Mental Health Outcomes of Collegiate Athletes Following Sport Related Concussion

by

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Abstract

The purpose of this study was to investigate the effect of sport related concussion (SRC) on quality of life and psychological distress ratings in collegiate athletes. Participants included 230 male and female athletes participating in hockey, football, rugby, soccer, volleyball, and basketball, attending full time studies at the University of Alberta. Participants ranged in age from 18 to 25 years old and were split into groups based on their reported concussion history; history of no concussion (n = 110), history of one or more concussions (n = 120). To assess quality of life and psychological distress outcomes, athletes completed the Patient-Reported Outcomes Measurement Information System (PROMIS) and the Brief Symptom Inventory-18 (BSI-18). The first analysis indicated that athlete PROMIS scores did not vary by previous concussion history, $F(7, 222) = 1.69, p = .112$; V = .05. However, while investigating the interaction between concussion history and biological sex, results suggested that the effect of concussion history may not the same for males and females on PROMIS scores, $F(7, 222) = 2.59, p = .014$; V = .08, partial $\eta^2 = .08$. The second analysis indicated that athlete BSI-18 GSI scores did not vary by previous concussion history, $F(1, 228) = 0.31, p = .577$. The effect of concussion history was not statistically significant for males and females on BSI-18 GSI ratings, $F(1, 226) = 0.99, p = .320$. These results suggest that SRC may not be a risk factor for poorer quality of life or psychological distress ratings in collegiate athletes.

Preface

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

Dedications

To my parents, for modelling a tireless work ethic, for instilling the importance of education and for their unconditional love as I have pursued my goals.

To my dear friend, Carley, for her advice, for her unwavering support and for always understanding.

To my husband, for his patience and for being the brightest light in my life.

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Chapter One: Introduction

Mental Health

According to the World Health Organization (WHO), mental health is defined as "a state of well-being in which every individual realizes his or her potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community" (WHO, 2014, p. 1). Articulated by the Mental Health Commission of Canada (MHCC), mental health is a crucial component in all stages of human development and is required for maintaining overall health across the lifespan (Khanlou & Khan, 2018; MHCC, 2013). Not only does mental health foster resiliency in the face of everyday stressors, it can also reduce an individual's risk of developing mental illness. As a broad construct, poor mental health and mental illness can impact an individual's ability to productively engage in school and work, participate in social interactions and live independently (MHCC, 2013).

In a pan-Canadian study, the MHCC reported that 6.7 million people in Canada, approximately one in five, will experience a mental health problem or mental illness in any given year (MHCC, 2013). These rates highlight the high incidence of mental health problems or mental illness in our population. Efforts by WHO have focused on creating and applying mental health policy to educate and encourage mental well-being, while also aiding individuals who are suffering from poor mental health or mental illness (WHO, 2018). Additional research is required in order for services and programs to promote mental health and accurately address the negative consequences of living with mental illness (MHCC, 2013).

Young Adults and Mental Health

Young adults represent a unique developmental stage transitioning between adolescence and early adulthood (Tanner & Arnett, 2016). Arnett (2000) coined the term *emerging adulthood*

to describe this new transition experienced by young adults in today's culture. It is described as a life stage, typically lasting from ages 18 to 29, in which young adults delay the assumption of long-term commitments (e.g., marriage, parenthood) while gradually gaining independence and responsibility (Fincham & Lucier-Greer, 2018; Tanner & Arnett, 2016). Emerging adulthood is characterized by identity exploration, instability, self-focus, feelings of being in-between and the openness to possibilities, and is often marked by unpredictability with a series of relationships and job changes or transitions. As a result of the many variables associated with this transition, Arnett, Žukauskienė and Sugimura (2014) indicate that emerging adults may especially be at increased risk for mental health difficulties. For a portion of young adults, the transition between adolescence and early adulthood is accompanied by higher education studies (Arnett, 2000). The added stresses of being involved in post-secondary education may also impact the risk for mental illness (Arnett et al., 2014).

The MHCC reported that approximately 28% of Canadians aged 20 to 29 experience mental illness in a given year (MHCC, 2013). Furthermore, in a study investigating mental health implications, Arnett, Žukauskienė and Sugimura (2014) reported that more than half of individuals aged 18 to 29 years experienced symptoms of anxiety and one third experienced symptoms of depression. These results indicate the prevalence of mental health in the young adult population. As statistics show differences in incidence rates of mental illness for individuals in their teens, twenties and thirties, it is crucial to understand the typical challenges experienced in order to effectively conceptualize the possible etiology of mental health concerns. For young adults, a wide range of factors can influence mental health problems, including social/cultural factors such as family conflict, limited coping skills and experimentation with high risk behaviours (Kitzrow, 2009). This highlights the importance of understanding the

unique characteristics of the emerging adulthood population that may impact mental health (Arnett et al., 2014).

Collegiate Athlete Population and Mental Health

Collegiate athletes are a subset of the young adult population with a variety of unique challenges (Moreland, Cox, & Yang, 2018). In comparison to other young adults, collegiate athletes often experience additional pressures involved in balancing academic studies while maintaining athletic commitments (Moreland et al., 2018). Previous evidence indicates that sport participation can be beneficial for mental health. This includes increased mood, decreased emotional distress and anxiety, and increased self-efficacy mastery and self-concept (Hughes & Leavey, 2012). However, the academic and athletic demands of collegiate athletes involve greater time and energy requirements, often resulting in a loss of independence for athletes (Hughes & Leavey, 2012). Furthermore, athletes also manage the stress associated with injury, burnout, failure, aging and retirement from sport (Hughes & Leavey, 2012; Moreland et al., 2018; Sudano, Collins & Miles, 2017; Rice et al., 2016). These factors may increase susceptibility to developing mental health difficulties and mental illness for collegiate athletes (Hughes & Leavey, 2012; Moreland et al., 2018; Sudano, Collins & Miles, 2017; Rice et al., 2016). In a recent systematic review, Rice and colleagues (2016) summarized research investigating the mental health of athletes, highlighting the fact that athletes who are "injured, approaching/in retirement or experiencing performance difficulties" may experience a greater risk of developing mental illness (Rice et al., 2016, p. 1). In order to best understand and manage mental health in collegiate athletes, further research is needed.

Mental Health Outcomes of Sport-Related Injury

Injury is a common occurrence for athletes. According to the National Collegiate Athletic Association Injury Surveillance Program from 2009 to 2014, over 1 million injuries were estimated during over 176 million athlete exposures (Kerr et al., 2015). Based on this data, Kerr and colleagues (2015) estimate an annual injury rate of 6 per every 1000 athlete exposures. Injury risk varies by sport, biological sex and whether or not the athlete exposure occurs during practice or competition. Putukian (2016) indicates that injury is one of the risk factors that may impact mental health by further exacerbating the stresses that collegiate athletes already experience due to their academic and athletic commitments. Injury may trigger mental health issues including depression, low motivation, isolation, loss of identity, loss of confidence, anxiety, eating disorders or substance abuse (Hughes & Leavey, 2012; Putukian, 2016). Overall, this evidence highlights the importance of understanding athlete mental health pre and post-injury as it will be crucial in providing suitable care (Putukian, 2016).

Mental health outcomes of sport-related concussion. One subset of sport-related injury is sport related concussion (SRC). SRC is defined as a "traumatic brain injury induced by biomechanical forces" (McCrory et al., 2017b, p. 2). Not only is it a frequently occurring injury, it is one of the most complex due to various challenges associated with accurately diagnosing, assessing and managing the injury. For instance, SRC is referred to as the "invisible injury" due to the difficulties with its identification and reliance on subjective report from the individual. With awareness of SRC increasing in public and scientific communities, there are evolving questions regarding the implications of sustaining concussions for athletes. Following SRC, research has shown that athletes display a wide range of physical, cognitive and emotional symptoms (Iverson et al., 2017). Evidence indicates that collegiate athletes may experience

emotional symptomology characterized by rapid changes in mood with strong emotions or feelings (McCrory et al., 2017b). Recent research is suggesting a stronger a link between SRC and negative psychological outcomes in the collegiate athlete population (Covassin, Elbin, Beidler, LaFevor, & Kontos, 2017; Kerr et al., 2014; Manley et al., 2017; McCrory et al., 2017b; Rice et al., 2018). However, to date the majority of studies focus on general symptoms of concussions, but not on more specific mental health outcomes using psychological tools. High-quality studies, including epidemiological and intervention studies, are required in order to best understand the mental health outcomes of SRC. As mental health is crucial in maintaining overall health across the lifespan, it is important to investigate how to best address these concerns (MHCC, 2013). As collegiate athletes represent a specialized population with a variety of unique challenges, it is beneficial to study the mental health outcomes following SRC.

The Current Study

Various biological, psychological and social factors can influence an individual's well-being and overall mental health (Hayden & Vandermeer, 2018; WHO, 2018). The factors that influence mental health will vary throughout the lifespan based on the interactions between individual, family and social environmental factors (Khanlou & Khan, 2018; MHCC, 2013). For this reason, a biopsychosocial model is used to describe the complexities involving biological, psychological, and social processes associated with SRC that emerge over the lifespan. The purpose of this study is not to describe these processes in depth but to highlight concepts important to younger adults who experience concussion.

The following research study will explore mental health outcomes of SRC of Canadian, collegiate athletes ranging in age from 18 to 25. This research hopes to contribute to sport

concussion literature by investigating specific quality of life and psychological distress ratings to provide a better understanding of the psychological outcomes following SRC.

Chapter Two: Literature Review

The purpose of this chapter is to review the literature related to SRC in the collegiate athlete population and its relevance to mental health outcomes. The chapter will begin with an investigation of the current consensus on SRC protocol. I will specifically review mental health outcomes of SRC by exploring quality of life outcomes and psychological distress outcomes for collegiate athletes. The chapter will conclude with a problem statement, the current research objectives and statements of hypotheses supported by the reviewed literature.

Consensus Regarding SRC

The Concussion in Sport Group (CISG) was formed in 2001 in order to develop a cohesive model for managing SRC for all levels of sport (Aubry et al., 2002). The CISG published a consensus statement outlining the position reached at the conference to inform and educate all individuals involved in the care of SRC, including health professionals, coaches and athletes (Aubry et al., 2002). Since 2001, the CISG has published four consensus statements based on the most up to date research and practices discussed and presented at the International Conference on Concussion in Sport occurring every four years. Consequently, the majority of SRC research has been developed in the 21st century as medical, scientific and cultural disciplines have come together to explore the gaps in our understanding of concussion (Williams & Danan, 2016). Even as awareness of concussion has increased across public and scientific communities, the field remains in the early stages of development and requires further research and constant modification to ensure that the best practices and models are used in athlete care (McCrory et al., 2017b; Williams & Danan, 2016).

