An Examination of the Potential Long-Term Psychosocial Effects of Sport-Related Concussion in Adolescent Male Hockey Players

by

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Abstract

Purpose: The main objective of this study was to examine whether elite youth male ice hockey players with a medical history of one or more concussion(s) would exhibit more pronounced deficits in their psychosocial functioning than a non-injured control. **Methods:** The study had a cross-sectional design. Data was collected at the start of the regular 2011-2012 competitive hockey season. The sample included 394 male ice hockey players from elite Bantam (12-14 years) and Midget (15-17 years) divisions of play (AA-AAA). Player concussion history was retrieved from a take-home Preseason Baseline Questionnaire that was completed by the player with parental input. A BASC-2 Parent Rating Scale was also completed by the player's parent and used to measure variable outcomes relevant to psychosocial functioning. **Data Analysis:** A Univariate ANCOVA was conducted using SPSS software to determine if a significant difference existed amongst concussion groups (e.g.; no concussion; 1 concussion; 2 or more concussions) with respect to each BASC-2 PRS variable outcome. Age was inputted as a fixed variable. **Results:** In general, there were no significant differences between players with a medical history of one or more concussion(s) and a non-injured control. Players with a history of cumulative concussions (2 or more) did not show significantly worse outcomes than those who reported one prior concussion injury. A significant group difference was found with regards to the BASC-2 PRS Withdrawal Clinical Scale [$F(2, 390)=.4.768$, $p<.009$, $\eta^2=.024$]. **Conclusions:** Based on BASC-2 PRS data, adolescent male ice hockey players with a history of prior concussion(s) typically do not exhibit significantly poorer psychosocial outcomes.

Preface

This thesis is an original work by Eileen Noelle Chipchar. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project name "Elite Youth Ice Hockey Concussion Study 2011 (Edmonton)", No. Pro Ethics ID E-24026, v.1- 6/17/2011.

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CHAPTER ONE

Introduction

Background

Mild traumatic brain injury (mTBI) alone or in combination with other traumatic injuries is a common reason for patients to obtain medical services from healthcare providers worldwide. Statistics Canada reports that 98,440 Canadians (>12 years) had their daily activities interrupted by brain injury in 2009-2010, an outcome placing a significant burden on health care in Canada (Billette & Janz, 2011). Head injury also results in significant annual federal expenditures with $151 million in direct costs such as hospital fees, physician care, and drug expenses (Alberta Centre for Injury Control & Research, 2010). MTBIs, including concussions, account for 70-90% of all treated traumatic brain injury (TBI) events and represent a serious public health concern due to accompanying morbidity and even tragic cases of mortality (Cassidy et al., 2004; Echlin, 2010; Wiebe, Comstock, & Nance, 2011).

Amongst youth aged 15 to 24 years old, participation in sport-related activities is the second leading cause of TBI following only behind motor vehicle accidents (Sosin, Sniezek, & Thurman, 1996). A recent national survey study found that roughly 75% of Canadian youth between 5 and 17 years of age participate in organized sports each year (Canadian Fitness and Lifestyle Research Institute, 2010). Researchers have estimated that the likelihood of an athlete in a contact sport experiencing a recognized concussion is as high as 20% each season (Cantu, 2013). According to the New York Times, at least fifty youth football players (high school or younger) from twenty different states have died or sustained serious head injuries on the field since 1997 (Schwarz, 2007).

Despite these statistics, the vast majority of published medical investigations on sport-related concussions (SRCs) have focused solely on collegiate and adult athletes (Meehan, Taylor, & Proctor, 2011). Although this research datum provides some insight into the assessment and management of SRC, there is very little data that specifically addresses SRC in adolescent aged athletes (Kirkwood, Yeates, & Wilson, 2006). This is worrisome because the human brain continues to develop well into young adulthood. In turn, the effects of SRC on the immature brain are not well understood (Meehan et al., 2011).

Evidence collected from scientific research and documented clinical cases suggest that TBI in adolescents and children may differ significantly from TBI in adults (Meehan et al., 2011). Additionally, the youth-athlete may encounter more demands based on their day-to-day activities than any other age group. For instance, they are obligated to participate as active learners both within their school, home, and community environment. Within these settings, individuals are expected to acquire knowledge, develop novel skill sets, interact socially, and frequently demonstrate their cognitive functioning by means of informal and formal academic assessments. With that being said, the recommendations for managing a SRC in a young athlete should differ from those of an adult given the unique demands they encounter in their daily lives.

Current research has been primarily focused on the immediate acute symptoms in both cognitive and physical functioning (Williamson & Goodman, 2006). As a result, the extent to which SRC affects an individual's psychosocial functioning and development has often been overlooked in the literature. In addition, empirical studies that examine the behavioral outcomes of SRC (and cumulative concussions) are scant. Recent high profile cases of professional athlete suicide, mental illness, and substance abuse have highlighted the need to better understand the long-term psychosocial effects of SRC in athletes (Kamberg, 2011; Iverson, Echemendia, LaMarre, Brooks, Gaetz, 2012). Emerging research has also served to confirm that sustaining multiple concussions can have a cumulative and significant impact on cognitive, psychosocial, and behavioral welfare in the short term, especially in pediatric populations (Williamson & Goodman, 2006).

Purpose of the Present Study

The International Concussion Group has identified a need for more research related to psychosocial outcomes in youth (McCrory et al., 2009). The current study is proposed to address this gap in the scientific literature. An examination of psychosocial outcomes in young athletes with a history of concussion can better evaluate outcomes that may not become fully apparent until later on in the individual's adolescence (Anderson & Moore, 2007). The purpose of the current study is to evaluate such outcomes as they have emerged over the years following injury. Specifically, it is hypothesized that youth with a history of one or more concussions will have more significant psychosocial impairments with regards to their behavioral and emotional functioning when compared to normal controls. It is also hypothesized that these impairments will be more profound in youth-athletes who have sustained multiple concussions as opposed to those who have incurred a singular concussion. Finally, it is hypothesized that these impairments will adversely impact the individual's adaptive skills, which are foundational to appropriate social functioning.

The conclusions drawn from this study could serve to highlight some of the potential long-term adverse psychosocial effects of SRC in youth-athletes. Furthermore, it would draw attention to the developmental considerations unique to this vulnerable population, thereby challenging current concussion management guidelines that were designed based on post-concussive observations of adult populations (Lovell, 2008). It may also confirm that youth-athletes, who have a known medical history of SRC, require additional support both at home and within the school environment during the recovery period (Price, Floyd, Fagan, & Smithson, 2011).

By developing comprehensive concussion management plans that are administered systemically, youth-athletes will likely experience more efficacious recovery outcomes. This study may also highlight the utility of psychosocial measures, such as the BASC-2, as an additional diagnostic tool for SRC. In the event that a specific psychosocial deficit is observed, the practitioner can then venture to incorporate empirically validated interventions, thus increasing the likelihood of positive psychosocial outcomes for this particular population (McKeever & Schatz, 2003).

Summary

Chapter I provided a brief introduction to the topic of SRC in pediatric populations. To date, there is a lack of research examining the long-term effects of SRC on psychosocial functioning in youth-athletes. The current study aims to address this gap within the research literature.

Chapter II will present a review of relevant literature on SRC. The discussion will appraise what is currently known about SRC, while also providing an overview of SRC in pediatric populations specifically. Finally, it will introduce the research questions of the present study in an attempt to extend the research in this area.

Chapter III will describe the participants, instrumentation, and the procedure of the present study. The results of this study will be reported in Chapter IV and Chapter V will include the discussion portion of this thesis.

CHAPTER TWO

Literature Review

Overview

To provide context for the study in question, this chapter will provide a comprehensive review of the current research literature relevant to the study of SRC. The chapter will begin by examining the economic burden of TBI and epidemiology of SRC specifically, at the international, national, and local level. The chapter will then proceed to briefly discuss SRC within the medical literature and the current definition of SRC based on expert consensus. The underlying pathophysiology of SRC will then be explored, followed by an overview of SRC sequalae and second impact syndrome. The most recent recommendations regarding the assessment and management of SRC will also be briefly outlined and discussed. In addition, factors contributing to the recovery of SRC and areas of particular concern regarding the treatment of SRC will be highlighted. Emphasis will then be placed on reviewing the literature concerning SRC in pediatric populations and psychosocial outcomes. The chapter concludes with the proposed research questions for the current study.

Traumatic Brain Injury

According to the National Institute of Neurological Disorders and Stroke (2015), "Traumatic brain injury (TBI), a form of acquired brain injury, occurs when a sudden trauma causes damage to the brain." Contingent upon the source of trauma, a TBI is classified as either an open or closed head injury (Keatley & Whittemore, 2010). Closed head injuries typically occur when the head either endures a sudden collision with another object or when it experiences a violent acceleration/deceleration without contact. This form of trauma can cause bruising, stretching, and shearing of the axons and tearing of brain tissue. Open head injuries, on the other hand, occur when an object penetrates the skull, causing damage to specific areas of brain tissue.

Symptoms of a TBI can be mild, moderate, or severe depending on the extent of the damage to the brain (Centers for Disease Control and Prevention, 2015). In 1993, The Mild Traumatic Brain Injury Committee of the American Congress of Rehabilitation Medicine (ACRM) published a medical definition of mild traumatic brain injury (mTBI) (Arciniegas, Anderson, Topkoff, & McAllister, 2005). According to this definition, a mTBI is a traumatically-induced physiological disruption of normal brain function that results in at least one of the following: any period of loss of consciousness; any loss of memory for events immediately before or after the accident; any alteration in mental state at the time of the accident; or focal neurologic deficit(s) that may or may not be transient (Kay et al., 1993). In addition, the ACRM definition of mTBI includes injuries in which loss of consciousness is approximately 30 minutes or less, the duration of post-traumatic amnesia is less than 24 hours, and a Glasgow Coma Scale score of 13-15 post-injury. If the injury exceeds these criteria, it should be considered to be of more than mild severity.

The terms mTBI and concussion have on occasion been defined as distinct injury constructs. Some have argued that a concussion represents a transient state involving a relatively short recovery period while mTBI involves a more permanent and enduring alteration of brain function. In 2012, the Concussion in Sport Group (CISG) acknowledged that the terms mTBI and concussion have been used interchangeably within both the sporting context and medical research literature (McCrory et al., 2013). Therefore, for the purposes of this paper, the two terms will be used interchangeably.

History of Concussion in the Medical Literature

The underlying pathophysiologic basis for concussion has been the product of much debate within the medical literature (McCrory & Berkovic, 2001). More specifically, there have been two prominent perspectives regarding the mechanism of injury. First, there are those who contend that the mechanism of injury can be associated with lesser degrees of diffuse structural change, as observed with severe TBI. Alternatively, others argue that the mechanism of injury is the result of reversible functional changes. This lack of consensus amongst medical practitioners can be partially attributed to limited critical data, as well as confusion in terminology throughout history.

Head injuries and concussion have been discussed in medical literature for thousands of years (Solomon, Johnston, & Lovell, 2006). The Greek physician Hippocrates (460-370 BC) made many specific comments about the clinical symptoms of head injury in his writings stating, “In cerebral concussion, whatever the cause, the patient becomes speechless, falls down immediately, loses their speech, cannot see and hear” (Hippocrates, 1525; 1950). Thereafter, during the rise of the Roman Empire, Galen (2^{nd} century) attempted to characterize the neurological trauma he witnessed firsthand as surgeon to the gladiators. However, neither practitioner sought to distinguish concussion from other forms of brain injury.

It wasn’t until the conclusion of the first millennium, that an Arabic physician, Rhazes (c. 853-929), would become the first to delineate the nature of concussion in detail. He expressed a clear appreciation of the fact that a concussion could occur independently of any gross pathology or skull fracture (Muller, 1975). Therefore, he is often credited with identifying concussion as a distinct abnormal physiologic state rather than an extension of severe brain injury. This revelation would forever mark a critical turning point in the history of the medical understanding of this condition. However, his notion would later be at odds with the more widely accepted theory put forth by a French military surgeon. Ambroise Pare (1510-1590) argued that concussion is a kind of short lasting paralysis of cerebral function due to head and brain movement and that any associated fractures, hemorrhages or brain swelling were simply by-products of concussion rather than a direct cause of it (Denny-Brown & Russell, 1941; Frowein & Firsching, 1990; Muller, 1975; Ommaya, Rockoff, & Baldwin, 1964; Parkinson, 1982).

