SCAT3 Symptom Reporting and Mental Health Screening in CFL Athletes

by

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Abstract

The purpose of this study is to evaluate the relationship between subjective mood symptoms on the four SCAT3 mood symptom items and more comprehensive mental health screening measures during baseline testing. Seven hundred and seventy-three male athlete participants consented and underwent baseline screening evaluations for the Canadian Football League (CFL). Participants ranged in age from 21 to 37 years old (M = 25.35, SD = 2.79) and reported a history of one or more sport related concussion(s) (SRC). CFL athletes completed the Sport Concussion Assessment Tool (SCAT3), the Brief Symptom Inventory (BSI-18) and Patient-Reported Outcomes Measurement Information System (PROMIS 29) to determine how well SCAT3 mood symptoms predicted broader measures of depression and anxiety. A stepwise regression analyses suggested that "sadness" and "irritability" best explained the greatest variance in the depression index scores from the BSI-18 [$F(1, 771) = 71.2$, $p < .01$, $R^2 = .085$, R^2Adjusted = .083; $F(1, 770) = 17.0$, $p < .01$, $R^2 = .104$, R^2Adjusted = .102)]. Significant findings were noted for the symptoms of "more emotional" and "nervousness" on the anxiety index scores of the BSI-18 and PROMIS 29. Subjective symptoms on the SCAT3, specifically "sadness," "more emotional", and "nervousness" appear to reasonably predict more comprehensive ratings of depression and anxiety. This information may help clinicians identify athletes dealing with mental health issues when more comprehensive questionnaires are not available.

Preface

This thesis is an original work by Richelle Wagner. This study was a part of a broader research project of which this thesis was developed. Data for this study was collected from the Active Rehabilitation Project conducted by the co-principle investigators Dr. Mrazik and Dr. Naidu. The Active Rehabilitation study was granted ethics approval prior to the beginning of this study (Pro00073481) by the Research Ethics Board at the University of Alberta. The research conducted for this thesis was supervised by Dr. Martin Mrazik at the University of Alberta.

Dedication

This thesis is dedicated to my family. To my father Rick, you are the perfect mixture of humour and rationality. And no, you are not 6’2. To my mother Julie, you have the funniest comebacks in the family, do not let anyone tell you otherwise. To my sister Larissa, I would take a nerf bullet for you. And finally, to my dog Jasper, you are a very, very, good boy. Thank you for celebrating every small step.

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Chapter 1 – Introduction

Sport Related Concussions

Since the 1970s, physicians and healthcare professions have worked to distinguish sport-related concussions (SRC) from other forms of mild traumatic brain injury (Langlois et al., 2006). This was largely driven by the sporting community's need for clearer diagnosis and management guidelines (Langlois et al., 2006; Langlois and Sattin, 2005; McCrory et al., 2017). In 2001 the First International Symposium on Concussion in Sport was held, providing recommendations towards the improvement of athlete SRC health and safety (Aubry et al., 2002). Since then the Concussion in Sport Group (CISG) has provided updated consensus statements, outlining the best clinical practices for physicians and athletic trainers regarding SRC management (McCrory et al., 2017). However, our understanding of SRC is evolving with researchers seeking to develop psychological instruments used to assess athletes' neurocognitive and neurobehavioral status at baseline and after a suspected concussion (McCrory et al., 2017). Immediate and brief neuropsychological (NP) test batteries allow physicians and healthcare professionals to evaluate athletes' neurocognitive functioning (i.e., memory, cognitive speed and reaction time), balance, and symptom scales (Harmon et al., 2013; Harmon et al., 2019). The Sport Concussion Assessment Tool 5 (SCAT5) is currently the most widely used SRC screening tool used in the assessment and management of SRC.

Athlete Mental Health

Historically, athletes at all levels of competition were perceived to be relatively unaffected by mental health and had low prevalence rates of psychiatric disorders (Bär & Markser, 2013). Yet there has been an increasing emphasis on athlete mental health. Multiple factors have been linked to athlete mental health, resulting in depression, anxiety, aggression,

eating disorders, and other mood disorders (Rice et al., 2016). Further, athletes have been seen to be at risk for experiencing mental health problems according to their age/competition level, gender, injury, and concussion history (Rice et al., 2016; Yang et al., 2007). To help manage athlete mental health, quantitative self-report measures are used to measure athlete mental health outcomes of SRC (Rice et al., 2018). Two of the most widely used measures when assessing psychological outcomes are the Patient-Reported Outcomes Measurement Information System (PROMIS 29) and the Brief Symptom Inventory-18 (BSI-18).

Elite and Professional Athletes

In the last decade, athlete mental health has received considerable attention in the sports community, with research showing high prevalence rates of psychological distress in athletes (Broshek et al., 2015; Markser, 2011; Wolanin, 2015). The literature shows that athletes can experience psychological stress as a result of intense training regimes, injuries, and performance evaluation (Schnike et al., 2018). In particular, elite athletes (i.e., athletes who currently or have previously competed at a varsity level) and professional athletes (i.e., athletes who are paid to play a sport) whose livelihood depends on their performance, may experience more pressure to manage their mental health (Hughes & Leavey, 2012). These unique and specific pressures experienced by elite and professional athletes may increase their susceptibility for specific mental health problems and suggest that they might be more at risk for psychological distress (Hughes & Leavey, 2012). This has been exemplified by gold Olympic medalist Clara Hughes when she opened up about her struggles with mental health in 2010. She currently partners with Bell's "Let's talk" program to support mental health awareness across Canada. Further, Mike Reilly, the CFL's Most Outstanding Player in 2017, publicly shared his experience with panic

attacks and anxiety in 2019, promoting and advocating for athletes experiencing mental health issues.

SRC

Currently, limited research is available on the mental health of athletes after sustaining SRC (Rice et al., 2016). However, some literature suggested that SRC can have a negative impact on athlete psychological well-being (Hutchinson et al., 2009; Mainwaring et al., 2004). For example, Mainwaring and colleagues' study in 2004 demonstrated that collegiate student athletes experienced significant spikes in depression, confusion, and mood disturbance ratings less than three weeks after sustaining SRC. This indicated that athletes are not immune to mental health problems and that athlete mental health can be impacted after sustaining SRC (Broshek et al., 2015).

In 2001 a group of international researchers met in Vienna, Austria to address complexities associated with SRC. This spurred high-quality, systematic studies leading to advancements in the diagnosis and management of SRC. Yet there has been a lag in the attention given to athlete mental health after sustaining SRC. Recently, the 5th meeting (in 2016) of the International Consensus Group on Concussion put forward a call for more high-quality methodologically sound studies related to mental health outcomes of SRC (McCrory et al., 2017). The goal of the committee's recommendation was to create evidence-based interventions that could be efficacious in the treatment of mental health (Deane et al., 2001). This emphasizes the importance of healthcare professionals and team personnel recognizing and supporting athletes to seek help for psychological distress (Gulliver et al., 2012).

Current Study

The purpose of this study was to add to the current scientific literature related to mental health outcomes associated with SRC. Athletes are not immune to psychological distress and require quantitative self-report measures to help identify and manage their mental health concerns (Rice et al., 2018). The purpose of this study was to evaluate the relationship between subjective mood symptoms on the SCAT3 and more comprehensive mental health screening measures during baseline testing. To do this, athletes from the Canadian Football League (CFL) completed the Sport Concussion Assessment Tool (SCAT3), the Brief Symptom Inventory (BSI-18) and Patient-Reported Outcomes Measurement Information System (PROMIS 29) to determine how well SCAT3 mood symptoms predicted broader measures of depression and anxiety.

Chapter 2 – Literature Review

History of Sport Related Concussions

The term concussion was originally derived from the Latin words “concutere” meaning agitation or shaking, and “commotio cerebri” meaning temporary loss of consciousness. Using the term “commotio cerebri”, the Arabic physician Rhazes (AD 850-923) was the first to define the entity of concussion as an “abnormal transient physiological state without gross brain lesions” (Mettler, 1947; Rhazes, 1548). From 1020 to 1578, other physicians supplied their own definitions of “commotio cerebri” focusing on transient (short lasting) effects (McCrory & Berkovic, 2001).

In the 16th century the definition of a concussion began to expand with Berengario da Carpi proposing that “cerebrum commotum” symptoms were a result of the brain moving against the skull (Di Ieva et al., 2011; McCrory & Berkovic, 2001). Fifty years later Ambrose Paré referred to the head injury as “a blow to the head causing symptoms”, lending itself to his term “embranlement”, also meaning “to shake” (Denny-Brown & Russell, 1941; Verjaal & Van T Hooft, 1975; Webbe, 2011). He believed that a concussion was caused by brain movement against the skull, inflicting brief periods of unresponsiveness, and leading to skull-fractures and cerebral hemorrhaging (Denny-Brown & Russell, 1941; Webbe, 2011). Overall, most medical definitions supported Rhazes’ term of a concussion occurring as a transient physiologic state but supplied little evidence towards the underlying mechanisms of the injury (McCrory & Berkovic, 2001).

