principal investigator, allowing him access to data. Furthermore, the sample was formed from the athletes who sustained a SRC during the 2017 – 2018 CFL and University of Alberta athletic seasons; consisting of 9% of the overall population. It could be argued that this form of sampling has the potential for concerns of internal validity, due to the nature of the sample not being a true representation of the population (Creswell, 2014). However, the formation of the sample is congruent with current research which indicates that concussions

account for 6.2% of all injuries and 4.47 per 10,000 athletic exposures (i.e. athletes exposed to injury in practice or competition) which is similar to the concussion rates in the current sample and therefore, presents as a true representation of the CFL and University of Alberta athletic population (Zuckerman et al., 2015).

This study was given ethics approval prior to the beginning of the study (Pro00073481). Each athlete was required to sign a consent form prior to participating in the study. The consent form contained information regarding the study purpose, benefits, risks, researchers involved, and commitment required to participate (see Appendix B). Participants were asked to complete a battery of measures at baseline (prior to the start of their athletic season), 24-48 hours post-injury, asymptomatic post-injury, and 1-month post return to play. An athlete suspected of sustaining a SRC underwent a medical examination by the team physician within 48 hours post-injury, as per the league and University of Alberta policies. When appropriate, the team physician provided a concussion diagnosis. Once diagnosed, athletes underwent rehabilitation protocols monitored by medical professionals. An athlete was fit to return to play after being asymptomatic and cleared by the team physician. For the purpose of this study, baseline results and initial post-injury assessments (24-48 hours) were used. Athletes' endpoint times were determined by the number of days from the date of the diagnosed concussion to the date they were medically cleared to return to play. For the focus of this study, the BSI-18 was utilized as the measure of psychological functioning.

Study Participants

The population for this study included 809 CFL and collegiate athletes. Participants who were diagnosed with a SRC during the 2017 – 2018 and 2018 – 2019 athletic season were included in the analysis. The overall sample included 74 athlete participants. Eleven athlete

participants were excluded as a result of study attrition. Attrition for this specific study may be due to a number of factors such as missing data, not being selected for an athletic team, lack of return to play date, and confounding variables such as multiple injuries impacting the recovery process. After exclusion criteria, a total of 63 athletes participated in the study. The participants included male CFL athletes along with male and female student athletes from the University of Alberta competing in rugby, soccer, football, volleyball, ice hockey, and wrestling. Ages ranged from 18 to 37 years old. According to Field (2018) the resulting sample size is sufficient to determine a large effect using three and eighteen predictor variables.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) Version 26. Frequency and descriptive analysis were applied to obtain participant characteristic. Scores on the BSI-18 were converted from raw scores to T Scores and a descriptive analysis was conducted to investigate athlete's outcomes on the BSI-18. An independent samples t-test was calculated to compare male and female athletes included in the study.

Regression Assumptions

Outliers were reviewed for the four proposed regression models. A casewise diagnostic test indicated there were some potential outliers impacting the results of the analysis. Further review of the outliers was conducted through tests of Cook's distance and the average leverage value. Cook's distance test resulted in outliers greater than 1.0, while the average leverage values were greater than twice the average of leverage, indicating results that are cause for concern (Cook & Weisberg, 1982; Hoaglin & Welsch, 1978). However, the average leverage was within three times the average which is satisfactory according to Stevens (2002). After reviewing these analyses, although there is cause for concern for outliers, it was concluded that the outlier(s)

would not be removed from the four regression models. The outliers were not removed based on a review of the data, indicating that those athletes had a longer recovery time than the majority of athletes in the study. Further review of the outlier data showed that the self-reported scores on the BSI-18 were not excessive. It was further concluded that the importance of keeping the outliers outweighed the harm of being removed, due to the fact that some athletes have a longer recovery time from SRC than others.

For the four proposed regression models the assumptions of non-zero variance and independence, linearity and homoscedasticity, normally-distributed errors, independent errors, and multicollinearity were assessed. Data collected for the analysis met the assumption of non-zero variance, as individuals independently completed the measures and a variety of responses and scores were collected. The scatter plots of outcome variables versus predictive variables showed that the outcome variables had linear relationships to the predictive variables. Furthermore, scatterplots for the models showed satisfactory homoscedasticity, as the variables were relatively distributed; however, there was a loading of variables below zero. Histograms and P-P plots of the residuals were conducted. The residuals reasonably fit with the normal curve of the histograms and along the diagonal line of the P-P plot; however, the histograms appeared slightly positively skewed. The satisfactory homoscedasticity and distribution of errors can be explained by athletes' recovery periods. The majority of athletes in the sample recovered quickly from concussion, typical of a SRC recovery, which resulted in variable loading and positive skews on scatterplots and graphs. The Durbin-Watson statistic ranged from 2.227 to 1.806 which indicates that the residuals were uncorrelated and assumptions of independent errors were met. Tests of variance inflation factor (VIF) and tolerance statistics were conducted to assess multicollinearity. Variance inflation factor scores were below 10 and tolerance statistics were

above 0.2, suggesting that the assumptions of multicollinearity have been met. As no assumptions were violated, the results can be interpreted with confidence.

Objective 1A

This analysis examined the degree to which baseline psychological functioning had an effect on predicting prolonged recovery from SRC as rated on the BSI-18 subscales. A multiple linear regression was used using a stepwise entry. A step-wise entry approach was used due to the study being exploratory in nature, as previous studies have not focused on baseline testing and an athletic population in combination with specific psychological variables. Significance of analysis was set at .05.

Objective 1B

This analysis examined the degree to which baseline symptoms of psychological functioning had an effect on predicting prolonged recovery of SRC using the BSI-18 symptom items. A multiple linear regression was used using a step-wise entry. Because of the exploratory nature of Objective 1B, a step-wise method was conducted. Significance analysis was set at .05.

Objective 2A

The second analysis examined the degree to which post-injury psychological functioning had an effect on predicting prolonged recovery from SRC as rated on the BSI-18 subscales. A multiple linear regression was used with a step-wise entry. A step-wise entry approach was conducted due to the nature of the study being exploratory. Although previous research suggests variables of psychological functioning, specifically total symptoms and somatic symptoms are stronger at predicting prolonged recovery, these studies have not been conducted on athletic populations. Significance of analysis was set at .05.

Objective 2B

This analysis examined the degree to which post-injury symptoms of psychological functioning had an effect on predicting prolonged recovery of SRC using the BSI-18 symptom items. A multiple linear regression, utilizing a step-wise entry, was used. A step-wise entry was utilized due to the exploratory nature of this analysis. Significance analysis was set at .05.

Ethical Considerations

Ethical approval for this study was granted by the Research Ethics Board at the University of Alberta (Pro00073481). The information obtained in this study will be useful for clinicians, as it recognizes the importance of identifying potential risk factors that may inhibit an athlete's recovery from SRC, along with the necessity of targeting these risk factors through individualized treatment plans with a focus on psychological functioning.