With the development of the microscope in 1694, and the advent of the Age of Enlightenment during the 18th century, medical minds began to forge a new pathophysiologic understanding of concussion (Shaw, 2006). As a result of the persuasive evidence amassed from numerous clinical case reports and detailed animal experimentation, the notion that a concussion was a distinct entity linked to significant neuropathological change rather than a mere transient phenomenon was yet again at the forefront. Subsequently, in 1801, Benjamin Bell, a neurosurgeon and entrepreneur at the Edinburgh Infirmary, formulated this classic definition,

> Every affection of the head attended with stupefaction, when it appears as immediate consequence of external violence, and when no mark or injury is discovered, is in general supposed to proceed from commotion of concussion of the brain, by which is meant such a derangement of this organ as obstructs its natural and usual functions, without producing such obvious effects on it as to render it capable of having its real nature ascertained by dissection (p. 353).

This definition has been widely reproduced within the current concussion literature, indicating that it remains a well-founded description of this medical condition which continues to mirror modern understanding (Foltz & Schmidt, 1956; Gronwall & Sampson, 1974; Haymaker & Schiller, 1970; Shetter & Demacus, 1979; Shaw, 2006; Ward, 1966).

Definition of Concussion

The word concussion was first coined in the 16th century and derived from the Latin concutere, which means "to shake violently" (Cantu & Hyman, 2013; Solomon, Johnston, & Lovell, 2006). Over the years, however, numerous definitions of concussion have since been developed and disseminated throughout the literature. This simply attests to the complexity of concussion as a condition and the multitude of differing medical opinions that exist amongst experts (Solomon et al., 2006). To further illustrate this point; below is a small sampling of the definitions offered by prominent organizations within the last century.

The Ad Hoc Committee to Study Head Injury Nomenclature of the Congress of Neurological Surgeons provided the following definition of concussion in 1966, "a clinical syndrome characterized by immediate and transient post-traumatic impairment in neural function, such as alteration of consciousness, disturbance of vision, equilibrium, etc. due to brain stem involvement due to mechanical forces" (Congress of Neurological Surgeons, 1966). While in 1997, The American Academy of Neurology defined concussion as:

> A traumatic induced alteration in mental status that may or may not involve loss of consciousness. Confusion and amnesia are the hallmarks of concussion. The confusional episode and amnesia may occur immediately after the blow to the head or several minutes later (Kelly & Rosenburg, 1997, p. 582).

Many professional groups perceive this lack of agreement as a major barrier to medical progress in terms of identification, diagnosis, and treatment of concussions (Solomon et al., 2006).

In November of 2001, the International Ice Hockey Federation, the FIFA Medical Assessment and Research Center, and the IOC Medical Commission organized and held a conference with the stated objective of providing recommendations for the improvement of the safety and health of athletes who suffer concussive injuries in ice hockey, soccer, and other sports (Cantu, 2006). Experts from various fields were invited to address specific issues regarding the epidemiology, basic and clinical science, grading systems, cognitive assessment, new research methods, protective equipment, management, prevention, and long-term outcome of concussive injury. At the conclusion of the conference, a small group of experts were given a mandate to draft a document that would subsequently be published in three separate journals. This document provided a revised definition of concussion as "a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces" (Aubry et al., 2002, p. 1).

This panel of concussion experts, now known as the Concussion in Sport Group (CISG), has continued to convene regularly over the last decade to refine their definition of concussion and address the initial issues put forth in light of emerging research findings and clinical data. The most current CISG definition serves to represent a consensus of opinion amongst prominent experts in the sports medicine field and therefore, it will be used for the purposes of this paper (McCrory et al., 2013). At the 4th International Conference on Concussion in Sport, CISG made minor revisions to the definition of concussion, and it is as follows:

> Concussion is a brain injury and is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces. Several common features that incorporate clinical, pathologic, and biomechanical injury constructs that may be utilized in defining the nature of a concussive head injury include:
>
> 1. Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an ''impulsive'' force transmitted to the head.

2. Concussion typically results in the rapid onset of short lived impairment of neurologic function that resolves spontaneously. However, in some cases, symptoms and signs may evolve over a number of minutes to hours.
3. Concussion may result in neuropathologic changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury, and as such, no abnormality is seen on standard structural neuroimaging studies.
4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course. However, it is important to note that in some cases symptoms may be prolonged (McCrory et al., p. 555).

Current understanding of concussion recognizes that pathologic damage may occur; however, the clinical features of concussion primarily reflect a functional neuronal disturbance. At present, the definition of concussion continues to be predominantly clinical in nature, and debate about the permanency of adverse symptoms continues to rage on.

Economic Burden of Traumatic Brain Injury in Canada

An estimated 98,440 Canadians (>12 years), or 2.4% of the population, sustained a TBI from 2009 to 2010 (Billette & Janz, 2011). Albeit occurring relatively less frequently than other personal injuries, head injuries, also known as traumatic brain injuries (TBI); are nonetheless noteworthy due to their often severe short- and long-term health implications including problems with memory, behavioural or personality changes, movement disorder, paralysis, change in vision, loss of hearing, persistent headaches or seizures, anger and impulse control problems, loss of motor function, impaired speech, loss of consciousness and death (Alberta Centre For Injury Control and Research, 2010). It should be noted that, mild traumatic brain injuries (mTBI), including concussions, account for 70-90% of all treated traumatic brain injury events in Canada (Cassidy et al., 2004). Of those injured approximately 57% (55,910) were working-age adults, 23% (22,720) were adolescents, and 20% (19,810) were seniors. When children under the age of 12 are accounted for, approximately 30% of those affected by TBI annually are school-aged children and adolescents (Alberta Centre For Injury Control and Research, 2010). TBI is the leading cause of morbidity and mortality in Canadian children, accounting for approximately 50% of all injury related deaths (Alberta Centre For Injury Control and Research, 2010; Chen & Wu, 2014).

From 2006 to 2008 an annual average of 2,227 Albertans were admitted to hospital for a traumatic head injury (Alberta Centre For Injury Control and Research, 2010). This admission rate remained consistent year to year. Males were twice as likely to be admitted to hospital for a TBI as females, accounting for 70% of annual admissions, or an average 1,565 admissions per year. Albertans between the ages of 15 and 24 years had the highest number of admissions with an average of 448 admissions each year. In the city of Edmonton, Alberta, the rate per 100,000 people treated in the Emergency Department for TBI between the ages of 10-14 and 15-19 was triple the rate for those 20-24 years old between 1997 and 2008 (Harris, Jones, Rowe, & Voaklander, 2012).

Children 9 years old or younger typically sustained a TBI during playground activities and when bicycling (Whyte, Benton, & Whyte, 2013). For youth between 10 to 19 years of age, males generally incurred TBIs while playing football or bicycling, whereas females incurred TBIs most often while playing soccer or basketball or while bicycling (Centres for Disease Control and Prevention, 2011; Whyte et al., 2013). In Canada, hockey, cycling, skiing/snowboarding/sledding, soccer, and football accounted for 59% of all TBIs requiring care (Harris et al., 2012).

In Canada, from 2000 to 2001, TBI accounted for $151 million in direct costs including hospital care, physician care, and drug expenses (Alberta Centre for Injury Control & Research, 2010). Furthermore, each severe TBI costs the Canadian medical system over $400,000 at the time of injury, with costs remaining approximately the same each year following the initial incident due to indirect expenses and follow-up treatment. The leading causes of TBI are falls, motor vehicle crashes, struck by or against events, and assaults (Langlois, Rutland-Brown, & Wald, 2006). In addition, sports and recreation activities have been identified as a major cause of TBI, especially among children and adolescent populations.

Sport Participation Rates in Canada

According to national survey data collected in 2010, one-third of Canadian men and one-sixth of Canadian women regularly participated in sport (Canadian Heritage, 2013). Young Canadians (age 15 to 19 years) had the highest participation rate in sport at 54%. While another survey study found that 75% of children and youth between 5 and 17 years of age participate in sport (Canadian Fitness and Lifestyle Research Institute, 2013). Gender appears to influence the rate of sport participation for children and youth-athletes; with more boys (81%) than girls (70%) participating in sport. It is estimated that 35% of all personal injuries suffered by Canadians occurred while participating in a sport or recreational activity. More specifically, 40.7% of males and 27.5% of females reported having sustained a sport-related injury. Among adolescents (aged 12 to 19 years) two–thirds (66%) of all injuries were sport-related. This rate of sport-related injury is twice as high as working-age adults (29%) and roughly seven times higher than seniors (9%).

Epidemiology of Sport-Related Concussion and Underreporting

TBI is a major cause of long-term disability around the world (Hyder, Wunderlich, Puvanachandra, Gururag, & Kobusingye, 2007). Each year an estimated 10 million people are affected by TBI, and by 2020, it will likely surpass other diseases as the leading cause of death and disability (Humphreys, Wood, Phillips, & Macey, 2013). The Centre for Disease and Control estimates that approximately 300,000 individuals acquire a TBI while participating in sport and recreational activities annually in the United States (Thurman, Branche, & Sniezek, 1998). This estimate may vastly underestimate the true prevalence of sport-related TBI because the majority of these injuries (81–92 %) are mild or moderate in nature making it common for them to go unrecognized by athletes; and, therefore unreported to coaching staff (Khurana & Kaye, 2012; Langlois, Rutland-Brown, & Wald, 2006). Within the context of sport, concussions have continued to be viewed by some as “primarily transient, routine events that occurred with regularity during athletic contests and rarely taken very seriously” (Solomon, Johnston, & Lovell, 2006, pg. 8). Traditionally, concussions were referred to as a “ding” or a “bell-ringer” by many sports medicine professionals (Yarnell & Lynch, 1973).

Only within the last decade or so, has the word “concussion” appeared with any regularity within the pages of weekly sports listings of professional athletes’ injuries (Solomon et al., 2006). Because a concussed player is often able to participate effectively to some degree in immediate play, the injury may be overlooked unless observant coaching staff or other players recognize and report it (Noble & Hesdorffer, 2013). In other instances, the athlete may also be disinclined to remove themselves from play due to extrinsic motivating factors. Players have reported the following reasons for nondisclosure to researchers: not wanting to leave the game; appear weak or injury-prone to the coach; risk playing time or a starting position; and/or, let their teammates down (Carroll & Rosner, 2011). Subsequently, players may endeavor to minimize and/or conceal the fact that they had sustained a concussion. With this in mind, a more accurate annual estimate for sport-related TBI among American athletes would likely be between 1.6 to 3.8 million injuries, including those for which no medical attention is sought (Khurana & Kaye, 2012; Langlois et al., 2006).

SRC is the most common form of TBI associated with sports play, and is a major public health problem particularly among children and adolescents (Institute of Medicine's Committee on Sports-Related Concussions in Youth, 2013). In the last decade, the number of children and adolescents visiting the emergency department for sport and recreation-related concussions has increased by 62% (Gilchrist, Thomas, Xu L, et al., 2011). From 1997 to 2008 there has been an increase in the annual concussion rate amongst American high school athletes of 16.5% with the overall concussion rate estimated to be 2.4 to 2.5 injuries per 10000 athletic exposures (AEs) (Lincoln et al., 2011). An AE simply refers to a singular practice or athletic competition (Marar, McIlvain, Fields, & Comstock, 2012). This rise in injury rate may be partially attributed to an overall increase in public awareness about SRC (Weinberger & Briskin, 2013).