From the 17th to the 19th century the next wave of definitions emerged during the era of pathophysiologic understanding. Medical professionals and scientists took on a more focused approach when analyzing concussions, placing greater emphasis on neuropathological changes in

the brain, post-concussion symptoms, and normal anatomical brain movement (McCrory & Berkovic, 2001; Webbe, 2011). Medical contributors such as Lanfrancus, Berengario da Carpi, and Jean-Louis Petit, proposed a new theory and introduced a concussion as a symptom rather than a physiological state (McCrory & Berkovic, 2001). Following this, Thomas Kirkland (1792) and John Bell's (1800) clinical observations differentiated concussions from other types of brain injuries and resulted in a general understanding that concussions are a functional process and separate from a structural brain injury (Kirkland, 1792). This era focused on the competing hypotheses and clinical observations of concussion of the brain.

In 1996, the Congress of Neurological Surgeons established their own definition of a concussion in hopes of providing the medical community with some form of uniformity and understanding (Giza et al., 2013). Yet, physicians and health care professionals were still not in agreement, leading to an array of differing concussion-grading systems and guidelines. This was especially problematic for community and professional sports programs, as these guidelines were important in the management of sport-related concussions (SRC). It wasn't until 2001, during the First International Symposium on Concussion in Sport in Vienna, Austria that a multidisciplinary team called the Concussion in Sport Group (CISG) established an agreed upon definition (Aubry et al., 2002). This definition incorporated clinical, pathological, and biomechanical constructs, allowing for the uniformity missing in past descriptions (Webbe, 2011). The CISGs definition, redefined in 2016, allowed for the advancement of specific diagnostic tools and injury management. Although national groups such as American and Canadian organizations have taken it upon themselves to establish their own individual guidelines, the medical community at large now agrees and operates under the same multifaceted, multidisciplinary approach (Center for Disease Control (CDC); Canadian Medical Association (CMA), 2011).

Current Definition

Developed during the most recent international conference on Concussion in Sport (Berlin 2016), the CISG's definition states that a "SRC is a traumatic brain injury induced by biomedical forces" (McCrory et al., 2017). The document outlining this current SRC definition incorporates several common features that outline causation, changes in neurological function, neuropathological changes, and range of clinical symptoms associated with SRCs (McCrory et al., 2017). These common features are important and can aid in the clinical definition of SRCs. The document is intended to guide clinical practice, but with the science of SRC continually evolving, physicians and health care professionals are still encouraged to use clinical judgment when making individual return-to-play decisions (McCrory et al., 2017).

The term mild traumatic brain injury (mTBI) is often used synonymously with the term concussion in literature. This can be problematic when comparing studies because some authors use the terms interchangeably, and place greater emphasis on concussions being functional mechanisms, transient in nature, or structural mechanisms (Webbe, 2011). To ensure objectivity and clarity throughout this paper, the most recent CISG definition and guidelines of a concussion, specifically a sport-related concussion (SRC), will be used. The following passages will outline diagnosis methods and injury management guidelines for SRCs by the 2016 Consensus Statement on Concussion in Sport.

Diagnosis and Management

SRCs have been identified as one of the most difficult injuries in sports to diagnose, assess, and manage (McCrory et al., 2017). Symptoms can be acute or prolonged, and to diagnose SRCs specific domains must be assessed: clinical symptoms, physical signs, cognitive impairment, neurobehavioral features, and sleep/wake disturbance (McCrory et al., 2017).

Concussion history should also be taken into consideration, as athletes with previous concussion history are more likely to incur a concussion than athletes with no previous concussion history (Zemper et al., 2003).

Clinical Signs and Symptoms

According to the Berlin expert panel, SRCs are caused by "a direct blow to the head, face, neck, or elsewhere on the body with an impulsive force transmitted to the head" (McCrory et al., 2017, p. 2). Resulting symptoms typically occur during onset and are short lived, with some symptoms developing minutes or hours later (McCrory et al., 2017). SRCs can negatively impact neurological function and cause neuropathological changes, with the majority of research supporting a functional disturbance in the brain (McCrory et al., 2017). Loss of consciousness is also a possible clinical sign of SRC but does not have to occur for a diagnosis to be made. Somatic, clinical and cognitive symptoms experienced by athletes generally follow a predictable pattern, although the duration of symptoms can be subjective (McCrory et al., 2017).

Categories. An evolving injury, athletes who incur SRCs can have an array of symptoms, therefore require discretion before returning back to play (McCrory et al., 2017). Symptoms are categorized into three different areas: somatic, cognitive, and/or emotional symptoms (McCrory et al., 2017). Somatic symptoms experienced by the athlete might include but are not limited to, headaches, dizziness, fatigue, sensory sensitivity, nausea, and vomiting. Cognitive somatic symptoms may be described by the athlete as "feeling like they are in a fog", like things are "moving in slow motion", or that they feel like they can not concentrate. Finally, emotional somatic symptoms typically present as lability, sadness, and/or nervousness (McCrory et al., 2017). This information can be gained by asking the athlete how they are feeling emotionally, or

by simply observing the athlete. It is important to keep in mind that although some somatic symptoms are unfalsifiable, others are subjective.

Domains. Further signs and symptoms of SRCs include physical signs, balance impairment, behavioural changes, cognitive impairment, and sleep/wake disturbance. Physical signs of SRC can include loss of consciousness, amnesia, and/or neurological deficits such as the inability to speak and balance impairment (McCrory et al., 2017). Cognitive impairment in the athlete can be seen in their slow reaction times to specific questions (e.g., orienting questions, attention, memory, executive functioning). Finally, if an athlete is being assessed for a suspected concussion diagnosis, they may experience sleep/wake disturbances such as somnolence and/or drowsiness. Using a neuropsychological (NP) assessment each of these domains can be accurately assessed. All five of the previously mentioned domains should be addressed before an athlete is considered ready to play. Current standards enforce no return to play activities until symptoms in all domains have returned to normal, pre-injury levels.

SCAT. The science of SRC was evolving, therefore it was important that researchers developed a tool to assess athletes' neurocognitive and neurobehavioral status immediately after a suspected concussion (McCrory et al., 2017). Immediate and brief NP test batteries used in baseline and post-injury testing are designed for rapid SRC screening, and in no way should be used for standalone SRC management or a replacement for comprehensive neurological assessments (McCrory et al., 2017). Although researchers and clinicians have progressed in their understanding of NP assessment of SRC, currently there is no "perfect" diagnostic test or marker to provide the immediate diagnosis of SRC (McCrory et al., 2017). The SCAT is recognized as the current gold standard for use with athletes.

The SCAT was developed in 2001 and revised three times. The latest revision was established in 2016 by CISG; the SCAT5 (McCrory et al., 2017). This test, which incorporates the Maddocks' questions and the Standardised Assessment of Concussion (SAC), is used by physicians and licensed healthcare professionals in the evaluation of SRC (Maddocks & Dicker, 1989; McCrea, 2001; Echemendia et al., 2017). Made up of six domains, the current SCAT5 is composed of an immediate or on-field assessment, a background and symptom evaluation, a cognitive screening of the athlete's current levels of orientation, memory, and concentration, a neurological screener and balance examination, a delayed recall section, and a decision domain to determine the extent of the injury (Echemendia et al., 2017).

Intended for athletes 13 years and older, the SCAT5 has been used across the world, producing vast amounts of normative data that have aided many research findings (McCrory et al., 2017). In the case where a physician or licenced professional is not available to conduct the SCAT5, the Concussion Recognition Tool 5 (CRT5) was created for non-medically trained individuals to help with the identification and initial management of SRC (McCrory et al., 2017). Furthermore, the Child SCAT5 was developed alongside the SCAT5 to help with the diagnosis and management of athletes aged 5-12 with a suspected SRC (McCrory et al., 2017). Overall, the SCAT5 was agreed upon and acknowledged by healthcare professionals, in systematic reviews, and by the 2016 Berlin consensus expert panel, as the most widely accepted NP assessment in concussion management (McCrory et al., 2017). Depending on specific league rules and regulations, the SCAT5 is the most widely used tool today in relation to other NP tests in the assessment of SRC.

Prevalence of SRC in Sport

Labelled by Goldstein in 1990 as a silent epidemic, SRCs have affected athletes since organized individual sports began in 776 BC (Echemendia, 2006). The Center for Disease Control and Prevention (CDC) estimated that in the United States alone, approximately 1.6-3.8 million athletes of all ages experience SRC annually (Langlois et al., 2006). Excluding the adult population, Bryan and colleagues (2016) estimated that 1.1 to 1.9 million athletes under the age of 18 experience SRCs every year. However, these estimates do not identify which sports incur the greatest number of SRC.

American Football

Collision sports have received more medical oversite than sports involving little physical contact. The highest incidence rates for SRC are currently seen in rugby, hockey, and American Football (Pfister et al., 2016). Sports with the lowest incidence rates include volleyball, baseball, and cheerleading (Pfister et al., 2016). Differences in incidence rates are observed between the sports, but American Football is recognized as having the largest amount of literature supporting high prevalence rates for SRC (Webbe, 2011). In 1904, 19 collegiate athletes were either killed or paralyzed while playing football (Schneider, 1973). These numbers spurred President Theodore Roosevelt to form the governing body for American collegiate sports, the National Collegiate Athlete Association (NCAA) (Schneider, 1973).

Prior to the 1970s, there was little evidence to reveal the prevalence rates in American football (Webbe, 2011). The first reliable incidence rates for SRCs in American football were collected in 1977, three years before the implementation of mandatory high school football helmets (Gerberich et al., 1983). Using the data from 3,802 high school football athletes, the researchers found that 24% of all high school football injuries were SRC (Gerberich et al., 1983).

