Impact of Mental Health on Cognitive Test Performance in CFL Athletes

by

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Abstract

Approximately 3.5 million Canadians will meet the criteria for a mood disorder in their life time. Previous research has found that athletes are at a greater risk for mental health disorders than the general public. This could be due to professional athletes having intense physical and mental demands placed upon them during their sports career which can increase their susceptibility to mental health problems. The purpose of this study was to evaluate the relationships between athletes' mental health and their cognitive performance during baseline concussion testing. Study participants included 951 Canadian Football League (CFL) athletes ages 21 to 37. The participants underwent cognitive baseline testing that included the Patient-Reported Outcomes Measurement Information System (PROMIS 29), the Brief Symptom Inventory (BSI-18), and the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT). Results found that the BSI-18 and PROMIS 29 index scores did not show significant differences on cognitive performance scores on the ImPACT. Researchers did note significant variables could influence cognitive performance. This study found that history of concussion, history of psychiatric disorder, diagnosed ADHD, and diagnosed SLD showed significant differences on the ImPACT index scores. This information may help mental health professionals interpret cognitive results in relation to the additional factors that can influence cognitive performances in athletes.

Preface

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

Dedication

This thesis is dedicated to my mother, Lois. You have always encouraged me to set my goals high and to work hard to get to accomplish them. Thank you for always encouraging me to celebrate every small step along the way.

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I would like to thank my supervisor, Dr. Martin Mrazik, for his continued support, guidance, and patience throughout this project. I am grateful to learn from his wealth of knowledge and experience in the field. I am fortunate for the opportunities Dr. Mrazik has provided for me to further develop my knowledge and skills. I would also like to thank my committee members Dr. Naidu and Dr. Whelton for their time and contributions on this project.

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Chapter One: Introduction

Mental Health

Approximately 3.5 million individuals will meet the criteria for a mood disorder in Canada over the course of a lifetime (Pearson et al., 2013). More specifically, approximately 3.2 million Canadians meet the criteria for a major depressive episode and 2.4 million Canadians meet the criteria for generalized anxiety disorder (Pearson et al., 2013). Furthermore, of those who met the criteria for generalized anxiety disorder, 54% also meet the criteria for depression. Within the literature, it is identified that anxiety and depression are common co-occurring conditions (Belzer & Schneier, 2004; Nguyen et al., 2005). Psychologists play a crucial role helping with the wide variety of mental health concerns. Many psychologists report acting in multiple professional capacities such as direct clinical care, leadership, and research (Gray et al., 2015). Studies show that the majority of individuals prefer psychologists over psychiatrists which could be attributed to patients' preference for psychotherapies over psychotropic medication treatments (Angermeyer et al., 2013; Qahar et al., 2020). Psychologists have many mental health skills that can help with a variety of populations including psychiatric patients, children, and athletes.

Athlete Mental Health

Athletes often use exercise as a means to cope with stress and anxieties which can help increase their overall well-being (BaniAsadi & Salehian, 2021). Previously, it was often assumed that athletes did not encounter mental health concerns because of their physical condition and increased activity which was thought to combat mental health issues; however, more recently there has been an increased amount of research and literature on athletes' mental health. Many mental health conditions have been linked to athletes including aggression, eating disorders, anxiety, depression, and other mood disorders (Rice et al., 2016). There are various methods of measuring psychological outcomes; however, some of the most commonly used tests are the Brief Symptom Inventory-18 (BSI-18) and the Patient-Reported Outcomes Measurement Information System 29 (PROMIS 29).

Elite and Professional Athletes

The importance of professional athletes' mental health is gaining increasing attention and research. A systematic review found that athletes are at a greater risk for mental health disorders than the general public which can be further increased in elite athletes who are experiencing difficulty, athletes who are injured, or are athletes that are close to or in retirement (Rice et al., 2016). Another review found that depression was the most common outcome of elite athletes following a sports related concussion (SRC; Rice et al., 2018). Professional athletes also have intense physical and mental demands placed upon them during their sports career which can increase their susceptibility to certain risk-taking behaviours and mental health problems (Hughes & Leavey, 2012). Some examples of the demands athletes experience include the psychological impacts of public and media scrutiny, competitive pressures to perform, overtraining, injury, and burnout (Nicholls & Polman, 2007). Professional athletes may avoid seeking mental health support for many reasons including the lack of understanding of mental health and its impact on performance (Bruner et al., 2008). Therefore, mental health education and support is needed in these populations especially in consideration to their increased likelihood of experiencing mental health concerns.

Mental Health and Cognitive Performance

Clinicians and mental health professionals need to be aware of the implications mental health issues can have on cognitive testing performances as they interpret test results. Studies show that different types of anxiety (i.e., social phobia, post-traumatic stress disorder, panic disorder, obsessive compulsive disorder, generalized anxiety disorder) are associated with negative effects on neuropsychological outcomes, most commonly with executive functioning, learning, memory, or attention (Castaneda et al., 2011; Castaneda et al., 2008; Fujii et al., 2013; Leonard & Abramovitch, 2019; Ludewig et al., 2003; McNally, 2006; Polak et al., 2012; Shin et al., 2014; Tempesta et al., 2013; Toren et al., 2000). One study assessed the relationship between anxiety, motor performance, and reaction time before and after sport competitions (Ciucurel, 2012). They conducted a correlational study on 70 male athletes and found that some anxious athletes had better reaction times but had reduced motor performance before competition. During the assessment after the competition, there was a relationship between anxiety and performance but not between reaction time and performance (Ciucurel, 2012). This shows that pre-game anxiety may increase reaction speed but hurt athletes' performance abilities.

It is important that sports professionals understand the impact mental health issues can have on cognitive performance not only during post injury cognitive testing, but also during baseline testing. The results obtained during baseline testing could be inaccurate if mental health effects are not taken into account when interpreting the results. Currently, limited research is available on the effect of athletes' mental health on baseline cognitive performance (Bailey et al., 2010). Bailey and colleagues (2010) evaluated the effect of anxiety on cognitive performance at baseline on college football athletes. They concluded that athletes with anxiety had worse reaction times and that anxiety at baseline may limit the athletes from performing to their full potential when assessing their cognitive abilities. Another study evaluated 37,945 adolescent student athletes to assess the impact of anxiety on emotional, physical, and cognitive symptom reporting at baseline (Champigny et al., 2020). They found that the students in the high anxiety group were more likely to be girls, had increased headaches, and had greater lifetime history of mental health issues. Although, the high anxiety group had lower cognitive test results, the differences were not practically meaningful but, they did endorse significantly more emotional, physical, and cognitive symptoms at baseline (Champigny et al., 2020). Current literature has focused on how specific conditions (i.e., anxiety or depression) influence cognitive performance; however, no studies to date have investigated mental health as well as other variables that could impact cognitive performance (i.e., history of concussion, history of psychiatric disorder, prior diagnosis of attention deficit hyperactivity disorder (ADHD) diagnosis, prior diagnosis of specific learning disability (SLD), sleep). Because of the limited research in this area, more information is needed to better understand the relationship between various mental health related issues and cognitive performance at baseline in professional athletes.

Current Study

Athletes are not immune to mental health issues and additional information regarding the influence of mental health issues is needed so mental health professionals know how to interpret results and how to help their players manage their mental health concerns when they arise (Rice et al., 2018). More specifically, it is important to assess the relationship between mental health and cognitive assessment results as previous studies have found there to be a significant impact (Bailey et al., 2010; Champigny et al., 2020; Tomczyk et al., 2020). The goal of this study is to better understand the relationship between mental health and cognitive test performance in professional athletes during baseline testing, so mental health professionals can interpret results accordingly. This will be accomplished by having the Canadian Football League (CFL) complete the Patient Reported Outcomes Measurement Information System (PROMIS 29), and Brief Symptom Inventory (BSI-18), and the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) to determine if mental health related issues are related to specific cognitive performances in professional athletes. Previous studies have found that collegiate football athletes sustain significantly more SRC compared to other sports (Kerr et al., 2018; Pierpoint & Collins, 2021); thus, they encounter an increased number of baseline and cognitive testing experiences. Additionally, this population is at a higher risk of mental health concerns such as depression, anxiety, ADHD, and impulsivity (Rice et al., 2018; Rice et al., 2016). Therefore, the CFL population was chosen for this study because of their heightened mental health risks as well as their increased cognitive testing pre- and post-concussion. This research can provide a unique understanding of the relationship between mental health and cognitive performance and provide additional information to the limited literature in this area. These findings can then be shared with mental health professionals so they can better support athletes and interpret their cognitive performance results with accuracy.