Chapter Four: Results

Participant Characteristics

A total of 63 athletes were included in the following analysis. The age of the athletes ranged from 18 to 37, with a mean of 25.11 years (*SD* = 3.63). The majority (88.9%) of athletes were male (*n* = 56). The sample contained 11.1% female athletes (*n* = 7). The athletes were both professional athletes (*n* = 49, 77.8%) and collegiate student athletes (*n* = 22, 34.9%). Within the collegiate student athletes, the majority participated in football (*n* = 7, 11.1%) and volleyball (*n* = 7, 11.1%). Participants obtained medical clearing and returned to play on average 16.3 (*SD* = 13.04) days after being diagnosed with a SRC. The somatization scale on the BSI-18 showed the highest mean at baseline (*M* = 43.81, *SD* = 5.56), while the depression scale indicated the highest mean at post-injury (*M* = 45.54, *SD* = 7.20). Descriptive statistics and athletes' average T Scores on the BSI-18 can be found below in Table 1. T Scores greater than or equal to 60 on the BSI-18 represent At-risk ranges of psychological conditions.

Additionally, an independent samples t-test was conducted to determine if there were any differences with regards to recovery between the male and female athletes included in the study. The t-test determined that there were no statistically significant differences between males and females on the dependent variable of days of recovery $t(35.66) = -.15$, $p = .88$, 95% CI [-5.02, 4.34].

Table 1

Descriptive Statistics and BSI-18 T Scores

	Minimum	Maximum	Mean	Std. Deviation
Age	18	37	25.11	3.63
Days of Recovery	4	83	16.33	13.04
Baseline BSI-18 Anxiety	39	58	40.06	3.60
Baseline BSI-18 Depression	41	59	42.65	4.44
Baseline BSI-18 Somatization	41	64	43.81	5.56
Baseline BSI-18 GSI	35	61	41.56	5.12
Post-injury BSI-18 Anxiety	39	55	42.60	4.92
Post-injury BSI-18 Depression	41	66	45.54	7.20
Post-injury BSI-18 Somatization	41	61	44.60	5.55
Post-Injury GSI	35	62	41.84	7.62

Objective 1A

A multiple regression analysis was conducted to determine if athletes' psychological functioning at baseline was predictive of prolonged recovery from SRC. As an initial check, Pearson's correlations coefficient was conducted to find correlations among the variables. The Pearson's correlations showed significant correlation between days of recovery and depression ($r = 0.283$, $p = .012$). There was no significant correlation between days of recovery and the subscales anxiety and somatization. Table 2 depicts the correlations between days of recovery and baseline BSI-18 subscales.

Table 2

Pearson Correlations between Days of Recovery and Baseline BSI-18 Subscales

Variables	Days	Anx	Dep	Som
Days	–			
Anx	.088	–		
Dep	.283*	.702***	–	
Som	.066	.652***	.589**	–

Note. Days = Days of Recovery; Anx = BSI-18 anxiety subscale; Dep = BSI-18 depression subscale; Som = BSI-18 somatization subscale.
*$p < .05$. **$p < .01$. ***$p < .001$.

A multiple regression analysis was calculated to predict days of recovery on baseline scores of anxiety, depression, and somatization subscales on the BSI-18. A significant regression was found for depression as a predictor of prolonged recovery at baseline ($F(1,61) = 5.301$, $p = .025$) and accounted for 8% of the total variance ($R^2 = .080$). These results suggest that pre-injury depression influenced the overall model, indicating that athletes who reported depression at baseline were susceptible of having prolonged recoveries from SRCs. The results of the multiple regression analyses for Objective 1A and 1B are reported in Table 3.

Objective 1B

A multiple regression analysis was conducted to determine if athletes' symptoms of psychological functioning at baseline were predictive of prolonged recovery from SRC. As an initial check, Pearson's correlations coefficient was conducted to find correlations among the variables. Pearson's correlations indicated significant correlations between days of recovery and the following BSI-18 items: "faintness or dizziness" ($r = .46$, $p < .000$), "numbness or tingling in parts of your body" ($r = .56$, $p = .000$), and "feeling so restless you couldn't sit still" ($r = .22$, $p = .046$).

A multiple regression analysis was used to determine if baseline symptoms of psychological function expressed through the BSI-18 items were predictive of prolonged recovery from SRC. A number of BSI-18 items were predictive of prolonged recovery of SRC including, "numbness or tingling in parts of your body" ($F(1, 60) = 27.773$, $p < .000$, $R^2 = .316$), "faintness or dizziness" ($F(2, 59) = 22.031$, $p < .000$, $R^2 = .428$), "feeling so restless you couldn't sit still" ($F(3, 58) = 18.170$, $p < .000$, $R^2 = .484$), "pains in the heart or chest" ($F(4, 57) = 15.615$, $p < .000$, $R^2 = .523$), and "feeling worthlessness" ($F(5, 56) = 15.344$, $p < .000$, $R^2 = .578$). These results suggested that the symptom items listed above influence an athlete's recovery from a

SRC. Furthermore, as symptoms of "numbness or tingling in parts of your body," "faintness or dizziness," "feeling so restless you couldn't sit still," and "feeling worthlessness" increased so did the amount of days it takes for an athlete to recovery from a SRC. There was a negative correlation between days of recovery and the symptom item "pains in the heart or chest," suggesting that as this symptom item decreased an athlete's recovery time from concussion increased. Table 3 depicts the multiple regression analyses for baseline BSI-18 subscales and items.

Table 3

Baseline Multiple Regression Analyses Results

Multiple regression model	*n*	*F*	R^2	*b*	95% CI for *b*	β	*p*
BSI-18 subscales regression							
BSI-18 depression	63	5.30	.08	3.19	[.42, 5.95]	.28	.03
BSI-18 item regression							
"numbness or tingling in parts of your body"	62	27.77	.32	41.20	[25.56, 56.83]	.56	.00
"faintness or dizziness"	62	22.03	.43	13.60	[5.56, 21.65]	.34	.00
"feeling so restless you couldn't sit still"	62	18.17	.48	24.53	[5.14, 43.93]	.24	.00
"pains in the heart or chest"	62	15.62	.52	-11.56	[-22.37, -.78]	-.25	.00
"feeling worthlessness"	62	15.34	.58	33.44	[8.69, 58.18]	.33	.00

Note. CI = confidence interval.

Objective 2A

A multiple regression analysis was used to determine if the psychological variables of anxiety, depression, and somatization subscales were predictive of prolonged recovery within 48 hours of sustaining a SRC. Pearson's correlation results indicated significant correlation between days of recovery and anxiety ($r = .556$, $p < .000$), depression ($r = .404$, $p = 001$), and somatization ($r = .303$, $p = .008$) subscales. Table 4 displays the correlations between days of recovery and post-injury BSI-18 subscales.

Table 4

Pearson Correlations between Days of Recovery and Post-Injury BSI-18 Subscales

Variables	Days	Anx	Dep	Som
Days	–			
Anx	.556***	–		
Dep	.404**	.537***	–	
Som	.303**	.627***	.543***	–

Note. Days = Days of Recovery; Anx = BSI-18 anxiety subscale; Dep = BSI-18 depression subscale; Som = BSI-18 somatization subscale.
*$p < .05$. **$p < .01$. ***$p < .001$.

Multiple regression was used to calculate post-injury BSI-18 subscales of anxiety, depression, and somatization as predictive of prolonged recovery, measured by days of recovery. Significant results were found for the anxiety subscale of the BSI-18 on days of recovery ($F(1, 61) = 27.290$, $p < .000$). The anxiety subscale accounted for 30.9% of the overall model variance ($R^2 = .309$). These results suggested that post-injury symptoms of anxiety influenced the recovery of SRCs with elite athletes. Table 5 depicts the multiple regression analyses for Objective 2A and 2B.