Although, since helmets were mandated by the National Operating Committee for Safety in Athletic Equipment (NOCSAE) in 1980, a noticeable decrease of SRC was seen compared to previous prevalence numbers (Barth et al., 1989; Covassin et al., 2003; Shankar et al., 2007).

Even with the decrease in prevalence rates due to high school and collegiate helmet mandates, research in the last two decades has shown an increase in SRC with more SRC incurring during games than practices (Webbe, 2011). Dick and colleagues (2007) found that varsity football players between the years 1988-2004 were 11 times more likely to sustain SRCs during games than practices. Research suggests that game situations are less controlled, and collisions occur at higher speeds, therefore resulting in more SRC (Dick et al., 2007; Webbe, 2011). Furthermore, researchers compared high school and collegiate American football SRC incident levels and found that the majority of studies supported higher incidence levels in high school American football. In Shankar and colleagues' (2007) study, high school football athletes had approximately an 11% incidence rate compared to 7% for collegiate football players. Overall, it is important for sport personnel, medical professionals, and researchers to be aware that American football plays have the highest SRC incidence rates compared to other mainstream sports (Webbe, 2011).

Mental Health in Athletes

The World Health Organization (WHO) defines health as an individual's positive physical, mental, and social well-being that contributes to their overall functioning (World Health Organization, 2016). Health is used on a global scale to evaluate an individual's adaptability when experiencing physical, mental, or social challenges (Schnike et al., 2018). When applying this definition to athletes, it is important to understand how physical and psychological challenges are intertwined. Athletes can experience psychological stress as a result

of intense training regimes, injuries, and performance evaluation (Schnike et al., 2018). Furthermore, if an athlete's physical health is negatively impacted (i.e., injury), psychological complications can arise such as relational problems, anxiety, depression, eating disorders, and aggression (Castonguay & Oltmanns, 2013). To understand the holistic implications of athlete health is to understand the importance of barriers to mental health diagnosis and management.

Barriers

The definition of mental health has historically been categorized into high functioning or poor functioning (Schnike et al., 2018). This infers that athletes seeking help for their mental health symptoms would be considered as either having a disease/disordered state or not (Murphy, 2012). This dichotomous categorization leaves a lot of room for negative misconceptions, possibly impeding athletes from seeking help. With youth and adults already showing a history of not seeking help for their mental health problems, it is not shocking that athletes, in particular, have been seen to seek help less than the general population (Sawyer et al., 2001; Gulliver et al., 2012). Some of the current barriers reported by athletes include poor mental health literacy, personal characteristics, and attitudes (Gulliver et al., 2010). Of these barriers, the most common barrier that showed up in the literature was the stigma surrounding mental health.

Athletes and their health have been idealized for centuries, perceived as physically superior to the general population (Bär & Markser, 2013). Athletes were and are still taught to overcome mental and physical barriers to achieve peak performance, revered for their toughness (Bär & Markser, 2013). This supports the notion that athletes are either immune to mental illness or are able to overcome it. Therefore, the stigma and heightened feeling by athletes to show no signs of weakness may impede them from seeking help. Delaying this support may lead to poorer mental health functioning to progress to clinically diagnosable levels without detection (Watson,

2005). The impact stigma has on athlete help seeking was reflected in a study by Gulliver and colleagues (2012). This study looked at barriers adolescent elite athletes perceived as being problematic when seeking help for their mental health. They found that over 40% of the barriers listed by participants related to stigma and embarrassment, suggesting that athletes may have high levels of self-stigmatizing attitudes, as is consistent with previous research (Van Raalte et al., 1992).

Mental Health Measures

Historically, clinical research in the assessment of patient-reported outcomes of mental health has lacked rigorous methodology, too often measuring broad symptoms (i.e., fatigue, pain, depression) (Gershon et al., 2010). The resulting data when measuring psychological outcomes are incomparable and the need for standardized symptom measurement is recognized. As a result, quantitative self-report measures have become the best measures of mental health outcomes of SRC (Rice et al., 2018). Two of the most widely used measures when assessing psychological outcomes are the Patient-Reported Outcomes Measurement Information System (PROMIS) and the Brief Symptom Inventory-18 (BSI-18).

PROMIS

The PROMIS was established by the National Institutes of Health (NIH) Roadmap for Medical Research Initiative (Gershon et al., 2010). The goal of the initiative was for PROMIS to help researchers create their own item banks and short forms to measure specific health outcome domains present in a variety of conditions (Gershon et al., 2010). Freely accessible through the National Institutes of Health, PROMIS is a self-report measure developed with item response theory, designed to measure quality of life outcomes (Dewitt et al., 2018). PROMIS was created to assess physical, mental and social well-being for a wide range of populations (Dewitt et al.,

2018). The PROMIS was implemented in Meehan and colleagues' (2016) study to measure quality of life outcomes in the collegiate athlete population.

PROMIS 29 is a version of the measure that assesses physical function, anxiety, depression, fatigue, sleep disturbance, ability to participate in social roles and activities and pain interference. These domains are meant to cover the most relevant areas of self-reported health when targeting individuals with a chronic illness (Craig et al., 2014). Higher anxiety, depression, fatigue, sleep disturbance and pain interference score indicate negative results, whereas higher physical function and ability to participate scores indicate positive results. Within the PROMIS 29, *t*-scores indicate more of the concept being measured.

BSI-18

The second widely used measure for assessing psychological outcomes is the BSI-18. This particular measure can be used to measure psychological distress outcomes and consists of 18 items on a 5-point Likert scale, yielding a Global Severity Index (GSI) score and three subscale scores: somatization, depression and anxiety (Combs et al., 2017; Lancaster et al., Weber et al., 2018). Previously used in a study by Lancaster and colleagues (2016), a collegiate athlete population was analyzed for internal consistency, test-retest reliability and concurrent validity. The results indicated high internal consistency with the GSI demonstrating higher internal consistency (.83) in comparison to the subscales (.66 to .76), indicating that the GSI is the most reliable marker of psychological distress in the collegiate athlete population. Due to these findings, the BSI-18 can be seen as a valid measure of psychological factors before and after an athlete sustains SRC. Such validity adds to the value of Weber and colleagues' (2018) study that compared BSI-18 baseline scores of athletes with concussion history and athletes with no concussion history. They found that student athletes with a history of concussions showed

higher anxiety, depression, and somatization index scores on the BSI-18 compared to athletes with no prior concussion history. This lends itself to the importance of the BSI-18 when understanding why mental health is influenced by baseline concussion assessment performance in clinical practice (Weber et al., 2018).

Current Study

As discussed, athletes are not immune to psychological distress and require quantitative self-report measures to help identify and manage their mental health concerns (Rice et al., 2018). The current study seeks to evaluate the relationship between subjective mood symptoms on the SCAT3 and more comprehensive mental health screening measures during baseline testing. To do this, athletes from the Canadian Football League (CFL) completed the Sport Concussion Assessment Tool (SCAT3), the Brief Symptom Inventory (BSI-18) and Patient-Reported Outcomes Measurement Information System (PROMIS 29) to determine how well SCAT3 mood symptom items predicted broader measures of depression and anxiety. The current study contributes to the literature by further exploring how current NP tests for SRC can be used in the screening and management of athlete mental health.

Objective 1

The first objective is to determine the relationship between the four SCAT3 mood symptom items, age, and history of concussion, and each of the four outcome measures (BSI-18 dpression subscale, BSI-18 anxiety subscale, the PROMIS 29 depression subscale, and the PROMIS 29 anxiety subscale).

Alternative hypothesis. There is a statistically significant correlation between one or more of the four SCAT3 mood symptom items and the four outcome measures (BSI-18

depression subscale, BSI-18 anxiety subscale, PROMIS 29 depression subscale, and PROMIS 29 anxiety subscale).

Null hypothesis. There is no statistically significant correlation between one more of the four SCAT3 mood symptom items and the four outcome measures (BSI-18 depression subscale, BSI-18 anxiety subscale, PROMIS 29 depression subscale, and PROMIS 29 anxiety subscale).

Objective 2

The second objective is to determine which of the four SCAT3 mood symptom items or set of SCAT3 mood symptom items, significantly predict each of the four outcome measures (BSI-18 depression subscale, BSI-18 anxiety subscale, the PROMIS 29 depression subscale, and the PROMIS 29 anxiety subscale).

Alternative hypothesis. As this study is exploratory in nature and has no theory that can be derived from previous literature, it is hypothesized that "sadness" and "irritability" are the strongest predictors for the BSI-18 depression and PROMIS 29 depression subscales, and that "nervousness or anxious" and "more emotional" are the strongest predictors for the BSI-18 anxiety and PROMIS 29 anxiety subscales.

Null hypothesis. None of the four SCAT3 mood symptom items or set of SCAT3 mood symptom items significantly predict any of the four outcome measures (BSI-18 depression subscale, BSI-18 anxiety subscale, PROMIS 29 depression subscale, and PROMIS 29 anxiety subscale).

Chapter Three: Method

This chapter provides an overview of research methods used in the study including an overview of the research design and key terms, the participants, measures, statistical analysis, data collection procedures, and ethics.