Chapter Two: Literature Review

Mental Health

Approximately 3.5 million Canadians meet the criteria for a mood disorder at some time in their life (Pearson et al., 2013). Statistics Canada reported major depressive episode to be the most common mood disorder with 3.2 million Canadians experiencing depression symptoms (Pearson et al., 2013). This is followed in prevalence by generalized anxiety disorder, which equates to 2.4 million Canadians experiencing anxiety symptoms during their lifetime (Pearson et al., 2013). Mental health issues can drastically influence an individual's daily functioning. Mental health disorders are significant predictors of social relationships, educational attainment, employment, productivity, and mortality (Breslau et al., 2008; Kessler et al., 1998; Ösby et al., 2001). An individual's age seems to play a significant role in mental health issues. For example, Statistics Canada reported depression to be the most prevalent mental health condition within the 15 to 24 age range (Pearson et al., 2013). Additionally, most mental health disorders occur by approximately age 24, demonstrating that this age range is the peak age of onset for many conditions (Gulliver et al., 2012; Kessler et al., 2005).

Psychologists can play a crucial role in helping young people with their psychosocial issues. There are many functions psychologists play in the community and in mental health settings that impact young people in diverse ways (Carr & Miller, 2017). For example, they hold positions such as supervisors, researchers, clinicians, team leaders, policy makers, evaluators, and administrators (Reddy et al., 2010). In these positions, their role is to intervene with the most vulnerable individuals and help them develop their ability to help themselves manage their conditions through behavioural, psychological, or medical techniques (Bonanno et al., 2019). Psychologists have important knowledge and perspectives to offer in their work as consultants, supervisors, trainers, administrators, and mental health advocates in the community (Ponce et al., 2019). Additionally, psychologists are able to educate their colleagues in different health care disciplines facilitating a collaborative approach to treatments. Psychologists collaborate with people in recovery, reduce mental health disparities, implement evidence-based practices, and enhance cultural competencies and as a result promote interprofessional education (Chu et al., 2012).

Qahar and colleagues (2020) investigated the opinions of a sample group of 15 participants made up of male and female adults who were all diagnosed with a psychiatric conditions over the age of 18 to understand their mental health attitudes. They found that approximately 70 percent of them preferred a psychologist over a psychiatrist. This preference for a psychologist could be due to the fact that psychologists are likely to talk to their clients about problems and use non-pharmacological treatments (Angermeyer et al., 2013). The study assessed some positive and negative factors related to mental health. They found that an unhappy childhood, lack of social support, and adjustment issues among spouses or parents influenced mental health issues while empathetic listening, physical health, social support, and marital adjustment have been shown to prevent mental health concerns (Qahar et al., 2020). With many Canadians statistically likely to meet the criteria for mental health conditions in their lifetime, psychologists provide a multidimensional background in mental health that can be an asset in promoting professional collaboration while treating patients from many populations including the general public, psychiatric patients, children, and athletes.

Mental Health in Athletes

While it is well known that there are positive effects of physical activity on mental health, current research suggests that intense physical activity can lead to mental health concerns including anxiety and depression (Hughes & Leavey, 2012). Professional athletes are often stereotyped or pressured to have enhanced mental and physical resilience which contributed to the belief that mental health issues in this population are rare (Bär & Markser, 2013). Current findings suggest that depression and anxiety within this population are similar to the general public (Reardon & Factor, 2010; Rice et al., 2016). The importance of professional athletes' mental health is gaining attention from mental health and sports professionals leading to an increase in research focus. A systematic review evaluated 27 studies to assess the impact of SRC on specified mental health outcomes in elite athletes (Rice et al., 2018). They found that depression was the most studied mental health outcome (70.4% of the studies), followed by anxiety, ADHD, and impulsivity. However, approximately 40% of the studies were deemed to have some risk of biases; thus, they concluded that causation could not be determined because of the lack of well-designed studies (Rice et al., 2018). Another review assessed 60 studies on the mental health of elite athletes (Rice et al., 2016). They concluded that athletes are especially vulnerable to mental health issues including substance abuse which may be due to sporting (i.e., burnout, injury, over training) and non-sporting factors. Athletes are at a greater risk of mental health concerns which can be heightened in elite athletes who are experiencing sport difficulty, who are injured, or are close to or in retirement. Elite athletes often face additional pressures that psychologically impacts them. These additional pressures can include public and media scrutiny, competitive pressures to perform, overtraining, injury, and burnout (Rice et al., 2016). Some research suggests that this population is at risk of a variety of metal health problems including eating disorders and suicide (Sundgot-Borgen & Torstveit, 2004).

As studies have established (Rice et al., 2018; Rice et al., 2016) athletes, especially those that perform at elite levels have an increased risk for mental health conditions. In addition to this heightened risk, because of the nature of many sports, mental health issues could be significantly impacted by an increased risk of concussion or number of concussions. Repeat concussions have been shown to be associated with increased level of anxiety, depression, distress, sleep disturbances, or substance abuse/dependence as well as neurogenerative disease later in life (Gouttebarge et al., 2017; McKee et al., 2016; Stewart et al., 2016). Similarly, Kerr and colleagues (2014) found an association between previous concussion in former collegiate athletes and a greater risk of higher impulsivity, aggression, and severe depression (Kerr et al., 2014). A systematic review on 13 studies evaluated the association between previous concussions and depression in former athletes (Hutchison et al., 2018). They found there was a consistent positive relationship between depression and number of concussions; however, they noted that there were several limitations such as selection bias, issues in measurement tools, research design, and operational definitions. Gouttebarge and colleagues (2017) explored the relationship between SRC and the occurrence of mental health disorders among prior professional athletes in soccer, ice hockey, and rugby. They found that athletes who had indicated having four or five concussions were 1.5 times more likely to have symptoms related to common mental health disorders. Further, those athletes who experienced six or more concussions were two to five times more likely to have common mental health disorder symptoms (Gouttebarge et al., 2017). Professional athletes have intense physical and mental demands placed on them during their sporting career which can increase their susceptibility to certain risk-taking behaviours and mental health problems (Hughes & Leavey, 2012). These pressures may exacerbate existing issues, cause past concerns to resurface, or increase psychological difficulties, which can increase the likelihood of an anxiety disorder in this population (Neal et al., 2015). When taking athletes' mental health conditions into consideration, it is imperative to not only consider the elevated risk for athletes to develop a condition but to also factor the number of concussions and the increased severity that concussions have on mental health.

Sports Related Concussion

The Center of Disease Control and Prevention predicted that there are approximately 1.6 to 3.8 SRC every year in the United States (Langlois et al., 2006). With concussion numbers largely underreported and concussions often untreated, it's likely that this number is much higher than predicted. During the 2016 international conference on Concussion in Sport Group (CISG) an expert panel collaborated and agreed that a "SRC is a traumatic brain injury induced by biomechanical forces" (McCrory et al., 2017, p.2). SRC are considered to be the most multifaceted injuries in sport to assess, diagnose, and manage (McCrory et al., 2017). Diagnosis of acute SRC involves assessing an athlete's symptoms, cognitive impairment, sleep/wake/disturbances, physical signs, neurobehavioral features, and concussion history immediately after the incident. Athletes can experience a variety of symptoms following a SRC. Having a past SRC increases the risk of future SRC and having multiple SRCs is associated with more physical, cognitive, and emotional symptoms (McCrory et al., 2017). This places athletes at a greater risk for future mental health concerns.