Objective 2B

A multiple regression analysis was used to determine if symptoms of psychological functioning reported on the BSI-18, within 48 hours of sustaining a SRC were predictive of prolonged recovery. Pearson's correlation results indicated significant correlation between days of recovery and "faintness or dizziness" ($r = .31$, $p = .008$), "feeling no interest in things" ($r = .47$, $p < .000$), "nervousness or shakiness inside" ($r = .29$, $p = .010$), "pains in the heart or chest" ($r = .32$, $p = .006$), "feeling tense or keyed up" ($r = .31$, $p = .008$), "nausea or upset stomach" ($r = .26$, $p = .022$), "feeling blue" ($r = .44$, $p < .000$), "numbness or tingling in parts of your body" ($r = .30$, $p = .009$), and "feeling so restless you couldn't sit still" ($r = .32$, $p < .000$).

Multiple regression was used to calculate symptoms reported on the BSI-18 post-injury as predictive of prolonged recovery from SRC. Multiple regression analysis resulted in a number of BSI-18 items as predictors for prolonged recovery including: "feeling no interest in things" ($F(1, 59) = 16.61$, $p < .000$, $R^2 = .220$), "feeling blue" ($F(2, 58) = 14.54$, $p < .000$, $R^2 = .334$), "feeling fearful" ($F(3, 57) = 14.15$, $p < .000$, $R^2 = .427$), and "numbness or tingling in parts of your body" ($F(4, 56) = 14.66$, $p < .000$, $R^2 = .512$). These results indicated that the post-injury symptom items listed above influenced an athlete's recovery from SRC. There was a negative correlation found between the item "feeling fearful" and days of recovery, suggesting that after sustaining a SRC athletes who report low scores on the item "feeling fearful" are at risk of suffering from a prolonged recovery from their concussion. All other symptom items that were significantly significant showed positive correlations with days of recovery, indicating that as athletes reported higher scores on the item's "feeling no interest in things," "feeling blue," and "numbness or tingling in parts of your body" their recovery time increased. Table 5 depicts the multiple regression analyses for post-injury BSI-18 subscales and items.

Table 5

Baseline Multiple Regression Analyses Results

Multiple regression model	*n*	*F*	R^2	*b*	95% CI for *b*	β	*p*
BSI-18 subscales regression							
BSI-18 anxiety	63	27.29	.31	6.43	[3.97, 8.89]	.56	.00
BSI-18 item regression							
"feeling no interest in things"	61	16.61	.22	9.59	[4.88, 14.31]	.47	.00
"feeling blue"	61	14.54	.33	11.79	[4.31, 19.28]	.35	.00
"feeling fearful"	61	14.15	.43	-33.88	[-56.20, 11.57]	-.33	.00
"numbness or tingling in parts of your body"	61	14.66	.51	9.11	[3.25, 14.97]	.29	.00

Note. CI = confidence interval

Chapter Five: Discussion

As awareness and research continue for the management of SRC, so does our understanding of the short-term and long-term implications for athletes participating in sports. There is an interest in understanding risk factors that have the potential to impact the recovery process of concussion. Research among emergency patients collected post-injury retrospectively and prospectively has provided growing evidence that psychological variables may be predictive of individuals suffering from a prolonged recovery from concussion and mTBI (Brooks et al., 2019; Corbin-Berrigan & Gagnon, 2017; Cunningham et al., 2008; Grubenhoff et al., 2016; Nelson et al., 2018; Zahniser et al., 2019). Although predictive research for concussion and mTBI has continued to develop, there is a lack of research conducted on athletes and SRC.

The current study examined psychological functioning of college and professional athletes as predictors of prolonged recovery from SRC. The study investigated specific measures of psychological functioning through the use of the BSI-18. The study focused on specific psychological subgroups of anxiety, depression, and somatization; along with, specific symptoms of functioning displayed through the BSI-18 items. Furthermore, the current study explored an athlete's functioning at two separate time points: baseline (prior to sustaining a SRC) and post-injury (within 48 hours of sustaining a SRC). The intention of this research is to develop the knowledge and understand the link between psychological functioning and SRC outcomes for athletes, in order to facilitate future research and inform psychological management and intervention for the rehabilitation of athletes recovering from a SRC.

Objective 1A

The first analysis examined athletes' baseline self-reported symptoms of anxiety, depression, and somatization as predictive of prolonged recovery from SRC. It was hypothesized that athletes who report At-risk levels of anxiety, depression, and/or somatization would have prolonged recovery of SRC. The overall model provided significant predictive results on the BSI-18 subscale of depression, indicating that athletes who reported symptoms of depression prior to sustaining a concussion had a longer recovery time after sustaining a SRC. Neither anxiety nor somatization subscales reached significant value and were found to not be predictive of prolonged recovery from SRC at baseline.

This finding is inconsistent with research done on baseline testing; however, it is consistent with previous predictive research conducted on prolonged concussion recovery. Previous baseline research found somatization to be the only significant predictor of prolonged recoveries in high school and collegiate student athletes (Nelson et al., 2016). Furthermore, previous research suggests baseline symptoms of anxiety and depression as not being significant for predicting prolonged recovery of SRC (Nelson et al., 2016). Although baseline symptoms of anxiety were not significant across studies, there are mixed results with symptoms of somatization and depression between Nelson and colleagues' research and the current study. However, it is important to note that there may be discrepancies in the results due to differences in the populations between the studies.

Although research on baseline studies may suggest inconsistent findings compared to this study, other studies have discovered emotional symptoms to be persistent in individuals suffering from prolonged recovery (Cunningham et al., 2008). Predictive studies, in fact, are consistent with the findings in the present study, suggesting that depression is a predictor of functional

limitations and influences prolonged concussion recovery (Grubenhoff et al., 2016; Ho et al., 2020; Zahniser et al., 2019). The study data conducted by previous researchers was not collected prospectively prior to injury as in the current study, which may account for differences in results. As the current study and Nelson and colleagues' study are two of few studies focusing on baseline self-reported symptoms collected prospectively with athletes, further research is warranted to determine the relationship between depression and prolonged symptoms of SRC.

Objective 1B

This next analysis investigated baseline reports of athletes' specific symptoms on the BSI-18 as being predictive of prolonged recovery from SRC. It was hypothesized that athletes who reported concerns on items related to somatic symptoms at baseline would experience a prolonged recovery from SRC. There were significant findings on somatic items referring to numbness, faintness/dizziness, and pains in heart/chest, along with significance on symptoms of restlessness and worthlessness. These results indicate that prior to injury, athletes who report these symptoms may experience a prolonged recovery from SRC. However, there was a negative correlation with pains in the heart/chest and days of recovery, suggesting that athletes with low scores on this item may be susceptible of a prolonged recovery from SRC. This negative correlation needs to be interpreted with caution as it appears to be a statistical anomaly.

The overall findings of this study are significant as there currently is limited research examining prospectively collected pre-injury symptoms as predictors of prolonged recovery in concussion or mTBI. One research study investigating risk factors of self-reported baseline scores as predictors of prolonged recovery discovered that the relationship between pre-injury somatization symptoms and symptom recovery was mediated by post-injury concussive symptoms (Nelson et al., 2016). However, as the mean age for Nelson and colleagues' study is

younger than the current study, comparisons between the two may be impacted. The current study supports the preliminary findings of Nelson and colleagues and the influence of somatic symptoms on the recovery of concussion.