Pathophysiology of Sport-Related Concussion

Immediately after a significant biomechanical force to the brain, the neuronal membrane deforms, which initiates a neurometabolic cascade of events (Barkhoudarian, Hovda, & Giza, 2011; Giza & Hovda, 2014). At the cellular level, a myriad of neurotransmitters begin to rapidly enter and exit through the lipid membrane creating a state of ionic flux and depolarization (Barkhoudarian et al., 2011). First, the neurotransmitter glutamate is released indiscriminately in above normal volumes (up to 50% above the normal rate) (Solomon, Johnston, & Lovell, 2006). If glutamate reaches a high enough volume, it can prove toxic to nerve cells.

Concurrently, there is an accelerated mass exodus of potassium from neuronal cells (up to 400% above the normal rate) (Solomon et al., 2006). If the level of potassium exceeds a critical concentration it can significantly disturb electrical processes within the brain such as the action potential and the individual may lose consciousness. Within the first two minutes following a concussive impact, blood flow within the brain decreases by approximately 50%. According to Giza and Hovda (2014), intracellular calcium flux occurs early (at up to 500% the normal rate) and tends to persist longer than other ionic disturbances. The brain attempts to address this calcium flux by temporarily allowing the calcium to be sequestered into neighboring mitochondria. Over time, this quick fix can lead to mitochondrial dysfunction, intensifying issues pertaining to oxidative metabolism and exacerbating the cellular energy crisis which will be described in greater detail below.

The neurometabolic cascade causes the brain to enter into a physiologic state referred to as hypermetabolism. According to Solomon and colleagues (2006) this can be described as a period of, "Distinctly increased activity in physical and chemical processes by which the body produces, maintains, and transforms energy" (p.29). In essence, the brain finds itself caught in an energy crisis. Ionic pumps within the cellular membrane are working tirelessly to re-establish ionic and cellular homeostasis, but due to depleted cerebral blood flow and limited energy reserves, including low levels of adenosine triphosphate (ATP), they are unable to address these issues effectively (Giza & Hovda, 2001).

The brain usually remains in such a state for a day or more. In general, it takes roughly 3.5 minutes for glutamate levels to return to baseline within the brain (Solomon et al., 2006). Potassium is subject to a longer restoration period of approximately 20 minutes. Finally, it may take upwards of 3 days for calcium to return to normal, and blood-flow usually requires a week or more to return to baseline rates post-concussion. Once this concludes, the brain enters into a state hypometabolism, which is characterized by an overall decrease in activity. This usually lasts between 5 to 10 or more days, until auto-regulation of blood flow and electrochemical processes are restored to normal.

The neurometabolic cascade can lead to damage of the microstructural components of neurons within the brain (Giza & Hovda, 2014; Solomon et al., 2006). More specifically, the influx of calcium can damage the axon’s neurofilaments; thus, compromising the structural integrity of the axon (Giza & Hovda, 2014; Pettus & Povlishock, 1996). Additionally, axons are particularly sensitive to biomechanical stretch. Axonal stretch can occur following either a linear or rotational impact to the brain and can lead to the destruction of microtubules. This can adversely affect neurotransmission and in severe cases can lead to neural disconnection. It should be emphasized that in the context of a singular SRC, these changes are thought to be somewhat self-limited and transient; however, there is growing evidence to suggest that repeat injuries may lead to a more enduring pathobiologic condition (Barkhoudarian et al., 2011).

Recent advances in the study of SRC have served to better illuminate the underlying neurobiology of concussive injuries (Giza & Hovda, 2014). This has allowed researchers to propose links between specific aspects of the neurometabolic cascade to clinical characteristics observed in injured patients. Subsequently, a more coherent understanding of the relationship amongst acute pathophysiology, long-term biological changes, and chronic sequelae may soon be a realized. For a detailed description, the interested reader should refer to Giza and Hovda (2014).

Acute and Chronic Sequalae or Sport-Related Concussion

The duration of symptoms following a SRC is variable (Center for Disease Control & Prevention, 2015). Although the vast majority (80% to 90%) of SRCs resolve within 7 to 10 days, roughly 10-15% of concussed athletes will experience persistent symptoms (McCrory et al., 2005; McCrory, et al., 2013). Moreover, athletes who initially appear asymptomatic following an impact may experience a delayed onset of symptoms (McCrory, et al., 2009). In the event of delayed recovery, practitioners should endeavor to rule out co-existing conditions. In addition, vulnerable populations, such as children and adolescents, may require special consideration as they tend to experience a longer recovery period (McCrory, et al., 2005).

Medical practitioners typically diagnose a SRC injury based on a thorough evaluation of the following patient domains: somatic and cognitive symptoms; physical signs; emotional and behavioral changes; and, sleep disturbances (Halstead & Walter, 2010; McCrory, et al., 2009; Upshaw et al., 2012). In a study examining SRC in high school athletes the most commonly reported symptoms were headache (94.3%), dizziness/unsteadiness (75.5%), difficulty concentrating (53.9%), confusion/disorientation (44.0%), and visual disturbance/sensitivity to light (34.4%) (Meehan, d'Hemecourt, Collins, & Comstock, 2012). Additional research indicates that approximately 90% of SRC do not involve loss of consciousness (LOC) (Cantu, 2006). Contrary to previous medical beliefs, LOC should not be considered an effective classification symptom.

As previously alluded to, common physical symptoms of a concussion include headache, nausea, vomiting, sensitivity to light and noise, visual and vestibular disturbance, and fatigue (National Institute of Neurological Disorders & Stroke, 2002). The individual may also report a heightened awareness of physical aches and pains (Keatley & Whittemore, 2010). According to

Keatley and Whittemore (2010), individuals typically describe the pain experience as sharp, dull, aching, burning, and throbbing. Individuals affected by concussions are likely to sleep either more or less than usual, and report having difficulty falling asleep (Centers for Disease Control & Prevention, 2015). It should be noted that prolonged pain has been linked to sleep disturbance as well as negative affect including feelings of fear, depression, anxiety, and anger.

SRC may also contribute to cognitive impairments that can affect a person's routine functioning and ability to return to work or school (Langlois, Rutland-Brown, & Wald, 2006). The most persistent cognitive problems include memory impairment and difficulties with attention and concentration (National Institute of Neurological Disorders & Stroke, 2002). In this case, the individual might report feeling mentally "foggy" or "slowed down." Deficits in frontal lobe functioning may also be observed, resulting in impaired executive skills in areas such as problem-solving, judgment, planning, information processing, and organization (National Institute of Neurological Disorders & Stroke, 2002).

Behavioral consequences may include verbal and physical aggression, learning difficulties, impulsivity, and an inability to inhibit certain behaviors. For example, individual's suffering from TBI may engage in excessive gambling and shopping as well as substance abuse (Keately & Whittemore, 2010). These issues may contribute to greater financial difficulties. In addition, research has found that there is an increased likelihood for the development of Mood Disorders, personality changes, altered emotional control, depression, and anxiety following injury (National Institute of Neurological Disorders & Stroke, 2002).

Over the course of the last two decades, researchers have found that certain observable signs and symptoms may provide a proximate indication of injury severity following an impact (Putukian, 2011). These include but are not limited to amnesia, prolonged confusion, neurocognitive deficits, and/or balance dysfunction (Collins et al., 2003; Erlanger et al., 2003). Although a diagnosis of SRC can occur in the absence of loss of consciousness (LOC), the presence of prolonged LOC, lasting one minute or more, has been linked with increased injury severity (McCrory et al., 2013). Furthermore, concussed athletes who report fatigue, fogginess, prolonged headache (60 hours of more), and/or four or more symptoms tend to have lengthier recovery times as indicated on cognitive tests (McCrory, Ariens, & Berkovic, 2000). These predictors have since been taken into consideration with regards to the assessment of SRC injuries.

Postconcussion syndrome is another notable concern pertaining to the treatment of SRC (Giza & Kutcher, 2014). An athlete who exhibits persistent symptoms lasting for a period of 3 months to a year or more may be eligible for this particular diagnosis (Centers for Disease Control and Prevention, 2015; Jordan, 2013). The presence of this chronic sequalae has been well documented in professional athletes, particularly those who have had long careers in contact sports (Giza et al., 2013). In the absence of research evidence, it is uncertain whether these impairments are progressive in nature. Given that some aspects of prolonged postconcussion syndrome closely approximate those regularly observed in psychiatric disorders, the implementation of empirically proven psychological approaches may be a justifiable treatment option (Donnell, Kim, Silva, & Vanderploeg, 2012; Noble & Hesdorffer, 2013).

Chronic traumatic encephalopathy (CTE) is a medical disease commonly diagnosed post-mortem in retired athletes and military personnel (McKee et al., 2013). The disease is marked by a pronounced accumulation of tau protein causing neurofibrillary tangles to develop throughout the brain (Wing & James, 2013). The outward materialization of this disease can take on many forms such as mood disturbances, parkinsonism, ataxia, dysarthric speech, poor concentration, impaired attention, memory loss, and behavioral outbursts (McKee et al., 2009; Wing & James, 2013). Many professional athletes with a known medical history of cumulative SRC have gone on to publicly acknowledge their ongoing battle with depression, substance abuse, anger, and suicidal ideation (Nowinski & Ventura, 2011). There has been a great deal of speculation as to whether or not a causal link between CTE and earlier concussions decidedly exists. If evidence for this assertion is found, it would imply that the disease has a progressive neurodegenerative course. Although some have claimed that CTE is essentially synonymous with dementia pugilistica, others have continued to classify it as distinct type of chronic TBI (Jordan, 2013; McKee, Stein, Nowinski, et al., 2013; Stern et al., 2013).

Assessment of Sport-Related Concussion

SRC is commonly perceived to be amongst the most complex injuries to diagnose, assess, and manage (McCrea, Iverson, Echemendia, Makdissi, & Raftery, 2013). At present, there is no foolproof diagnostic test or biological marker that can act to establish the presence of a concussion irrefutably within the immediate sporting environment (McCrory et al., 2013). In fact a hallmark of SRC is that neurological signs and symptoms exist in the absence of macroscopic neural damage (Giza & Hovda, 2014; McCrory et al., 2013). A SRC is generally considered to be a functional or microstructural injury to neural tissue rather than a structural injury (Giza & Hovda, 2014). More definitively, the injury results in disturbed cellular and/or physiological functioning that is not readily visible on computed tomography (CT) scans or magnetic resonance imaging scans (MRI). As a result, clinical diagnosis and recommendations for return to play (RTP) are primarily based on the observed injury mechanism, signs, behaviors, and difficulties with cognition and/or balance following the initial impact (Chen, Johnston, Collie, McCrory, & Ptito, 2007; McCrea et al., 2013; Putukian, 2011).

Appraising the severity of a SRC at the time of injury with the resolve to establish useful prognostic information, such as RTP guidelines, has prompted the creation of a wide array of grading and classification systems (Cantu, 1998; Colorado Medical Society School and Sports Medicine Committee, 1994; Kelly et al., 1997; Solomon et al., 2006). In the past, popular grading scales have included those of Dr. Cantu (1986, 2001) and the 1997 American Academy of Neurology (AAN) Practice Parameter (Kelly et al., 1997). Although the premise of such a diagnostic tool is appealing, these scales have largely been abandoned by medical practitioners in recent years due to insufficient empirical support (Putkian, 2011). For example, Hinton-Bayre and Geffen (2002) found no correlation between the grade of concussion and the level of neurocognitive impairment in rugby players. These results highlight the fact that all grading scales, with the exception of Dr. Cantu's Evidence-Based Rating Scale (2001),were developed based solely on clinical experience and expert consensus rather than scientific data regarding the recovery process (Bender, Barth, & Irby, 2004; Solomon et al., 2006).