Mental Health and Cognitive Performance

There have been several studies on the effect of mental health on neuropsychological performance. Different types of anxiety disorders (i.e., social phobia, post-traumatic stress disorder, panic disorder, obsessive compulsive disorder, generalized anxiety disorder) are associated with negative effects on neuropsychological outcomes, most commonly related to executive functioning, including learning, memory, or attention (Castaneda et al., 2011; Castaneda et al., 2008; Fujii et al., 2013; Leonard & Abramovitch, 2019; Ludewig et al., 2003; McNally, 2006; Polak et al., 2012; Shin et al., 2014; Tempesta et al., 2013; Toren et al., 2000). A review of 30 papers on neuropsychological performance of adult patients and the effect of social anxiety disorder (SAD) found that SAD participants had worse scores compared to the health controls on visuoconstructional and visual scanning abilities (O'Toole & Pedersen, 2011). Not only is it important to assess anxiety, but depression can also impact neurocognitive tests performance in adults with concussion (Terry et al., 2019). Terry and colleagues (2019) investigated the impact of depression on cognitive performance of adults with a concussion in a clinical setting. Researchers found that depression symptom severity was correlated with lower fluid cognitive scores. Another study examined the effect of a mild traumatic brain injury (mTBI) on mental health in an adult population (Chaytor et al., 2007). They found that depression was weakly related to neuropsychological test performance, but was more correlated to everyday functioning. Rapoport and colleagues (2005) assessed the effect of major depressive disorder (MDD) on participants who had a TBI. Participants with MDD had significantly lower scores in executive function, working memory, verbal memory and processing speed when compared to participants without MDD. On average, individuals experiencing depression perform poorer on many neuropsychological tests (Barker-Collo et al., 2015; Levin et al., 2001; Rapoport et al., 2005; Terry et al., 2019); however, some studies found no difference between depressed and non-depressed groups (Rohling et al., 2002; Stenberg et al., 2020; Veiel, 1997). Stenberg and colleagues (2020) did not find any associations between anxiety and depressive symptoms on the BSI-18 and cognitive test performance. Similarly, the study conducted by Rohling and colleagues (2002) found no differences in neuropsychological performance associated with depression in patients putting forth a valid effort. Similarly, another study found no differences between the depressed and non-depressed group on measures of concentration and attention, but found varying memory differences among the two groups (Veiel, 1997).

Mental Health and Cognitive Performance in Athletes with SRC

Other studies have focused on the cognitive effects of athletes post injury. A systematic review of 21 studies of 790 athletes compared athletes with mild head injuries to 2014 control participants (Belanger & Vanderploeg, 2005). They found there to be large effects in the domains of memory acquisition and delayed memory after 24 hours and a moderate effect overall for declined neuropsychological performance after a SRC. A concussion can affect many cognitive domains including reaction time (Erlanger et al., 2003; Erlanger et al., 2001;

Macciocchi et al., 1996; Voller et al., 1999), visualspatial memory (Lovell et al., 2003), verbal learning and memory (Bruce & Echemendia, 2003; Echemendia et al., 2001; Field et al., 2003; Lovell et al., 2003), attention/concertation (Bohnen et al., 1992; Echemendia et al., 2001), speed of information (Barth et al., 1989), working memory (Echemendia et al., 2001; Lovell et al., 2003) and executive functions (Bruce & Echemendia, 2003; Guskiewicz et al., 2001; Macciocchi et al., 1996). Willer and colleagues (2018) compared former NFL and NHL athletes to age matched non-contact athletes to assess their executive functioning and mental health. They found no significant difference among the neuropsychological profiles of former athletes and non-athletes. However, the contact sport athletes had significantly higher raw depression and anxiety scores than non-contact sport athletes, but only anxiety showed a significant difference (Willer et al., 2018). From these results, one can conclude that contact professional sport does not seem to lead to more dysfunction later in life as many studies suggest (Willer et al., 2018). Another study investigated premorbid depression influences on neurological functioning and post-concussion symptoms (Cicerone & Kalmar, 1997). This study found no differences between the group with a history of depression and the control group on neurocognitive measures, MMPI scales, or post-concussive symptoms. It is significant to note that this study was conducted 25 years ago, so updated research is needed. These studies highlight the significance of mental health within the professional athlete population; however, it is difficult to pinpoint specifically where these mental health and cognitive aspects have influenced the athletes' lives. Overall, professional athletes' cognitive performance can be significantly altered following a concussion (Bruce & Echemendia, 2003; Echemendia et al., 2001; Erlanger et al., 2001; Field et al., 2003; Lovell et al., 2003; Rice et al., 2016); therefore, it is important to understand the relationship between other variables such as history of psychiatric disorder, ADHD, SLD, and sleep as well as cognitive performance before introducing complex concussions into the formula.

Mental Health and Cognitive Performance at Baseline

Most studies have focused on post-concussion somatic issues, anxiety, depression, irritability, and frustration (Brewer, 2001; Leddy et al., 1994; Mainwaring et al., 2004; Smith et al., 1990), but athletes can also experience psychological distress before an injury for various reasons. Some of these include leaving home for college or the challenges that often arise for athletes during the first year of college sports because of an elevated level of play. Since anxiety, depression, and other mental health concerns can influence cognitive performances (Belanger & Vanderploeg, 2005), it is possible that these mental health issues can also impact their abilities prior to injury (Bailey et al., 2010). The evaluation of psychological distress is clearly important after a concussion, but it is important to understand the cognitive impact on athletes at baseline as well. There is limited literature on the impact of psychological implications on baseline neurocognitive assessment results (Bailey et al., 2010). Cicerone and Kalmar (1997) evaluated the impact of depression at baseline on neurocognitive results. They found no significant differences found between the depressed group and the controls; although, this could be due to the small sample size (n = 20). Bailey and colleagues (2010) examined 47 collegiate football athletes ages 17 to 19 years old. They investigated the relationship between psychological distress and neurocognitive performance during baseline concussion testing. Participants with suicidal ideation showed significantly slower reaction time (both simple and complex reaction time), with similar processing speed (Bailey et al., 2010). Bailey and colleagues (2010) also found a substantial portion of athletes (32-55%) have some psychological distress at baseline on the PAI (i.e., anxiety, depression, substance use, suicidal ideation). Anxiety displayed at baseline may limit the athlete's ability to perform to their full potential, which could affect results when assessing their cognitive abilities.

Williams and Anderson (1997) examined the peripheral and central vision and reaction time at baseline and then during a demanding and stressful task. They found there was an increase in anxiety between baseline and during the demanding task (Williams & Andersen, 1997). This increase seems to slow down athletes' reaction times during the task. Champigny and colleagues (2020) evaluated 37,945 adolescent student athletes who were divided into a low anxiety or high anxiety group. Students in the high anxiety group were more likely to be girls and have higher lifetime history of mental health concerns and headaches. The high anxiety group had lower cognitive test results, but the differences were not practically meaningful; however, the assessments did endorse that there were an increased amount of emotional, physical, and cognitive symptoms at baseline for those in the high anxiety group (Champigny et al., 2020). Another study found that college athletes with anxiety had slower simple and complex reaction times, both before and after a competition (Tomczyk et al., 2020). Thus, college athletes who have anxiety may display decreased performance on neurocognitive assessments. Studies show that examining anxiety and how it affects baseline concussion assessment is novel, but preliminary studies have shown the need for more investigation on this topic (Tomczyk et al., 2020). Anxiety has been shown to effect elements of cognition that are key to baseline assessments (Bailey et al., 2010; Ciucurel, 2012; Williams & Andersen, 1997). Another study evaluated college athletes before and after competition and found that pre-competition anxiety led to slower reaction times; however, high pre-competition anxiety led to faster reaction times (Ciucurel, 2012). Clinicians should be aware of the implications anxiety and other mental health concerns have on baseline testing performance (Tomczyk et al., 2020). There is a large need to target players' mental health prior to adding in the complex obscured concussion deficits post injury to better understand how to support these players and how to interpret their cognitive test results in an accurate more holistic way while investigating other variables (i.e., history of concussion, history of psychiatric disorder, ADHD diagnosis, SLD diagnosis, sleep) that could influence cognitive performance.

Current Study

The current study seeks to evaluate the relationships between athletes' mental health and their cognitive performance during baseline concussion testing. To do this, athletes from the Canadian Football League (CFL) completed the Patient-Reported Outcomes Measurement Information System (PROMIS 29), the Brief Symptom Inventory (BSI-18), and the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) to determine the relationship between how mental health is related to cognitive performance. The current study contributes to the literature by further exploring how mental health can impact neuropsychological tests at baseline, so mental health professionals can better understand the relationship between these variables to interpret results with accuracy.

Objective 1

The first objective is to determine the relationship between the five ImPACT index scores (i.e., visual memory, verbal memory, visual motor speed, impulse control, reaction time) and each of the mental health index measures (PROMIS 29 depression index score, PROMIS 29 anxiety index score, BSI-18 anxiety index score, BSI-18 depression index score, and BSI-18 somatization index score). Next, additional variables (i.e., history of concussion, history of psychiatric disorder, diagnosed ADHD, diagnosed SDL, sleep) will be investigated to further understand their relation to the predictor and outcome variables.

Alternative hypothesis. There is a statistically significant correlation between one or more of the ImPACT index scores and the mental health index scores.

Null hypothesis. There is no statistically significant correlation between one or more of the ImPACT index scores and the mental health index scores.

Objective 2

The first objective is to determine if mental health severity (i.e., average, mild, moderate, severe for BSI-18 or average, high average for PROMIS 29) influences cognitive scores on the ImPACT (i.e., visual memory, verbal memory, visual motor speed, impulse control, reaction time).