Participants

A total of 809 participants were approached to participate in the study. Thirty-six participants did not complete portions of the SCAT3, BSI-18 and PROMIS 29 and were removed from the study. Overall, the final sample size (*N*) was 773 CFL players. Data was collected from 90% of the total population, indicating a good representation of the CFL population. This reduces the risk of missing information for participants that are not included in the study. However, there is no guarantee that this data is an accurate representation of the entire population. All information was collected at the start of the 2017 and 2018 football seasons.

Inclusion Criteria

a) consent/agreement of CFL to participate in the study,
b) completion of SCAT3, BSI-18, and PROMIS 29 at the start of the 2017 – 2019 season
c) cleared by medical personnel prior to participating in baseline testing

Exclusion Criteria

a) non - proficient English language speaker,
b) not medically cleared from previous concussion diagnosis

These exclusion criteria were selected to minimize the influence of variables on SCAT3 mood symptoms, and BSI-18 and PROMIS 29 depression and anxiety indexes. Players with a history of mental health disorders were included as long as they were medically cleared (fit to play) by team physicians.

Key Terms

For the purpose of this study, and as previously stated in Chapter 2, the term "concussion" or "Sport Related Concussion" or SRC is defined in accordance with CISG's 2016 definition (McCrory et al., 2017). Additionally, the term "mental health" in this study refers to the definition provided by the World Health Organization (WHO). The WHO describes mental health as "a state of well-being in which every individual realizes his or her potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community" (WHO, 2014, p. 1). Finally, the term "athlete" will be used to describe the age demographic of this sample of athletes competing in the Canadian Football League (CFL), ranging in age from 21 to 37 years old.

Research Design and Data Collection

The data for this study used a quasi-experimental design and was collected from the Canadian Football League (CFL). This study was a part of a broader research project of which this thesis was developed. Data for this study was collected from a larger multi-site study Active Rehabilitation, funded by the National Football League. Dr. Mrazik and Dr. Naidu were the lead site investigators for the CFL (see Appendix D). In accordance to the CFL league regulations, all athletes are required to complete baseline testing prior to participation in the CFL. Male CFL athletes were recruited from 9 teams across Canada. Players' ages were from 21 to 37 years old ($M = 25.35$, $SD = 2.79$). For recruitment to this study, all consented participants underwent standardized preseason medical evaluations in keeping with regulations outlined by the CFL. This included administration of the SCAT3, the PROMIS 29, and the BSI-18. All tests were administered electronically by iPads by team athletic trainers or trained graduate assistants.

Predictor Measures

Mood Symptoms

The SCAT3 was used to assess the presence of concussion related symptoms and signs using the symptom evaluation checklist. The SCAT3 was revised from the previous SCAT2 by the International Concussion Group (ICG) in 2013 and is a predecessor to the SCAT5 which was established by ICG in 2016, and later published in 2017. The SCAT5 was unavailable at the beginning of the study, therefore the SCAT3 was used. The major revision of the SCAT and SCAT2 was space to record qualitative data regarding patient background information, injuries, signs of concussion, and neck examination (Chin et al., 2016). The symptom evaluation checklist used in the SCAT3 is a subjective list that the athlete is required to complete on their own (see Appendix A). The symptom evaluation includes twenty-two symptoms that players must rate on a seven-point Likert Scale (i.e., 0 is none; 1 is mild; 2 is mild; 3 is moderate, 4 is moderate, 5 is severe, and 6 is severe). These symptoms include current cognitive, physical, and mood symptoms. Mood symptoms account for four of the twenty-two symptoms (i.e., more emotional, irritability, sadness, nervousness or anxious). Athletes are expected to rate the presence or absence of each mood symptom they are experiencing that day (McCrory et al., 2013). The four mood symptoms were chosen as the four predictor measures in this study. The SCAT5 was not published until 2017, so the SCAT3 was used for this study.

The SCAT3 was chosen for its easy deployability and availability. Depending on specific league rules and regulations, the SCAT3 has been one of the most widely used tools in relation to other NP tests in the assessment of SRC and was therefore selected for this study. The SCAT3 was also selected for this study because it has been established as a valid tool used in the diagnosis of SRC and subsequently tracking a player's readiness to return to play. In a study by

Nelson and colleagues (2016) the SCAT3, along with the BSI-18, proved to be one of the most accurate and sensitive measures of acute symptom recovery in high school and collegiate athletes. Overall, the SCAT3 is the most widely accepted NP assessment in concussion management (McCrory et al., 2017).

Outcome Measures

BSI-18 Depression

The purpose of using the *BSI-18 depression subscale* was to assess the frequency of depressive symptom outcomes in CFL athletes with concussion history (see Appendix C). Established as one of the two Brief Symptom Inventory versions of the Symptom Checklist SCL-90-R (53 items), the BSI-18 includes three subscales (somatization, depression, anxiety) and a Global Severity Index (GSI) (Derogatis,1993; Franke, et al., 2017). Each of the three subscales contains six items ranked on a five-point Likert Scale (i.e., 0 is not at all; 1 is a little bit; 2 is moderately; 3 is quite a bit, and 4 is extremely) (see Appendix B). The GSI score can range from 0 – 72 and the three subscales can range from 0 – 24 (Combs et al., 2017; Weber et al., 2018). Higher scores on this subscale reflect higher levels of distress (Lancaster et al., 2016).

The BSI-18 depression subscale is a quantitative self-report measure that is one of the most widely used measures of depressive mental health outcomes for SRC used by physicians and athletic trainers (Rice et al., 2018). Further, this depression subscale was chosen for its good internal consistency. In 2008, Meachen and colleagues investigated the psychometric properties of the BSI-18 in relation to individuals with traumatic brain injuries (TBI). The results of their study showed moderate to strong internal consistency of the depression index for inpatients to follow-up patients (Cronbach α = .64-0.84) (Dancey & Reidy, 2007). Due to these findings, the BSI-18 is seen as a valid measure of psychological factors.

Specifically, this index was chosen because it addresses depressive mental health symptoms for athletes with a history of concussion, which is the population included in this study. A study conducted by Weber and colleagues (2018) compared BSI-18 baseline scores of athletes with concussion history and athletes with no concussion history. They found that student athletes with a history of concussions showed higher BSI-18 depression subscale scores compared to athletes with no prior concussion history. This provides further support that the BSI-18 Depression subscale is an accurate measure of psychological distress experienced by athletes with a history of concussion.

BSI-18 Anxiety

The purpose of using the *BSI-18 anxiety subscale* was to assess the frequency of anxiety symptom outcomes in CFL athletes with concussion history (see Appendix C). As previously stated, the BSI-18 anxiety subscale is one of three subscales included in the BSI-18 (somatization, depression, anxiety) (Franke, et al., 2017). The anxiety subscale contains six items ranked on a five-point Likert Scale (i.e., 0 is not at all; 1 is a little bit; 2 is moderately; 3 is quite a bit, and 4 is extremely), with an overall score ranging from 0 – 24 (Combs et al., 2017; Weber et al., 2018). Higher scores on this subscale reflect higher levels of distress (Lancaster et al., 2016).

As described by Meachen and colleagues (2008), the BSI-18 anxiety subscale was chosen for its widely used measures and its strong internal consistency (Cronbach α = .74-.83) (Dancey & Reidy, 2007). When accounting for demographics, the anxiety subscale shows incremental validity when predicting a patient's psychosocial, psychological, and functional status (Meachen et al., 2008). Further, this subscale has been used to investigate the psychometric properties of individuals with TBI, as well as the emotional functioning of athletes after SRC (Meachen et al.,

2008; Lancaster et al., 2016). In Lancaster and colleagues' (2016) study, psychometric analyses of test-retest reliability, internal consistency reliability, and concurrent validity were conducted on athletes' BSI-18 scores. Their results indicated good internal consistency, fair to poor test-retest reliability, and good convergent validity in relation to other measures of emotional functioning. This index was chosen because it specifically addresses anxiety mental health symptoms for athletes with a history of concussion, which is the population included in this study.

PROMIS 29 Depression

The PROMIS was established by NIH Roadmap for Medical Research Initiative (Gershon et al., 2010). The goal of the initiative was for PROMIS to help researchers create their own item banks and short forms to measure specific health outcome domains present in a variety of conditions (Gershon et al., 2010). Freely accessible through the National Institutes of Health, PROMIS is a self-report measure developed with item response theory, designed to measure quality of life outcomes (Dewitt et al., 2018). PROMIS was created to assess physical, mental and social well-being for a wide range of populations (Dewitt et al., 2018). Further, the PROMIS was previously selected as a measure in Meehan and colleagues' (2016) study to measure quality of life outcomes in the collegiate athlete population.

PROMIS 29 is a version of the measure that assesses physical function, anxiety, depression, fatigue, sleep disturbance, ability to participate in social roles and activities and pain interference. Higher anxiety, depression, fatigue, sleep disturbance and pain interference scores indicate negative results, whereas higher physical function and ability to participate scores indicate positive results.