As a result of the rapid changes in the understanding of SRC, there have been various and updates to the definition and terms used to describe it (McCrory et al., 2017a). It is important to

note that varying definitions still exist posing difficulties in diagnosis, management and treatment of SRC. According to citation statistics, the CISG definitions have become the gold standard to follow. The current definition of SRC, as created by the CISG in 2016, is as follows:

> Sport related concussion is a traumatic brain injury induced by biomechanical forces. Several common features that can be utilized in clinically defining the nature of a concussive head injury include:
>
> - 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;
> - 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;
> - 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;
> - 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.
> - The clinical signs and symptoms cannot be explained by drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction, etc.) or other comorbidities (e.g., psychological factors or coexisting medical conditions) (McCrory et al., 2017b, p. 2).

SRC in Collegiate Athletes

Collegiate athletes are viewed as a distinct population with unique characteristics and challenges (Moreland et al., 2018). In comparison to students, collegiate athletes often experience additional pressures involved in balancing academic studies while maintaining athletic commitments. As noted above, collegiate athletes may be more likely to experience mental health difficulties (Moreland et al., 2018; Sudano et al., 2017). The risk of injury further exacerbates the issue. Specifically, following SRC, evidence indicates that collegiate athletes may experience emotional symptomology characterized by rapid changes in mood with strong emotions or feelings (McCrory et al., 2017b).

For the purposes of this study, the collegiate athlete population can be defined as student athletes typically aged 18 to 24 enrolled in undergraduate programs. Concussions in the collegiate athlete population are of specific concern to the public and medical communities as they are one of the most commonly reported injuries in sport (Black, Sergio & Macpherson, 2017; Schneider et al., 2017; Yang et al., 2018). Due to the high occurrence of injury and the possibility of long-term effects, collegiate athlete concussion research remains an important component of SRC research (Yang et al., 2018). Globally, most universities are involved in the understanding and management of SRC by conducting research, collecting concussion data and implementing protocols for athletic programs (Yang et al., 2018). However, there are inconsistencies in these procedures that limit the ability to use this data to investigate incidence rates and outcomes of SRC. Current efforts focus on implementing standardized procedures for concussion records, including the collection of baseline, injury and post-injury assessments and medical care information. These common elements will allow researchers to study concussion incidence and outcomes more effectively (Yang et al., 2018).

Prevalence and incidence. According to the Canadian Institute for Health Information (CIHI), there were a total of 17,081 sport-related brain injury emergency department visits in 2016 to 2017 in Ontario and Alberta. This number indicates a 28% increase from 2012 to 2013. Of the total number of visits, 60% were male and 94% were diagnosed with a concussion. More specific to the collegiate athlete population, there were a total of 2,407 sport-related brain injury emergency department visits for individuals aged 18 to 24. This represents an increase of 19% from 2012 to 2013 data. Hockey-related injuries were most common for this age group with a total of 323 visits (CIHI, 2018).

In a systematic review, Prien, Grafe, Rossler, Junge and Verhagen (2018) summarized and compared the most recent incidence rates of SRC in elite level athletes, 17 years or older, in football (i.e., soccer), rugby, ice hockey and American football. Most studies in this review investigated the collegiate athlete population while the remaining focused on international level athletes and professional athletes. Incidence rates varied based on various factors including sport, context (i.e., match play vs. training), and sex (Prien et al., 2018). While rugby match play yielded the highest rates at 3.89 concussions per 1,000 hr and 3.00 concussions per 1,000 athletic exposures, football training yielded the lowest at 0.01 concussions per 1,000 hr and 0.08 concussions per 1,000 athletic exposures. Across all sports, training concussions were infrequent in comparison to match concussions. Further, in comparison to male athletes, female incidence rates were higher in ice hockey and football. Prien and colleagues (2018) reiterate the need for additional data on concussion outcomes in female contact sports and encourage future investigations to provide adequate sample sizes in order to produce meaningful results.

Specific to the Canadian population, ongoing research is required in order to provide accurate incidence rates among Canadian collegiate athletes. Recently, Black and colleagues

(2017) investigated SRC incidence in a Canadian, mixed-sex, mixed-sport sample within the 2008-2009 to 2010-2011 academic years. In accordance with previous findings, the higher incidence of SRC occurred in contact sports, with the highest incidence rates in women's rugby, women's ice hockey and men's basketball respectively. There were significantly more female concussions reported than male concussions (Black et al., 2017). Black and colleagues (2017) report that these results were due to the high incidence rates of concussion in women's rugby, with no male team for comparison. As the incidence rates reached 20% in some sports, concussion in Canadian collegiate athletes remains a concern. Although further information in required in order to best understand the prevalence and incidence rates of SRC in the Canadian collegiate athlete population, this evidence highlights the severity and concern for this type of injury (Black et al., 2017).

Recognizing and Evaluating SRC

Due to the fast-paced nature of competitive sport, identifying SRC can be a difficult task for healthcare professionals (McCrory et al., 2017b). Sideline evaluations have become an important tool for rapidly screening for suspected SRC. This type of assessment aims to recognize the injury and assess symptoms, cognitive functioning and balance. However, signs and symptoms of SRC are not always immediate.

The CISG recommends using the Standard Concussion Assessment Tool – Fifth Edition (SCAT5) to evaluate suspected concussion (Echemendia et al., 2017; McCrory et al., 2017b). The SCAT5 is a standardized, multimodal assessment that is effective in the screening of SRC; however, it is not meant to replace a complete diagnostic assessment when appropriate (McCrory et al., 2017b).

Recovery Following SRC

Following SRC, athletes display a wide range of physical, cognitive and emotional symptoms (Iverson et al., 2017). The SCAT5 includes a symptom scale that is used for athletes to rate their symptoms post-injury (see Appendix A). Clinical recovery, as outlined by the CISG, involves the resolution of symptoms and the return to school, work, and sport and recreation activities (Iverson et al., 2017; McCrory et al., 2017b). Research suggests that for many injured athletes, rapid improvement occurs within the first 10 to 14 days of recovery; for a portion of youth and collegiate populations, clinical recovery occurs within the first month post injury. However, for some, symptoms may persist for much longer leading to questions about what variables are associated with poorer recovery (Iverson et al., 2017; McCrory et al., 2017b). As the SCAT5 symptom scale is not specific to mental health outcomes, there may be gaps in our assessment of symptoms experienced post-SRC.

Factors influencing recovery. Researchers continue to explore factors that may impact a player's recovery. Results from the literature suggest that multiple factors may predict recovery and persistent symptoms (Iverson et al., 2017). Several factors are of particular interest. First, a high number of symptoms rated in the severe range in the acute phase of SRC is one of the strongest markers for a slower recovery (Iverson et al., 2017; McCrory et al., 2017b). An athlete is less likely to experience long-term difficulties following SRC if he/she is experiencing a low number of symptoms in the acute phase. Second, a history of pre-morbid psychological factors may play a role in delayed recovery and persistent symptoms. For instance, Iverson and colleagues (2017) noted children with a history of mental health diagnoses increased the likelihood of persistent SRC symptoms in children (McCrory et al., 2017b). Fewer studies have been conducted in young adults. In order to provide better understanding of outcomes in

collegiate athletes, studies are needed to explore what variables may impact progress. For the purposes of this research study, I will review the literature related to history of concussion and biological sex. History of concussion and biological sex may be variables that impact collegiate athletes' mental health following SRC.

History of concussion. As awareness of SRC has increased in public and scientific communities, there are evolving questions regarding the implications of multiple concussions and long-term outcomes. In a systematic review of the literature, Iverson and colleagues (2017) summarized research investigating the relationship between history of concussion and recovery. Most studies suggest no statistically significant relationship between concussion history and cognitive impairments. However, a history of concussion does increase the likelihood of sustaining future concussions (Abrahams et al., 2014; Iverson et al., 2017). According to the CISG, an athlete with a history of concussion is more likely to demonstrate physical, cognitive and emotional symptoms at baseline (McCrory et al., 2017b). Recent evidence suggests that multiple concussions may affect an individual's psychological state (Iverson et al., 2017; Manley et al., 2017; McCory et al., 2017b; Rice et al., 2018). In a sample of high school athletes, Brooks and colleagues (2016) found that athletes with three or more previous concussions reported more symptoms on the Post-Concussion Symptom Scale on the total-symptoms score and cognitive-sensory, sleep-arousal, vestibular-somatic and affective domain scores than athletes with no or fewer previous concussion. Furthermore, when studying retired athletes, evidence suggests that depression symptom severity increases with the number of previous concussions (Manley et al., 2017; Rice et al., 2018). Taken together, this evidence indicates that a previous history of concussion may be a significant component in the assessment and management of SRC (Iverson et al., 2017; McCrory et al., 2017b). There is need for additional research that uses specific

mental health measures to examine potential psychological issues associated with a history of concussion (Covassin et al., 2017). In the context of mental health, this study will explore how a history of concussion may impact an athlete's mental health by exploring specific constructs of quality of life and psychological distress.

Biological sex differences. There is growing interest in determining any differences that may exist for males and females experiencing SRC. Literature examining the relationship between sex and clinical recovery is mixed; however, on average, females are slower to recover in comparison to males (Iverson et al., 2018; Bauman, Ray, & Joseph, 2017). In recent research by Bauman and colleagues (2017), females report a higher number of symptoms post-SRC. Research is currently exploring the reasons for these biological sex differences. In a systematic review, Brown, Elsass, Miller, Reed and Reneker (2015) reported differences in symptom presentation for males and females at baseline and post-SRC. However, the collective results were not clinically significant (Brown et al., 2015). Recent work continues to support increased symptomology for females (Moser, Olek, & Schatz, 2018). Authors suggest that these differences may be influenced by hormonal changes during a female's menstrual cycle, and that further research is required in order to help explain these results (Brown et al., 2015; Moser et al., 2018). Since mood and anxiety disorders are more common in females than in males, it can be hypothesized that males and females may report different mood outcomes pre and post SRC (American Psychiatric Association, 2013). Although gaps remain in the understanding of biological sex differences and SRC in concussion literature, it is argued that sex may be an important component in the assessment and management of SRC. Additional well-designed, representative studies that include baseline assessments with multiple assessments throughout SRC recovery are required. In the context of mental health, this study will explore how a

biological sex may impact an athlete's ratings on quality of life and psychological distress measures following SRC.

Mental Health Outcomes

Following SRC, athletes display a wide range of physical, cognitive and emotional symptoms (Iverson et al., 2017). There is growing interest in addressing and understanding emotional sequelae and psychological consequences of SRC in the rehabilitation and return to play process of concussed collegiate athletes (Covassin et al., 2017; Kerr et al., 2014; Manley et al., 2017; McCrory et al., 2017b; Rice et al., 2018). There is a wide range of negative psychological outcomes currently being researched including depression, anxiety, general mood disturbance, cognitive function, quality of life, psychological distress, attention deficit hyperactivity disorder, apathy, suicide and aggression (Covassin et al., 2017; Manley et al., 2017; Rice et al., 2018). Findings indicate that these negative outcomes typically resolve one-month post-SRC (McCrory et al., 2017b; Rice et al., 2018). However, some athletes experience long term outcomes. The purpose of this thesis is not to explore all variables, but instead highlight the variables that are most common to college athletes. For the purposes of this research study, I will review the literature related to quality of life outcomes and psychological distress outcomes of SRC in the collegiate athlete population specifically.