Additional studies investigating predictive psychological symptom items of prolonged recovery show consistent outcomes when compared to the current study. Post-injury retrospective and prospective studies suggest that symptoms of emotionality, irritability, and nervousness are predictive of prolonged recovery (Corbin-Berrigan & Gagnon, 2017; Cunningham et al., 2008; Ho et al., 2020). The current study supports these findings, as items of worthlessness and restlessness are associated with symptoms of emotionality. Additionally, irritability and restlessness are both symptoms of anxiety (APA, 2013). These findings support previous research suggesting that anxiety symptoms influence the recovery of concussion; however, further research is needed to look at the similarities and differences between symptoms of irritability and restlessness, specifically. The findings in the current study not only support predictive psychological symptom items of prolonged recovery in research; but indicate that a number of somatic symptoms, along with anxiety symptoms of restlessness and depression/emotional symptoms of worthlessness, do in-fact influence the recovery of SRC. After a concussion, somatic symptoms of numbness and dizziness are commonly reported, along with feelings of agitation and sadness (Sattler & Mrazik, 2014). This suggests that athletes who report such symptoms prior to sustaining a concussion may struggle with adjusting to their concussions symptoms, resulting in a prolonged recovery from SRC.

Objective 2A

The second analysis examined athletes within 48 hours of sustaining a SRC and their symptoms of anxiety, depression, and somatization as predictors of prolonged recovery from

SRC. It was hypothesized that At-risk levels of anxiety, depression, and/or somatic symptoms would be predictive of prolonged recovery from SRC. The overall model was significant for symptoms of anxiety, indicating that athletes who reported anxious symptoms within 48 hours of sustaining a SRC suffered from prolonged recoveries. However, in contrast to the hypothesis, neither depression nor somatization showed significant results at predicting prolonged recovery and the results were inconclusive. The difference in findings highlights the importance of further research on this topic.

This finding is consistent with some of the mixed results discovered in the literature. Several studies showed predictive variables in all, one, or none of the psychological factors measured (Nelson et al., 2016; Nelson et al., 2018; Theadom et al., 2016). This study suggests that athletes experiencing increased symptoms of anxiety post-injury are at risk of experiencing prolonged symptoms. Anxiety disorders are common after a TBI and have the potential to impact the recovery of brain injuries (Mallya et al., 2015). The results found in this study support previous literature by indicating that early signs of anxiety symptoms impact the recovery from SRC. It is important to note that previous predictive literature focuses on emergency department patient populations, and athletic populations may be experiencing different psychological symptoms unique to their population. Although the study's findings show mixed results and warrant further research, the implications that were found for athletes reporting symptoms of anxiety after a SRC are useful for clinicians.

Objective 2B

This portion of the analysis examined athletes within 48 hours of sustaining a SRC and athletes' specific symptoms on the BSI-18 as predictors of a prolonged recovery from SRC. It was hypothesized that items related to emotionality, irritability, and nervousness would be

predictive of prolonged recovery. Statistical significance was found on items associated with a lack of interest, feeling "blue", feeling fearful, and somatic symptoms of numbness or tingling. The item "feeling fearful" was negatively correlated with days of recovery and appears to be a statistical anomaly as it suggests that low scores of fearfulness may influence an athlete's recovery from SRC. These results indicate that athletes who report levels of decreased interests and/or feeling "blue," along with somatic symptoms of numbness and tingling may be susceptible to a prolonged recovery from SRC.

These results are partially consistent with previous research findings. Previous research shows post-injury symptoms on items of emotionality, irritability, and nervousness are predictive of prolonged recovery, post-concussive depression, and persistent in prolonged recovery groups (Corbin-Berrigan & Gagnon, 2017; Cunningham et al., 2008; Ho et al., 2020). The results of this study support findings of emotionality as influencing concussion recovery, as the items, "feeling no interest in things," "feeling blue," and "feeling fearful" are items related to emotionality, and were found to not only influence the recovery of prolonged SRC, but to be predictive of such. However, items related to irritability and nervousness were not significant in this study. It is important to note that previous research findings were conducted on emergency department patients and the lack of consistency may be due to the current study's difference in population. These findings indicate that athletes who report symptoms of emotionality within 48 hours of sustaining a SRC may be at risk of experiencing a prolonged recovery from their SRC.

Strengths and Limitations

General strengths to the current study include inclusion and exclusion criteria that explore professional and collegiate athletes aged 18 to 37. The current study relied on quantitative self-report measures which have been shown to be a successful measure of predicting a delayed

recovery in concussion and mTBI populations (Corbin-Berrigan & Gagnon, 2017). Additionally, utilizing baseline self-reported symptoms collected prospectively has had limited investigation in predictive research of concussion, mTBI, or SRCs. Previous research focused on collecting pre-injury functioning retrospectively which has the potential for recall bias (Arends et al., 2019; Gunstad & Suhr, 2001; Iverson et al., 2010). Strengths to his study include a high level of standardization and clear guidelines involved in the prospective collection of data. Throughout recovery, athletes along with medical professionals were involved in daily assessments, providing a high level of standardization and control of outside variables contributing to an athlete's recovery. Furthermore, the data collected within 48-hours of sustaining a concussion provides consistent reporting immediately following a SRC; whereas previous studies were unable to ensure this consistency as they used emergency department admissions.

However, the current study is not without limitations. Firstly, there are several limitations when collecting self-report measures from athletic populations that question the reliability and validity of the information gathered. Although mental health is not uncommon in athletic populations and is increasing in prevalence, athletes are known for underreporting their symptoms (Meier et al., 2015; Proctor & Boan-Lenzo, 2010; Reardon & Factor, 2010; Solomon, 2020). Athletes have unique perceptions with regards to the consequences of reporting psychological struggles due to pressure to preform, stigma from teammates and coaches, and wanting to be perceived as being "tough" (Moreland et al., 2008). This unique perception of reporting mental health has the potential to impact athletes' reporting on measures of psychological functioning. Furthermore, there are concerns with concussed athletes reporting symptoms. Due to SRC not being a visible injury, many athletes feel pressure from themselves, teammates, and coaches to live up to the sport culture of 'tough as nails' and therefore may

provide a misconception of their symptoms on self-report measures (Broshek et al., 2015). These limitations are unavoidable when conducting research with athletes; however, they are important to consider when interpreting the data.

An additional limitation to note is the negative correlation found on two of the BSI-18 items. The baseline item "pains in the heart or chest" was negatively correlated with days of recovery, suggesting that athletes who reported low scores for these symptoms prior to their injury suffered from prolonged recovery from concussion. A negative correlation was also found at post-injury for the item "feeling fearful" and suggests that athletes who reported low scores of fearfulness post-injury suffered from prolonged recovery from SRC. These findings appear to be a statistical anomaly and the results should be interpreted with caution.