Alternative hypothesis. At a group level, athletes who report more anxiety, depression, and somatization will have significantly different cognitive results compared to the lower anxiety, depression, and somatization groups.

Null hypothesis. None of the four ImPACT index scores were affected by mental health severity.

Objective 3

The third objective is to further understand the influence of other variables that can influence cognitive performance. The other variables previous research has found to influence cognitive scores are history of concussion, history of psychiatric disorder, diagnosed ADHD, diagnosed SLD, and sleep. Therefore, these variables will be added and investigated further to assess their relationship with cognitive performance in athletes at baseline testing.

Alternative hypothesis. One or more of the variables will display a significant difference on cognitive performance. It is hypothesized that a history of concussions, ADHD and SLD will show a statistically significant difference on one or more of the cognitive tests.

Null hypothesis. None of the other variables show a significant difference on cognitive performance.

Chapter Three: Method

This chapter provides a summary of the overall research methods that were used in this study which include the participants, research design and key terms, measures, data collection procedures, ethics, and statistical analyses.

Participants

A total of 961 CFL Athletes underwent cognitive testing and were approached to participate in the study. Over two consecutive seasons, 46 players were diagnosed and underwent post-injury evaluations; however, for this study just the baseline data will be analyzed. Ten players were eliminated from this study due to missing data on the, BSI-18, PROMIS 29, or ImPACT. The final sample included 951 CFL players. The players ethnicities included Asian (0.5%), native Hawaiian (0.1%), African American (1.6%), White (18.8%), other (0.6%), and the rest was unavailable (72.3%). The sample included 2.1% of players with a diagnosed psychiatric disorder, 9.0% with diagnosed ADHD, 3.6% with SLD. The information was collected throughout the 2017 and 2018 football seasons through the Active Rehab Study.

Research Design and Data Collection

The study used a prospective, quasi-experimental design since the participants were selected naturally with no random selection taking place. One issue with quasi-experimental designs is that it can pose a threat to internal validity since it cannot be concluded that the athletes are equivalent to one another (i.e., age, years of education, psychological functioning, pre-injury mood disorders, etc.; Creswell & Creswell, 2017). In line with CFL regulations, all athletes were required to complete baseline testing prior to starting their season. The athletes were all male and ranged from 21 to 37 years old (M= 25.35, SD = 2.79). All tests were administered electronically on iPads by trained graduate students or athletic professionals.

Inclusion and Exclusion Criteria

The data was collected as part of the Active Rehabilitation project in the 2017 to 2018 football seasons. The inclusion criteria for the study were as follows:

a) Consent/ agreement of the CFL to participate in the study (see Appendix B).

b) The completion of the BSI-18, PROMIS 29, and ImPACT.

Athletes were excluded if:

a) They were not medically cleared from previous concussion diagnosis.

This exclusion criteria were selected to minimizes the influence of variables on the PROMIS 29, BSI-18, and ImPACT. Players with a history of mental health disorders were included if they were medically cleared by a physician.

Key Terms

For the purposes of this study, the term “concussion” or “sport related concussion (SRC)” will be defined in accordance with the most recent CISG (2017) consensus as a “traumatic brain injury induced by biomedical forces” (McCrory et al., 2017, p.2). While the term “mental health” will refer to the athletes psychological functioning and overall mental health functioning during the study.

Measures

BSI-18

The BSI-18 is a measure of general psychological distress in the areas of anxiety, depression, and somatization (see Appendix A). Each domain has six items that correspond to the overall composite score. Adding these items together creates the BSI-18 total or Global

Severity Index (GSI). The BSI-18 is comprised of 18 items that are on a five-point Likert scale and total scores range from 0 to 72. This is an abbreviated version of the 90-item symptoms checklist (SCL-90; Meachen et al., 2008). The BSI-18 has been considered a psychometrically appropriate test for high school athletes, collegiate athletes, and the brain injury population (Lancaster et al., 2016; Meachen et al., 2008). Specifically, Meachen et al. (2008) investigated 257 participants (81 moderate to severe TBI patients and 176 control participants). The researchers found the internal consistency of the GSI to be high in both the patient (α =.84) and participant groups (α =.91) and was associated with other measures of psychological adjustment. Overall, this study showed very high validity and reliability of the BSI-18 in the TBI and control populations (Meachen et al., 2008). Another study investigated 2,031 high school and collegiate athletes who completed the BSI-18 as well as other cognitive measures (Lancaster et al., 2016). Researchers then assessed the psychometric properties of these tests. Overall, they found that the BSI-18 showed good internal consistency, moderate test-retest reliability, and good convergent validity to other emotional functioning measures such as the Multidimensional Personality Questionnaire Negative Emotionality (r = .43) and the Sport Concussion Assessment Tool (SCAT-3; r = .58). The researchers found that the criterion validity was high (.74 to .81) and the GSI internal consistency (.83) was high compared to other subscales (Lancaster et al., 2016). This suggests that the BSI-18 is an appropriate tool to measure psychological functioning in athletic populations.

PROMIS 29

The PROMIS was a research initiative developed by the National Institutes of Health (NIH) designed to develop, standardize, and validate item banks of patient reported outcomes of common medical conditions (Cella et al., 2007). The domain mapping is constructed using the

World Health Organization (WHO) structure of mental, physical, and social health. Researchers were able to develop specific domains using the item banks that best represent a variety of conditions (Gershon et al., 2010). The domains include pain, fatigue, emotional distress, physical functioning, social role participation, and global health (Cella et al., 2007). The PROMIS has been useful in the athlete population as well. Meehan and colleagues (2016) investigated the psychological outcomes of collision sports in 3702 retired athletes. They found that individuals with a history of concussion had worse self-reported mental health measures. Then, when number of concussions were removed, consequences of alcohol use remained high among the athletes in contact sports (Meehan III et al., 2016). Therefore, it is important to further investigate the history of concussion and, if possible, alcohol use, when evaluating athletes' mental health.

The PROMIS 29 is a version of the measure that evaluates sleep disturbance, anxiety, depression, fatigue, physical function, pain, and ability to participate in social roles or activities. Higher scores on the sleep disturbance, anxiety, and depression indexes indicates negative results. In comparison, higher ability to participate in social roles and physical function indicates more positive results. The subscales included items that were ranked on a five-point Likert scale (i.e., 1 is Never, 2 is Rarely, 3 is Sometimes, 4 is Often, and 5 is Always) and the total score ranges from 0 to 20. The PROMIS 29 has displayed valid results with diverse populations, has shown good reliability with minimal items, and has demonstrated to be good in both clinical and research settings (Cella et al., 2007). For instance, the NIH has used the PROMIS 29 to compare between different conditions with various mental, physical, and social symptoms (Cella et al., 2010). Therefore, the PROMIS 29 was chosen for this study to better assess athletes' mental health symptoms.

ImPACT

Computerized neuropsychological assessments have become increasingly popular in the last few decades. The ImPACT is the most widely used tool to assess concussions (Alsalaheen et al., 2016). It was primarily developed for use with the athletic population, as it is often used to assess for cognitive changes and evaluates recovery over the following days or weeks (Alsalaheen et al., 2016; Gaudet & Weyandt, 2017). The ImPACT produces four composite scores including visual-motor speed, reaction time, verbal memory, and visual memory (Maroon et al., 2002). A quantitative review evaluated the validity of the ImPACT on 69 different studies (Alsalaheen et al., 2016). They found that the convergent validity was supported; however, the results from diagnostic accuracy, responsiveness, and predictive validity were inconclusive. Iverson and colleagues (2005) administered the ImPACT to 72 amateur athletes to evaluate the validity of its processing speed ability following a SRC. They compared the processing speed composite score to another similar processing speed test titled 'Symbol Digit Modalities Test' (SDMT). The researchers found that the processing speed and reaction time composite scores were measuring a similar construct as the SDMT (Iverson et al., 2005). This suggests the ImPACT is a valid measurement of processing speed and reaction time in amateur athletes. A systematic review evaluated 17 studies on the prevalence and assessment of invalid performance on the ImPACT (Gaudet & Weyandt, 2017). They concluded that many elements could decrease the validity of ImPACT scores such as administering to large groups verses individual administration, the use of the ImPACT in nonclinical settings, and the use of ImPACT with those with ADHD or SLD. Another study found that sleep prior to testing, testing environments, and instructions can influence the validity of the ImPACT (Alsalaheen et al., 2016). Therefore, for this study covariates of history of concussion, history of psychiatric disorder, diagnosed ADHD, diagnosed SLD, and sleep will be added to further understand how they relate to the mental health and cognitive performance.