Quality of life following SRC. Quality of life is a broad construct that lacks a universally accepted definition (Fayers & Machin, 2016). Although it is a concept recognized by most people, the perception of quality of life varies for different people. Fayers and Machin (2016) indicate that the term health-related quality of life is often used by researchers to narrow the scope of quality life to include subjective and objective markers that effect physical and mental health specifically (Wilson & Cleary, 1995). As defined by Testa and Simonson (1996), health-

related quality of life is the "physical, psychological and social domains of health, seen as distinct areas that are influenced by a person's experiences, beliefs, expectations and perceptions" (p. 835). In order to better understand athlete health, researchers are currently exploring health-related quality of life in current and retired athletes (Houston et al., 2016; Simon & Docherty, 2014; Simon & Docherty, 2016). In a sample of retired collegiate athletes, Simon and Docherty (2014) established that former collegiate athletes have lower health-related quality of ratings in comparison to non-collegiate athletes. On five of the seven Patient-Reported Outcomes Measurement Information System (PROMIS) scales (i.e., physical function, depression, pain interference, fatigue and sleep disturbance scales), former athletes scored significantly worse than non-athletes (Simon & Docherty, 2014). Further, in comparison with limited-contact and contact sport, former collision athletes may be at greater risk for lower health-related quality of life. Houston, Bay, and Valovich McLeod (2016) investigated the relationship between traditional SRC assessments and health-related quality of life measures in a population of adolescent athletes. Findings indicated that health-related quality of life ratings were significantly associated with severity of symptoms and significantly predicted time lost post-SRC (Houston et al., 2016). Additionally, health-related quality of life measures were shown to capture social and personal concerns experienced by the athlete post-SRC that traditional assessment measures are unable to capture. Together, these results demonstrate that it is important to address the overall quality of life of athletes at risk of experiencing SRC (Houston et al., 2016; Simon & Docherty, 2014; Simon & Docherty, 2016). As articulated by Houston and colleagues (2016), this evidence indicates that traditional SRC assessments may not capture the entirety of the injury. Additional research is required in order to understand the importance of

health-related quality of measures and their use in the management of SRC in the collegiate athlete population (Houston et al., 2016).

Quality of life and history of concussion. There is limited research investigating the relationship between health-related quality of life outcomes in collegiate athletes with a history of multiple concussions. Kuehl, Snyder, Erickson, and McLeod (2010) investigated the relationship between concussion history and health-related quality of life in collegiate athletes. Athletes with a history of concussion reported lower ratings of bodily pain, vitality and social functioning as measured by the Medical Outcomes Short Form (SF-36) (Kuehl et al., 2010). Meehan and colleagues (2016) also established that former collegiate athletes with a history of SRC experience poorer quality of life than those with no history of SRC. Although their research design lacked an injury control group for comparison, the findings supported the trend that a history of concussion may be associated with negative quality of life ratings (Meehan et al., 2016). Taken together, this evidence suggests that health-related quality of life measures may be an important tool in the assessment of SRC pre-injury and post-injury (Houston et al., 2016). However, it remains unclear whether health-related quality of life is impacted by SRC or if it is influenced by the athlete's absence from sport participation. Further investigation into health-related quality of life is important in order to better understand and serve concussed collegiate athletes post-injury.

Quality of life and biological sex. To date, there is limited research investigating the differences between males and females in the relationship between history of concussion and quality of life ratings. Although previous studies have included data from both male and female participants, there is a lack of research exploring how males and females may differ in their ratings of quality of life pre and post-injury. Current SRC research investigating biological sex

suggests that females tend to report a higher number of symptoms pre and post-SRC (Bauman et al., 2017; Moser et al., 2018). Based on this, it can be hypothesized that other differences may exist in the outcomes of SRC experienced for males and females. In order to best serve collegiate athletes post-injury, it may be beneficial to understand how biological sex may impact quality of ratings in order to inform SRC procedures.

Psychological distress following SRC. Psychological distress is described as a dysfunctional emotional state, that may include symptoms of anxiety, depression and somatization (Derogatis, 2017). There is a gap in the literature investigating whether or not an athlete's psychological state is influenced by a history of multiple concussions. It is argued that this information may be useful in identifying risks and developing individualized assessment for athletes at baseline. Although, research investigating psychological distress within the collegiate athlete population is in its infancy, emerging evidence suggests that assessing psychological distress may provide unique information for managing SRC recovery (Lancaster, McCrea, & Nelson, 2016). Specifically, the Brief Symptom Inventory-18 (BSI-18) has been shown to evaluate general psychological distress rather than targeting mood or anxiety symptoms specifically. It has been proposed as a useful tool in navigating psychological factors that could be influencing SRC (Lancaster et al., 2016).

Psychological distress and history of concussion. Weber and colleagues (2018) explored the relationship between psychological distress and concussion history. Using the BSI-18 to measure psychological distress, researchers assessed a sample of 8652 male and female collegiate athletes (Weber et al., 2018). Their findings suggest that athletes with a greater number of concussions may demonstrate elevated levels of psychological distress at baseline assessments. In comparison to student-athletes with fewer concussions (i.e., 0, 1, 2, 3), players

with 4 or more concussions demonstrated greater psychological distress (Weber at al., 2018). Although the study included a large sample of collegiate athletes, it lacked a control group for comparison. Comparatively, research by Combs, Wasserman, Rodrigo, Guskiewicz and Mihalik (2017) yielded no difference in BSI-18 outcomes for collegiate athletes with a history of one or more concussions (n = 128) versus collegiate athletes with no previous concussion history (n = 286). Taken together, the evidence is inconclusive and suggests that further research is required to determine if collegiate athletes with a history of multiple concussions report greater levels of psychological distress (Combs et al., 2017; Weber et al., 2018). More research is required in order to investigate trends in the research. Overall, the evidence suggests that it may be beneficial to screen collegiate athletes with a history of concussion for psychological distress. If an athlete's concussion history is identified at baseline, it may allow for more appropriate and individualized treatment and management of the athlete post-SRC. (Weber et al., 2018).

Psychological distress and biological sex. To date, there is limited research investigating the differences between males and females in the relationship between history of concussion and psychological distress. Provided that mood and anxiety disorders are more common in females than in males, it can be hypothesized that females may also report higher ratings of psychological distress (American Psychiatric Association, 2013). In order to best serve collegiate athletes post-injury, it may be beneficial to understand how biological sex may impact psychological distress ratings in order to inform SRC protocols.

Current Research Objectives

Mental health is a crucial component in human development required for maintaining overall health across the lifespan (MHCC, 2013). Collegiate athletes represent a specialized population that experience a variety of unique challenges that may place them at a greater risk

for the development of poor mental health (Moreland et al., 2018). There are still uncertainties in the understanding of how a history of multiple concussions may impact collegiate athlete mental health. The purpose of this study is to investigate the potential impacts of SRC on quality of life and psychological distress ratings in order to best understand the implications for the collegiate athlete population.

Objective 1A: Does a history of concussion impact quality of life ratings in a sample of collegiate student-athletes?

Independent Variable: Player concussion history

Dependent Variable: Quality of life ratings

Participants: Collegiate athletes

Research site: University of Alberta

***Hypothesis*:** *Collegiate student-athletes with a history of one of more concussions will report statistically significant lower quality of life ratings in comparison to collegiate student-athletes with no history of concussion. Collegiate student-athletes with a history of one of more concussions will report higher anxiety, depression, fatigue, sleep disturbance and pain interference PROMIS scores with lower physical function and ability to participate PROMIS scores in comparison to collegiate student-athletes with no history of concussion.*

Objective 1B: Does history of concussion impact quality of life ratings differently for males and females?

Independent Variables: Player concussion history, biological sex

Dependent Variable: Quality of life ratings

Participants: Collegiate athletes

Research site: University of Alberta

***Hypothesis*:** *History of concussion will have a greater effect on quality of life ratings for females in comparison to males. Specifically, when comparing no history of concussion to a history of one or more concussion, females will report a greater increase in anxiety, depression, fatigue, sleep disturbance and pain interference PROMIS scores with greater reduction of physical function and ability to participate PROMIS scores in comparison to males.* Current research trends indicate that females may report a higher number of symptoms at baseline assessment and post-SRC.

Objective 2A: Does a history of concussion impact psychological distress ratings in a sample of collegiate student-athletes?

Independent Variable: Player concussion history

Dependent Variable: Psychological symptom ratings

Participants: Collegiate athletes

Research site: University of Alberta

***Hypothesis*:** *Collegiate students-athletes with history of one of more concussions will report statistically significant higher psychological distress ratings in comparison to collegiate student-athletes with no history of concussion.* Although research is limited examining the relationship between psychological distress and concussion history, current trends suggest that collegiate athletes with a history of multiple concussions may report greater levels of psychological distress.

Objective 2B: Does history of concussion impact psychological distress ratings differently for males and females?

Independent Variable: Player concussion history, biological sex

Dependent Variable: Quality of life ratings

Participants: Collegiate athletes

Research site: University of Alberta

***Hypothesis*:** *History of concussion will have greater effect on psychological distress ratings for females in comparison to males. Specifically, when comparing samples of no history of concussion to a history of one or more concussion, females will report a greater increase of psychological distress in comparison to males.* Current research trends indicate that females may report a higher number of symptoms at baseline assessment and post-SRC.

Chapter Three: Methods

The purpose of this chapter is to review the methodology used in the study. This will include a review of the research design, a description of the sampled participants, an analysis of the selected measures and an outline of the data collection and statistical analyses employed in the study.

Research Design of the Current Project

The study data used a retrospective, quasi-experimental design. The participant groups were formed naturally with no random assignment in order to keep groups intact. This may pose a threat to internal validity as the process of random assignment equates the groups by evenly distributing variability of individuals (Creswell, 2015). Although quasi-experiments allow for the utilization of existing groups, there are various threats that need to be considered including history, maturation, selection, mortality and interaction with selection threats (Creswell, 2015).

Inclusion and exclusion criteria. All data was collected as a part of the Active Rehabilitation project. Inclusion criteria for the study was as follows:

a) Rostered students attending full-time studies at University of Alberta
b) Students aged 18 to 25
c) Rostered athletes participating in hockey, football, rugby, soccer, volleyball, and basketball

Furthermore, exclusion criteria included:

a) Rostered athletes under age 18
b) Rostered athletes over age 25

These exclusion criteria were selected in order to concentrate on the collegiate athlete population specifically.

Key terms. For the purposes of this study, the term "concussion" will be defined in accordance with the definition outlined by the CISG in 2016 (McCrory et al., 2017b). Additionally, the term "collegiate athlete" will be used to describe the age demographic of this sample of Canadian, University athletes ranging in age from 18 to 25 years old.