Management and Return to Play Guidelines

The CISG unanimously agreed that in the event of a suspected SRC, an athlete should not be permitted to return to play (RTP) on the same day of injury (McCrory et al., 2013). The phrase, "When in doubt, sit them out!" captures this approach to suspected SRC management quite succinctly (Aubry et al., 2002). Studies with collegiate and high school athletes have shown that concussed athletes who were authorized to RTP on the same day often experience a delayed onset of symptoms as well as deficits in neuropsychological functioning (Collins et al., 1999; Collins et al., 2002; Collins et al., 2003; Guskiewicz et al., 2003; Lovell, Collins, & Bradley, 2004; McCrea et al., 2003; McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004). It should be emphasized that sideline evaluation cannot be used to accurately assess SRC as it evolves;

therefore, RTP decisions that occur on the same day of injury may unintentionally exacerbate the athlete's injury.

During the initial period following a SRC, a concussed athlete should be advised to refrain from physical and cognitive exertion until their acute symptoms have resolved (McCrory et al., 2013). Standard RTP protocol involves a stepwise procedure in which the athlete progresses from one level to the next, typically over the course of a week. This rehabilitation procedure is initiated once the athlete is asymptomatic both at rest and during strenuous exercise. Each level should take approximately 24 hours; however, if symptoms should return at any point, the athlete must drop back a level and engage in 24 hours of complete rest. Following this rest period, the athlete can once again attempt to progress to the next level. After the athlete has successfully completed all of the designated levels without exhibiting SRC symptoms, they may RTP.

During the acute recovery period certain cognitive stressors may worsen symptoms (Halstead et al., 2013). Some examples include video games, loud or bright TV/movies, and prolonged computer usage (Giza, 2014). Return to learn decisions should be determined based on symptoms and cognitive testing. Student athletes should be discouraged from extended absences from school; however, temporary academic accommodations may be necessary and should be developed collaboratively with school personnel. Overall, studies evaluating the long-term effects of rest post-injury are finite and clinical recommendations regarding the optimal duration and type of rest are not well substantiated. Nonetheless, the CISG suggests that a reasonable approach to post-injury rest should involve the gradual re-integration of activity into the athlete's daily routine to an extent that avoids further aggravating their symptoms (McCrory et al., 2013).

As discussed previously, the majority of SRC injuries will resolve within a period of several days. Under these ideal circumstances, the athlete is expected to steadily advance through a stepwise RTP procedure without complication (Johnston et al., 2004). Individuals who experience delayed recovery may benefit from low-level exercise, although the optimal timing of this treatment post-injury has yet to be established within the research literature. A recent study conducted by Leddy and colleagues (2010) demonstrated that subthreshold exercise improved postconcussion symptoms in concussed athletes without negative side-effects. In situations where the athlete experiences persistent affective symptoms, psychological approaches may be an appropriate consideration for SRC management (Bloom, Horton, McCrory, & Johnston, 2004; Weiss & Gill, 2005).

Repeated Injury and Second Impact Syndrome

Elevated susceptibility for repeated injuries is a palpable aspect of SRC (Giza & Kutcher, 2014). The risk for repeated injury is greatest in the first 7–10 days after RTP, possibly during the initial asymptomatic period (McCrea et al., 2009).The exact rate of repeat TBI broadly ranges from as low as 5.6% to as high as 36% of all individuals with a diagnosed TBI (Prins & Giza, 2012). Higher rates are likely to be observed amongst those who are actively engaged in contact sports. According to Noble and Hesdorffer (2013), severe and repeated concussions can lead to decidedly poorer cognitive outcomes including slower recovery, persistent cognitive impairment and acute and chronic neuropsychiatric symptoms including late-life depression (Gardner, Shores, & Batchelor, 2010; Guskiewicz et al., 2003; Guskiewicz et al., 2005; Guskiewicz et al., 2007). Perhaps a more alarming reason why repeated injury following a SRC is of concern to all those involved in the player's recovery, is the unknown probability of second impact syndrome (Cantu, 1998).

In the early 1970s, Richard Schneider documented two unusual cases in which a young athlete, after having sustained a SRC, died abruptly following what appeared to be a minor secondary head injury (Schneider, 1973). The term second impact syndrome (SIS) was later coined by Saunders and Harbaugh (1984), after having documented a similar case involving the death of a 19-year-old college football player. In this case, the player had received immediate clearance to RTP, despite having experienced a head injury involving brief LOC earlier in the game. Afterwards, the athlete continued to report a headache until he eventually collapsed several days later and died. In his autopsy report there was no indication of either a space-occupying hematoma or extensive cerebral edema (Wetjen, Pichelmann, John, & Atkinson, 2010). Cumulative brain injury is associated with disordered cerebral autoregulation that leads to diffuse cerebral swelling and herniation (Cantu, 1998; McCrory & Berkovic, 1998). The estimated mortality rate of SIS ranges between 50% and 100%.

SIS is typically said to occur when an individual sustains a second concussion prior to fully recovering from an initial concussion (Marshall, 2012). In younger athletes, the ionic imbalance and energy deficit that ensues following the initial injury creates a situation within the brain that may impede its ability to sufficiently manage the adverse effects of a second neurometabolic cascade. It is hypothesized that the additional calcium influx, mitochondrial dysfunction, and loss of cerebral blood-flow can subsequently lead to massive cerebral swelling, and in some cases patient death (Cantu, 1998; Cantu & Register-Mihalik, 2011; Giza & Hovda, 2001; Signoretti, Lazzarino, Tavazzi, & Vagnozzi, 2011; Vagnozzi, Signoretti, Cristofori, et al., 2010). The lack of empirical evidence relevant to the study of SIS has made this rare diagnosis controversial. Some have gone so far as to suggest that this condition may not even exist.

Although there have only been 17 documented cases involving what appears to be a true second impact syndrome resulting in patient death, researchers have nonetheless established that a period of heightened brain vulnerability occurs following a concussion (McCrory, Davis, & Makdissi, 2012). This period of vulnerability is marked by depleted energy reserves within the brain, including low levels of adenosine triphosphate (ATP), and evidence of unresolved metabolic deficiencies. A second concussive impact serves to further exacerbate ATP depletion leading to prolonged recovery times (Giza & Hovda, 2001; Longhi et al., 2005; Signoretti, Vagnozzi, Tavazzi, & Lazzarino, 2010; Vagnozzi et al., 2005; Vagnozzi et al. 2007).

Risk Factors and Gender Differences

Evaluation of risk is a central component to effective concussion management (Kutcher & Eckner, 2010). RTP decisions should hinge on a careful evaluation of the associated risks involved such as possible symptom exacerbation, subsequent concussion, or catastrophic injury. An inherent risk of injury inevitably exists for every athlete; however, an athlete's propensity to injury may stem from several identifiable risk factors.

A small percentage of the general population may possess a genetic predisposition to SRC injury (Kerr, 2014). Even though two individuals may experience an impact of the same magnitude, the subsequent outcome will not necessarily be the same for both. There is an observable tendency towards either a tolerance or susceptibility to a SRC injury that varies on an individual basis. While not verified, this phenomenon has been linked to gene APOE4 as well as neurotransmitter excitation at the cellular level (MrCrory et al., 2009; Terrell et al., 2008). Other biomechanical properties that may influence injury susceptibility include greater thickness of the skull, more cerebrospinal fluid, presence of Arnold-Chiari malformation, and properties of the cervical spine such as limited strength, range of motion, and flexibility (Kerr, 2014).

Kutcher and Eckner (2010) assert that, "Gender is emerging as an important consideration in concussion management" (p. 17). Overall, the total concussion rate is almost two times higher for boys than girls (3.1 vs 1.6 per 10000 AEs) (Lincoln et al., 2011). This is likely due to the fact that boys generally have much higher participation rates in contact sports, specifically football. In gender comparable sports, the reverse is observed; the total concussion rate is almost two times higher for girls than boys (1.7 vs 1.0 per 10000 AEs) (Lincoln et al., 2011). The source of this discrepancy in gender has yet to be determined; however, the majority of studies have examined differences in neck strength, symptom reporting, socialization, and hormones (Giza & Kutcher, 2014; Preiss-Farzanegan, Chapman, Wong, Wu, & Bazarian, 2009; Tierney et al., 2005; Wunderle, Hoeger, Wasserman, & Bazarian, 2013;).

Research indicates that female athletes typically present with more acute concussion symptoms and experience longer recovery periods following a SRC than male athletes (Broshek et al., 2005; Colvin et al., 2009). Recent investigations have found that women who have incurred a SRC reported greater total symptoms and decreased reaction time than injured males (Broshek et al., 2005). In addition, females reported increased symptoms, mainly with regard to headache, dizziness, fatigue, and poor concentration in comparison to their male counterparts (Preiss-Farzanegan et al., 2009). Broshek and colleagues (2005) also found that female athletes tend to report more concussion symptoms than male athletes.

Some have speculated that this disparity in self-reporting of SRC symptoms can be attributed to the nature of the male sporting environment, particularly in contact and collision sports (Covassin & Elbin, 2011). Masculinity and toughness are often emphasized as desirable athletic traits amongst males, which likely imposes added pressure to conceal one's symptoms. It is not uncommon for a male athlete to receive praise for "toughing it out" and playing in spite of injury. There is also evidence to suggest that female athletes may be more concerned about the long term implications of injury on their future health when compared to male athletes (Granito, 2002). Differences within the social context of sport may partially account for the observed gender discrepancies in self-reporting of symptoms following a SRC.

Age at the time of injury appears to be a risk factor that holds across gender, with young athletes particularly vulnerable to sustaining an initial concussion injury and experiencing poorer recovery outcomes (McCrory et al., 2013). Research has shown a higher incidence rate for SRC amongst high school athletes when compared to adult populations (Lovell, Collins, Iverson, Johnston, & Bradley, 2004; McKeever & Schatz, 2003; Webbe & Barth, 2003). Following a SRC, high school students require an average of 10-14 days to return to pre-concussion baselines on neurocognitive tests whereas collegiate and professional athletes only require 5-7 days and 3-5 days respectively (Field, Collins, Lovell, & Maroon, 2003; Grady, 2010; Pellman, Lovell, Viano, & Casson, 2006). Moreover, there is evidence to suggest that high school athletes may experience enduring neurocognitive deficits that supersede the resolution of self-reported symptoms (Lovell et al., 2003; Van Kampen, Lovell, Pardini, Collins, & Fu, 2006).To further illustrate this point, a recent investigation found that high school athletes, who report being asymptomatic, experienced lingering verbal memory deficits nearly 14 days after the initial SRC incident (McClincy, Lovell, Pardini, Collins, & Spore, 2006). Even more alarming, 26% of concussed-athletes who indicate that they are ready to RTP continue to exhibit deficits on neurocognitive tests (McCrea et al., 2003).

The underlying cause of this discrepancy in concussion vulnerability between pediatric and adult populations remains unknown (Karlin, 2011). Following a moderate to severe TBI, studies have shown that children endure a more prolonged and widespread cerebral swelling than adults (Pickles, 1950). It has been theorized that the immature brain may be more sensitive to certain aspects of the neurometabolic cascade including the accelerated release of glutamate within the brain (McDonald & Johnston, 1990). This pathophysiological sensitivity may be causally linked to longer recovery times in youth-athletes post-concussion (Reddy, Collins, & Gioia, 2008). Yet another distressing notion is that the injured brain's normal neuronal developmental trajectory may be distorted due to disturbances caused by trauma (McCrory, Collie, Anderson, & Davis, 2004).

Additional characteristics of the immature brain that have been attributed to increased vulnerability include larger head-to-body ratio, thinner cranial bones, a larger subarachnoid space, and cerebral blood volume (Karlin, 2011). The immature brain may be particularly susceptible to shear injury as a result of deficient myelination and the elasticity of the skull vault (Cook, Schweer, Shebesta, Hartjes, & Falcone, 2006; Kieslich, Fielder, Heller, Kreuz, & Jacobi, 2002; Ommaya, Goldsmith, & Thibault, 2002). Although overall weight and mass gain may be observed in youth-athletes due to puberty, the neck and shoulder musculature has not yet fully developed. Subsequently, this creates a scenario where force and momentum applied from the head impact to the rest of the body are both increased and less likely to effectively dissipate (Buzzini & Guskiewicz, 2006).