In this study, the *PROMIS 29 depression subscale* was chosen to assess the frequency of depression symptom outcomes in CFL athletes with concussion history (see Appendix B). The depression subscale contains four-items 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), with an overall score ranging from 0 – 20 (Kroenke et al., 2014). Higher scores on this subscale reflect a higher presentation of depressive symptoms. The PROMIS 29 depression subscale was chosen for its feasibility in a clinical and research environment, its efficiency in minimizing the number of items without compromising reliability, and its diverse population validity (Cella et al., 2007; Cella et al., 2010). For example, the NIH promoted the use of this measure across multiple studies to establish intra- and inter-disease comparisons (Cella et al., 2010). Overall, this index was chosen for its applicability to measure depressive mental health symptoms for athletes with a history of concussion, which is the population included in this study. In addition to the BSI-18, the PROMIS 29 depression and anxiety indexes were included in this study because it is a widely used measure of psychological distress. Further, it is a measure of quality of life, a broader measure of overall health. In this study, it was concluded that the PROMIS 29 would be beneficial when exploring the predictive value of SCAT3 mood symptoms items to more comprehensive measures of depression and anxiety.

PROMIS 29 Anxiety

As previously stated, the PROMIS 29 is used to assess the physical function, anxiety, depression, fatigue, sleep disturbance, ability to participate in social roles and activities, and pain interference. In this study, the *PROMIS 29 anxiety subscale* was chosen to assess the frequency of depression symptom outcomes in CFL athletes with concussion history (see Appendix B). The Anxiety subscale contains four-items 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), with an overall score ranging from 0 – 20 (Kroenke et al., 2014). Higher anxiety scores indicate negative results and *t*-scores indicate more of the concept being measured.

The PROMIS 29 anxiety subscale was chosen for its efficiency in minimizing the number of items without compromising reliability, feasibility in a clinical and research environment, and its minimal error in measurement (Cella et al., 2010). Further, in Cella and colleagues' study (2010), they proved that the PROMIS 29 anxiety bank had a strong correlation with a Mood and Anxiety Symptom Questionnaire (Cronbach α =.80), strong correlation with the Center for Epidemiological Studies-Depression Scale (Cronbach α =.75), and a strong correlation with the PROMIS 29 anxiety short form (Cronbach α = .96). Overall, this index was chosen for its applicability to measure depressive mental health symptoms for athletes with a history of concussion, which is the population included in this study.

Statistical Analysis

A correlation analysis was first conducted to determine the statistical relationship between Age (age), history of concussion (HoC), the four SCAT3 mood symptom items (more emotional; SCAT3-E; irritability, SCAT3-I; sadness, SCAT3-S; and nervousness or anxious, SCAT3-NA), and the four outcome measures BSI-18 depression index (BSI-D), BSI-18 anxiety index (BSI-A), PROMIS 29 depression index (PROMIS-D), and PROMIS 29 anxiety index (PROMIS-A).

A multiple linear regression was then used using a stepwise entry to explore the relationship between the four mood symptom items on the SCAT3 symptom evaluation and the four outcome measures. A stepwise regression was chosen due to the exploratory nature of this study, as previous studies have not focused on using SCAT3 mood symptoms to predict more

comprehensive measures of depression and anxiety. Therefore, due to the novelty of this study, there is no theory to inform or predict which of the subjective symptoms are the best representations of more comprehensive depression and anxiety. All statistical analysis and figures were generated using IBM SPSS Statistics, Version 26 and descriptive data analyses were conducted to demonstrate the characteristics of the participants. Overall, a multiple linear regression using a stepwise entry was deemed appropriate for evaluating the unique variance in four continuous outcome variables that are explained by a set of four continuous predictor variables.

Ethics

This study was a part of a broader research project of which this thesis was developed. Data for this study was collected from the Active Rehabilitation Project conducted by the co-principal investigators Dr. Mrazik and Dr. Naidu. The Active Rehabilitation study was granted ethics approval prior to the beginning of this study (Pro00073481) by the Research Ethics Board at the University of Alberta. To participate in the study participants were required to sign a consent form including information on the purpose of the study, commitment requirements, and risks and benefits (see Appendix D). In accordance with the CFL league regulations, all athletes are required to complete baseline testing (which included SCAT3 other NP tests) prior to participation in the CFL.

Chapter 4 – Results

The purpose of this study was to first examine the relationship between the four SCAT3 mood symptom items and each of the four outcome measures. Secondly, this study sought a predictive model to determine whether the four SCAT3 mood symptom items or set of SCAT3 mood symptom items, significantly predict each of the four outcome measures. This chapter presents the assumptions of the multiple regression and the results of the data analysis.

Assumptions

Prior to running the Pearson correlation and the stepwise multiple regression, the assumptions were evaluated in SPSS. To manage outliers in this dataset, casewise diagnostics were analyzed for the four proposed regression models. Further, Cook's test and the average leverage value were applied to check for influential points. The results of these tests revealed potential outliers influencing the data. Cook's distance and the average leverage value were then assessed. Outliers greater than 1.0 were indicated for the Cook's distance test; as well, values of twice the average or three times the average were indicated for all four proposed regression models (Cook & Weisberg, 1982; Hoaglin & Welsch, 1978; Stevens, 2002). Although there is a concern for outliers, they were explainable through the clinical relevance of this data. This data represents a healthy population of CFL athletes; therefore, it was expected that athletes would report fewer mental health symptoms on the self-report measures. Further, it was expected that some athletes would present with higher scores on the SCAT3 mood symptoms, BSI-18 indexes, as well as the PROMIS 29 indexes in comparison to the majority. These outliers would be important when identifying which, if any, SCAT3 mood symptoms are predictive of higher BSI 18 and PROMIS 29 depression and anxiety scores. For this reason, the outliers were retained in the data. The assumptions of normality also did not yield the errors were normally distributed

due to an expected and accurate representation of a healthy CFL population. Overall, a normal mental health distribution was not expected in a healthy population of CFL athletes, therefore the data was maintained in the study.

The four proposed regression models were then assessed for the assumptions of non-zero variance and independence, linearity and homoscedasticity, normally distributed errors, independent errors and multicollinearity. The assumption of non-zero variance was met as all athletes completed the measures separately, providing an array of self-reported responses. Linearity and homoscedasticity were both achieved through scatter plot observations. Scatter plots of predictor and versus outcome variables indicated linear relationships between outcome and predictor variables, as well as satisfactory homoscedasticity. Although the homoscedasticity of the variables showed relative distribution, the variables were overloaded below two. Residuals were then assessed through histograms and P-Plots. For each of the four proposed regression models, the histograms were heavy tailed and positively skewed. The P-Plots were also skewed to lower values; however, the majority of the data can be explained by athlete mental health. An expected and normal distribution of mental health data for a health CFL population results in variable loading and heavy tailed, skewed scatterplots and graphs.

The assumptions of independence of errors were assessed using the Durbin-Watson statistic, assuring that the errors were uncorrelated from each other. The residuals from this statistic showed that the residuals were uncorrelated, ranging from 2.040 to 1.806 and meeting the assumption of independent errors. Finally, multicollinearity was examined through tolerance and the Variance Inflation Factors (VIF). Overall, a significantly high tolerance statistic (>.7) was determined for all of the reviews of collinearity. Myers (1990) suggests that a tolerance value below 0.1 indicates violates of assumptions, and Menard and colleagues (1995) suggested

that a value below 0.2 is worthy of concern. Further, a sufficiently low variance inflation factor was present (VIF; <1.0). Overall, no multicollinearity was found within the dataset. As noted above, a normal mental health distribution was not expected in a healthy population of CFL athletes and the assumptions of multicollinearity were not violated.

Table 1

Descriptive Table of Variables

	N	Min	Max	M	SD	Skewness		Kurtosis	
Age	773	20	37	25.35	2.79	1.05	.088	1.21	.176
HoC	773	0	1	.45	.50	.19	.088	-1.97	.176
BSI-D	773	0	14	.25	.93	6.93	.088	73.718	.176
BSI-A	773	0	11	.41	1.14	4.34	.088	23.642	.176
PROMIS-D	773	3	16	4.12	.725	9.49	.088	118.051	.176
PROMIS-A	773	2	16	4.53	1.48	3.79	.088	17.044	.176
SCAT3-E	773	0	5	.05	.36	9.22	.088	104.560	.176
SCAT3-I	773	0	6	.08	.43	9.00	.088	104.022	.176
SCAT3-S	773	0	3	.03	.23	8.01	.088	72.209	.176
SCAT3-NA	773	0	4	.18	.58	3.54	.088	13.115	.176

Pearson Correlation

The results of this correlation sought to determine whether the four predictor variables were significant and positively correlated with the outcome variables. There was a significant and positive correlation found between age and BSI-D. Further, HoC was found to be positively and significantly correlated with both the BSI-D and PROMIS-D indexes. Thus, age and HoC could be moderating variables. This suggests that these two variables may be influencing the

strength and direction of the relationship between the four SCAT3 mood symptom items and the four outcome measures. Therefore, partial correlations were conducted to control for the possible influence of age and HoC. The results of the partial correlation determined that the four predictor variables remained significant and positively correlated with the outcome variables (see Table 2). In accordance with these results, the decision was maintained to add all predictors to the stepwise multiple regression model.