Measures

Quantitative self-report measures are the most frequently used method for measuring the mental health outcomes of SRC (Rice et al., 2018). To assess psychological outcomes, two measures were selected, the Patient-Reported Outcomes Measurement Information System (PROMIS) and the Brief Symptom Inventory-18 (BSI-18).

PROMIS. The PROMIS was selected to measure quality of life outcomes. This measure has previously been used to assess quality of life in the collegiate athlete population (Meehan et al., 2016). The PROMIS is free system accessible through the National Institutes of Health. It was designed to provide precise and efficient measurement of patient-reported outcomes including health-related quality of life for a wide range of populations (Cella et al., 2010). The PROMIS is a self-report measure developed with item response theory used to assess physical, mental and social well-being (Dewitt et al., 2018).

The Active Rehabilitation project selected the PROMIS 29. This version of the measure assesses physical function, anxiety, depression, fatigue, sleep disturbance, ability to participate in social roles and activities and pain interference (see Appendix B). A higher PROMIS *t*-score indicates more of the concept being measured. Higher anxiety, depression, fatigue, sleep disturbance and pain interference score indicate negative results, whereas higher physical function and ability to participate scores indicate positive results.

BSI-18. The BSI-18 was selected to measure psychological distress outcomes (see Appendix C). This measure has previously been used to assess psychological distress in the collegiate athlete population (Combs et al., 2017; Weber et al., 2018). It consists of 18 items on a 5-point Likert scale, yielding a Global Severity Index (GSI) score and three subscales scores: somatization, depression and anxiety (Lancaster et al., 2016). In a psychometric analysis of the measure in the collegiate athlete population, Lancaster and colleagues (2016) analyzed internal consistency, test-retest reliability and concurrent validity. The BSI-18 showed high internal consistency. The GSI demonstrated higher internal consistency (.83) in comparison to the subscales (.66 to .76), indicating that the GSI is the most reliable marker of psychological distress in the collegiate athlete population. Test-retest reliability estimates were moderate (.56 to .70) over seven days and poor (.26 to .53) over 165 days (Lancaster et al., 2016). This may indicate concern for using the BSI-18 in tracking recovery. Furthermore, the BSI-18 showed high criterion validity (.74 to .81) in comparison with other measures. However, the measure is not intended for diagnostic use due to its poor discriminant validity (Lancaster et al., 2016). These results indicate that the BSI-18 may be useful in the clinical assessment of SRC in the collegiate athlete population by providing insight into psychological factors pre and post-injury.

Data Collection

The population of interest in this study includes collegiate athletes participating in Canadian University Sports. However, due to feasibility, a convenience sampling approach was used to recruit participants. Therefore, University of Alberta collegiate athlete sport teams were recruited to participate. This type of sampling does not guarantee representation of the population or generalizability to the population (Creswell, 2015). Ethics approval was granted prior to starting the study (Pro00073481). Participants were required to sign a consent form in

order to participate in the study. The consent form included information on the purpose of the study, and explains the benefits, risks and commitments required in participation (see Appendix D). At baseline, all participants were required to complete a battery of baseline measures. For the purposes of this study, I will focus on the measures of quality of life (i.e., PROMIS) and psychological distress (i.e., BSI-18).

Study Participants

A total of 248 participants enrolled in the overall study. Due to incomplete data, eight participants were immediately excluded from the study sample. Further, due to exclusion criteria, an additional 10 participants were excluded from the study sample. These exclusions left a total of 230 participants. The participants included male and female rostered athletes participating in hockey, football, rugby, soccer, volleyball, and basketball, attending full time studies at the University of Alberta. Athletes ranged in age from 18 to 25 years old.

Statistical Analysis

All statistical analyses were executed using SPSS. Descriptive statistics were used to demonstrate the characteristics of the participants. Independent samples t-tests and chi-square tests were calculated to compare demographic variables and test outcomes of individuals who were included and excluded from the analysis.

MANOVA assumptions. The assumptions of MANOVA were evaluated. For all general linear models, the dependent variables were continuous and the independent variables consisted of two or more categorical, independent groups. Further, the study design ensured adequate sample size and independence of observations. The PROMIS scores of each athlete were independent of the scores of the other athletes. The sample size of 230 includes over 30 cases for each cell of the design. This includes more than 20 degrees of freedom of error suggested to

assure multivariate normality even with unequal sample sizes (Tabachnick & Fidell, 2014). There were no univariate or multivariate outliers. Box's M was used to test the homogeneity of variance-covariance matrices. The results of this test were significant for all general linear models indicating a violation of MANOVA. As a result, the more stringent Pillai's criterion was used to evaluate multivariate significance (Tabachnick & Fidell, 2014). Results of linearity were satisfactory and correlations between dependent variables indicated no issues of multicollinearity. Based on the above findings, the results can be interpreted with confidence.

ANOVA assumptions. The assumptions of ANOVA were verified. The dependent variable was continuous and the independent variables consisted of two or more categorical, independent groups. Further, the study design ensured independence of observations. That is, the BSI-18 GSI score of each athlete was independent of the scores of the other athletes. The normality assumption was satisfactory based on relatively large and equal sample sizes and the Levene test indicated that the homogeneity of variances assumption was satisfied (Gamst, Meyers & Guarino, 2008). As no ANOVA assumptions were violated, the results can be interpreted with confidence.

Objective 1A. This analysis examined the degree to which an athlete's history of concussion had an effect on quality of life ratings. Quality of life ratings included the seven PROMIS *t*-scores of physical function, anxiety, depression, fatigue, sleep disturbance, ability to participate and pain interference. A one-way MANOVA was used to compare the PROMIS scores between athletes with no history of concussion and athletes with a history of one or more concussion. For further exploration, an additional one-way MANOVA was used to compare the PROMIS scores between athletes with no history of concussion, athletes with a history of one concussion and athletes with a history of two or more concussions. Significance for the analyses

was set at an alpha level of .05. Due to the exploratory nature of this study, the univariate ANOVAs were examined to determine how the PROMIS scores differed by concussion history. To account for multiple ANOVAs inflating type I error, a stricter alpha level of .007 was employed to evaluate the univariate ANOVAs (Tabachnick & Fidell, 2014). This was calculated by dividing the original alpha level of .05 by the number of dependent variables in the analysis. Post hoc analyses using the Bonferroni method were conducted to further investigate differences between groups and partial eta squared values were calculated for significant findings to complement the interpretation of the results.

Objective 1B. This analysis examined the relationship between biological sex and history of concussion on quality of life ratings. Quality of life ratings included PROMIS *t*-scores of physical function, anxiety, depression, fatigue, sleep disturbance, ability to participate and pain interference. A two-way MANOVA was used to compare the PROMIS scores between male and female athletes with no history of concussion and a history of one or more concussion. Significance for the analysis was set at an alpha level of .05. Due to the exploratory nature of this study, the univariate ANOVAs were examined to determine how the PROMIS scores differ for the interaction. To account for multiple ANOVAs inflating type I error, a stricter alpha level of .007 was employed to evaluate the univariate ANOVAs (Tabachnick & Fidell, 2014). Post hoc analyses using the Bonferroni method were conducted to further investigate differences between groups and partial eta squared values were calculated for significant findings to complement the interpretation of the results. No further exploration was done to compare the PROMIS scores between males and females with no history of concussion, a history of one concussion and a history of two or more concussions due to the small, unequal sample sizes between males and females across concussion history groups.

Objective 2A. This analysis examined the degree to which an athlete's history of concussion had an effect on psychological distress ratings. Psychological distress ratings were based on BSI-18 GSI *t*-scores. A one-way between-subjects ANOVA was used to compare the BSI-18 GSI scores between athletes with no history of concussion and athletes with a history of one or more concussion. For further exploration, an additional one-way ANOVA was used to compare the BSI-18 GSI scores between athletes with no history of concussion, athletes with a history of one concussion and athletes with a history of two or more concussions. Significance for the analyses was set at an alpha level of .05.

Objective 2B. This analysis examined the relationship between biological sex and history of concussion on psychological distress ratings. A two-way between-subjects ANOVA was used to compare the BSI-18 GSI *t*-scores between male and female athletes with no history of concussion and a history of one or more concussion. Significance for the analyses was set at an alpha level of .05. Due to the exploratory nature of this study, post hoc analyses using the Bonferroni method were conducted to further investigate how BSI-18 GSI scores differed for males and females by concussion history. No further exploration was done to compare the BSI-18 GSI scores between males and females with no history of concussion, a history of one concussion and a history of two or more concussions due to the small, unequal sample sizes between males and females across concussion history groups.

Ethical Approval

Ethics approval for this study was granted by the Research Ethics Board at the University of Alberta (Pro00073481). The ethics board determined that this study was low risk for the participants, with a potential risk of fatigue after completing the questionnaires. Furthermore, when completing the PROMIS and BSI-18, participants may identify psychological difficulties

that they were unaware prior to completion of the questionnaires. As a safeguard for the participants, the questionnaires were scanned for abnormally high ratings that may require further psychological intervention. However, the benefits of this study were determined to outweigh the potential risks. The possible benefits of this study include a greater understanding of how a history of concussion may impact quality of life ratings or psychological distress ratings in the collegiate athlete population and a greater understanding of the relationship between history of concussion and biological sex in quality of life and psychological distress outcomes. This information can be used to educate about potential psychological outcomes following concussion and contribute to developing more appropriate and individualized treatment plans for management of the athlete pre and post-SRC.

Data Storage

The Carolina Data Acquisition and Reporting Tool, CDART, is a commercial quality data management tool designed and implemented by the CSCC as a scalable, web-based, customizable technology which supports data management for multi-center clinical trials, observational studies and patient registries. Technology components were designed to provide maximum flexibility and re-use, with minimal customization required for each new protocol application. Ideally, use of CDART for a new study requires only the specification of case report forms, reports and optional customizable executable code fragments.

Features of CDART include interactive web-based data entry with real-time field validation, audit logs to record database modifications, database integrity checks, complex form-specific field dependencies and optional form-specific algorithms. A flexible ETL (extract, transform, load) capability allows data capture from external sources (labs, reading centers, electronic medical records) in a variety of input formats.

The system includes a graphical screen designer which allows researchers to design and configure data input screens to match complex, case report forms, including ones with specialized graphical images. CDART has robust security features – logins, granular permissions based on user requirement, and encrypted data transmission. All Participants created a unique login and password for access into the CDART system. Only Dr. Mrazik had administrative access to the data.

Chapter Four: Results

The purpose of this study is to investigate the potential psychological impacts of SRC in order to best understand the implications for the collegiate athlete population. More specifically, the study examined the potential impact that a history of concussion may have on quality of life ratings and psychological distress ratings and whether or not there is a relationship between history of concussion and biological sex on these ratings. This chapter provides a summary of the results.