In early animal studies, a standard procedure for examining head injury involved administering a concussive blow to the specimen's head using a pendulum apparatus (Denny-Brown, 1941; Marshall, 2012). Results from these studies revealed that a concussive injury would not occur if the head and neck of the specimen were fixed in place; while, even slight movement of the head during the same impact led to a concussion injury (Denny-Brown, 1941; Marshall, 2012). During football impacts, it was similarly found that forces in the neck influenced head acceleration of the struck player and that increased neck stiffness served to stabilize the head and decrease acceleration (Vianno, Casson, & Pellman, 2007). This has subsequently led to the notion that increased neck strength may decrease the risk of concussion.

A recent examination of adolescent hockey players found no evidence to support this hypothesis (Mihalik et al. 2011). This is likely due to the fact that overall neck strength doesn't necessarily lead to increased neck rigidity. In order for neck strength to effectively decrease the acceleration of the head caused by impact, the player must purposefully contract his or her cervical musculature preceding the impact itself (Marshall, 2012). This implies that the player must be aware of an imminent collision prior to impact, in order to allow sufficient time to effectively contract their cervical musculature and decrease their overall risk of SRC (Dezman, Ledet, & Kerr, 2013; Kumar, Narayan, Amell, 2000; Marshall, 2012; Mihalik et al., 2010). This could partially explain why during a collision, it is less probable that the player delivering the hit will sustain a SRC than the struck player.

Preexisting conditions have also been found to increase an athlete's propensity to SRC injury and delayed recovery times (McCrory et al., 2009). Examples may include attention-deficit/hyperactivity disorder (ADHD), migraine headaches, or mood disorder. Research in children with mTBI have suggested that a primary cause of chronic symptomatology and neurocognitive impairment is related to pre-existing behavioral and environmental conditions (Babikian, McArthur, & Asarnow, 2013; Giza, 2014; McNally et al., 2013). Several studies examining TBI in pediatric populations suggest that 30% to 50% of children with an mTBI had a pre-injury lifetime psychiatric disorder (Brown, Chadwick, Shaffer, Rutter, & Traub, 1981; Max et al., 1997; Max et al., 2005; Max et al., 2012).

To further substantiate this finding, Bijur and colleagues (1988) examined epidemiologic data from a birth cohort with data points at age 5 years and at age 10 years. They found that children who eventually went on to sustain an injury during this 5 year period had greater behavioral problems before their injuries compared with uninjured children (Max, 2014). Some have posited that children with certain pre-injury diagnoses such as ADHD tend to exhibit elevated levels of impulsivity and risk-seeking behaviors that serve to increase the overall likelihood of injury (Gerring et al., 1998).

Sport-Related Concussion and Pediatric Populations

There is a growing consensus amongst medical experts that additional research is needed in order to better understand the long-term effects of SRC in youth-athletes (Iverson, Echemendia, LaMarre, Brooks, & Gaetz, 2012). The vast majority of research studies examining SRC are based upon collegiate and adult populations. Given the considerable lack of age-related research for youth-athletes, healthcare practitioners commonly recommend injury management strategies that were developed and intended for use with collegiate and adult aged individuals rather than those within the pediatric population (Karlin, 2011). Therefore, it is fair to assume that these guidelines may be limited in their capacity to appropriately address the unique physiological properties of the developing pre-adolescent and adolescent brain.

Emerging research indicates that a concussion sustained during childhood or adolescence rather than in adulthood may have a more pronounced effect on the individual long term (Anderson & Moore, 2007). It has been suggested that well known skills are less vulnerable to head injury than skills that are in the process of being developed or have yet to emerge within the immature brain (Anderson & Moore, 2007; McKinlay, 2009). Therefore, a head injury incurred during one's early life has the potential to adversely impede the developmental trajectory of an individual across a variety of adaptive functional domains. In light of this, Lazar and Menaldino (1995) have urged clinicians to take a developmental perspective when working with youth who have suffered a TBI. This involves expressly recognizing that the recovery process exists within the context of maturational and developmental changes (Lazar & Menaldino 1995; McKinlay, 2009).

Several studies have examined the effect of mTBI on emerging skills in child and adolescent populations. A study by Barnes et al. (1999) found that reading skill level varied depending on the individual's age at the time of injury. Results revealed that children who suffered a mTBI prior to the age of six had poorer reading skills, including word identification and passage comprehension, than participants who had been injured between the ages of six and nine. The discrepancy in reading skill level was even more pronounced when these results were compared to those who had suffered a mTBI after 9 years of age. In a more recent study, Donders and Warschausky (2007) compared individuals who experienced a complicated mild to severe TBI between the ages of 16 and 20 with individuals who were injured between the age of 6 and 12. Those who sustained a head injury earlier in life showed more noticeable signs of long-term deficits in skills including social integration, driving and legal guardianship. Based on these and other research findings, it would appear that the developmental stage of the child at the time of injury may contribute to the long term outcomes experienced by the individual following an mTBI (Barnes & Dennis 2001; Keenan, Hooper, Wetherington, Nocera, & Runyan, 2007; Turkstra, Williams, Tonks, & Frampton, 2008; Wrightson et al., 1995).

As emphasized by Satz et al. (1997), a youth and an adult encounter different life experiences that serve to influence the course of recovery following mTBI in distinct ways. In general, youth exhibit the same common cognitive outcomes as adults following a concussion;

these include compromised executive functioning, poor attention span, and a reduced rate of information processing (McCrory, Collie, Anderson, & Davis, 2004). However, the secondary impact of these cognitive impairments can be especially problematic for a youth-athlete given the nature of their day-to-day activities. In essence, learning or acquiring new knowledge and skills is a child's "major job." In order for a student to effectively meet the demands of a classroom environment, he or she must rely heavily on these cognitive processes to successfully navigate learning activities and social interactions with peers (McCrory et al., 2004). This leads to increased levels of cognitive exertion far beyond that which is typically experienced by adults during their recovery process.

Following a SRC, the youth-athlete may also experience symptoms that can significantly impact their academic performance. These may include a decline in reading comprehension, difficulty recalling new or previously learned material, and an inability to hold instructions in mind (Karlin, 2011). In addition, the student may experience a decreased capacity to focus on lectures, complete tests, and finish homework assignments on time. Injury related sleep disturbances can serve to impede a student's ability to engage in early morning activities due to decreased arousal levels (Centers for Disease Prevention and Control, 2015). It is important that educators are informed about the unique learner needs of recovering students, so that they can adjust their expectations for class participation and homework completion accordingly until symptoms desist and cognitive function has normalized (McGrath, 2010).

Psychosocial Outcomes in Pediatric Populations

Concussions have been linked to deficits in behavioral functioning in children and adolescents (Mcleod & Register-Mihalik, 2011). Two of the most commonly self-reported behavioral issues associated with SRC are depression and anxiety (Giza, 2014). Chrisman &

Richardson (2013) recently found that adolescents with a history of concussion were three times more likely to develop depression than their non-injured peers. Other commonly reported sequelae of mTBI include disinhibition, irritability, aggression, reduced anger control, impaired social perception, low mood and social withdrawal (Taylor, Barrett, McLellan, & McKinlay, 2015). It is often difficult to determine whether these behaviors emerge as a direct consequence of SRC, are indicative of a pre-existing psychological condition, or are merely the expression of an underlying predisposition. Nonetheless, research evidence strongly suggests that psychosocial problems have a profound impact on both recovery and quality-of-life outcomes post-injury making this a topic worthy of further investigation (Beauchamp & Anderson, 2013; Ylvisaker et al., 2007).

The term novel psychiatric disorder (NPD) is often used to describe a diagnosis that arises following an injury (Max, 2014). With regards to SRC, this can happen in one of two ways: 1) a youth without a pre-existing psychiatric disorder may manifest a psychiatric disorder after sustaining a SRC; and, 2) a youth with a pre-existing psychological disorder may develop an additional psychiatric disorder that was not present before the SRC. Contingent on research methods, the rate of NPD ranges from 10% to 100% in pediatric patients with mTBI (Brown, Chadwick, Shaffer, Rutter, & Traub, 1981; Massagli et al., 2004; Max & Dunisch, 1997; Max et al., 1998; Max et al., 2013; Rune, 1970;). Studies restricted to consecutively treated children with mTBI have shown a narrower range of 10%–40%, with higher rates found predominantly in large scale studies. When researchers compared children with mTBI to uninjured controls they found rates of NPD that were not significant, marginally elevated but not significant, or significant depending on the study (Lehmkuhl & Thoma, 1990; Massagli et al., 2004; McKinlay, Dalrymple-Alford, Horwood, & Fergusson, 2002). This simply attests to the inconsistency observed within the current literature regarding the psychosocial implication of SRC in pediatric populations. The following paragraphs will explore several studies of this nature in greater detail.

Levin and colleagues (2007) conducted a prospective cohort study involving children between the ages of 5 and 15 years who had suffered a mild to severe TBI. The participants were examined immediately following injury and then again at 6, 12, and 24 months post-injury. Based on the data, approximately 23% of the children had ADHD symptoms prior to injury, while 20% reported ADHD symptoms as a secondary symptom of their head injury. However, at the 24 month mark, the socioeconomic status of participants significantly predicted whether or not ongoing problems were reported confounding the results. Another study examined the psychiatric outcomes of 46 youth aged 6 to15 years old with mild to severe TBI (Bloom et al., 2001). The results revealed that approximately 74% of participants had developed a NPD one year after injury. The more commonly reported disorders were attention-deficit/hyperactivity and depressive disorders. Furthermore, the severity of the initial TBI did not appear to significantly influence participant results. In fact, participants in the mTBI group were just as likely to report adverse behavioral outcomes as individuals with moderate to severe TBI.

As mentioned previously, the majority (80% to 90%) of mTBIs, including SRCs, resolve within 7 to 10 days (McCrea et al., 2013). However, persistent problems have been reported by injured patients across the entire injury spectrum (McKinlay, 2009; Ylvisaker, Turkstra et al., 2007). In some cases, impairments continue to be evident into late adolescence and even adulthood. Anderson et al. (2009) report that young adults that have suffered a TBI were 3 times less likely to finish high school, 2.3 times less likely to obtain a University degree, and 1.7 times more likely to be in an unskilled career or unemployed when compared to a non-injured control. In addition, 25% of adults who have suffered a TBI report engaging in aggressive behavior at 6, 24 and 60 months post-injury (Ylvisaker et al., 2009). It has also been proposed that the combined effect of lower educational attainment, low mood, and lowered inhibitory control may result in an increased propensity to criminal behavior (Silver, McAllister, & Archinigas, 2009).

Another recent study found that adult individuals with a history of childhood mTBI experienced more adverse life experiences (ALEs) when compared with individuals without a history of childhood TBI (Taylor, Barrett, McLellan, & McKinlay, 2015). Moreover, the number of ALE reported by the individual correlated with additional adverse outcomes including: (1) more visits to the doctor; (2) lower educational achievement level and (3) greater dissatisfaction with their material standard of living. Individuals who had sustained a TBI were also more likely to report that they had had a major depressive disorder in the past 12 months. To rationalize these findings, the researchers proposed that when a TBI was sustained during a period of extreme stress it may act to temporarily interfere with the body's normal coping mechanisms and subsequently cause an enhanced stress response. Further, they posited that stress is commonly associated with depression or apathy, which often leads to a reduced motivation for academic pursuits. According to Taylor et al. (2015), "This reduced motivation and subsequent lack of, or incomplete, education could result in poorer long-term outcomes" (p. 4).

Finally, it is important to acknowledge the systemic variables that are at play in a child's life following a TBI. Studies have shown that a child's level of psychiatric and/or behavioral functioning following a mild to severe TBI is strongly correlated with family outcomes (Max, 2014). Not surprisingly, families of children with mTBI report experiencing more feelings of distress and burden than families of children with orthopedic injuries (Ganesalingam et al., 2008). Other factors associated with family outcome include lower pre-injury family function, more stressors, and use of fewer sources of support (Ganesalingam et al., 2008; Josie et al., 2008; Max et al., 1998; Rivara et al., 1993; Taylor et al., 1999; Taylor et al., 2001; Yeates et al., 1997).