Ethics

This study was part of a larger research project from the Active Rehabilitation Project that was conducted by Dr. Mrazik and Dr. Naidu. More information regarding the format of this study can be found in the article titled "Methodology and Implementation of a Randomized Controlled Trial (RCT) for Early Post-concussion Rehabilitation: The Active Rehab Study" by Register-Mihalik and colleagues (2019). This project was granted ethics approval prior to this study by the Research Ethics Board at the University of Alberta (Pro00073481). To be included in this study, the athletes were asked to sign a consent form which outlined the purpose of the study, committee requirements, and the risks and benefits of the study. In line with CFL regulations, all athletes completed baseline testing (which included the ImPACT and other neuropsychological tests) prior to beginning their CFL season.

Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS), Version 28. A correlation analysis was first conducted to understand the relationship between mental health and cognitive index scores. More specifically, the relationship between the PROMIS 29 anxiety, PROMIS 29 depression, BSI-18 anxiety, BSI- depression, BSI-somatization, BSI-GSI with the ImPACT scores (i.e., visual memory, verbal memory, visual-motor speed, impulse control, reaction time) was evaluated as well as other aspects that have been related to cognitive performance (i.e., history of concussion, history of psychiatric disorder, diagnosed ADHD, diagnosed SLD, sleep). A MANOVA was chosen due to the previous research in this area. Variables such as the BSI-18 anxiety, depression, somatization, and GSI was categorized into groups of average, mild, moderate, and severe symptoms while the PROMIS 29 was categorized into average and high average categories. Then groups were compared on their cognitive scores on the ImPACT (i.e., verbal memory, visual memory, visual motor speed, reaction time, impulse control). Additionally, history of concussion, history of psychiatric disorder, prior diagnosis of ADHD, prior diagnosis of SLD, and sleep were analyzed in the MANOVA to better understand their role in cognitive test performance. Overall, a MANOVA was deemed appropriate to assess the variance of the cognitive variables by the mental health covariates and additional covariates. If results were significant, then a follow up ANOVA was conducted to better understand these relationships.

Chapter Four: Results

The purpose of this study was to further understand the relationship between the BSI-18 and PROMIS 29 measures within the context of the five ImPACT measures. Next, this study sought to better understand additional variables or covariates (i.e., history of concussion, history of psychiatric disorder, prior diagnosis of ADHD, prior diagnosis of a SLD, sleep) that could influence cognitive performance. This chapter involves the assumptions of the MANOVA and the results that were found.

Pearson Correlation

Initially, a Pearson Correlation was conducted to further understand the relationships between the predictor and outcome variables. There were significant correlations between PROMIS anxiety and ImPACT visual motor speed and BSI-18 anxiety and ImPACT visual motor speed (See Table 1). There were also significant positive correlations between BSI-18 depression and ImPACT visual motor speed and BSI-18 depression and reaction time. Next, there was a significant positive correlation between BSI-18 somatization and ImPACT visual memory. Then there were significant relationships between BSI-18 total with ImPACT visual memory, verbal memory, and visual motor speed. Lastly, the other variables (i.e., history of concussion, history of psychiatric disorder, prior diagnosis of ADHD, prior diagnosis of a SLD, sleep) that previous research has shown to influence cognitive performance were added to assess their relation to the predictor and outcome variables. Results showed that history of concussion, history of psychiatric disorder, diagnosed ADHD, diagnosed SLD, and sleep were all related to cognitive performance results (see Table 1). This shows that these additional variables are important to investigate further to better understand their relationship with cognitive testing performance.

MANOVA

Two MANOVAs were computed, the first to examine the BSI-18 mental health scores on cognitive performance, and the second to examine the PROMIS 29 mental health scores on cognitive performance. For all general linear models, the dependent variables were continuous, and the independent variables consisted of four categorical (two for PROMIS 29 data), independent groups. The BSI-18 scores were separated using the BSI-18 norm chat developed from male collegiate athletes that separated anxiety, depression, somatization, and GSI scores into average, mild, moderate, and severe symptoms (Lancaster et al., 2016). The PROMIS 29 raw scores were converted to t-scores then categorized into average and high average groups based on t-score ranges. The first MANOVA was on BSI-18 index scores. The Box's M Test value of 182.95 was not significant (p = .12) indicating covariance was equal across groups. An alpha value of 0.05 was used to determine significance. Next, homogeneity of variance was assessed by Levene's Test of Homogeneity of Variance. The results showed that homogeneity of variance was violated within some of the ImPACT groups (i.e., verbal composite, p < .001;

visual composite, $p < .05$; visual motor speed, $p < 0.05$; reaction time composite, $p < .001$). Due to the violation of homogeneity of variance between groups, Pillai's Trace was interpreted. Results indicated no significant difference between the BSI-18 subtests or total score. More specifically, the BSI-18 anxiety ($V = .03$, $F(20, 3540) = 1.29$, $p = .15$, $\eta^2 = .01$, $\alpha = .05$), depression ($V = .03$, $F(20, 3540) = 1.28$, $p = .18$, $\eta^2 = .01$, $\alpha = .05$), and somatization ($V = .02$, $F(20, 3540) = .77$, $p = .75$, $\eta^2 = .004$, $\alpha = .05$) groups displayed no significant difference on the ImPACT domains. Additionally, the BSI-18 GSI groups were not significantly different among the ImPACT cognitive domains, $V = .01$, $F(15, 2652) = .83$, $p = .64$, $\eta^2 = .01$, $\alpha = .05$.

Then covariates were analyzed to assess if they account for any of the variance. Results showed significant differences among groups who experienced a concussion ($V = .05$, $F(15, 882) = 9.06$, $p < .001$, $\eta^2 = .05$, $\alpha = .05$), were diagnosed with ADHD ($V = .02$, $F(5, 882) = 3.63$, $p < .05$, $\eta^2 = .02$, $\alpha = .05$), were diagnosed with a SLD ($V = .02$, $F(5, 882) = 3.29$, $p < .05$, $\eta^2 = .02$, $\alpha = .05$), or those experiencing sleeping problems ($V = .01$, $F(5, 882) = 2.49$, $p < .05$, $\eta^2 = .01$, $\alpha = .05$) while previously diagnosed psychiatric disorder did not show significant differences among groups ($V = .01$, $F(5, 882X) = 1.08$, $p = .37$, $\eta^2 = .01$, $\alpha = .05$). Then to understand where these differences lie, the between subjects' effects were further investigated. Results showed previous concussions affected verbal memory, $F(1, 886) = 18.76$, $p < .001$, visual memory, $F(1, 886) = 18.76$, $p < .001$, visual motor speed, $F(1, 886) = 15.68$, $p < .001$, and reaction time $F(1, 886) = 11.70$, $p < .001$. The presence of diagnosed ADHD affected verbal memory, $F(1, 886) = 7.37$, $p < .05$, visual memory, $F(1, 886) =12.98$, $p < .05$, and impulse control $F(1, 886) = 4.06$, $p < .05$. The presence of diagnosed SLD showed to affect verbal memory $F(1, 886) = 4.30$, $p < .05$, visual motor speed $F(1, 886) = 6.86$, $p < .05$, reaction time $F(1, 886) = 5.41$, $p < .05$, and impulse control $F(1, 886) = 6.97$, $p < .05$. Then sleep tended to affect athletes reaction time $F(1, 886) = 5.06$, $p < .05$ and impulse control $F(1, 886) = 3.86$, $p < .05$.

Following, a MANOVA was conducted on the PROMIS 29 anxiety and depression subtest severity levels to assess if there was a difference among cognitive ImPACT performance results. The Box's M test of equality of covariance matrices was used to test the homogeneity of variance across groups. Results of this test were not significant ($p = .18$) for all the general linear models indicating no MANOVA violations. Similarly, the Levene's Test of Homogeneity of Variance was not violated ($p > .38$); therefore, the results can be interpreted with confidence. Since there are no violations, the Wilks' Lambda was interpreted. Overall, results indicated PROMIS 29 mental health measures were not significantly different among ImPACT scores. More specifically, depression ($V = .99$, $F(5, 934) = 1.08$, $p = .37$, $\eta^2 = .001$, $\alpha = .05$) and anxiety ($V = 1.00$, $F(10, 1868) = .49$, $p = .90$, $\eta^2 = .003$, $\alpha = .05$) were not correlated with ImPACT cognitive scores.