Participant Characteristics

Independent sample t-tests were performed to determine any differences between athletes included and excluded from the sample, alpha level set at $p < .05$. Results showed no significant differences between athlete BSI-18 GSI scores, $t(238) = 0.66$, $p = .513$, 95% CI [-3.37, 6.72]; PROMIS physical function scores, $t(238) = -0.55$, $p = .582$, 95% CI [-1.49, 0.84]; PROMIS anxiety scores, $t(238) = -0.60$, $p = .551$, 95% CI [-6.65, 3.56]; PROMIS depression scores, $t(238) = 0.57$, $p = .570$, 95% CI [-2.58, 4.67]; PROMIS fatigue scores, $t(236) = -0.65$, $p = .515$, 95% CI [-7.91, 3.98]; PROMIS sleep disturbance scores, $t(236) = 0.55$, $p = .586$, 95% CI [-3.56, 6.29]; PROMIS ability to participate in social roles and activities scores, $t(236) = 0.36$, $p = .721$, 95% CI [-2.89, 4.18]; and PROMIS pain interference scores, $t(236) = -0.14$, $p = .892$, 95% CI [-4.34, 3.78]. This suggests that excluding the participants did not skew or compromise the results. Table 1 depicts the differences in dependent variables between inclusion and exclusion groups.

Chi square tests were used to determine if there were any differences between participants who were excluded versus those who were included for the following categorical variables: biological sex, athlete history of concussion and athlete mental health history. Mental health history was determined based upon athlete subjective reporting. Athletes who reported a

previous diagnosis of a psychiatric disorder, learning disorder, ADD/ADHD, autism spectrum disorder, depression and/or bipolar were identified as having a positive mental health history. Results indicated that there were no differences in between participants who were excluded versus those that were included for athlete biological sex, X^2 (1, n = 230) = 1.46, p = .227; athlete history of concussion, X^2 (1, n = 230) = 0.61, p = .435; or athlete mental health history, X^2 (1, n = 230) = 0.45, p = .503. This suggests that conclusions can be interpreted with confidence and results are still applicable to the larger population sampled for the overall study.

A total of 230 student athletes were included in the following analyses. The athletes' ages ranged from 18 to 25 years, with a mean of 20.18 years (SD = 1.87). The majority (68.3%) of athlete participants were male (n = 157). The sample contained 31.7% female athletes (n = 73). Athletes were split into groups based on their reported concussion history; history of no concussion (n = 110), history of one or more concussions (n = 120). For exploratory purposes, the former was also split further into a history of one concussion (n = 65) and a history of two or more concussions (n = 55). Table 2 depicts characteristics of male versus female participants.

Table 1

Differences in Dependent Variables between Athletes Included and Excluded

BSI/PROMIS Score	2-tailed p value	Mean Difference
GSI	.513	1.68
Physical Function	.582	-0.33
Anxiety	.551	-1.55
Depression	.570	1.05
Fatigue	.515	-1.97
Sleep Disturbance	.586	1.36
Ability to Participate	.721	0.64
Pain Interference	.892	-0.28

Table 2

Participant Characteristics

Characteristic	Males (n = 157), Frequency (%) or Median (range)	Females (n = 73), Frequency (%) or Median (range)
Age	21.0 (18.0 to 25.0)	19.0 (18.0 to 25.0)
No History of Concussion	68 (43.3)	42 (57.5)
History of 1+ Concussion	89 (56.7)	31 (42.4)
History of 1 Concussion	45 (28.7)	20 (27.4)
History of 2+ Concussions	44 (28.0)	11 (15.1)

Objective 1A

Pearson correlations between the PROMIS scores were calculated to test multicollinearity. Table 3 reports the correlations between the PROMIS scores. Results indicate no problems of multicollinearity as no dependent variables are strongly correlated (Tabachnick & Fidell, 2014).

Table 3

Pearson Correlations between PROMIS Scores

Variable	PF	A	D	F	SD	AP	P
PF	1	-.30	-.29	-.15	-.16	.37	-.43
A	-	1	.60	.46	.40	-.51	.20
D	-	-	1	.33	.42	-.53	.16
F	-	-	-	1	.22	-.30	.20
SD	-	-	-	-	1	-.29	.16
AP	-	-	-	-	-	1	-.23
P	-	-	-	-	-	-	1

Note. PF = Physical Function; A = Anxiety; D = Depression; F = Fatigue; SD = Sleep Disturbance; AP = Ability to Participate; P = Pain.

Table 4 depicts the means and standard deviations for the PROMIS scores by each concussion history group. A one-way MANOVA was used to compare the PROMIS scores between athletes with no history of concussion and athletes with a history of one or more concussion. There was not a statistically significant difference in PROMIS scores based on athlete history of concussion, $F(7, 222) = 1.69, p = .112$; V = .05. History of concussion did not

have a statistically significant effect on PROMIS physical function scores, $F(1, 228) = 0.21, p = .649$; PROMIS anxiety scores, $F(1, 228) = 0.30, p = .588$; PROMIS depression scores, $F(1, 228) = 0.45, p = .502$; PROMIS fatigue scores, $F(1, 228) = 0.31, p = .578$; PROMIS sleep disturbance scores, $F(1, 228) = 1.39, p = .240$; PROMIS ability to participate scores, $F(1, 228) = 3.66, p = .057$; and PROMIS pain interference scores, $F(1, 228) = 0.06, p = .810$. Table 5 depicts the pairwise comparisons of PROMIS scores.

Table 4

Mean PROMIS Scores by Concussion History

PROMIS Score [mean (SD)]	Concussion History			
	Zero ($n = 110$)	One or more ($n = 120$)	One ($n = 65$)	Two or more ($n = 55$)
Physical Function	56.63 (1.62)	56.52 (2.08)	56.76 (1.10)	56.23 (2.81)
Anxiety	45.77 (7.81)	45.20 (7.99)	45.19 (7.01)	45.22 (9.08)
Depression	43.60 (5.98)	43.10 (5.53)	42.94 (5.04)	43.28 (6.10)
Fatigue	42.87 (8.65)	43.50 (8.18)	44.37 (7.41)	42.45 (8.96)
Sleep Disturbance	45.69 (7.14)	46.76 (6.64)	45.90 (6.11)	47.79 (7.13)
Ability to Participate	62.64 (4.07)	61.40 (5.64)	61.63 (5.27)	61.12 (6.08)
Pain Interference	43.76 (6.21)	43.94 (5.32)	44.09 (5.01)	43.77 (5.71)

Note. Zero = no history of concussion; One or more = history of one or more concussion; One = history of one concussion; Two or more = history of two or more concussions.

For exploratory purposes, an additional one-way MANOVA was conducted to compare PROMIS scores between athletes with no history of concussion, athletes with a history or one concussion and athletes with a history of two or more concussions. There was not a statistically significant difference in PROMIS scores based on athlete history of concussion, $F(14, 444) = 1.45, p = .128$; V = .09. History of concussion did not have a statistically significant effect on PROMIS physical function scores, $F(2, 227) = 1.31\ p = .272$; PROMIS anxiety scores, $F(2, 227) = 0.15, p = .864$; PROMIS depression scores, $F(2, 227) = 0.28, p = .758$; PROMIS fatigue scores, $F(2, 227) = 0.94, p = .393$; PROMIS sleep disturbance scores, $F(2, 227) = 1.83, p = .162$;

PROMIS ability to participate scores, $F(2, 227) = 1.98, p = .140$; and PROMIS pain interference scores, $F(2, 227) = 0.07, p = .930$. Table 5 depicts the pairwise comparisons of PROMIS scores.

Table 5

Pairwise Comparisons of PROMIS Scores by Concussion History

			Comparison 0 to 1+	
			99.3% CI	
PROMIS Score	Mean Difference	*p*	*LL*	*UL*
Physical Function	0.11	.649	-0.56	0.79
Anxiety	0.57	.588	-2.27	3.41
Depression	0.51	.502	-1.56	2.58
Fatigue	-0.62	.578	-3.64	2.40
Sleep Disturbance	-1.07	.240	-3.54	1.40
Ability to Participate	1.25	.057	-0.53	3.03
Pain Interference	-0.18	.810	-2.25	1.89
		Comparison 0 to 1		
Physical Function	-0.13	.656	-0.93	0.66
Anxiety	0.58	.640	-2.79	3.95
Depression	0.67	.460	-1.79	3.12
Fatigue	-1.50	.254	-5.08	2.07
Sleep Disturbance	-0.20	.850	-3.13	2.72
Ability to Participate	1.02	.191	-1.09	3.13
Pain Interference	-0.33	.718	-2.77	2.13
		Comparison 0 to 2		
Physical Function	0.40	.195	-0.44	1.24
Anxiety	0.55	.676	-3.01	4.11
Depression	0.33	.733	-2.27	2.92
Fatigue	0.42	.760	-3.35	4.20
Sleep Disturbance	-2.10	.066	-5.18	0.99
Ability to Participate	1.53	.064	-0.70	3.76
Pain Interference	-0.01	.989	-2.61	2.58
		Comparison 1 to 2		
Physical Function	0.53	.122	-0.40	1.46
Anxiety	-0.03	.982	-3.98	3.92
Depression	-0.34	.746	-3.22	2.53
Fatigue	1.93	.212	-2.26	6.11
Sleep Disturbance	-1.89	.133	-5.32	1.53
Ability to Participate	0.51	.577	-1.97	2.98
Pain Interference	0.31	.768	-2.57	3.19

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit; 0 = no history of concussion; 1+ = history of one or more concussion; 1 = history of one concussion; 2 = history of two more concussions.

Objective 1B

Table 6 depicts the mean PROMIS scores for males and females by concussion history. A two-way MANOVA was used to examine if there is an interaction between biological sex and athlete no history of concussion and athletes with a history of one or more concussion on PROMIS scores. There was a statistically significant interaction between biological sex and athlete concussion history on the combined dependent variables, $F(7, 222) = 2.59, p = .014$; V $= .08$, partial $\eta^2 = .08$.

Table 6

Mean PROMIS Scores for Males and Females by Concussion History

	Male		Female	
PROMIS Score [mean (SD)]	Zero ($n = 68$)	One or more ($n = 89$)	Zero ($n = 42$)	One or more ($n = 31$)
Physical Function	56.73 (1.41)	56.90 (0.00)	56.47 (1.92)	55.43 (3.93)
Anxiety	44.12 (7.28)	43.09 (4.78)	48.43 (7.98)	51.27 (11.62)
Depression	42.84 (5.39)	41.95 (3.18)	44.85 (6.72)	46.37 (8.76)
Fatigue	40.12 (8.36)	42.34 (7.70)	47.33 (7.21)	46.80 (8.71)
Sleep Disturbance	44.33 (6.90)	46.45 (6.31)	47.90 (7.04)	47.67 (7.54)
Ability to Participate	63.30 (3.05)	62.34 (4.25)	61.59 (5.19)	58.68 (7.93)
Pain Interference	42.73 (6.32)	43.32 (4.58)	45.43 (5.72)	45.72 (6.81)

Note. Zero = no history of concussion; One or more = history of one or more concussion.