Stepwise Regression

A stepwise multiple regression was performed to determine which of the four SCAT3 mood symptom items or set of SCAT3 mood symptom items, (i.e., more emotional, irritability, sadness, and nervousness or anxious) significantly predicted each of the four outcome measures (BSI-18 depression subscale, BSI-18 anxiety subscale, the PROMIS 29 depression subscale, and the PROMIS 29 anxiety subscale). Four predictor variables were indicative of high BSI-D scores: SCAT3-S ($F(1, 771) = 71.2$, $p < .000$, $R^2 = .085$), SCAT3-I ($F(1, 770) = 17.013$, $p < .000$, $R^2 = .104$), age ($F(1, 769) = 7.303$, $p < .000$, $R^2 = .113$), and SCAT3-NA ($F(1, 768) = 6.331$, $p < .000$, $R^2 = .120$) (see Table 3). Of these predictor variables, the SCAT3-S accounted for 8.5% of the overall model variance (R^2 Change = .085) and the SCAT3-I accounted for 2% of the overall model variance (R^2 Change = .020) (see Figure 1). For the BSI-A, four predictor variables were identified of higher BSI-A scores: SCAT3-E ($F(1, 771) = 155.163$, $p < .000$, $R^2 = .166$), SCAT3-NA ($F(1, 770) = 50.301$, $p < .000$, $R^2 = .219$), SCAT3-I ($F(1, 769) = 11.886$, $p < .000$, $R^2 = .230$), and SCAT3-S ($F(1, 768) = 9.676$, $p < .000$, $R^2 = .240$) (see Table 4). Of these predictor variables, the SCAT3-E accounted for 16.8% of the overall model variance (R^2 Change = .168) and the SCAT3-NA accounted for 5.1% of the overall model variance (R^2 Change = .051) (see Figure 2).

Figure 1

Stepwise Analysis: Matrix Scatter Plots of the Predictor Variables SCAT3-S and SCAT3-I and the Outcome Variable BSI depression (BSI-D)

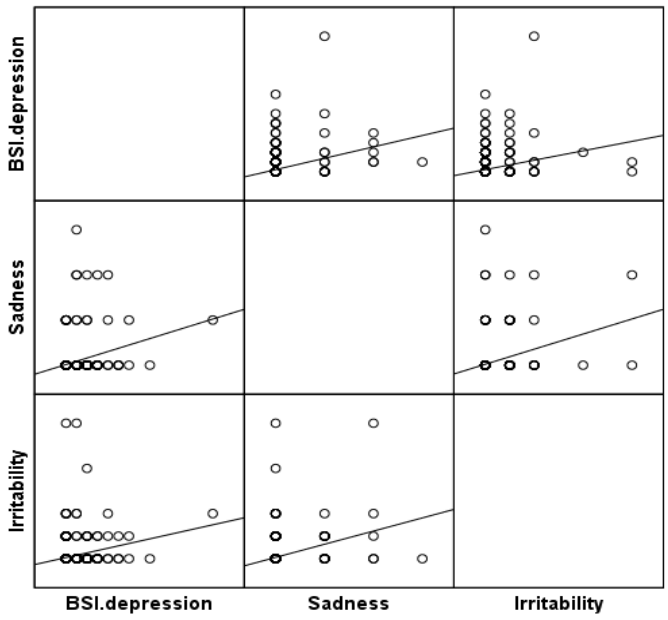
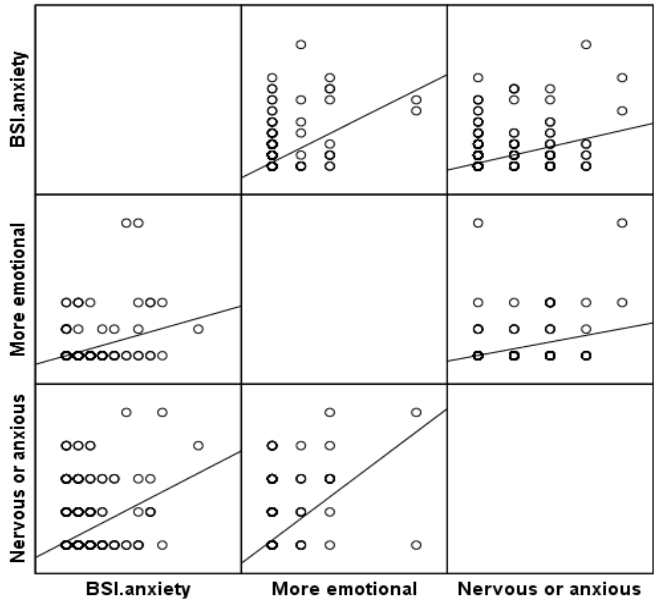


Figure 2

Stepwise Analysis: Matrix Scatter Plots of the Predictor Variables SCAT3-E and SCAT3-NA and the Outcome Variable BSI anxiety (BSI-A)



For the PROMIS-A, three predictor variables were identified of higher PROMIS-A scores: SCAT3-E ($F(1, 771) = 112.254$, $p < .000$, $R^2 = .127$), SCAT3-NA ($F(1, 770) = 17.718$, $p < .000$, $R^2 = .147$) and SCAT3-I ($F(1, 769) = 5.808$, $p < .000$, $R^2 = .153$) (see Table 5). Of these predictor variables, the SCAT3-E accounted for 12.7% of the overall model variance (R^2 Change = .127) and the SCAT3-NA accounted for 2.0% of the overall model variance (R^2 Change = .020) (see Figure 3). Regarding the PROMIS-D, two variables were indicative of higher PROMIS scores: SCAT3-NA ($F(1, 771) = 20.154$, $p < .000$, $R^2 = .025$) and SCAT3-I ($F(1, 770) = 10.782$ $p < .000$, $R^2 = .039$) (see Table 6). Of these predictors the SCAT3-NA accounted for 2.5% of the overall model variance (R^2 Change = .025) and the SCAT3-I accounted for 1.3% of the overall model variance (R^2 Change = .013) (see Figure 4).

Figure 3

Stepwise Analysis: Matrix Scatter Plots of the Predictor Variables SCAT3-E and SCAT3-NA and the Outcome Variable PROMIS anxiety (PROMIS-A)

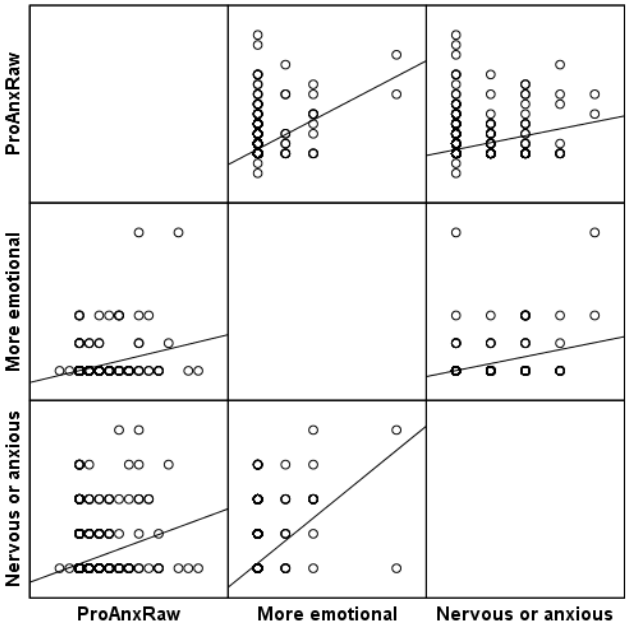
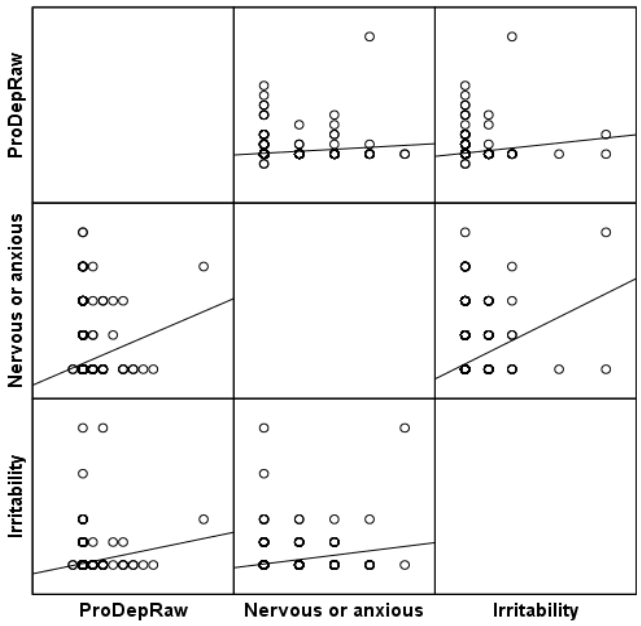


Figure 4

Stepwise Analysis: Matrix Scatter Plots of the Predictor Variables SCAT3-NA and SCAT3-I and the Outcome Variable PROMIS depression (PROMIS-D)



Objective 1

The first objective of the study was to investigate the relationship between the four SCAT3 mood symptom items and the four outcome measures. To test this objective, Pearson correlations were calculated between age, HoC, the four SCAT3 mood symptoms, and the four outcome measure scores. The correlation revealed age and HoC to be moderating variables. These variables could possibly influence the strength and direction of the relationship between the four SCAT3 mood symptom items and the four outcome measures. Therefore, partial correlations were conducted to control for the possible influence of age and HoC. The results of this final correlation determined that the four predictor variables were still slightly significant and positively correlated with the outcome variables, confirming the study's alternative

hypothesis that there is a statistically significant correlation between one or more of the four SCAT3 mood symptom items and the four outcome measures (see Table 2).