When investigating the covariates further, there was a significant difference among athletes with a history of concussion, those diagnosed with ADHD, and those diagnosed with a SLD. More specifically, the presence of a previous concussion affected athletes verbal memory $F(1, 938) = 19.53$, $p < .001$, visual memory $F(1, 938) = 15.73$, $p < .001$, visual motor speed $F(1, 938) = 33.17$, $p < .001$ and reaction time $F(1, 938) = 15.64$, $p < .001$. Additionally, the presence of diagnosed ADHD affected athletes verbal memory $F(1, 938) = 7.39$, $p < .001$), visual memory $F(1, 938) = 12.86$, $p < .001$, visual motor speed $F(1, 938) = 4.53$, $p < .05$), and reaction time $F(1, 938) = 4.07$, $p < .03$. Next, the presence of a diagnosed SLD affected athletes verbal memory $F(1, 938) = 7.20$, $p < .05$, visual memory $F(1, 938) = 3.84$, $p < .05$, visual motor speed $F(1, 938) = 8.78$, $p < .05$, reaction time $F(1, 938) = 4.50$, $p < .05$, and impulse control $F(1, 938) = 7.92$, $p <$

.05. Lastly, sleep was not significantly correlated to cognitive scores (p = .33) when added as one of the covariates.

Due to these significant effects, follow-up ANOVAs were computed. First, a one-way ANOVA was conducted on history of concussions and ImPACT cognitive scores. The Levene's test of homogeneity was violated for verbal memory and visual motor speed. The ANOVAs were computed using a 0.05 alpha value. Results showed that there was a significant difference in verbal memory, visual memory, visual motor speed, and reaction time when comparing athletes who have had a history of concussion and athletes who have not had a concussion (see Table 2). Next, a one-way ANOVA was conducted on history of psychiatric disorder and ImPACT cognitive scores. Levene's test of homogeneity was not violated (p > .08). Results showed there was a significant difference among athletes with a history of psychiatric disorder and those with no history of psychiatric disorder in visual motor speed and reaction time (see Table 3). Following a one-way ANOVA was conducted on athletes with and without a diagnosis of ADHD. Homogeneity of variance was violated for both reaction time and impulse control (p < .005). The results showed significant differences among athletes with and without ADHD on verbal memory, visual memory, visual motor speed, reaction time, and impulse control (see Table 4). Then a one-way ANOVA was conducted on athletes diagnosed with a SLD. The Levene's homogeneity of variance was violated for verbal memory, visual motor speed, and impulse control (p < .03). Results indicated significant differences among those diagnosed with a SLD and those not diagnosed with a SLD in verbal memory, visual memory, visual motor speed, reaction time, and impulse control (see Table 5). Overall, history of concussion, history of psychiatric disorder, diagnosed ADHD, and diagnosed SLD all significantly influenced cognitive performance in professional athletes.

To retrospectively better understand the elements that influence the athletes with severe mental health concerns, only the average and severe BSI groups were compared. This comparison better isolates the severe mental health group to better understand the elements that influence this group specifically without allowing the vast majority of the players in the middle ranges to influence results. A MANOVA was conducted on the BSI index scores to investigate if there were significant differences between average BSI index scores and severe BSI index scores among the athletes. Additionally, covariates of history of concussion, history of psychiatric disorder, diagnosed ADHD, diagnosed SLD, and sleep were added to the model. The Box's M test of equality of covariance was not significant ($p = .11$). Additionally, Levene's test of homogeneity of variance was not significant ($p > .23$). This demonstrates equal variance across groups; therefore, the Wilks' Lambda was interpreted. Results indicated there were significant differences among the BSI total average and severe group on most of the covariates added. Specifically, history of concussion ($V = .95$, $F(5, 878) = 10.19$, $p < .001$, $\eta^2 = .06$), history of psychiatric diagnosis ($V = .99$, $F(5, 878) = 2.69$, $p < .05$, $\eta^2 = .02$), diagnosed ADHD ($V = .98$, $F(5, 878) = 3.78$, $p < .05$, $\eta^2 = .02$), and diagnosed SLD ($V = .98$, $F(5, 878) = 3.21$, $p < .05$, $\eta^2 = .02$) were significant with cognitive scores while sleep was not ($V= .99$, $F(5,878) = 1.64$, $p = .15$, $\eta^2 = .009$).

These significant differences between the groups were then investigated further to assess which ImPACT scores are affected by these covariates. There were significant differences between average BSI total scores and severe total scores on ImPACT scores with those who have a history of concussion. More specifically, verbal memory $F(1, 883) = 22.63$, $p < .001$, visual memory $F(1, 883) = 20.29$, $p < .001$, visual motor speed $F(1, 883) = 36.51$, $p < .001$, and reaction time $F(1, 883) = 13.26$, $p < .001$ were all influenced by history of concussion. Notably, history of psychiatric diagnosis influenced athletes reaction time $F(1, 883) = 9.92$, $p < .001$. It was observed that prior diagnosis of ADHD influenced the athletes verbal memory $F(1, 883) = 6.98$, $p < .05$, visual memory $F(1, 883) = 14.92$, $p < .001$, and impulse control $F(1, 883) = 3.71$, $p < .05$, while a prior SLD diagnosis influenced their visual motor speed $F(1, 883) = 7.23$, $p < .05$, reaction time $F(1, 883) = 6.44$, $p < .05$, and impulse control $F(1, 883) = 7.01$, $p < .05$. Overall, this demonstrates that there are significant differences among the average and severe BSI on their ImPACT results especially when history of concussions, history of psychiatric disorder, prior ADHD diagnoses, or prior SLD diagnoses are included in the model.

Objective 1

The first objective was to investigate if the predictor variables were significant and correlated with the outcome variables. Pearson correlations were calculated on the PROMIS 29 anxiety, PROMIS 29 depression, BSI-18 anxiety, BSI-18 depression, BSI-somatization, BSI-total score, and the five outcome variables. The history of concussion, history of psychiatric disorder, history of ADHD, history of SDL, and sleep were added since they could possibly influence cognitive performance. The results of the correlation determined that all five of the additional variables added were significantly correlated with most of the outcome variables (See Table 1). In accordance with these results, they were added in the MANOVA as covariates to better understand where this significance occurs.

Objective 2

The second objective was to determine if mental health severity influences cognitive performance. Results on the first MANOVA revealed no significant different between the BSI-18 index scores or GSI on the ImPACT cognitive scores. This means that there is no significant difference among athletes of different mental health severity levels on the BSI-18 and their cognitive results. Next, a MANOVA was conducted on the PROMIS 29 index scores and the ImPACT cognitive scores. These results showed no significant difference among different severity levels of the PROMIS anxiety or depression index scores on their cognitive performance results. Therefore, neither the BSI-18 or the PROMIS 29 mental health severity groups seem to display a significant difference on the ImPACT index scores. The null hypothesis was accepted since there were no significant differences among either of the BSI-18 or PROMIS 29 severity groups on cognitive performance.

Objective 3

The third objective was to understand the additional variables and their role in cognitive performance. The variables that were added were: history of concussion, history of psychiatric disorder, diagnosed ADHD, diagnosed SLD, and sleep. MANOVA results showed that history of concussion groups (concussion or no concussion) showed significantly different results in verbal memory, visual memory, visual motor speed, and reaction time. Then the history of psychiatric disorder (presence of psychiatric disorder or not) showed significantly different results in visual motor speed and reaction time. Notably, ADHD and SLD influenced all the cognitive domains while sleep did not influence any cognitive domains. Overall, history of concussion, history of psychiatric disorder, diagnosed ADHD, and diagnosed SLD all significant influence cognitive performance in athletes. Additionally, after further investigation these specific covariates also showed significant differences among the average and severe BSI index scores when they were introduced. Therefore, at all levels of mental health severity (average, mild, moderate, severe) results indicated that history of concussions, history of psychiatric disorder, prior ADHD diagnosis, and prior SLD diagnosis significantly influence cognitive performance.

Of note, when retrospectively comparing only the severe and average BSI-18 groups significant differences were found between groups on the five ImPACT measures. More specifically, for this, the additional variables were added in as covariates and tended to show significant differences among the cognitive results with the four variables: history of concussions, history of psychiatric disorder, prior ADHD diagnoses, or prior SLD diagnoses.