The study design, particularly the participant group formation, also was a notable limitation as it resulted in a small sample size that was largely male skewed. From a large database of athletes, the participant group was naturally formed from athletes who sustained a SRC. This group formation poses a threat to the internal validity of this study and inferences being made as a result of the findings (Creswell, 2014). However, it is important to note that the group formation resulted in 9% of the total population sustaining a SRC and consequently being selected for the study, which is consistent with the literature suggesting that for an athlete exposed to an activity (i.e. practice or competition) where there is a risk of injury, the overall concussion rate accounts for 4.47 per 10,000 athletic exposures (Zuckerman et al., 2015). Nonetheless, due to the formation of this participant group, a generalization of the results to non-elite athletes, pediatric athletes, and non-sport concussion populations should be done cautiously. Furthermore, the male skewness of the sample suggests caution when generalizing the findings to elite female athletes, although independent t-tests did not suggest a statistically significant

difference between males and females. A balance of elite male and female athletes is suggested to provide a refined understanding to this area of research.

Furthermore, the reliability of the BSI-18 on athletic populations produced limitations. Although the BSI-18 has been recommended by the National Institute of Neurological Disorders and Stroke to use in TBI and mTBI treatment, there is limited research to suggest that this measure can be generalized to SRC and athletic populations (Hicks et al., 2013; Lancaster et al., 2016). The test-retest reliability shows low stability across time (Lancaster et al., 2016). As a result, it is difficult to interpret whether the findings in this study resulted from sustaining a SRC or due to error. Despite these limitations, the BSI-18 is an effective measure to use for athletic populations, due to its shorter length and the amount of time it takes to complete. Athletic organizations and athletes are under strict time constraints and have limited time to complete psychological questionnaires. Additionally, concussed athletes struggle with concentration and shorter measures are a reliable way to collect information on their functioning during their recovery. Furthermore, the criterion validity of the BSI-18 shows good to moderate correlation to other psychological measures making its utility feasible for clinicians. Although limitations to the use of the BSI-18 warrant caution when interpreting results, the utility of the measure provides a cost effective, time effective, and standardized approach to gathering data.

Conclusion and Future Directions

This study represents one of few studies using prospective baseline testing in both SRC and mTBI research, along with post-injury studies among elite athletes. Further, to my knowledge, this is the only predictive study utilizing baseline testing with elite athletes and psychological risk factors impacting SRC. Results indicated that baseline depression symptoms, in addition to specific somatic items and items related to restlessness and worthlessness, were

predictive of prolonged recovery from SRC. Post-injury results stated that subscales of anxiety and items of emotionality and numbness/tingling were predictive of prolonged recovery from SRC. It is important to note that athletes self-report of psychological functioning may not be an accurate representation of their true functioning due to underreporting as a result of athletes' unique characteristics. Additionally, the measure used may also pose a threat to accurate information obtained in this study. Finally, the findings need to be cautiously interpreted when generalizing to other populations.

Future studies for SRC research with elite athletes should include a larger and more diverse sample involving a number of sports across genders. As this was a novel study, future studies are suggested to be conducted to re-test the findings from this study and develop the research of baseline and post-injury predictive research of SRC. As a result of this study, continual development of appropriate psychological measures for the athletic population is warranted to decrease underreporting. Nevertheless, the current findings give clinicians a clearer understanding of the influence psychological functioning have on the recovery of SRC and provide a unique contribution to the overall field of study. Additionally, the current findings suggest the need for early intervention with concussed elite athletes, as psychological variables significantly contribute to an athlete's recovery and rehabilitation process. This research will assist clinicians to be aware of psychological functioning symptoms when screening for risk factors in the recovery of SRC. The results of this study reinforce the need for further investigations of this topic and the need for in depth understanding of additional psychological variables contributing to the rehabilitation process of a SRC.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.).* American Psychiatric Publishing.

Arends, P., Wagner, R., & Mrazik, M. (2019, July). SCAT symptom recall bias in concussed athletes. *Archives of Clinical Neuropsychology, 34*(5), 733–733. https://doi.org/10.1093/arclin/acz026.03

Brooks, B. L., Kadoura, B., Turley, B., Crawford, S., Mikrogianakis, A., & Barlow, K. M. (2014). Perception of recovery after pediatric mild traumatic brain injury is Influenced by the "good old days" bias: Tangible implications for clinical practice and outcomes research. *Archives of Clinical Neuropsychology, 29*(2), 186–193. https://doi.org/10.1093/arclin/act083

Brooks, B. L., Plourde, V., Beauchamp, M. H., Tang, K., Yeates, K. O., Keightley, M., Anderson, P., Désiré, N., Barrowman, N., & Zemek, R. (2019). Predicting psychological distress after pediatric concussion. *Journal of Neurotrauma, 36*, 679–685. https://doi.org/10.1089/neu.2018.5792

Broshek, D. K., De Marco, A. P., & Freeman, J. R. (2015) A review of post-concussion syndrome and psychological factors associated with concussion, *Brain Injury,* 29(2), 228–237. https://doi.org/10.3109/02699052.2014.974674

Broughton, E., & Neyer, M. (2001). Advising and counseling student athletes. *New Directions for Student Services, 93*, 47–53. https://doi.org/10.1002/ss.4

Cook, R. D., & Weisberg, S. (1982). *Residuals and influence in regression.* Chapman & Hall

Corbin-Berrigan, LA., & Gagnon, I. (2017). Postconcussion symptoms as a marker of delayed recovery in children and youth who recently sustained a concussion: A brief report.

Clinical Journal of Sports Medicine, 27(3), 325–327. https://doi.org/10.1097/JSM.0000000000000355

Covassin, T., Crutcher, B., Bleecker, A., Heiden, E. O., Dailey, A., & Yang, J. (2014). Postinjury anxiety and social support among collegiate athletes: A comparison between orthopaedic injuries and concussions. *Journal of Athletic Training, 49*(4), 462–468. https://doi.org/10.4085/1062-6059-49.2.03

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Sage Publications.

Cunningham, J., Brison, R. J., & Pickett, W. (2008). Concussive symptoms in emergency department patients diagnosed with minor head injury. *The Journal of Emergency Medicine, 40*(3), 262–266. https://doi.org/10.1016/j.jemermed.2008.08.017

Currie, D. W., Kraeutler, M. J., Schrock, J. B., McCarty, E. C., & Comstock, R. D. (2017). Time trends in concussion symptom presentation and assessment methods in high school athletes. *American Journal of Sports Medicine, 45*, 3368–3373. https://doi.org/10.1177/0363546517725068

Evans, A. N. (2008). *Using basic statistics in the social sciences* (4th ed.). Pearson Prentice Hall.

Field, A. (2018). *Discovering statistics using IBM SPSS Statistics: North American edition* (5th ed.). Sage Publications.