Objective 2

The second objective of this study was addressed using a stepwise multiple regression. This analysis examined which of the four SCAT3 mood symptom items, or set of SCAT3 mood symptom items, significantly predicted each of the four outcome measures. As this study is exploratory in nature and is not based on any one particular theory, it was hypothesized that SCAT3-S and SCAT3-I would be the strongest predictors for the BSI-D and PROMIS 29 depression subscales and that SCAT3-E and SCAT3-NA are the strongest predictors for the BSI-D and PROMIS-D. Overall, the alternative hypothesis of the second objective of this study was confirmed for both the BSI-A and PROMIS-A, as well as the BSI-D.

Table 2

Correlation Coefficients

		Age	BSI-D	BSI-A	HoC	PROMI-A	PROMIS-D	SCAT3-E	SCAT- I	SCAT3-S	SCAT3-NA
Age	PCorr	1	.10**	-.00	.15**	-.03	.06	.02	.05	.00	-.07
BSI-D	PCorr	-	1	.54**	.07*	.33**	.59**	.27**	.22**	.29**	.20**
BSI-A	PCorr	-	-	1	.07	.37**	.312**	.41**	.30**	.37**	.37**
HoC	PCorr	-	-	-	1	.06	.07*	.06	.05	.01	.07
PROMIS-A	PCorr	-	-	-	-	1	.47**	.36**	.24**	.28**	.27**
PROMIS-D	PCorr	-	-	-	-	-	1	.10**	.15**	.14**	.16**
SCAT3-E	PCorr	-	-	-	-	-	-	1	.44**	.67**	.41**
SCAT3-I	PCorr	-	-	-	-	-	-	-	1	.31**	.26**
SCAT3-S	PCorr	-	-	-	-	-	-	-	-	1	.36**
SCAT3-NA	PCorr	-	-	-	-	-	-	-	-	-	1

Note. Pearson Correlation (PCorr), Sig

* $p < .05$, ** $p < .01$

Table 3

Dependent Variable: BSI depression (BSI-D) Stepwise Regression

Model	R	R^2	Adjusted R^2	SE of the Estimate	Change Statistics					Durbin-Watson
					R^2 Change	F Change	df1	df2	Sig. F Change	
1	.29[a]	.09	.08	.90	.09	71.223	1	771	.00	-
2	.32[b]	.10	.10	.89	.02	17.01	1	770	.00	-
3	.34[c]	.11	.11	.88	.01	7.30	1	769	.01	-
4	.35[d]	.12	.12	.88	.01	6.33	1	768	.01	1.88

a. Predictors: (Constant), Sadness

b. Predictors: (Constant), Sadness, Irritability

c. Predictors: (Constant), Sadness, Irritability, Age

d. Predictors: (Constant), Sadness, Irritability, Age, Nervous or anxious

Table 4

Dependent Variable: BSI anxiety (BSI-A) Stepwise Regression

Model	R	R^2	Adjusted R^2	SE of the Estimate	Change Statistics				
					R^2 Change	F Change	df1	df2	Sig. F Change
1	.41[a]	.17	.17	1.04	.17	155.16	1	771	.00
2	.47[b]	.22	.22	1.01	.051	50.30	1	770	.00
3	.48[c]	.23	.23	1.00	.012	11.89	1	769	.00
4	.49[d]	.24	.24	.99	.010	9.68	1	768	.00

a. Predictors: (Constant), More emotional

b. Predictors: (Constant), More emotional, Nervous or anxious

c. Predictors: (Constant), More emotional, Nervous or anxious, Irritability

d. Predictors: (Constant), More emotional, Nervous or anxious, Irritability, Sadness

Table 5

Dependent Variable: PROMIS anxiety (PROMIS-A) Stepwise Regression

					Change Statistics				
Model	R	R^2	Adjusted R^2	SE of the Estimate	R^2 Change	F Change	df1	df2	Sig. F Change
1	.36[a]	.13	.13	1.38	.13	112.25	1	771	.00
2	.38[b]	.15	.15	1.37	.02	17.72	1	770	.00
3	.39[c]	.15	.15	1.36	.01	5.81	1	769	.02

a. Predictors: (Constant), More emotional

b. Predictors: (Constant), More emotional, Nervous or anxious

c. Predictors: (Constant), More emotional, Nervous or anxious, Irritability

Table 6

Dependent Variable: PROMIS depression (PROMIS-D) Stepwise Regression

					Change Statistics				
Model	R	R^2	Adjusted R^2	SE of the Estimate	R^2 Change	F Change	df1	df2	Sig. F Change
1	.16[a]	.03	.02	.72	.03	20.15	1	771	.00
2	.20[b]	.04	.04	.71	.01	10.78	1	770	.00

a. Predictors: (Constant), Nervous or anxious

b. Predictors: (Constant), Nervous or anxious, Irritability

Chapter 5 – Discussion

SRCs continue to be a concern for athletes, spurring research dedicated to reducing, preventing, and treating SRC. In the last decade, athlete mental health has received considerable attention in the sports community, with research showing high prevalence rates of psychological distress in athlete populations (Broshek et al., 2015; Markser, 2011; Wolanin, 2015). In particular, elite and professional athletes may experience more pressure to manage their mental health than other athletes (Hughes & Leavey, 2012). Although there is limited research addressing mental health concerns for athletes after sustaining SRC, some literature does suggest that SRC can have a negative impact on athlete psychological well-being (Hutchinson et al., 2009; Mainwaring et al., 2004; Rice et al., 2016).

The purpose of this study was to evaluate the relationship between subjective mood symptoms on the SCAT3 and more comprehensive measures of depression and anxiety during baseline testing. To do this, athletes from the Canadian Football League (CFL) completed SCAT3, the BSI-18 and the PROMIS 29 to determine how well SCAT3 mood symptoms predicted broader measures of mental health. The goal of this explorative study was to better understand the mental health outcomes of SRC in the CFL population. Further, this study intended to facilitate future research on improving existing SRC management strategies, introducing the concept of mental health screeners during baseline testing.

BSI-18 and PROMIS 29 Depression Models

Upon review of the steps in the regression analyses, it was determined that models 1 and 2 explained the greatest amount of variance in the BSI-D. The symptoms SCAT3-S (8.5%) and SCAT3-I (2.0%) accounted for the greatest amount of variance in the model compared to age (0.8%) and SCAT3-NA (0.7%) (see Table 1). Further, SCAT3-S and SCAT3-I are more

clinically representative of depressive symptoms found in the DSM-5. Although age and SCAT3-NA can be representative of depressive symptoms, they do not have as strong of a relationship with depression as SCAT3-S and SCAT3-I and are not symptoms representative of depression disorder symptoms described in the DSM-5 (American Psychiatric Association, 2013).

The stepwise regression analysis for the PROMIS-D accounted for a limited amount of variance. Although the steps in the regression analysis identified the symptoms SCAT3-NA and SCAT3-I as the most significant predictors, the models overall did not account for a lot of variance in comparison to other outcome models. Further, only one of the predictor models identified a common symptom of depression in the DSM-5 (American Psychiatric Association, 2013). As a result, the stepwise regression analysis for the PROMIS-D was deemed a poor predictor of depression when analyzing which of the four SCAT3 mood symptom items, or set of SCAT3 mood symptom items, significantly predicted each of the four outcome measures. Taken together, these results suggest that the PROMIS-D may either be a poor measure of depression or that the SCAT3 mood symptom items do not predict PROMIS-D item scores.

BSI-18 and PROMIS 29 Anxiety Models

A review of the steps in the regression analysis for the BSI-A and PROMIS-A both determined that SCAT3-E and SCAT3-NA were the two strongest predictors accounting for the greatest amount of variance. Regarding the BSI-A, it was determined that SCAT3-I (1.2%) and SCAT3-S (1.0%), included in the third and fourth model of the regression, did not account for enough variance to be considered significant predictors (see Table 4). Further, SCAT3-I (0.6%), rounded to 1.0%, was included in the third step of the PROMIS-A regression analysis, also not accounting for enough variance to be considered a significant predictor (see Table 5).

Additionally, SCAT3-E and SCAT3-NA are symptoms that are more representative of anxiety disorder symptoms described in the DSM-5 (American Psychiatric Association, 2013).

It is important to note that the anxiety indexes accounted for more overall variance than both the BSI-D and PROMIS-D. This could be due to CFL athletes having a low level of mental health literacy. For example, “butterflies” and “pre-game jitters” may be more likely to be discussed in competitive settings, whereas depressive symptoms may feel less familiar in a sports context. However, depressive symptoms may not be as familiar to athletes and might result in less reliable self-reports of mental health symptoms. The greater variance could also be due to the BSI-18 and PROMIS 29 being more accurate measures of anxiety than the BSI-18 and PROMIS 29 measure of depression. Further, this difference could also be a result of the four SCAT3 mood symptoms, indicating that they are too broad or are not representative enough of depressive symptoms.