Chapter Five: Discussion

Athlete mental health is gaining increasing attention and research. Previous research shows professional athletes are at a greater risk for developing mental health disorders than the general public (Hughes & Leavey, 2012; Rice et al., 2018; Rice et al., 2016). Several studies have investigated the athletes' mental health on cognitive performance post-concussion (Bruce & Echemendia, 2003; Echemendia et al., 2001; Erlanger et al., 2003; Erlanger et al., 2001; Guskiewicz et al., 2001; Lovell et al., 2003; Voller et al., 1999); however, limited research is available on the effect of mental health on baseline performance (Bailey et al., 2010). Previous studies found that athletes with psychological distress, anxiety, or suicidal ideation at baseline had significantly slower reaction times compared to athletes without these mental health concerns (Bailey et al., 2010; Tomczyk et al., 2020); while other research suggests depression has no impact on cognitive results (Cicerone & Kalmar, 1997). Although there are many studies on athletes' mental health and neurocognitive performance post-concussion, there is a lack of research conducted on mental health and cognitive performance at baseline.

The current study evaluated the relationship between mental health domains (i.e., anxiety, depression, somatization) and cognitive performance. To do this, athletes from the CFL completed the PROMIS 29, BSI-18, and the ImPACT to assess if they affect cognitive performance at baseline. The goal of this study was to understand if mental health influences baseline cognitive performance. Additionally, other variables such as history of concussion, history of psychiatric disorder, diagnosed ADHD, diagnosed SLD, and sleep were further investigated to assess if they influence baseline cognitive performance in professional athletes. Further, this study aimed to better understand these relationships so mental health professionals can better understand these distinct relationships, so they are able to accurately interpret results.

Objective 1

The first analysis investigated if the predictor variables were correlated with the outcome variables. It was hypothesized that there would be a statistically significant correlation between one or more of the mental health index scores and the ImPACT cognitive results. Then additional variables such as history of concussion, history of psychiatric disorder, ADHD diagnosis, SLD diagnosis, and sleep were added to assess if they influence the predictor or outcome variables. Results showed that most the additional variables related to the outcome variables and some of the predictor variables (see Table 1). This is consistent with previous research that found that history of concussion is related to sleep disturbances, depression, anxiety, distress, and impulsivity (Gouttebarge et al., 2017; Kerr et al., 2014; McKee et al., 2016; Stewart et al., 2016).

Objective 2

The second analysis examined athletes' baseline self-reported anxiety, depression, and somatization groups on cognitive scores on the ImPACT. It was hypothesized that athletes that reported more anxiety, depression, and somatization would have significantly different cognitive results compared to lower anxiety, depression, and somatization groups. Results revealed that none of the mental health conditions on either the BSI-18 or PROMIS 29 showed statistically significant differences on any of the ImPACT cognitive index scores. This finding is inconsistent with research done on baseline testing (Bailey et al., 2010; Tomczyk et al., 2020; Williams & Andersen, 1997); however, these studies used different measures to assess mental health and cognitive outcomes. For example, Bailey and colleagues (2010) used the Personality Assessment Inventory (PAI) which is a much more comprehensive assessment of mental health with 344 items, compared to the BSI-18 and the PROMIS, which may have been more sensitive and able to capture more of the athletes' mental health issues. Other studies used the State Trait Anxiety Inventory (STAI) and found there to be a difference in state anxiety before and after completion or a demanding task (Ciucurel, 2012; Williams & Andersen, 1997). Since the BSI-18 and PROMIS 29 had very low correlation between related index measures, another measure may be better at evaluating mental health in professional athletes (i.e., PAI, MMPI). It would be important to validate these new mental health measures in the professional athlete population to assess if they are more sensitive at evaluating mental health compared to other previous measures. In regards to the clinical utility of measuring mental health concerns within this population, it would be beneficial to develop specific normative data on professional athletes to better predict their mental health functioning incase baseline information is missed or unavailable. This would allow professionals to compare players results to a more similar group instead of comparing their results to normative information just based on age or education. Since there are often issues with self-reports and the authenticity of the reported results, it would be valuable to obtain other mental health information such as a clinical interview and third-party reports (i.e., completed by partners, parents, etc.) to assess their mental functioning in addition to self-reports to better assess athletes' mental health status. Additionally, the sensitivity and specificity of the ImPACT should also be addressed. Although the ImPACT was developed for the athlete population, it is likely not as proficient at producing the same cognitive results compared to a full neurocognitive evaluation administered by a psychologist over several hours. Additionally, the ImPACT may not be as sensitive at producing accurate results for these professional athletes compared to more amateur athletes. Since it is often much easier to obtain access to amateur athletes, the norms and development of the ImPACT may be more capable at producing scores for this population. In ideal circumstances, athletes would participate in a full neurocognitive evaluation to obtain the most sensitive and accurate baseline cognitive information. Because of the time commitment necessary for neurocognitive evaluations, it is highly unlikely that athletes would participate in a full neurocognitive evaluation. As a result, other measures such as the Concussion Resolution Index (CRI) or other cognitive measures with good psychometric properties should be investigated to assess if they are providing a more sensitive assessment of cognitive abilities for highly competitive athletes. It is important to note that this is a unique population who likely are reluctant to show mental health concerns. Therefore, they are likely to underreport mental health concerns in comparison to the general public. Additional methods may be needed to ensure the athletes' candid participation including ensuring confidentiality, assessing mental health in various ways (i.e., various self-reports, third-party reports, clinical interview), and providing mental health services to athletes when needed. Overall, this population is complex and will require various methods and procedures to accurately evaluate their mental health and cognitive functioning. Further research is warranted with different mental health and cognitive measures to determine the relationship between mental health and cognitive results.

Objective 3

This next analysis investigated if history of concussion, history of psychiatric disorder, diagnosed ADHD, diagnosed SLD, or sleep influences cognitive testing at baseline. It was hypothesized that history of concussion, diagnosed ADHD, and diagnosed SLD would show a statistically significant difference on cognitive domains. As predicted, history of concussions, diagnosed ADHD, and diagnosed SLD were related to the most cognitive domains. More specifically, results showed ADHD and SLD influenced all the cognitive domains including visual memory, verbal memory, visual motor speed, reaction time, and impulse control. History of concussions also affected visual memory, verbal memory, visual motor speed, and reaction time. These results were consistent with previous research that suggests that history of concussion influences different cognitive domains (Barth et al., 1989; Bohnen et al., 1992; Bruce & Echemendia, 2003; Echemendia et al., 2001; Erlanger et al., 2003; Erlanger et al., 2001; Field et al., 2003; Guskiewicz et al., 2001; Lovell et al., 2003; Macciocchi et al., 1996; Voller et al., 1999). Notably, psychiatric disorder influenced visual motor speed and reaction time while sleep did not seem to impact cognitive performance. Sleep did not show a statistically significant difference on any of the cognitive domains. This was inconsistent with that previous research found that sleep prior to testing influenced their cognitive performance on the ImPACT (Alsalaheen et al., 2016). Overall, these variables should be investigated when administering cognitive tests as they have shown to significantly influence cognitive performance in athletes.

Strengths and Limitations

There were some noteworthy strengths within this study. First, there was a large sample size of 951 CFL athletes. However, because of such a large sample size it was more difficult to find a statistically significant result among the variables. Additionally, the study had clearly determined inclusion and exclusion criteria which made for meaningful results. Second, since the measures were completed mostly independently there was increased standardization as athletes were completing them without much variation between administrators. This could be seen as a strength or it could be limitation if the measures are not sensitive enough to pick up the results, as individual administrators can be more sensitive to mental health issues. Third, since the

ImPACT was developed to assess concussions and primarily developed for the athlete population, there is lots of research supporting its use for the athlete population (Alsalaheen et al., 2016). Therefore, the ImPACT has a wide range of evidence supporting its applicability within this population (Alsalaheen et al., 2016; Gaudet & Weyandt, 2017).

Despite the demonstrated strengths of this study, it is not without limitations. First, there are several limitations when collecting self-report measures from an athlete population. Even though the questionnaires are valid in most populations, athletes may have ulterior motives to under report their symptoms. Studies have shown it is not uncommon for athletes to underreport their symptoms (Meier et al., 2015; Reardon & Factor, 2010). Other methods such as third-party reports or a clinical interview with a mental health professional in addition to self-reports may have been more inclusive to obtaining a more holistic mental health evaluation. Second, the BSI-18 and PROMIS 29 may not be the best measures for assessing mental health in an athlete population. Anxiety domains of each test had a moderate correlation between the two tests, but the depression domains had a low correlation which may mean they are not the most robust measures to measure mental health for this population. There are limited results that show the BSI can be effective to measure athlete populations. Results have shown the BSI-18 test-retest reliability to have low stability across time (Lancaster, 2016). Although there are limitations regarding the BSI-18, it is standardized, cost effective and time effective to gather information as lengthy questionnaires are often not feasible in this population. Third, as mentioned above the ImPACT may not produce accurate results for this unique population. Professional athletes are a unique population who are often difficult to get access to; thus, ImPACT norms likely have minimal professional athletes in their normative samples. This creates a problem because professional athletes scores are then compared to the general athlete’s normative information which is likely not an accurately representation of their abilities. Fourth, the sample was also an all-male, professional athlete sample. Therefore, because this sample is such a unique group, the results from this study cannot be applied to make generalized assumptions about the general public.