Given the significance of the overall test, the univariate ANOVAs were examined to determine how the PROMIS scores differ for the interaction. Biological sex and athlete concussion history have did not have a statistically significant interaction effect on PROMIS physical function scores, $F(1, 226) = 5.47, p = .020$; PROMIS anxiety scores, $F(1, 226) = 3.38, p = .067$; PROMIS depression scores, $F(1, 226) = 2.29, p = .132$; PROMIS fatigue scores, $F(1, 226) = 1.45, p = .229$; PROMIS sleep disturbance scores, $F(1, 226) = 1.46, p = .228$; PROMIS ability to participate scores, $F(1, 226) = 2.02, p = .157$; and PROMIS pain interference scores, $F(1, 226) = 0.03, p = .855$, based on the alpha level of .007. A post hoc analysis using the

Bonferroni method was conducted to further investigate the findings. Table 7 depicts the pairwise comparisons of PROMIS scores for males and females by concussion history.

Table 7

Pairwise Comparisons for Male and Female PROMIS Scores by Concussion History

	Comparison of 0 to 1+					
	Male			Female		
PROMIS Score	Mean Difference	*p*	99.3% CI for Difference	Mean Difference	*p*	99.3% CI for Difference
PF	-0.17	.561	[-0.97, 0.67]	1.05	.016	[-0.12, 2.22]
A	1.04	.383	[-2.19, 4.26]	-2.84	.105	[-7.58, 1.90]
D	0.89	.324	[-1.55, 3.32]	-1.53	.248	[-5.11, 2.06]
F	-2.22	.085	[-5.71, 1.27]	0.53	.779	[-4.60, 5.70]
SD	-2.12	.054	[-5.10, 0.86]	0.23	.885	[-4.15, 4.61]
AP	0.96	.217	[-1.15, 3.06]	2.91	.011	[-0.18, 6.00]
P	-0.59	.517	[-3.07, 1.89]	-0.30	.825	[-3.95, 3.36]

Note. 0 = no history of concussion; 1+ = history of one or more concussion; PF = Physical Function; A = Anxiety; D = Depression; F = Fatigue; SD = Sleep Disturbance; AP = Ability to Participate; P = Pain.

Objective 2A

Table 8 depicts the means of the BSI-18 GSI scores by concussion history. A one-way ANOVA was used to compare BSI-18 GSI scores for athletes with no history of concussion and athletes with a history of concussion of one or more concussions. There was not a statistically significant difference in BSI-18 GSI scores based on athlete history of concussion, $F(1, 228) = 0.31, p = .577$.

For exploratory purposes, an additional one-way ANOVA was conducted to compare the BSI-18 GSI scores for athletes with no history of concussion, athletes with a history of one concussion and athletes with a history of two or more concussions. The model did not reach statistical significance, $F(2, 227) = 0.20, p = .817$. Table 9 depicts the pairwise comparisons of PROMIS scores by concussion history.

Table 8

Mean BSI-18 GSI Scores by Concussion History

			95% CI	
Concussion History	*n*	*M* (*SD*)	*LL*	*UL*
No History of Concussion	110	41.37 (8.40)	39.78	42.96
History of Concussion	120	41.96 (7.50)	40.60	43.31
History of 1 Concussion	65	41.75 (7.08)	40.00	43.51
History of 2+ Concussions	55	42.20 (8.04)	40.03	44.37

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

Table 9

Pairwise Comparisons of BSI-18 GSI Scores by Concussion History

			95% CI	
Comparison	Mean Difference	*p*	*LL*	*UL*
0 to 1	-0.38	1.0	-3.39	2.62
0 to 2	-0.83	1.0	-4.00	2.34
1 to 2	-0.45	1.0	-3.96	3.07

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit; 0 = no history of concussion; 1 = history of one concussion; 2 = history of two more concussions.

Objective 2B

Table 10 depicts the mean BSI-18 GSI scores for males and females by concussion history. A two-way ANOVA was used to determine if there is an interaction between biological sex and athletes with no history of concussion and athletes with a history of concussion of one or more concussion on BSI-18 GSI scores. The model did not reach statistical significance, $F(1, 226) = 0.99, p = .320$. Due to the exploratory purposes of this study, a post hoc analysis using the Bonferroni method was conducted to further investigate these findings. Table 11 depicts the results from the pairwise comparisons for males and females by concussion history.

Table 10

BSI-18 GSI Scores for Males and Females by Concussion History

	Male			Female		
History	*n*	*M* (*SD*)	95% CI	*n*	*M* (*SD*)	95% CI
Zero	68	40.13 (7.76)	[38.29, 41.98]	42	43.38 (9.09)	[41.04, 45.73]
One or more	89	40.55 (5.96)	[38.94, 42.16]	31	46.00 (9.83)	[43.27, 48.73]

Note. Zero = no history of concussion; One or more = history of one or more concussion.

Table 11

Pairwise Comparisons of BSI-18 GSI Scores for Males and Females by Concussion History

	Male			Female		
Comparison	Mean Difference	*p*	95% CI for Difference	Mean Difference	*p*	95% CI for Difference
0 to 1+	-0.42	.737	[-2.87, 2.03]	-2.62	.153	[-6.22, 0.98]

Note. 0 = no history of concussion; 1 = history of one or more concussion

Chapter Five: Discussion

SRC remains a public health concern in the Canadian population. It is a frequently occurring injury that involves complex diagnosis, assessment and management (McCrory et al., 2017b). Collegiate athletes represent a specialized population with unique characteristics and challenges (Moreland et al., 2018). Research suggests that athletes display a wide range of physical, cognitive and emotional symptoms following SRC (Iverson et al., 2017). As a result of challenges involved in balancing academic responsibilities while maintaining athletic commitments, collegiate athletes may be more likely to experience mental health difficulties following SRC (Moreland et al., 2018; Sudano et al., 2017). The topic of mental health and SRC is emerging as a prominent area of concern in SRC research**.** There is growing interest in addressing and understanding emotional sequelae and psychological consequences of SRC in the rehabilitation and return to play process of concussed athletes. In addition to the physical and cognitive symptoms experienced by athletes, research is suggesting a link between SRC and negative psychological outcomes in the collegiate athlete population (Covassin et al., 2017; Kerr et al., 2014; Manley et al., 2017; McCrory et al., 2017b; Rice et al., 2018).

Taken together, the current study examined the potential psychological outcomes following SRC in the collegiate athlete population. The study investigated specific measures of quality of life and psychological distress for collegiate student-athletes with no history of concussion in comparison to collegiate student-athletes with a history of one or more concussion. Furthermore, the study also analyzed if there was an interaction between history of concussion and biological sex on quality of life ratings and psychological distress. The intention of this research was to further expand knowledge around psychological outcomes of SRC in the

collegaite athlete population in order to facilitate future research and inform SRC management and treatment strategies for collegiate athletes who sustain a SRC.

Objective 1A

The first analysis examined differences between athletes with no history of concussion and athletes with a history of one or more concussion on a self-report quality of life measure. It was hypothesized that collegiate student-athletes with a history of one of more concussions would report higher anxiety, depression, fatigue, sleep disturbance and pain interference PROMIS scores with lower physical function and ability to participate PROMIS scores in comparison to collegiate student-athletes with no history of concussion. For further exploration, a second analysis was conducted to explore the differences between athletes with no history of concussion, athletes with a history of one concussion and athletes with a history of two more concussions. Neither model reached statistical significance, indicating that athlete PROMIS scores did not vary by previous concussion history. However, post hoc analyses indicated small differences between groups on sleep disturbance and ability to participate scores. Athletes with no history of concussion reported lower sleep disturbance scores and higher ability to participate scores in comparison to athletes with a history of one or more concussion. This was also replicated when further separating the concussion groups. Athletes with no history of concussion and a history of one or more concussion reported lower sleep disturbance scores in comparison to athletes with a history of two or more concussions. Ability to participate scores decreased at each level of concussion history.

Trends investigating the relationship between history of concussion and quality of life in collegiate athletes indicated that athletes with a history of concussion will report a poorer quality of life than those with no history of concussion (Houston et al., 2016; Kuehl et al., 2010; Meehan

et al., 2016; Simon & Docherty, 2014). The results of this study did not replicate this trend. Small differences were noted between concussion groups, but they were not statistically significant. These differences may warrant further research in order to determine if there is an effect of concussion history on these ratings with a larger sample size with more representation of each level of concussion history. Furthermore, the inclusion of a control group may provide beneficial information. It would be valuable to explore how the collegiate athlete population compares to the general collegiate population in baseline quality of life ratings.

Objective 1B

This portion of the analysis examined the relationship between biological sex and history of concussion on a self-report measure of quality of life. It was hypothesized that history of concussion will have a greater effect on quality of life ratings for females than males. Specifically, when comparing no history of concussion to a history of one or more concussion, it was hypothesized that females would report a greater increase in anxiety, depression, fatigue, sleep disturbance and pain interference PROMIS scores with a greater reduction of physical function and ability to participate PROMIS scores in comparison to males. The overall model was significant, indicating that the effect of concussion history is not the same for males and females. Post hoc analyses were not significant; however, mean differences provided evidence of small differences between males and females on anxiety, depression, fatigue, sleep disturbance, and ability to participate scores. Females reported a greater increase in anxiety and depression scores and a greater reduction in ability to participate scores in comparison to males. In contrast to the hypothesis, males reported a greater increase in fatigue and sleep disturbance scores. As these differences are not statistically significant, the findings were not conclusive. However, these differences highlight the need for further research and exploration of this topic.

Although there was limited research investigating the effect of concussion history for males and females on quality of life ratings, current SRC research investigating biological sex suggested that females tend to report a higher number of symptoms pre and post-SRC (Bauman et al., 2017; Moser et al., 2018). Results of this study do not conclusively replicate or contradict this trend. The differences observed between males and females indicated that there may be a more complicated interaction of concussion history and biological sex. However, it is important to note that the differences observed in this study are not statistically significant. Therefore, as the findings were not conclusive, there is still a need for further research and exploration of this topic in order to determine if there is a multifaceted effect of concussion history in combination with biological sex on quality of life ratings. It will be important to explore the reasons why males and females may differ on quality of life ratings. Furthermore, additional research may explore how if PROMIS is sensitive to different symptom for males and females.

Objective 2A

The second analysis examined differences between athletes with no history of concussion and athletes with a history of one or more concussion on a self-report measure of psychological distress. It was hypothesized that collegiate students-athletes with history of one of more concussions would report higher BSI-18 GSI ratings in comparison to collegiate student-athletes with no history of concussion. For further exploration, a second analysis was conducted to explore the differences between athletes with no history of concussion, athletes with a history of one concussion and athletes with a history of two more concussions. Results were not significant indicating that athlete BSI-18 GSI scores did not vary by previous concussion history.