Conclusion

There is tangible concern surrounding the lingering effects of SRC within the general public. Perhaps the most alarming is the theorized associative risk between SRC and other debilitating medical conditions including post-concussion syndrome, second impact syndrome, and chronic traumatic encephalopathy. Pediatric populations are of particular concern given their increased propensity to SRC injury, prolonged symptoms, and repeat injury. Nonetheless, research has traditionally focused on only the acute symptoms in both cognitive and physical functioning in collegiate and adult populations (Williamson & Goodman, 2006). The extent of psychosocial deficits associated with SRC is often overlooked, and current research related to the behavioral outcomes of SRC (and cumulative concussions) is both scant and inconsistent.

Research Questions

Previous research has highlighted the inherent challenges in identifying, assessing and managing SRC in pediatric populations. Studies directly aimed at examining the long-term effects of SRC on youth-athletes are limited. After reviewing the literature on this topic, the current study aims to investigate the following research questions:

Research question 1. On average, do male youth hockey players with a medical history of one or more concussion(s) exhibit elevated scores on the BASC-2 PRS clinical composites and scales when compared to a non-injured control?

Research question 2. On average, do male youth hockey players with a medical history of one or more concussion(s) exhibit lower scores on the BASC-2 PRS adaptive composite and scales when compared to a non-injured control?

Research question 3. On average, do male youth hockey players who have a known medical history of cumulative concussions (2 or more) exhibit more profound deficits on the BASC-2 PRS in their adaptive and behavioral functioning than athletes who have previously sustained only one concussion?

Research question 4. Are there specific clinical or adaptive scales included within the BASC-2 PRS that appear to be more susceptible to sport-related concussion?

CHAPTER THREE

Research Design and Methodology

Overview

Chapter Three will present an overview of the current research study design including the methods for data collection, ethical considerations, and the measurement tools. These included a Preseason Questionnaire (PSQ), and the BASC-2 Parent Rating Scale for Adolescents (PRS-A) (Emery & Meeuwisse, 2006; Emery et al., 2010; Emery et al., 2011; Reynolds & Kamphaus, 2004). The structure, administration procedures, and psychometric properties of each tool will be described in detail. Finally, a brief overview of the data analysis will be provided.

Data Collection

Data collection occurred at the onset of the regular 2011-2012 competitive hockey season as part of a larger 44 team cohort study (Blake et al., 2012; McKay et al., 2012; Schneider, Emery, Kang, Blake, & Meeuwisse, 2012). The subjects were asked to participate in pre-season education sessions provided to all teams as part of a mandate from various hockey associations in Alberta. Because participation was mandated for this particular population, the sampling design was single staged. To maximize the likelihood of parent-child attendance, several sessions were held to accommodate varying work schedules. Parents were able to pre-register for a session with the coaching staff of their child’s team.

Participants

Initial inclusion criteria for the larger cohort study included the following: male or female players; written informed assent/consent to participate (player assent and consent from one parent or guardian); players registered with Hockey Calgary, Girls Hockey Calgary, or the Edge School in Calgary, Alberta, Canada; players registered with Hockey Edmonton or Edmonton

Girls Hockey in Edmonton, Alberta, Canada; players participating in the Bantam (ages 12–14) or Midget (15–17 years) leagues only; players in the most elite 20% of divisions of play (AA, AAA); agreement of the player's head coach to participate in the study; and agreement of the team therapist to collect information about individual player participation and injury throughout the season.

Each athlete was screened for pre-existing medical, mental health or behavioral conditions prior to the start of study. More specifically, the PSQ was used to identify participants having a previous diagnosis of a) mental retardation; b) learning disorder; c) communication disorder; d) pervasive developmental disorder; e) attention-deficit/hyperactivity disorder and/or other disruptive behaviour disorders; f) mood disorders such as depression & bi-polar disorder; and g) anxiety disorder. If a significant medical condition was indicated this was deemed grounds for exclusion. Finally, athletes having sustained a concussion within 30 days of the study start date were also excluded.

All Midget and Bantam teams within the Edmonton and Calgary area were invited to participate in this project. In the end, 44 teams responded (35%) and a total of 768 elite youth ice hockey players were recruited and enrolled in the larger cohort study. Of the sample, 118 players (15.0%) were female. Upon further consideration, female participants were excluded from data analysis for several reasons.

First, female athletes typically present with more acute concussion symptoms and experience longer recovery periods following a SRC than male athletes (Broshek et al., 2005; Colvin et al., 2009). There is also evidence to suggest that females and males report SRC symptoms differently (Broshek et al., 2005). The source of these discrepancies in gender has yet to be determined; however, the majority of studies have examined differences in neck strength, symptom reporting, socialization, and hormones (Giza, Wunderle, Hoeger, Wasserman, & Bazarian, 2014; Preiss-Farzanegan, Chapman, Wong, Wu, & Bazarian, 2009; Tierney et al., 2005).

According to the National Collegiate Athletic Association (NCAA), body checking is not permitted in any area of the ice in women's hockey (NCAA, 2014, p. 85). Due to this variable, female hockey players are at a lower risk of injury and concussions in comparison to their male counterparts (Emery et al., 2010). Given the differences surrounding the legal use of contact between men and women's hockey it may not be a gender comparable sport. Finally, there are significant discrepancies between genders across BASC-2 clinical norm data (Reynolds & Kamphaus, 2004). As a result, it may be inappropriate to compare BASC-2 data across genders as males and females tend to respond to psychological stressors in distinct ways. In accordance with the reasons stated above, incorporating a female sample was deemed to be beyond the scope of the present study and findings were restricted to male elite hockey players.

After eliminating female data, 650 male subjects remained. Of these, a total of 10 teams did not submit BASC-2 parent data (n=162). Of the remaining 488 subjects, 18 declined participation and another 19 had missing/incomplete data. There were 10 participants with English as a second language and 10 with a reported history of learning disabilities, 8 with diagnosed ADHD, and 9 reported a history of diagnosed mental health conditions for which they were receiving medication. These subjects were eliminated from the dataset given the possibility that these variables may influence the BASC-2 results. There were also 14 questionnaires where the validity index scores on the BASC-2 were outside normal limits, raising questions about the validity of test data. Finally, 6 participants did not indicate the number of concussion(s) incurred. These 6 participants were included in the preliminary explorative Univariate ANCOVA analyses where concussion was inputted as a categorical variable (Yes or No) and age was inputted as a covariate. However, they were subsequently eliminated prior to the Univariate ANCOVA analyses conducted for the purposes of this study. Participants included in the final data analyses included 394 male hockey players between the ages of 12 and 17 years (M= 15.36 years).

Current research indicates that ice hockey has the second highest concussion rate for high school sports in the US, with concussions accounting for approximately 22.2% of all reported injuries during a regular ice hockey season (Marar, McIlvain, Fields, & Comstock, 2012). By examining youth hockey players, the participant pool provided a large sample group consisting of several hundred participants. A significant proportion of participants reported having no medical history of concussions (N=225), one concussion (N=136), and two or more concussions (N=33). Those with no medical history of concussion served as a control group for comparison. By utilizing a large convenience sample, it ensured that valid inferences about the effects of concussion on psychosocial functioning could be made with regards to the general population of youth male hockey players.

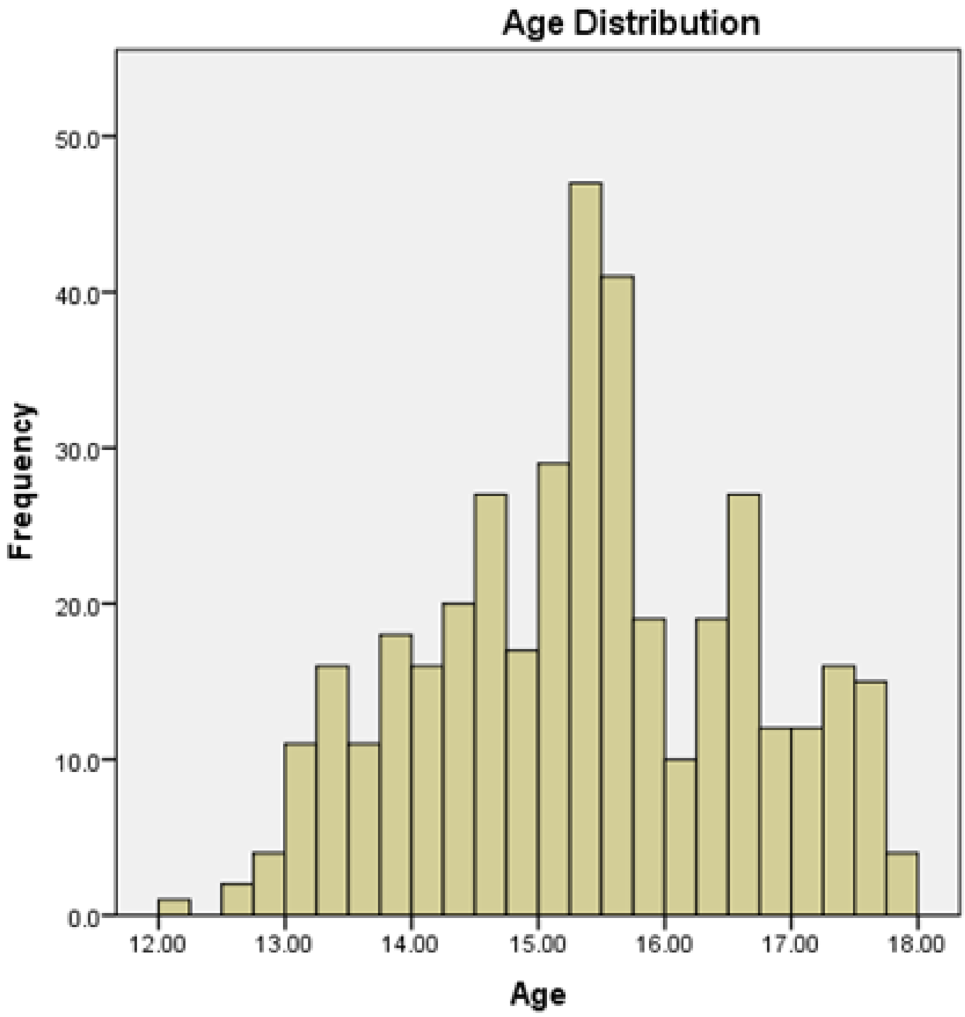

Figure 1. Age Distribution of Sample Population Bar-Graph

Ethical Considerations

The University Conjoint Health Research Ethics Board granted approval for this study (Ethics ID E-24026). Each participant and their parent/guardian were required to provide assent/consent prior to being admitted into the larger cohort study. The consent an assent form can be found in **Appendix A** and **Appendix B** respectively. There were no anticipated risks associated with this study as it did not modify normal hockey training. Some benefits associated with this study include being referred to the Sport Medicine Clinic for follow-up after concussion or injury. A study ID number was assigned at the time of baseline testing, which ensured that all personal information and findings remained confidential.

Preseason Questionnaire

Background. To acquire relevant concussion data, a self-administered preseason questionnaire (PSQ) was completed at home by each participant with the assistance of a parent or legal guardian (Emery & Meeuwisse, 2006; Emery et al., 2010; Emery et al., 2011; Reynolds & Kamphaus, 2004). A self-administered survey was chosen for several reasons: it can be utilized with a large sample population, the economy of design, and the rapid turnaround in data collection (Creswell, 2009). The participants were provided with the BASC-2 PRS-A as well as the study consent and assent forms approximately 2 to 3 weeks prior to the preseason testing session.

Structure and administration. The PSQ was given to the athlete prior to baseline testing so that it could be completed with the assistance of a parent or guardian as needed (**Appendix C**). It is a validated measure that has previously been used in injury-surveillance studies with youth ice hockey players (Emery & Meeuwisse, 2006; Emery, et al., 2010; Emery et al., 2011). It was designed to pre-screen athletes for medical, mental health, or behavioral conditions. More specifically, it is a paper and pencil questionnaire that collects information pertaining to participant demographics (i.e., sex, age, date of birth, address and telephone number, etc.), physical characteristics (i.e., weight, height, etc.), level of play, current sport participation, type of equipment used, and previous medical history, including previous history of concussion.