Overall, the alternative hypothesis of the second objective of this study was confirmed for both the BSI-A and PROMIS-A, as well as the BSI-D. The PROMIS-D did not account for a great amount of variance, and as a result, the model was deemed a poor predictor of depression. Due to the novelty of this study, it is difficult to determine whether the results support theoretical expectations outside of the study’s hypothesis. As each of the four mood symptom items are intended to represent both depression and anxiety symptoms to some extent, it is difficult to discern which of the subjective symptoms are the best representations of more comprehensive depression and anxiety measures. However, SCAT3-S and SCAT3-I are symptoms associated with depressive disorders in the DSM-5, as well as SCAT3-E and SCAT3-NA are associated with anxiety disorders in the DSM-5 (American Psychiatric Association, 2013). This would

suggest that these mood symptom items are expected predictors of more comprehensive measures of depression and anxiety.

Strengths and Limitations

Inclusion and exclusion criteria were introduced in this study to appropriately analyze 773 CFL athletes aged 21 to 37 with a history of concussion. Although this large population size is a strength of the study, it is also recognized as a limitation. Due to such a large population size, a small statistically significant and positive correlation was identified amongst the predictor and outcome variables. The large sample size in this study may have contributed to the significance of variable relationships and determined a positive relationship when one was not present. Further, the decision was made to retain outlier points in the data used in this study, which may be another limitation in the data set. This decision was made due to the expectation that a normal health distribution was not expected in a healthy population of CFL athletes and that multicollinearity was maintained. Both of these limitations may have impacted the validity of the conclusions drawn from this study's results. To address this limitation, it is suggested that the SCAT3, BSI-18 depression and anxiety subscales, and PROMIS 29 depression and anxiety subscales are administered to future CFL athletes during baseline testing to attempt to replicate these findings.

Few standardized measures exist when assessing athlete mental health after SRC (Lancaster, 2016). However, the BSI-18 and PROMIS 29 are quantitative self-report measures that the literature has recognized as appropriate measures of mental health amongst athletes (Lancaster et al., 2016; Dewitt et al., 2018). The BSI-18 and PROMIS 29 were selected for their efficiency in minimizing the number of items without compromising reliability, feasibility in a clinical and research environment, and their minimal error in measurement. Although the BSI-18

and PROMIS 29 are two of the most widely used measures of mental health outcomes, this study's design was limited in its ability to determine whether the BSI-18 and PROMIS 29 are accurate measures of depression and anxiety specific to the CFL population.

As indicated earlier in the paper, the anxiety scales for both the BSI-18 and the PROMIS 29 accounted for more overall variance compared to the depression scales. Further, the PROMIS 29 depression index was deemed a poor measure of depression in this study, accounting for little variance. However, this study acknowledges that lengthy psychological questionnaires are not always feasible in an athletic environment. Therefore, while it is addressed that the BSI-18 and PROMIS 29 may not be the best measures of psychological distress for CFL athletes, it is also understood that other, more comprehensive measures do not fit the practical demands of shorter questionnaires. Further evidence of this is seen in the psychometric properties of the BSI-18 and PROMIS 29 anxiety subscales, where a low correlation was indicated between the two subscales. This suggests that the BSI-18 and PROMIS 29 may not be the most robust measures for the population within this research. To fix this issue, sport health care teams should focus on training athletes on how to better report concussion symptoms (Warmath & Winterstein, 2019). This can occur in ages as early as 12-to 16-year old elite athletes (Warmath & Winterstein, 2019).

A significant limitation within this study is the use of self-report measures for the SCAT3 Symptom Evaluation, BSI-18 Depression and Anxiety subscales, and the PROMIS 29 Depression and Anxiety subscales. Self-report measures allow athletes to subjectively report their symptoms, leading to socially desirable and inaccurate answers (Duckworth & Yeager, 2015). Athletes have been reported to both inflate and deflate their symptoms, altering the data to reflect the expectations of researchers and clinicians (Duckworth & Yeager, 2015). Poor mental health literacy, personal characteristics, and attitudes have also been reported by athletes to

impede their willingness/ability to report mental health symptoms (Gulliver et al., 2012; Sawyer et al., 2001).Of these barriers, the most common is the stigma surrounding mental health.

The impact stigma has on athlete help seeking was reflected in a study by Gulliver and colleagues (2012) which looked at barriers adolescent elite athletes perceived as being problematic when seeking help for their mental health. The results showed that over 40% of the barriers listed by participants related to stigma and embarrassment, suggesting that athletes may have high levels of self-stigmatizing attitudes, as is consistent with previous research (Van Raalte et al., 1992). In this current study, to account for biased and socially desirable answers, athletes were asked to complete the questions in private and told that their confidentiality would be maintained. However, this does not ensure reliable answers as memory bias can still impact their responses (Rice et al., 2018). Further, athletes may also have under reported their symptoms on these measures due to pressures to play (Warmath & Winterstein, 2019). A study by Warmath and Winterstein (2019) demonstrated that an athlete's reporting skill (i.e., mastery of the actions required to report a concussion) is associated with higher intentions of reporting symptoms in comparison to concussion symptom knowledge. Reporting skill is typically unaccounted for when educating athletes on concussion symptoms, therefore without this consideration athletes may under or over report their symptoms. Overall, athlete report bias is a limitation to the reliability of the self-report measures used in this study.

From a statistical standpoint, the correlation analysis revealed age and history of concussion to be possible moderating variables. This suggests that these two variables may be influencing the strength and direction of the relationship between the four SCAT3 mood symptom items and the four outcome measures. Therefore, partial correlations were conducted to control for the possible influence of age and HoC. This was a statistical adjustment that was not

seen as a limitation. The study then conducted multiple linear stepwise regression analyses, which increased the probability of excluding predictors involved in suppressor effects. The use of a stepwise regression also increased the chance of a Type II error, suggesting that predictors that do in fact predict the outcome variable may have been overlooked. As a result of using a stepwise regression, clinical judgment was required to choose which models, or which predictor variables, contributed to the most variance in each of the four stepwise regression analyses. Taken together, although the sample size for this regression was large and representative, the use of a stepwise regression is still a significant limitation to this study.

Conclusions and Future Directions

In summary, the findings of this study determined that subjective symptoms on the SCAT3, specifically SCAT3-S, SCAT3-E, and SCAT3-NA appear to reasonably predict more comprehensive ratings of depression and anxiety. This suggests that the SCAT3 mood symptom items may be useful screeners for CFL athlete mental health. This information may help clinicians identify athletes dealing with mental health issues when more comprehensive questionnaires are not available.

When looking at the results of this study, it is also important to consider whether the subjective SCAT3 mood symptom items truly address the depressive and anxiety symptoms of CFL athletes. Although the SCAT3 is the most widely accepted NP assessment in concussion management, the mood symptoms presented in the symptom evaluation may not be enough to accurately predict psychological distress in more comprehensive measures. Further, it is also important to consider whether the more comprehensive measures of depression and anxiety (BSI-18 and PROMIS 29) accurately measure psychological distress. As seen in the results, the PROMIS-D did not account for much variance, and the anxiety measures predicted more overall

variance than either of the depression indexes. In conjunction with anxiety measures predicting more overall variance, the next step would be to identify what SCAT3 mood symptom scores are identifiable with athletes struggling with diagnosable anxiety disorders. Future studies should look at the normative data to determine which SCAT3 mood symptom scores are indicative of BSI-18 (t-score ≥ 63) and PROMIS 29 (t-score ≥ 60) anxiety scores worthy of a DSM-5 diagnosis (Cella et al., 2010; Recklitis et al., 2017).

Further, future studies should consider applying this study's measures to different populations. For example, future studies should look at different professional sports (i.e., basketball, soccer, baseball, etc.), different levels of competition and age (i.e., high school and collegiate), as well as female athletes to see if results differ. As indicated in the literature, gender has been seen to impact incidence and prevalence rates, therefore it is important to explore how females may respond differently to the quantitative self-report measures used in this study (Chiang Colvin et al., 2009; Covassin et al., 2003). Finally, these results may indicate the need for more sensitive measures for detecting depression and anxiety in CFL athletes. Future studies should look to explore more robust psychological tools when measuring psychological distress.

Overall, as a result of numerous high-quality, systematic studies, advancements have been made in the areas of SRC diagnosis and management. This study advocates for the same attention to be dedicated to athlete mental health after sustaining SRC. This increased attention would hopefully generate more research to improve intervention treatments and produce higher-quality methodology, ensuring more accurate diagnoses and management of athlete mental health. This study, and future studies like it, could advance SRC and mental health research, as well as increase awareness surrounding mental health screeners in sport.

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Appendix A: SCAT 3 Symptom Evaluation

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

Note. Adapted from “Evidence-based approach to revising the SCAT2: introducing the SCAT3” by Guskiewicz, K. M., Register-Mihalik, J., McCrory, P., McCrea, M., Johnston, K., Makdissi, M., ... & Meeuwisse, W. (2013). *British journal of sports medicine*, *47*(5), 289-293. Highlighted items are indicative of the four mood symptom items used in this study.

Appendix B: Active Rehabilitation Project - PROMIS 29 Anxiety and Depression Measure

ACTIVE REHAB

Quality of Life

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

0b. Clinician initials: _____

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

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

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

Quality of Life

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

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

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

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

Appendix C: Active Rehabilitation Project BSI-18 Measure

ACTIVE REHAB

Brief Symptom Inventory 18 (BSI-18)

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

0b. Clinician initials: _____

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

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

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

BSI-18

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

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

Appendix D: Active Rehabilitation Project Consent Form

Consent to Participate in a Research Study

T **tudy**: 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