As discussed in the literature review, evidence was inconclusive regarding the impact of history of concussion on psychological distress ratings. This study's results were consistent with

research by Combs and colleagues (2017) in which there were no differences in BSI-18 outcomes for collegiate athletes with a history of one or more concussions in comparison to collegiate athletes with no previous concussion history. However, results may contradict findings that student-athletes with 4 or more concussions demonstrated greater psychological distress in comparison to student-athletes with fewer concussions (Weber at al., 2018). It is important to note that the sample size and group discrepancies within this study impacted the ability to investigate concussion history at the same segregated level as Weber and colleagues (2018). Therefore, more research is required in order to determine if psychological distress increases at a specific number of previous concussions.

Objective 2B

This portion of the analysis examined the relationship between history of concussion and biological sex on a self-report measure of psychological distress. It was hypothesized that history of concussion would have a greater effect on psychological distress ratings for females than males. Specifically, when comparing samples of no history of concussion to a history of one or more concussion(s), females would report a greater increase of psychological distress in comparison to males. Results were not significant, indicating that the effect of concussion history was the same for males and females on BSI-18 GSI ratings. Upon further exploration, small differences were found between males and females. Females reported a greater increase in BSI-18 GSI scores in comparison to males. However, these differences were not conclusive as they are not statistically significant.

Although there was limited research investigating the effect of concussion history for males and females on psychological distress ratings, current trends in the research suggested that females may report higher ratings of psychological distress due to a higher prevalence of mood

and anxiety disorders (American Psychiatric Association, 2013). The results of this study did not replicate this trend. As additional research may be necessary to determine if psychological distress ratings increase at a specific number of previous concussions, it would be beneficial to determine if this impacts males and females in the same way.

Strengths and Limitations

The current study included inclusion and exclusion criteria that explored collegiate athletes aged 18 to 25 specifically. Furthermore, quantitative self-report measures, the most popular approach to measuring mental health outcomes within the SRC population, were chosen in order to explore personal and sensitive topics from the collegiate athlete perspective (Covassin et al, 2017; Rice et al., 2018). The selected self-report measures were cost effective and provided a standardized approach to data collection.

However, this research study was not without limitations. Primarily, there were disadvantages to using self-reported quantitative measures. There was concern of the social desirability bias in which raters provide desirable answers regardless of accuracy (Duckworth & Yeager, 2015). Duckworth and Yeager (2015) also discuss the possibility of faking. It is important to consider that collegaite athletes may inflate or deflate on scores to provide desirable answers for the researchers and medical staff surrounding their sport participation. In order to combat this concern and encourage honest responses, athletes completed questionnaires privately and were informed that responses were confidential. However, it may be possible that the subjective ratings from the questionnaires impacted the results of the study. Additionally, the study design required self-reported concussion history. As Rice and colleagues (2018) indicate that relying on self-reported history may be problematic due to memory bias and the possibility of inaccurate self-diagnosis, it was difficult to ensure an accurate report of concussion history.

However, due to ethical and privacy concerns, self-report was the only possible method for obtaining medical history and information. There was also a concern regarding accurate reporting of symptoms following SRC. Evidence indicates that elite athletes are often willing to minimize short and long-term consequences of SRC while pursuing their athletic goals (Broshek, De Marco, & Freeman, 2015). Broshek and colleagues (2015) indicate that athletes may experience various fears surrounding SRC, including fears of losing a role on the team, being seen as weak, and losing scholarship funding due to lack of participation. These fears and the invisible nature of the injury may encourage athletes to return to play as quickly as possible by minimizing symptoms (Broshek et al., 2015). This limitation was unavoidable and part of the imperfections of research; however, it is important to consider when interpreting the results of this study.

The reliability of the BSI-18 was also a notable limitation. The poor to moderate test-retest reliability scores were of concern when interpreting the results of the study (Lancaster et al., 2016). If the measure is not stable across time, it may pose difficulties in tracking psychological functioning following SRC. More specifically, according to Lancaster and colleagues (2016), it will be challenging to interpret whether varying ratings on the BSI-18 are due to previous concussion history or due to error.

Furthermore, the study design produced limitations. Primarily, the study lacked a control group. Due to participant burden, the quality of life and psychological distress measures were not administered to an additional healthy control group. A healthy control comparison would have been beneficial in exploring the uniqueness of the collegiate athlete population. Therefore, generalization of the results to non-elite athletes, younger athletes and non-sport concussion populations should be done with caution. The sample was also male skewed, especially when

separating athletes by no history of concussion, history of one concussion and history of two or more concussions. A balanced representation of male and female athletes would better illustrate the relationship between history of concussion and biological sex on measures of quality of life and psychological distress.

Conclusion and Future Directions

In summary, the findings of the current study suggest that a history of SRC was not a risk factor for poorer quality of life or psychological distress ratings in collegiate athletes. Furthermore, females with a previous SRC were not at a greater risk for poorer quality of life or psychological distress ratings. However, the sample size of the study was not able to adequately and accurately assess the potential effect of multiple prior concussions and the relationship between history of concussion and biological sex on measures of quality of life and psychological distress. It is important to consider whether or not the subjective measures truly examined the quality of life and psychological distress of collegiate athletes. Moving forward, it will be valuable to consider how the collegaite athlete population may differ from a comparison group. It is possible that pressures involved in collegiate sport may result in providing desirable answers on questionnaires in order to facilitate participation in sport. Additionally, it may be possible that males and females differ in their approach and therefore important to explore how males and females may respond differently to quality of life and psychological distress questionnaires.

Future studies should incorporate a more diverse, representative sample for further segregation of concussion groups. Furthermore, the results of this study may indicate the need for more sensitive measures for detecting poorer quality of life and psychological distress in collegiate athletes.

References

Abrahams, S., Mc Fie, S., Patricios, J., Posthumus, M., & September, A. V. (2014). Risk factors for sports concussion: an evidence-based systematic review. *British Journal of Sports Medicine*, *48*(2), 91-97.

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub.

Arnett, J. J. (2016). College students as emerging adults: The developmental implications of the college context. *Emerging Adulthood*, *4*(3), 219-222.

Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist*, *55*, 469–480.

Arnett, J. J., Žukauskienė, R., & Sugimura, K. (2014). The new life stage of emerging adulthood at ages 18–29 years: Implications for mental health. *The Lancet Psychiatry*, *1*(7), 569-576.

Aubry, M., Cantu, R., Dvorak, J., Graf-Baumann, T., Johnston, K., Kelly, J., ... & Schamasch, P. (2002). Summary and agreement statement of the first international conference on concussion in sport, Vienna 2001. *British Journal of Sports Medicine*, *36*(1), 6-7.

Bauman, S., Ray, M., & Joseph, P. P. (2017). Gender differences in clinical presentation and recovery of sports related concussion. *British Journal of Sports Medicine*, *51*(11), A35.

Black, A. M., Sergio, L. E., & Macpherson, A. K. (2017). The epidemiology of concussions: Number and nature of concussions and time to recovery among female and male Canadian varsity athletes 2008 to 2011. *Clinical Journal of Sport Medicine*, *27*(1), 52-56.

Bloom, G. A., Loughead, T. M., Shapcott, E. J., Johnston, K. M., & Delaney, J. S. (2008). The

prevalence and recovery of concussed male and female collegiate athletes. *European Journal of Sport Science*, *8*(5), 295-303.

Brooks, B. L., Mannix, R., Maxwell, B., Zafonte, R., Berkner, P. D., & Iverson, G. L. (2016). Multiple past concussions in high school football players: Are there differences in cognitive functioning and symptom reporting? *The American Journal of Sports Medicine*, *44*(12), 3243-3251.

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.

Brown, D. A., Elsass, J. A., Miller, A. J., Reed, L. E., & Reneker, J. C. (2015). Differences in symptom reporting between males and females at baseline and after a sports-related concussion: A systematic review and meta-analysis. *Sports Medicine*, *45*(7), 1027-1040.

Canadian Institute for Health Information. (2018). *Injury and trauma emergency department and hospitalization statistics, 2016-2017*. Retrieved from https://www.cihi.ca/en/heads-up-on-sport-related-brain-injuries-0

Canadian Mental Health Association. (2018). *Mental health*. Retrieved from https://cmha.ca/document-category/mental-health

Cella, D., Riley, W., Stone, A., Rothrock, N., Reeve, B., Yount, S., ... & Cook, K. (2010). Initial adult health item banks and first wave testing of the patient-reported outcomes measurement information system (PROMIS™) network: 2005–2008. *Journal of Clinical Epidemiology*, *63*(11), 1179-1194.

Combs, P. R., Wasserman, E. B., Rodrigo, C. J., Guskiewicz, K. G., & Mihalik, J. P. (2017). The association between psychological distress and concussion history in college athletes. *Br J Sports Med*, *51*(11), A26.

Covassin, T., Elbin, R. J., Beidler, E., LaFevor, M., & Kontos, A. P. (2017). A review of psychological issues that may be associated with a sport-related concussion in youth and collegiate athletes. *Sport, Exercise, and Performance Psychology*, *6*(3), 220-229.

Creswell, J. (2015). *Educational research: Planning, conducting and evaluating quantitative and qualitative research.* Upper Saddle River, NJ: Pearson.

Derogatis, L. R. (2017). Symptom checklist-90-revised, brief symptom inventory, and BSI-18. In M. E. Maruish (Ed.), *Handbook of psychological assesment in primary care settings,* (pp. 599-629). New York, NY: Routledge.

Dewitt, B., Feeny, D., Fischhoff, B., Cella, D., Hays, R. D., Hess, R., ... & Yu, L. (2018). Estimation of a preference-based summary score for the patient-reported outcomes measurement information system: The PROMIS®-Preference (PROPr) scoring system. *Medical Decision Making*, *38*(6), 683-698.

Duckworth, A. L., & Yeager, D. S. (2015). Measurement matters: Assessing personal qualities other than cognitive ability for educational purposes. *Educational Researcher*, *44*(4), 237-251.

Echemendia, R. J., Meeuwisse, W., McCrory, P., Davis, G. A., Putukian, M., Leddy, J., ... & Schneider, K. (2017). The sport concussion assessment tool 5th edition (SCAT5): Background and rationale. *British Journal of Sports Medicine*, *51*(11), 848-858.

Engel, G. L. (1977). The need for a new medical model: A challenge for biomedicine. *Science*, *196*(4286), 129-136.

Fayers, P. M., & Machin, D. (2016). *Quality of life: the assessment, analysis and interpretation of patient-reported outcomes*. West Sussex, United Kingdom: John Wiley & Sons.

Fincham, F. D. & Lucier-Greer, M. (2018). Emerging Adulthood. In M. H. Bornstein (Ed.), *The SAGE encyclopedia of lifespan human development* (pp. 723-724). Thousand Oaks, CA: Sage.

Gamst, G., Meyers, L. S., & Guarino, A. J. (2008). *Analysis of variance designs: A conceptual and computational approach with SPSS and SAS*. New York, NY: Cambridge University Press.

Hayden, E. P. & Vandermeer, M. R. J. (2018). Mental Illness. In M. H. Bornstein (Ed.), *The SAGE encyclopedia of lifespan human development* (pp. 1389-1391). Thousand Oaks, CA: Sage.