Conclusions and Future Directions

This study represents one of few studies that investigates the influence of mental health on cognitive testing at baseline with professional athletes. Results indicated no significant difference among athletes of different anxiety, depression, or somatization severity levels on cognitive performance. However, there were significant differences on cognitive performance with athletes with a history of concussion, history of psychiatric disorder, and those who were diagnosed with ADHD or a SLD. This was consistent to the literature that found that history of concussion can influence cognitive results (Barth et al., 1989; Bohnen et al., 1992; Bruce & Echemendia, 2003; Echemendia et al., 2001; Erlanger et al., 2003; Erlanger et al., 2001; Field et al., 2003; Guskiewicz et al., 2001; Lovell et al., 2003; Macciocchi et al., 1996; Voller et al., 1999). It is important to note that minimal research has been conducted on the influence of psychiatric disorder, ADHD, and SLD on baseline cognitive performance. This information may help mental health professionals interpret results for athletes that have any of these conditions.

Future studies for mental health and cognitive performance in professional athletes should consider using additional methods to measure mental health (i.e., interview, third-party questionnaires) and cognitive performance (i.e., full neurocognitive evaluation, other tests with high psychometric properties) to obtain more accurate results. This is a unique population that is reluctant to show mental health concerns; therefore, additional steps should be taken to allow them to feel comfortable reporting mental health issues (i.e., confidentiality, access to mental health professional). To obtain a broader understanding of athletes' mental health and cognitive impacts, other studies should consider including other athletes (i.e., hockey, soccer, volleyball) at different competitive levels (i.e., high school, professional, recreational) to better understand the relationship between mental health and cognitive performance in athletes. Overall, there are not many mental health and cognitive studies within the professional athlete population at baseline. This study shows that more studies are needed to better understand the relationship between mental health and cognitive performance during baseline testing. The current study could be a start to grow this field, which could help professionals understand how to support athletes' mental health and obtain the most accurate results for each athlete.

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Table 1

Correlation Coefficients

	P-Anx	P-Dep	B-Anx	B-Dep	B-Som	B-total	Visual	Verbal	Motor	Reaction	Impulse	HOC	Psych	ADHD	SLD	Sleep
P-Anx	1	.61**	.58**	.47**	.41**	.59**	.04	-.00	.08*	-.06	-.00	.04	.17**	-.03	-.01	.31**
P-Dep	-	1	.09**	.16**	.07*	.13**	.01	-03	.05	-.05	-.02	.07*	-.08	-.07	.03	.34**
B-Anx	-	-	1	.64**	.64**	.91**	.08*	.08*	.10*	-.06	.00	.05	.17**	.03	.01	.23**
B-Dep	-	-	-	1	.44*	.84**	.06	.05	.07*	-.08*	.01	.03	.14**	.01	.01	.14**
B-Som	-	-	-	-	1	.77*	.07*	.04	.05	-.06	.06	.06	.17**	.03	.06*	.21**
B-Total	-	-	-	-	-	1	.08*	.07*	.09*	-.08	.02	.05	.18**	.03	.03	.23**
Visual	-	-	-	-	-	-	1	.51**	.38**	-.23**	-.06*	.12**	.03	-.13**	-.10**	.02
Verbal	-	-	-	-	-	-	-	1	.41**	-.15**	-.13**	.14**	-.02	-.12**	-.12**	.03
Motor	-	-	-	-	-	-	-	-	1	-.50**	-.09**	.19**	.07*	-.09**	-.12**	.07*
Reaction	-	-	-	-	-	-	-	-	-	1	-.07*	-.13**	-.08*	.09**	.09**	-.01
Impulse	-	-	-	-	-	-	-	-	-	-	1	.06	.01	.10**	.12**	.24
HOC	-	-	-	-	-	-	-	-	-	-	-	1	.05	.05	.03	.05
Psych	-	-	-	-	-	-	-	-	-	-	-	-	1	.12**	.04	-.03
ADHD	-	-	-	-	-	-	-	-	-	-	-	-	-	1	.36**	.05
SLD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	.06*
Sleep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1

Note. Pearson Correlation (PCorr), Sig (Sig. 2 tailed), PROMIS 29 Anxiety (P-Anx), PROMIS 29 Depression (P-Dep), BSI-18 Anxiety (B-Anx), BSI-18 Depression (B-Dep), BSI-18 Somatization (B-Som), BSI-18 Total Score (B-Total), ImPACT Visual Memory Composite (Visual), ImPACT Verbal Composite (Verbal), ImPACT Visual Motor Speed (Motor), ImPACT Reaction Time Composite (Reaction), ImPACT Impulse Control Composite (Impulse), History of Concussions (HOC), Previously Diagnosed Psychiatric Disorder (Psych), Previously Diagnosed ADHD (ADHD), Previously Diagnosed Specific Learning Disorder (SLD), and Sleep (Sleep).

** Correlation is significant at the 0.001 level

* Correlation is significant at the 0.05 level

Table 2

Analysis of the Variance (ANOVA) History of Concussion

Measure	History of Concussion Mean	History of Concussion SD	No History of Concussion Mean	No History of Concussion SD	F (1, 952)	η^2
Verbal Memory	88.05	10.25	84.92	12.18	18.65**	.02
Visual Memory	78.75	13.02	75.65	13.51	13.16**	.01
Visual Motor Speed	42.14	6.60	39.52	7.11	35.21**	.04
Reaction Time	.61	.10	.64	.10	17.25**	.02
Impulse Control	5.60	4.49	5.08	4.53	3.23	.003

History of Concussion
** Significant at the 0.001 level
* Significant at the 0.05 level

Table 3

Analysis of the Variance (ANOVA) History of Psychiatric Disorder

Measure	History of Psychiatric Disorder Mean	History of Psychiatric Disorder SD	No History of Psychiatric Disorder Mean	No History of Psychiatric Disorder SD	F (1, 950)	η^2
Verbal Memory	84.74	11.45	86.52	11.37	.55	.001
Visual Memory	79.52	11.34	77.09	13.42	.74	.001
Visual Motor Speed	43.72	5.94	40.77	6.97	4.03*	.004
Reaction Time	.57	.10	.62	.10	5.99*	.006
Impulse Control	5.65	3.33	5.31	4.56	.13	.000

History of Psychiatric Disorder
** Significant at the 0.001 level
* Significant at the 0.05 level

Table 4

Analysis of the Variance (ANOVA) History of Attention Deficit Hyperactivity Disorder (ADHD)

Measure	History of ADHD Mean	History of ADHD SD	No History of ADHD Mean	No History of ADHD SD	F (1, 952)	η^2
Verbal Memory	82.45	12.86	86.87	11.15	13.03**	.013
Visual Memory	71.83	13.90	77.73	13.19	16.90**	.017
Visual Motor Speed	38.94	7.88	41.04	6.83	7.77*	.008
Reaction Time	.65	.13	.62	.10	7.07*	.007
Impulse Control	6.71	6.02	5.16	4.31	10.02*	.010

History of ADHD
** Significant at the 0.001 level
* Significant at the 0.05 level

Table 5

Analysis of the Variance (ANOVA) History of Speech and Language Disorder (SLD)

Measure	History of SLD Mean	History of SLD SD	No History of SLD Mean	No History of SLD SD	F (1, 952)	η^2
Verbal Memory	79.85	13.50	86.71	11.23	13.76**	.014
Visual Memory	70.46	12.35	77.43	13.35	10.24*	.011
Visual Motor Speed	36.88	8.54	41.00	6.85	13.26**	.014
Reaction Time	.67	.13	.62	.10	8.54*	.009
Impulse Control	8.03	7.10	5.20	4.36	14.75**	.015

History of SLD
** Significant at the 0.001 level
* Significant at the 0.05 level

Appendix A: Measures

ACTIVE REHAB

Brief Symptom Inventory 18 (BSI-18)

0a. Date assessment completed: ______ /______/_________ Participant ID: ___________________

0b. Clinician initials: _______________

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

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

0e. Data entry date: ________/ _______/ ____________

BSI-18

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

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

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Appendix B: Consent Form

Consent to Participate in a Research Study

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

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

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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