Forsdyke, D., Smith, A., Jones, M., & Gledhill, A. (2016). Psychosocial factors associated with outcomes of sports injury rehabilitation in competitive athletes: A mixed studies systematic review. *British Journal of Sports Medicine, 50*, 537–544. https://doi.org/10.1136/bjsports-2015-094850

Gouttebarge, V., Hopley, P., Kerkhoffs, G., Verhagen, E., Viljoen, W., Wylleman, P., & Lambert, M. (2018). A 12-month prospective cohort study of symptoms of common mental disorders among professional rugby players. *European Journal of Sport Science, 18*(7), 1004–2012. https://doi.org/10.1080/17461391.2018.1466914

Grady, M. F. (2010). Concussion in the adolescent athlete. *Current Problems in Pediatric and Adolescent Health Care, 40*(7), 154–169. https://doi.org/10.1016/j.cppeds.2010.06.002

Grubenhoff, J. A., Currie, D., Comstock, D., Juarez-Colunga, E., Bajaj, L., & Kirkwood, M. W. (2016). Psychological factors associated with delayed symptom resolution in children with concussion. *The Journal of Pediatrics, 174,* 27–32. http://doi.org/10.1016/j.jpeds.2016.03.027

Gunstad, J., & Suhr, J. A. (2001). "Expectation as etiology" versus "the good old days": Postconcussion syndrome symptom reporting in athletes, headache sufferers, and depressed individuals. *Journal of the International Neuropsychological Society, 7,* 323–333. https://doi.org/10.1017/S1355617701733061

Haskell, W. L., Lee, I., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., Macera, C. A., Heath, G. W., Thompson, P. D., & Bauman, A. (2007). Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine & Science in Sports & Exercise, 39*(8), 1423–1434. https://doi.org/10.1249/mss.0b013e3180616b27

Henry, L. C., Elbin, RJ., Collins, M. W., Marchetti, G., & Kontos, A. P. (2015). Examining recovery trajectories after sport-related concussion with a multimodal clinical assessment approach. *Neurosurgery, 78*(2), 233–241. https://doi.org/10.1227/NEU.0000000000001041

Hicks, R., Giacino, J., Harrison-Felix, C., Manley, G., Valadka, A., & Wilde, E. A. (2013). Progress in developing common data elements for traumatic brain injury research: Version two – the end of the beginning. *Journal of Neurotrauma, 30*, 1852–1861. https://doi.org/10.1089/neu.2013.2938

Ho, R. A., Hall, G. B., Noseworthy, M. D., & DeMatteo, C. (2020) Post-concussive depression: Evaluating depressive symptoms following concussion in adolescents and its effects on executive function, *Brain Injury,* 34(4), 520–527. https://doi.org/10.1080/02699052.2020.1725841

Hoaglin, D. & Welsch, R. (1978). The hat matric in regression and ANOVA. *American Statistician, 32*, 17–22.

Iverson, G. L., Gardner, A. J., Terry, D. P., Ponsford, J. L., Sills, A. K., Broshek, D. K., & Solomon, G. S. (2017). Predictors of clinical recovery from concussion: A systematic review. *British Journal of Sports Medicine, 51*(12), 941–948. https://doi.org/10.1136/bjsports-2017-097729

Iverson, G. L., Lange, R. T., Brooks, B. L., & Ashton, R. (2010). "Good old days" bias following mild traumatic brain injury. *The Clinical Neuropsychologist, 24*(1), 17–37. https://doi.org/10.1080/13854040903190797

Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*(40), 1–16. https://doi.org/10.1186/1479-5868-7-40

Lancaster, M. A., McCrea, M. A., & Nelson, L. D. (2016). Psychometric properties and normative data for the Brief Symptom Inventory-18 (BSI-18) in high school and

collegiate athletes. *The Clinical Neuropsychologist,* 30(2), 321–333. https://doi.org/10.1080/13854046.2016.1138504

Mallya, S., Sutherland, J., Pongracic, S., Mainland, B., & Ornstein, T. J. (2015). The manifestation of anxiety disorders after traumatic brain injury: A review. *Journal of Neurotrauma, 32,* 411–421. https://doi.org/10.1089/neu.2014.3504

McCrea, M., Barr, W. B., Guskiewicz, K., Randolph, C., Marshal, S. W., Cantu, R., Onate, J. A., & Kelly, J. (2005). Standard regression-based methods for measuring recovery after sport-related concussion. *Journal of International Neuropsychological Society, 11*, 58–69. https://doi.org/10.10170S1355617705050083

McCrea, M., Guskiewicz, K., Randolph, C., Barr, W. B., Hammeke, T. A., Marshall, S. W., Powell, M. R., Ahn, K-W., Wang, Y., & Kelly, J. P. (2012). Incidence, clinical course, and predictors of prolonged recovery time following sport-related concussion in high school and college athletes. *Journal of the International Neuropsychological Society, 19,* 22–33. https://doi.org/10.1017/S1355617712000872

McCrory, P. R., & Berkovic, S. F. (2001). Concussion: The history of clinical and pathophysiological concepts and misconceptions. *Historical Neurology, 57*(12), 2283–2289. https://doi.org/10.1212/WNL.57.12.2283

McCrory, P., Meeuwisse, W., Dvorak, J., Aubry, M., Bailes, J., Broglio, S., Cantu, R. C., Echemendia, R. J., Castellani, R. J., Davis, G. A., Ellenbogen, R., Emery, C., Engebretsen, L., Feddermann-Demont, N., Giza, C. C., Guskiewics, K. M., Herring, S., …Vos, P. E. (2017). Consensus statement on concussion in sport-The 5th International Conference on Concussion in Sport held in Berlin, October 2016. *British Journal of Sports Medicine, 51*, 838–847. https://doi.org/10.1136/bjsports-2017-097699

McKinley, A. (2009). Controversies and outcomes associated with mild traumatic brain injury in childhood and adolescences. *Child: Care health and development, 36*(1), 3–32. https://doi.org/10.1111/j.1365-2214.2009.01006.x

McMahon, E. M., Corcoran, P., O-Regan, G., Keeley, H., Cannon, M., Carli, V., Wasserman C., Hadlaczky, G., Sarchiapone, M., Apter, A., Balazs, J., Balint, M., Bobes, J., Brunner, R., Cozman, D., Haring, C., Iosue, M., Kaess, M., Kahn, J., … Wasserman, D. (2017). Physical activity in European adolescents and associations with anxiety, depression and well-being. *European Child & Adolescence Psychiatry, 26*(1), 111–122. https://doi.org/10.1007/s00787-016-0875-9

Meachen, SJ., Hanks, R. A., Millis, S. R., & Rapport, L. J. (2008). The reliability and validity of the Brief Symptom Inventory–18 in persons with traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 89*(5), 958–965. https://doi.org/10.1016/j.apmr.2007.12.028

Meehan, W. P., & Mannix, R. (2010). Pediatric concussions in united states emergency departments in the years 2002 to 2006. *The Journal of Pediatrics, 157,* 889–893. https://doi.org/10.1016/j.jpeds.2010.06.040

Meehan, W. P., Mannix, R., Monuteaux, M. C., Stein, C. J., & Bachur, R. G. (2014). Early symptom burden predicts recovery after sport-related concussion. *American Academy of Neurology, 83*(24), 2204–2210. https://doi.org/10.1212/WNL.0000000000001073

Meehan, W. P., Mannix, R. C., Stracciolini, A., Elbin, R. J., & Collins, M. W. (2013). Symptom severity predicts prolonged recovery after sport-related concussion, but age and amnesia do not. *The Journal of Pediatrics, 163*(3), 721–725. http://doi.org/10.1016/j.jpeds.2013.03.012

Meier, T. B., Brummel, B. J., Singh, R., Nerio, C. J., Polanski, D. W., & Bellgowan, P. S. F. (2015). The underreporting of self-reported symptoms following sports-related concussion. *Journal of Science and Medicine in Sport, 18*(5), 507–511. http://doi.org/10.1016/j.jsams.2014.07.008

Moreland, J. J., Coxe, K. A., & Yang, J. (2018). Collegiate athletes' mental health services utilization: A systematic review of conceptualizations, operationalizations, facilitators, and barriers. *Journal of Sport and Health Science, 7,* 58–69. https://doi.org/10.1016/j.jshs.2017.04.009

Morgan, C. D., Zuckerman, S. L., Lee, Y. M., King, L., Beaird, S., Sills, A. K., & Solomon, G. S. (2015). Predictors of postconcussion syndrome after sports-related concussion in young athletes: A matched case-control study, *Journal of Neurosurgery: Pediatrics, 15*(6), 589–598. https://doi.org/10.3171/2014.10.PEDS14356.