The majority of questionnaire items include categorical scales (e.g., yes/no) to collect factual information. In some instances, a personal written response or explanation may be required (e.g., please describe the injury to the best of your ability). The primary purpose of this survey was to collect information pertaining to the independent variable, the participant's history of sport-related concussions. The survey also provided relevant medical information to further screen out participants based on the study's exclusion criteria.

BASC-2

Background. The Behavior Assessment System for Adolescents (BASC-2) was employed to provide a measure of participant psychosocial functioning (Reynolds & Kamphaus, 2004). It is a multidimensional and multi-method tool that measures positive (adaptive) as well as negative (clinical) characteristics of behavior and personality through several report based measures. For the purpose of this study one component of the BASC-2 was used, the Parent Rating Scale (PRS-A).

Epidemiological studies have indicated that the frequency and severity of psychopathological problems reported by parents and children vary depending on the clinical status of the child (Breuk, Clauser, Stams, Slot, & Doreleijers, 2007). More specifically, adolescents in non-clinical samples tend to endorse higher rates of psychopathology on self-report measures than their parents (Achenbach, 1991; Stanger & Lewis, 1993; Verhulst, van der

Ende, & Koot, 1996, 1997). In contrast, adolescents in clinical samples tend to endorse lower rates of psychopathology (Kazdin, French, & Unis, 1983; Kolko & Kazdin, 1993; Mokros, Poznanski, Grossman, & Freeman, 1987; Thurber & Osborn, 1993; Thurber & Snow, 1990). Under-reporting of psychopathology by adolescents in clinical samples has previously been attributed to unrealistic self-perception, biased attribution processes and lack of self-reflection (Dodge, 1993; Kazdin, 1993, Moffitt, 1990). In addition, adolescents with a history of juvenile delinquency have been shown to have higher levels of narcissism and inflated self-esteem (Baumeister, Smart, & Boden, 1996). For these reasons, the BASC-2 PRS-A was chosen as it may provide more valuable and unbiased information regarding participant psychosocial functioning.

Structure and administration. The PRS-A consists of approximately 134 to 160 items that can be completed in approximately 10 to 20 minutes (Reynolds & Kamphaus, 2004). It uses a 4-point response format (N for Never, S for Sometimes, O for Often, or A for Almost Always). The rater's scores are then entered into the BASC-2 ASSIST computer software program. Items are subsequently assigned a numerical value with N, O, S, and A corresponding to 0, 1, 2, and 3 points respectively. The summation of these points provides a raw score, which is then converted into a normative T-score that delegates the distance of the original raw score from the norm-group mean.

The BASC-2 PRS-A generates four composite index scores and fourteen primary scales. It includes the following clinical composite index scores: Externalizing Problems (Hyperactivity, Aggression, and Conduct Problems), Internalizing Problems (Anxiety, Depression, and Somatization), and a Behavior Symptom Index (Hyperactivity, Aggression, Depression, Attention Problems, Atypicality, and Withdrawal). The PRS-A also includes an Adaptive Skills composite index score (Adaptability, Social Skills, Leadership, Activities of Daily Living, and Functional Communication). Germane to concussion research are indexes measuring Depression, Anxiety, Hyperactivity, and Attention Problems.

According to Reynolds and Kamphaus (2004), the Externalizing Problems composite consists of disruptive-behavior problems including aggression, hyperactivity, and delinquency. In general, manifestations of externalizing behavior are more stable and discernible than those of internalizing problems. This may partially account for the slightly higher level of interrater agreement on the Externalizing Problems composite. Given the disruptive nature of their behavior, adolescents who exhibit externalizing problems commonly come to the attention of the teachers and health care professionals. Furthermore, they often appear unresponsive to adult direction, and have more problematic relationships with peers. Not surprisingly, this composite has been associated with less favorable prognoses long-term (Robins, 1979).

In contrast, the Internalizing Problems composite is sometimes referred to as “over-controlled” behavior (Achenbach & Edelbrock, 1978; Reynolds & Kamphaus, 2004). Adolescents with internalizing problems are typically not disruptive to others; rather, they are inclined to excessively monitor their actions and comply with external requests. For these reasons, their problems often go undetected by adult observers. Although internalizing symptomology is not marked by “acting-out,” it is nonetheless associated with adverse social functioning including strained interpersonal relationships with peers (Kamphaus, DiStefano, & Lease, 2003).

The Behavioral Symptoms Index (BSI) composite indicates the overall level of problem behavior (Reynolds & Kamphaus, 2004). It appears to provide an accurate estimate of an individual’s level of day-to-day functioning and/or the presence of impairment for an individual with a disability or diagnosed condition. Finally, the Adaptive Skills composite encapsulates appropriate emotional expression and control, daily-living skills, communication skills, as well as prosocial skills. All of these skills have been deemed fundamental to successful functioning at home, school, and within the greater community. A lack of such skills may be indicative of poor prognosis including cognitive and mental disorders. For definitions of the individual clinical and adaptive scales please refer to **TABLE 1** and **TABLE 2** included below.

Table 1.

BASC-2 PRS Clinical Scale Definitions

Clinical Scale	Definition
Aggression	The tendency to act in a hostile manner (either verbal or physical) that is threatening to others.
Anxiety	The tendency to be nervous, fearful, or worried about real or imagined problems
Attention Problems	The tendency to be easily distracted and unable to concentrate more than momentarily
Atypicality	The tendency to behave in ways that are considered "odd" or commonly associated with psychosis
Conduct Problems	The tendency to engage in antisocial and rule-breaking behavior, including destroying property
Depression	Feelings of unhappiness, sadness, and stress that may result in an inability to carry out everyday activities or may bring on thoughts of suicide
Hyperactivity	The tendency to be overly active, rush through work or activities, and act without thinking
Somatization	The tendency to be overly sensitive to and complain about relatively minor physical problems and discomforts
Withdrawal	The tendency to evade others to avoid social contact

Note. Retrieved from "Behavioral Assessment System for Children (2nd ed.)," by C. R. Reynolds and R. W. Kamphaus. Copyright 2004 by Circle Press.

Table 2.

BASC-2 PRS Adaptive Scale Definitions

Adaptive Scale	Definition
Activities of Daily Living	The skills associated with performing basic, everyday tasks in an acceptable and safe manner
Adaptability	The ability to adapt readily to changes in the environment
Functional Communication	The ability to express ideas and communicate in a way others can easily understand
Leadership	The skills associated with accomplishing academic, social, or community goals, including the ability to work with others
Social Skills	The skills necessary for interacting successfully with peers and adults in home, school, and community settings

Note. Note. Retrieved from "Behavioral Assessment System for Children (2nd ed.)," by C. R. Reynolds and R. W. Kamphaus. Copyright 2004 by Circle Press.

Table 3.

BASC-2 PRS Scale and Composite Score Classification

Classification		
Adaptive Scales	Clinical Scales	T-Score Range
Very High	Clinically Significant	70 and above
High	At-Risk	60-69
Average	Average	41-59
At-Risk	Low	31-40
Clinically Significant	Very Low	30 and below

Note. Retrieved from "Behavioral Assessment System for Children (2nd ed.)," by C. R. Reynolds and R. W. Kamphaus. Copyright 2004 by Circle Press.

Psychometric properties.

Norm sample. The BASC-2 rating scales and self-reports were developed using both general and clinical norm samples (Reynolds & Kamphaus, 2004). In addition, combined–sex and separate-sex norms are provided for each norm sample. The authors contend that the standardization sample closely approximates the U.S. Census data with regard to gender, race/ethnicity, clinical or special education classification. To further ensure the clinical utility of this instrument, specific constructs were incorporated to provide a measure of validity and reliability.

Reliability. Studies have been conducted to determine the internal consistency, test-retest, and inter-rater reliability of the PRS-A. The internal-consistency reliabilities of the BASC-2 PRS-A composites and scales were found to be high and consistent: between females and males; between clinical and nonclinical groups; and at different age levels (Reynolds & Kamphaus, 2004). As a result, the composite and scale scores were deemed to be effective measures in respect to their behavioral dimensions. The PRS-A test-retest reliabilities for the composite scores were reported as high, generally in the low .80s to the low .90s (Reynolds & Kamphaus, 2004). In terms of the individual scales, the median test-retest reliability at the adolescent level is .81 while the median inter-rater reliability for the adolescent PRS-A was determined to be .77.

Validity. The PRS-A measurement tool may be susceptible to several threats to validity such as: (1) positive or negative response sets; (2) intentional dissimulation; (3) stress on the part of the parent; and, (4) inadequate familiarity of the respondent with the child (Reynolds & Kamphaus, 2004). Reynolds and Kamphaus (2004) incorporated positively and negatively worded items on the rating scales to guard against positive and negative response sets. To control for some of these additional threats to validity, the PRS-A uses three indexes: F-Index, Response

Pattern Index, and Consistency Index. The report also controls for omitted and multiply-marked items.

The F index acts to increase the validity of all components by determining if the respondent has a predisposition to rate the child in an exceedingly negative manner (Reynolds & Kamphaus, 2004). This index employs a classic validity scale that consists of items that relate to maladaptive and adaptive behaviors. A high score on this index would occur if the respondent primarily answers "Almost Always" to items that are representative of maladaptive behavior and "Never" to items that relate to adaptive behaviors. This would either indicate that an extraordinarily maladaptive behavior is present or that the parent has rated the child more severely than admissible.

To control for dissimulation, the BASC-2 report lists the number of omitted or multiply-marked items from each administration (Reynolds & Kamphaus, 2004). In some instances, the respondent may omit items merely because he or she is having difficulty understanding the item's meaning. On other occasions, the respondent may deliberately choose not to answer an item because he or she is personally sensitive towards a certain topic. Finally, the respondent may also choose to omit an item due to his or her unfamiliarity with the child. A maximum of two unscorable items are permissible per scale. If there are 3 or more unscorable items then the affected scale, as well as any subsequent composite scale score(s), are dismissed as invalid. In this instance, the raw score is adjusted in order to provide a more accurate scale-score estimation.

The BASC-2 software program includes a Response Pattern Index that is designed to identify PRS-A forms that may be invalid due to the respondent's inattention to item content (Reynolds & Kamphaus, 2004). This index identifies patterns within the respondent's answers. For instance, does the respondent provide an identical response to many items in succession or is an alternating/cyclical response pattern observed? Finally, the Consistency Index is used to identify cases where the respondent has answered two items in a manner that serves to contradict one another, rather than responding in a similar fashion to both. This data would again suggest that the respondent has failed to attend to the item content.

Data Analysis

In the explorative stage of this research project Regression Analyses were performed using SPSS software to compare the BASC- 2 PRS-A variable outcomes (the dependent variables) with the number of concussion(s) reported by participants on the PSQ (the independent variable). For these analyses, the number of concussion(s) was inputted as a continuous variable (i.e., 0, 1, 2, 3, 4, 5.) and age was inputted as a fixed variable. Univariate ANCOVA analyses were also conducted with concussion as a categorical variable (Yes or No) and age as a covariate. These analyses were run twice as both a CUSTOM analysis that included the interaction effect between age and concussion, and as a FACTORIAL analysis without interaction effect. In addition, all necessary statistical tests were conducted to ensure that the sample data did not violate assumptions relevant to ANOVA procedures.

In the end, a cross sectional one-way between subject design was utilized for the purposes of this study. Participants were categorized into three groups based on their self-reported concussion history: 1) no concussion; 2) 1 concussion; and 3) two or more concussions. This was chosen in order to ensure comparable group sizes while also allowing the effect of multiple concussions to be examined. Univariate ANCOVA analyses were then conducted using SPSS software to compare the BASC-2 PRS-A variable outcomes with the number of concussion(s) reported by participants in the PSQ. Age was inputted as a fixed variable to ensure that it would not confound results. Succeeding a significant F-ratio, a post-ANCOVA multiple comparison procedure was performed to determine which of the three group means differed significantly. For the purposes of this study, a post-hoc Bonferroni test was chosen and all possible pairwise comparisons were performed.