Houston, M. N., Bay, R. C., & Valovich McLeod, T. C. (2016). The relationship between post-injury measures of cognition, balance, symptom reports and health-related quality-of-life in adolescent athletes with concussion. *Brain Injury*, *30*(7), 891-898.

Hughes, L., & Leavey, G. (2012). Setting the bar: Athletes and vulnerability to mental illness. *The British Journal of Psychiatry*, *200*(2), 95-96.

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.

Kerr, Z. Y., Evenson, K. R., Rosamond, W. D., Mihalik, J. P., Guskiewicz, K. M., & Marshall, S. W. (2014). Association between concussion and mental health in former collegiate athletes. *Injury Epidemiology*, *1*(1), 28.

Kerr, Z. Y., Marshall, S. W., Dompier, T. P., Corlette, J., Klossner, D. A., & Gilchrist, J. (2015). College sports–related injuries—United States, 2009–10 through 2013–14 academic years. *Morbidity and Mortality Weekly Report*, *64*(48), 1330-1336.

Khanlou, N. & Khan, A. (2018). Mental Health. In M. H. Bornstein (Ed.), *The SAGE encyclopedia of lifespan human development* (pp. 1386-1388). Thousand Oaks, CA: Sage.

Kitzrow, M. A. (2009). The mental health needs of today's college students: Challenges and recommendations. *NASPA Journal*, *46*(4), 646-660.

Kuehl, M. D., Snyder, A. R., Erickson, S. E., & McLeod, T. C. V. (2010). Impact of prior concussions on health-related quality of life in collegiate athletes. *Clinical Journal of Sport Medicine*, *20*(2), 86-91.

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.

Manley, G. T., Gardner, A. J., Schneider, K. J., Guskiewicz, K. M., Bailes, J., Cantu, R. C., ... Dvořák, J. (2017). A systematic review of potential long-term effects of sport-related concussion. *British Journal of Sports Medicine*, *51*(12), 969-977.

McCrory, P., Feddermann-Demont, N., Dvořák, J., Cassidy, J. D., McIntosh, A., Vos, P. E., ... & Tarnutzer, A. A. (2017A). What is the definition of sports-related concussion: A systematic review. *British Journal of Sports Medicine*, *51*(11), 877-887.

McCrory, P., Meeuwisse, W. H., Aubry, M., Cantu, B., Dvořák, J., Echemendia, R. J., ... & Sills, A. (2013). Consensus statement on concussion in sport: The 4th international conference on concussion in sport held in Zurich, November 2012. *British Journal of Sports Medicine*, *47*(5), 250-258.

McCrory, P., Meeuwisse, W., Dvorak, J., Aubry, M., Bailes, J., Broglio, S., ... & Davis, G. A. (2017b). 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.

Meehan III, W. P., Taylor, A. M., Berkner, P., Sandstrom, N. J., Peluso, M. W., Kurtz, M. M., ... Mannix, R. (2016). Division III collision sports are not associated with neurobehavioral quality of life. *Journal of Neurotrauma*, *33*(2), 254-259.

Moreland, J. J., Coxe, K. A., & Yang, J. (2017). Collegiate athletes' mental health services utilization: A systematic review of conceptualizations, operationalizations, facilitators, and barriers. *Journal of Sport and Health Science, 7*(1), 58-69.

Moser, R. S., Olek, L., & Schatz, P. (2018). Gender differences in symptom reporting on baseline sport concussion testing across the youth age span. *Archives of Clinical Neuropsychology,* 1-10.

Prien, A., Grafe, A., Rössler, R., Junge, A., & Verhagen, E. (2018). Epidemiology of head injuries focusing on concussions in team contact sports: A systematic review. *Sports Medicine*, *48*(4), 953-969.

Putukian, M. (2016). The psychological response to injury in student athletes: a narrative review with a focus on mental health. *British Journal of Sports Medicine*, *50*(3), 145-148.

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*(2), 447-465.

Rice, S. M., Purcell, R., De Silva, S., Mawren, D., McGorry, P. D., & Parker, A. G. (2016). The mental health of elite athletes: A narrative systematic review. *Sports Medicine*, *46*(9), 1333-1353.

Schneider, K. J., Leddy, J. J., Guskiewicz, K. M., Seifert, T., McCrea, M., Silverberg, N. D., ... & Makdissi, M. (2017). Rest and treatment/rehabilitation following sport-related concussion: A systematic review. *British Journal of Sports Medicine*, *51,* 930-934.

Simon, J. E., & Docherty, C. L. (2014). Current health-related quality of life is lower in former division I collegiate athletes than in non–collegiate athletes. *The American Journal of Sports Medicine*, *42*(2), 423-429.

Simon, J. E., & Docherty, C. L. (2016). Current health-related quality of life in former national collegiate athletic association division I collision athletes compared with contact and limited-contact athletes. *Journal of Athletic Training*, *51*(3), 205-212.

Stone, J. L., Patel, V., & Bailes, J. E. (2014). The history of neurosurgical treatment of sports concussion. *Neurosurgery*, *75*(4), S3-S23.

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.

Tabachnick, B. G., & Fidell, L. S. (2014). Pearson New International Edition: Using Multivariate Statistics (6th Ed.) Boston: Allyn & Bacon.

Tanner, J. L., & Arnett, J. J. (2017). The emergence of emerging adulthood: The new life stage between adolescence and young adulthood. In A. Furlong (Ed.), *Routledge Handbook of Youth and Young Adulthood* (pp. 50-56). Abingdon, Oxon: Routledge.

Testa, M. A., & Simonson, D. C. (1996). Assessment of quality-of-life outcomes. *New England Journal of Medicine*, *334*(13), 835-840.

Weber, M. L., Dean, J. H. L., Hoffman, N. L., Broglio, S. P., McCrea, M., McAllister, T. W., ... & Kelly, L. A. (2018). Influences of mental illness, current psychological state, and concussion history on baseline concussion assessment performance. *The American Journal of Sports Medicine*, *46*(7), 1742-1751.

World Health Organization. (2014). *Mental health: a state of well-being*. Retrieved from http://www.who.int/features/factfiles/mental_health/en/

Williams, V. B., & Danan, I. J. (2016). A historical perspective on sports concussion: Where we have been and where we are going. *Current Pain and Headache Reports*, *20*(6), 43.

Wilson, I. B., & Cleary, P. D. (1995). Linking clinical variables with health-related quality of life: A conceptual model of patient outcomes. *Journal of American Medical Association*, *273*(1), 59-65.

Yang, J., Peek-Asa, C., Noble, J. M., Torner, J., Schmidt, P., Cooper, M. L., & Big Ten – Ivy League Traumatic Brain Injury Research Collaboration Data Collection Working Group. (2018). Common data elements collected among universities for sport-related concussion studies. *Injury Epidemiology*, *5*(1), 2.

Appendix A: SCAT5 Symptom Evaluation

Table A1 depicts the symptoms evaluated on the SCAT5. For a baseline assessment, an athlete rates his/her symptoms based on how he/she typically feels. Post-SRC, an athlete rates his/her symptoms based on how he/she feels at that specific moment in time (Echemendia et al., 2017).

Table A1

SCAT5 Symptom Evaluation

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

Note. Adapted from "Sport Concussion Assessment Tool 5th Edition (SCAT5): Background and Rationale" by Echemendia, R. J., Meeuwisse, W., McCrory, P., Davis, G. A., Putukian, M., Leddy, J., ... & Schneider, K, 2017, *British Journal of Sports Medicine*, *51*(11), p. 853.

Appendix B: Active Rehabilitation Project Quality of Life Measure

ACTIVE REHAB

Quality of Life

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: _____/ _____/ _____

Quality of Life

Please respond to each question or statement by marking one box per row.

Physical Function	Without any difficulty	With a little difficulty	With some difficulty	With much difficulty	Unable to do
1. Are you able to do chores such as vacuuming or yard work?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
2. Are you able to go up and down stairs at a normal pace?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
3. Are you able to go for a walk of at least 15 minutes?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
4. Are you able to run errands and shop?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

Anxiety In the past 7 days....	Never	Rarely	Sometimes	Often	Always
5. I felt fearful.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
6. I found it hard to focus on anything other than my anxiety.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
7. My worries overwhelmed me.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
8. I felt uneasy.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Depression In the past 7 days...	Never	Rarely	Sometimes	Often	Always
9. I felt worthless.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
10. I felt helpless.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
11. I felt depressed.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
12. I felt hopeless.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Participant ID: _____

Fatigue During the past 7 days...	Not at all	A little bit	Somewhat	Quite a bit	Very much
13. I feel fatigued.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
14. I have trouble starting things because I am tired.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
15. How run-down did you feel on average?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
16. How fatigued were you on average?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Sleep Disturbance In the past 7 days...	Very poor	Poor	Fair	Good	Very good
17. My sleep quality was...	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

Sleep In the past 7 days...	Not at all	A little bit	Somewhat	Quite a bit	Very much
18. My sleep was refreshing.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
19. I had a problem with my sleep.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
20. I had difficulty falling asleep.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Ability to Participate in Social Roles and Activities	Never	Rarely	Sometimes	Usually	Always
21. I have trouble doing all of my regular leisure activities with others.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
22. I have trouble doing all of the family activities that I want to do.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
23. I have trouble doing all of my usual work (include work at home).	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
24. I have trouble doing all of the activities with friends that I want to do.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

Pain Interference In the past 7 days...	Not at all	A little bit	Somewhat	Quite a bit	Very much
25. How much did pain interfere with your day to day activities?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
26. How much did pain interfere with work around the home?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
27. How much did pain interfere with your ability to participate in social activities?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
28. How much did pain interfere with your household chores?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Participant ID: _____

Pain Intensity
In the past 7 days…

29. How would you rate your pain on average?

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10

No pain **Worst pain imaginable**

Cognitive Function During the past 7 days…	**Never**	**Rarely (once)**	**Sometimes (2-3 times)**	**Often (once a day)**	**Very often (several times a day**
30. I had to read something several times to understand it.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
31. My thinking was slow.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
32. I had to work really hard to pay attention or I would make a mistake.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
33. I had trouble concentrating.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

How much difficulty do you currently have…	**None**	**A little**	**Somewhat**	**A lot**	**Cannot do**
34. reading and following complex instructions (e.g. directions for a new medication)?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
35. planning for and keeping appointments that are not part of your weekly routine (e.g. therapy or doctor appointments or a social gathering with friend and family)?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
36. managing your time to do most of your daily activities?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
37. learning new tasks or instructions?	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

Fatigue In the past 7 days…	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
38. I felt exhausted.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
39. I felt that I had no energy.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Participant ID: _____

	Never	Rarely	Sometimes	Often	Always
40. I felt fatigued.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
41. I was too tired to do my household chores.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
42. I was too tired to leave the house.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
43. I was frustrated by being too tired to do the things I wanted to do.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
44. I felt tired.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
45. I had to limit my social activity because I was tired.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Appendix C: Active Rehabilitation Project BSI-18 Measure

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 D: 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

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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