Nelson, L. D., Furger, R. E., Ranson, J., Tarima, S., Hammeke, T. A., Randolph, C., Barr, W. B., Guskiewicz, K., Olsen, C. M., E. Lerner, B., & Michael A. McCrea, M. A. (2018). Acute clinical predictors of symptom recovery in emergency department patients with uncomplicated mild traumatic brain injury or non-traumatic brain injuries. *Journal of Neurotrauma, 35*(2), 249–259. https://doi.org/10.1089/neu.2017.4988

Nelson, L. D., Tarima, S., LaRoche, A. A., Hammeke, T. A., Barr, W. B., Guskiewicz, K., Randolph, C., & McCrea, M. A. (2016). Preinjury somatization symptoms contribute to clinical recovery after sport-related concussion. *American Academy of Neurology, 86*(20), 1865–1863. https://doi.org/10.1212/WNL.0000000000002679

Proctor, S. L. & Boan-Lenzo, C. (2010). Prevalence of depressive symptoms in male intercollegiate student-athletes and nonathletes. *Journal of Clinical Sport Psychology, 4,* 204–220. https://doi.org/10.1123/jcsp.4.3.204

Public Health Agency of Canada. (2018, June 7). *Concussion in sport: Sport and recreation-related traumatic brain injuries among Canadian children and youth.* https://www.canada.ca/content/dam/phac-aspc/documents/services/publications/diseases-conditions/PHAC-concussion-sport-infographic_may8-eng.pdf

Rabinowitz, A. R., Li, X., McCauley, S. R., Wilde, E. A., Barnes, A., Hanten, G., Mendez, D., McCarthy, J. J., & Levin, H. S. (2015). Prevalence and predictors of poor recovery from mild traumatic brain injury. *Journal of Neurotrauma, 32*(19), 1488–1496. https://doi.org/10.1089/neu.2014.3555

Reardon, C. L. & Factor, R. M. (2010). Sport psychiatry a systematic review of diagnosis and medical treatment of mental illness in athletes. *Sports Medicine, 40*(11), 961–980. https://doi.org/10.2165/11536580-000000000-00000

Rice, S. M., Parker, A. G., Rosenbaum, S., Bailey, A., Mawren, D., & Purcell, R. (2018). Sport-related concussion and mental health outcomes in elite athletes: A systematic review. *Sports Medicine, 48,* 447–465. https://doi.org/10.1007/s40279-017-0810-3

Sattler, J. M. & Mrazik, M. (2014). Brain injuries: Theory and rehabilitation. In J. M. Sattler (Eds.), *Foundations of behavioral, social, and clinical assessment of children* (pp. 619-650). Jerome M. Sattler, Publisher, Inc.

Singh, R., Savitz, J., Teague, T. K., Polanski, D. W., Mayer, A. R., Bellgowan, P. S. F., & Meier, T. B. (2015). Mood symptoms correlate with kynurenine pathway metabolites following

sports-related concussion. *Journal of Neurology, Neurosurgery, & Psychiatry, 87,* 670–675. https://doi.org/10.1136/ jnnp-2015-311369

Solomon, G. (2020, July 24). Concussion in the National Football League: An update. [Virtual Presentation]. Sports Neuropsychology Society, Virtual Symposium.

Stevens, J. P. (2002). *Applied multivariate statistics for the social sciences* (4th ed.). Erlbaum.

Strong, W. B., Malina, R. M., Blimkie, C. J. R., Daniels, S. R., Dishman, R. K., Gutin, B., Hergenroeder, A., C., Must, A., Nixon, P. A., Pivarnik, J. M., Rowland, T., Trost, S., & Trudeau. (2005). Evidence based physical activity for school-age youth. *The Journal of Pediatrics, 146*(6), 732–737. https://doi.org/10.1016/j.jpeds.2005.01.055

Sudano, L. E., Collins, G., & Miles, C. M. (2017). Reducing barriers to mental health care for student-athletes: An integrated care model. *Families, Systems, & Health, 35*(1), 77–84. https://doi.org/10.1037/fsh0000242

Theadom, A., Parag, V., Dowell, T., McPherson, K., Starkey, N., Barker-Collo, S., Jones, K., Ameratunga, S., & Feigin, V. L. (2016). Persistent problems 1 year after mild traumatic brain injury: A longitudinal population study in New Zealand. *British Journal of General Practice, 66*(642), 16–23. https://doi.org/10.3399/bjgp16X683161

Yang, CC., Yuen, KM., Huang, SJ., Hsia, SH., Tsai, YS., & Lin, WC. (2014). "Good-old-days" bias: A prospective follow-up study to examine the preinjury supernormal status in patients with mild traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology, 36*(4), 399–409. http://doi.org/10.1080/13803395.2014.903899

Zahniser, E., Nelson, L. D., Dikmen, S. S., Machamer, J. E., Stein, M. B., Yuh, E., Manley, G. T., & Temkin, N. R. (2019). The temporal relationship of mental health problems and

functional limitations following mTBI: A TRACK-TBI and TED Study. *Journal of Neurotrauma, 36*, 1786–1793. https://doi.org/10.1089/neu.2018.6172

Zillmer, E. A., Spiers, M. V., & Culbertson, W. C. (2008). *Principles of Neuropsychology* (2nd ed.). Thomson Wadsworth.

Zuckerman, S. L., Kerr, Z. Y., Yengo-Kahn, A., Wasserman, E., Covassin, T., & Solomon, G. S. (2015). Epidemiology of sports-related concussion in NCAA athletes from 2009-2010 to 2013-2014. *The American Journal of Sports Medicine, 43*(11), 2654–2662. https://doi.org/10.1177/0363546515599634

Zuckerman, S. L., Yengo-Kahn, A. M., Buckley, T. A., Solomon, G. S., Sills, A. K., & Kerr, Z. Y. (2016). Predictors of postconcussion syndrome in collegiate student-athletes, *Neurosurgical Focus, 40*(4), 1–10. https://doi.org/1–10. 10.3171/2016.1.FOCUS15593.

Appendix A: Active Rehabilitation Project BSI-18 Measures

ACTIVE REHAB

Brief Symptom Inventory 18 (BSI-18)

0a. Date assessment completed: _____ /_____/_____ Participant ID: _____

0b. Clinician initials: _____

0c. Form completed: ☐ Online (1) ☐ On Paper (2)

If on paper:
0d. Initials of person completing data entry: _____

0e. Data entry date: _____/ _____/ _____

BSI-18

Below is a list of problems people sometimes have. Read each one carefully and mark the number that best describes HOW MUCH THAT PROBLEM HAS DISTRESSED OR BOTHERED YOU DURING THE PAST 7 DAYS INCLUDING TODAY.
Do not skip any items.

How much were you distressed by:	Not at all	A little bit	Moderately	Quite a bit	Extremely
1. Faintness or dizziness	0	1	2	3	4
2. Feeling no interest in things	0	1	2	3	4
3. Nervousness or shakiness inside	0	1	2	3	4
4. Pains in the heart or chest	0	1	2	3	4
5. Feeling lonely	0	1	2	3	4
6. Feeling tense or keyed up	0	1	2	3	4
7. Nausea or upset stomach	0	1	2	3	4
8. Feeling blue	0	1	2	3	4
9. Suddenly scared for no reason	0	1	2	3	4
10. Trouble getting your breath	0	1	2	3	4
11. Feeling of worthlessness	0	1	2	3	4
12. Spells of terror or panic	0	1	2	3	4
13. Numbness or tingling in parts of your body	0	1	2	3	4
14. Feeling hopelessness about the future	0	1	2	3	4
15. Feeling so restless you couldn't sit still	0	1	2	3	4
16. Feeling weak in parts of your body	0	1	2	3	4
17. Thoughts of ending your life	0	1	2	3	4
18. Feeling fearful	0	1	2	3	4

Appendix B: Consent Form

Consent to Participate in a Research Study

Title of Study: Role of Rehabilitation in Concussion Management: A Randomized, Controlled Trial
Principal Investigator: Johna Register-Mihalik, University of North Carolina

Co-Investigators: Kevin Guskiewicz, Mike McCrea, Steve Marshall, Karen McCulloch, Jason Mihalik
Canadian Site-Investigators: Dr. Martin Mrazik, Dr. Dhiren Naidu, University of Alberta
Funding Source and/or Sponsor: National Football League (NFL) Foundation

---

What is the purpose of this study?
The potential benefit of introducing a program of active rehabilitation *during* symptom recovery following has been proposed as a new method for injury management, but there have been no studies that help us understand how this might help with recovery and function after concussion. The purpose of this study is to understand what types of activities improve outcomes following a concussion. You are being asked to be in the study because you are currently an active collegiate athlete.

Are there any reasons you should not be in this study? As long as you are an athlete on a team, there is no reason you should not be in the study.

How many people will take part in this study? Approximately 6,600 participants from high schools, colleges/universities, and professional organizations (Canadian Football League) will participate in this study.

How long will your part in this study last? If you only complete the baseline assessment, your time will only last the 1 hour and 30 minutes it takes to complete the baseline assessment. Should you complete the post-injury assessments and either set of study rehabilitation activities (graded exertion only OR multidimensional), your participation would include this baseline assessment and would last until 1-month following the concussion that triggered your entrance into the rehabilitation activities.

What will happen if you take part in the study? This is a randomized control trial and your team may either be randomized to the multidimensional rehabilitation group (MDR) or enhanced graded exertion (EGE) group.

You will complete the following as part of the study:

- Pre-season baseline tests (many that are similar to previous baseline medical evaluations) of your thinking/memory, symptoms, balance, coordination, vision, quality of life, demographics, and medical history.
- If you are concussed and complete the post-injury activities, you would also complete these same measures (except medical history) more detailed demographics and a timed gait/memory task 24-48 hours post-concussion, when you no longer have symptoms, and 1-month after your concussion.
- At the 1-month assessment, you will also complete some questions about your experience in the study and the care you received.
- From 24-48 hours after the injury you *along with your Athletic Therapist*, will also be asked to track your activities (physical and cognitive) and your symptoms each day until 7 days after you have fully returned to participating in your sport. The study team *from the University of Alberta* will also track your care over the period of your concussion recovery.

- Rehab exercises, supervised by a medical provider *(team physicians and Athletic Therapists)* at your site, that work on your thinking, balance, vision, and general well-being four times per week until you have fully returned to play in your sport.
- Once you no longer have symptoms, you will continue to be progressed through the graded exertion protocol (per above), while continuing your rehabilitation (graded exertion or multidimensional) exercises, supervised by *your team physician and Athletic Therapist* at your site, until you fully return to play.

What are the possible benefits from being in this study? Research is designed to benefit society by gaining new knowledge. You may benefit from the exercises during the rehabilitation post-injury paradigm.

What are the possible risks or discomforts involved from being in this study? Your risk of experiencing discomfort or issues as a result of the assessments is minimal. However, when participating in the graded exertion or the multidimensional activities (should you be in this group), you may experience increases in symptoms or other unknown discomforts. You should report these to the researchers and/or medical professionals from *your team*. *Your team physician* will decide if you need to stop exercises or activities during an assessment or exercise session. In addition, should you feel you need to stop, you may do so at any time. The research staff and medical professionals at your school will help you get follow-up care if needed. There may be uncommon or previously unknown risks and you should report any problems to the researcher listed at the back.

If you choose not to be in the study, what other treatment options do you have? You do not have to be in this research study in order to receive treatment. You should reach out to *your team physician and/or team Athletic Therapist* for additional treatment options.

What if we learn about new findings or information during the study? You will be given any new information gained during the course of the study that might affect your willingness to continue your participation.

How will information about you be protected? You will be assessed and if you complete post-injury exercise activities, these will occur in your normal athletic training environment. No study-specific data about you will be shared outside the research team or the data center. Data sent to UNC-Chapel Hill will not have personal information. Every participant is given a research identification number that removes personal information. Only the Canadian site investigators will have a master list. You will not be mentioned individually in publications or presentations and all study data will be stored in a secure location.

Participants will not be identified in any report or publication about this study. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, UNC-Chapel Hill will take steps allowable by law to protect the privacy of personal information. In some cases, your information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies (for example, the FDA) for purposes such as quality control or safety.

What will happen if you are injured by this research? If you become ill or injured as a result of being in this study, you will receive necessary medical treatment, at no additional cost to you. By signing this consent form you are not releasing the investigator(s), institution(s) and/or sponsor(s) from their legal and professional responsibilities. The University of Alberta will provide you medical care.

What if you want to stop before your part in the study is complete? You can withdraw from this study at any time, without penalty. The investigators have the right to stop your participation at any time because you have had an unexpected reaction, failed to follow instructions, or because the entire study has been stopped.

Will you receive anything for being in this study? No compensation is provided for completing this study.

Will it cost you anything to be in this study? It will not cost you anything to be in this study.

Who is sponsoring this study? This research is funded by the National Football League Foundation. This means that the research team is being paid by the sponsor for doing the study.

What if you have questions about this study? You have the right to ask, and have answered, any questions you may have about this research. If you have questions about the study (including payments), complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form. A description of this clinical trial will be available on www.clinicaltrials.gov, as required by U.S. Law. This website will not include information that can identify you. At most, the website will include a summary of the results. You can search this website at any time.

What if you have questions about your rights as a research participant? All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject, or if you would like to obtain information or offer input, you may contact the Institutional Review Board at the University of Alberta Research Ethics Office at 780-492-2615 or by email to *the University of Alberta (reo@ualberta.ca)*. The study's principle investigator (Johna Register-Mihalik) can be reached at (919) 962-2702 (johnakay@email.unc.edu) and the Canadian Investigator (Martin Mrazik) 780-492-8052 (mrazik@ualberta.ca)

Participant's Agreement: I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

_____ _____

Signature of Research Participant Date

_____

Printed Name of Research Participant

_____ _____

Signature of Research Team Member Obtaining Consent Date

_____

Printed Name of Research Team Member Obtaining Consent