CHAPTER FOUR

Results

Overview

This Chapter will evaluate the study results with regards to the four research questions outlined in Chapter Two. First, do athletes with a known history of concussion exhibit elevated scores on the BASC-2 PRS clinical composites and scales compared to a non-injured control group? Second, do athletes with a known history of concussion exhibit lower scores on the BASC-2 PRS adaptive composite and scales compared to a non-injured control? Third, do athletes with a history of cumulative concussions (two or more) show more pronounced deficits when compared to athletes who have sustained only one prior concussion? Finally, are there any clinical or adaptive scales included within the BASC-2 PRS that appear to be significantly more susceptible to sport-related concussion?

Research Question 1

On average, do male youth hockey players with a medical history of one or more concussion(s) exhibit elevated scores on the BASC-2 PRS clinical composites and scales when compared to a non-injured control?

Based on previous research, it was hypothesized that athletes with a known history of concussion would exhibit elevated scores on the BASC-2 PRS clinical composites and scales when compared to a non-injured control. An ANCOVA analysis was conducted for each BASC-2 PRS composite and scale score in order to compare the results of the three concussion groups (no concussion, one concussion, two or more concussions). The clinical composite scores and clinical scales are as follows: Externalizing Behavior Index (hyperactivity scale, aggression scale, conduct disorder scale); Internalizing Behavior Index (anxiety scale; depression scale;

somatization scale); and, Behavior Symptom Index (atypicality scale, withdrawal scale, attention scale).

After controlling for age, the results indicated that the mean scores of the three concussion groups (no concussion, one concussion, two or more concussions) did not differ significantly on the BASC-2 PRS clinical composites: Externalizing Behavior, $F(2, 390)=.167$, $p>.846$; Internalizing Behavior, $F(2, 390)=.051$, $p>.950$; and, Behavior Symptom Index, $F(2, 390)=.477$, $p>.621$. Non-significant results were also found for the following clinical scale scores: hyperactivity scale $F(2, 390)=.145$, $p>.865$; aggression scale $F(2, 390)=.925$., $p>.397$; conduct disorder scale $F(2, 390)=.219$, $p>.803$; anxiety scale $F(2, 390)=.138$, $p>.871$; depression scale $F(2, 390)=.096$, $p<.908$; somatization scale $F(2, 390)=.559$, $p>.572$; atypicality scale $F(2, 390)=.250$, $p>.779$; and attention scale $F(2, 390)=.252$, $p>.778$. Overall, the proposed hypothesis was not supported by the results. However, a significant mean difference was found with regards to the withdrawal scale $F(2, 390)=4.768$, $p>.009$, $\eta^2=.024$. Contrary to the proposed hypothesis, the results attained for this scale indicated that participants with two or more concussions exhibited lower scores overall when compared to the other two concussion groups (no concussion, one concussion). These results will be explored in greater detail later on.

Table 4.

BASC-2 PRS Descriptive Statistics: Clinical Composites & Scales

Clinical Composites & Scales	Number of Concussions								
	No concussion			One concussion			Two or more concussions		
	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
HYP-T score	47.3	7.3	39.0	47.5	6.8	30.0	46.8	6.1	24.0
AGG-T score	47.3	7.4	42.0	46.4	6.2	38.0	47.3	5.0	21.0
CND-T score	48.0	6.5	39.0	47.8	6.3	36.0	48.5	5.5	18.0
EXT-T score	47.3	6.7	41.0	47.0	5.9	29.0	47.3	5.2	20.0
ANX-T score	48.7	9.1	50.0	48.8	9.9	54.0	49.6	8.3	31.0
DEP-T score	46.5	6.4	36.0	46.6	8.3	72.0	46.0	5.7	19.0
SOM-T score	48.0	7.2	34.0	48.2	7.1	29.0	46.7	7.5	28.0
INZ-T score	47.2	7.6	42.0	47.3	8.3	57.0	46.8	6.9	26.0
ATP-T score	48.0	6.7	34.0	47.8	7.3	42.0	47.2	5.8	22.0
WDL-T score	45.3	6.9	37.0	46.4	8.8	57.0	42.0	5.2	20.0
ATT-T score	47.8	8.3	38.0	47.4	8.1	32.0	48.4	9.6	38.0
BSI-T score	46.2	7.0	43.0	46.1	6.3	40.0	45.1	5.6	20.0

Table 5.

BASC-2 PRS Mean T-scores: Clinical Composites & Scales

BASC-2 PRS Composites & Scales	Zero	One	≥Two	*Sig.*
Externalizing Problems Composite	47.289	46.963	47.333	.846
Hyperactivity	47.289	47.493	46.758	.865
Aggression	47.333	46.382	47.273	.397
Conduct Problems	47.951	47.765	48.545	.803
Internalizing Problems Composite	47.204	47.331	46.848	.950
Anxiety	48.662	48.787	49.606	.871
Depression	46.529	46.566	46.030	.908
Somatization	47.956	48.206	46.727	.572
Behaviour Symptom Index	46.218	46.140	45.091	.621
Atypicality	48.009	47.750	47.212	.779
Withdrawal	45.307	46.434	41.970	.009
Attention Problems	47.849	47.441	48.394	.778

Note. Clinical scale (Externalizing Problems Composite, Internalizing Composite, and Behavior Symptom Index) scores of T> 60 are considered *At-Risk*.

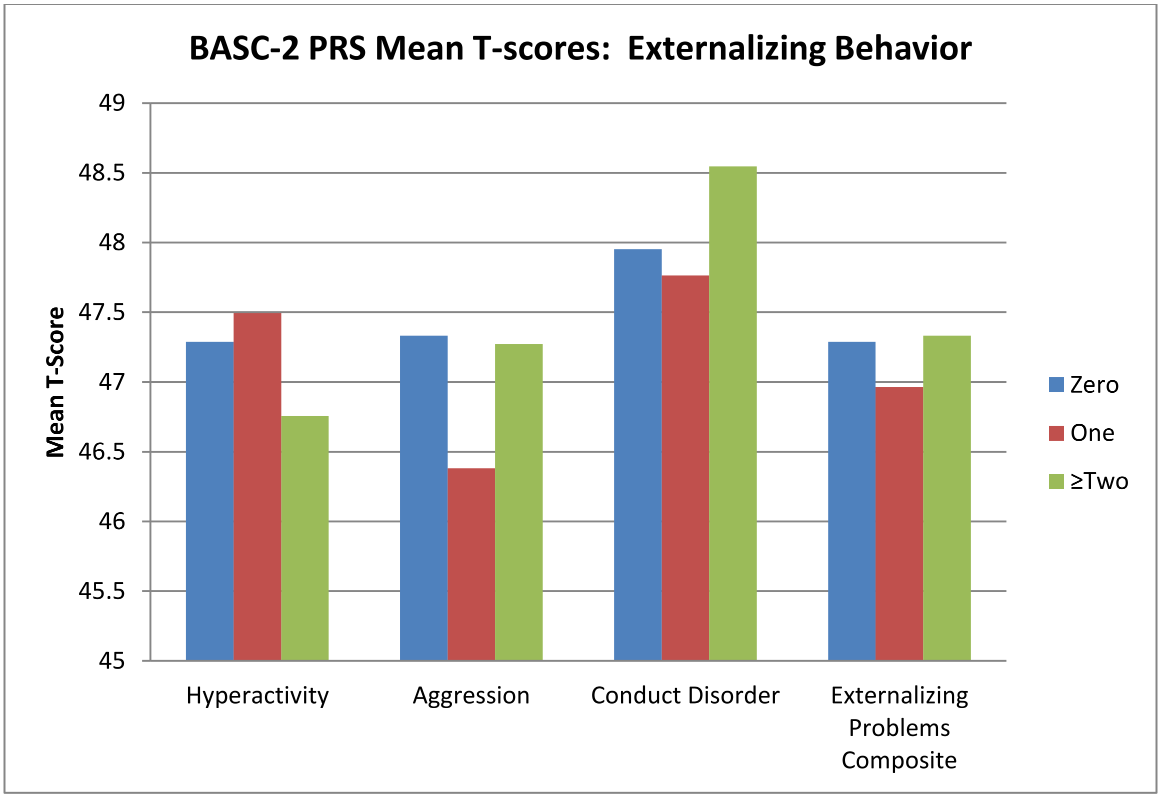

Figure 2. BASC-2 PRS Mean T-scores: Externalizing Behavior

Note. Clinical scale (Hyperactivity, Aggression, and Conduct Problems) scores of T>60 are considered *At-Risk*.

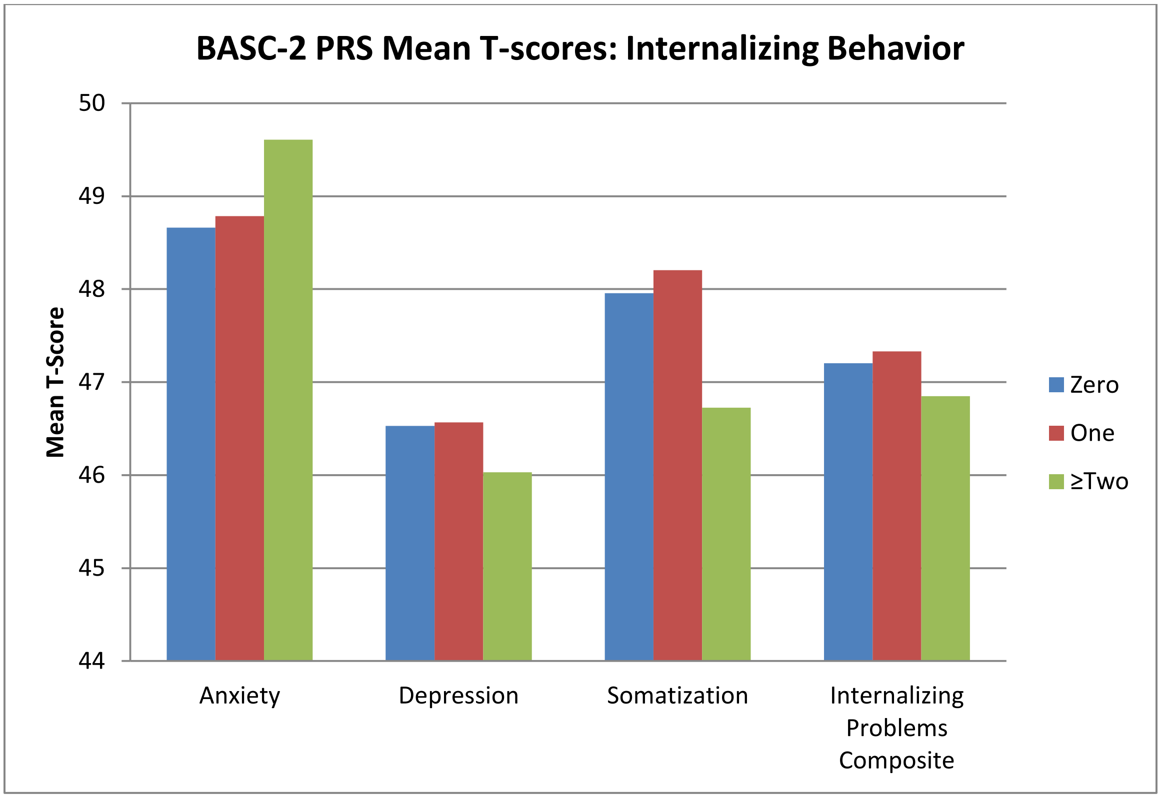

Figure 3. BASC-2 PRS Mean T-scores: Internalizing Behavior

Note. Clinical scale (Anxiety, Depression, and Somatization) scores of T> 60 are considered *At-Risk*.

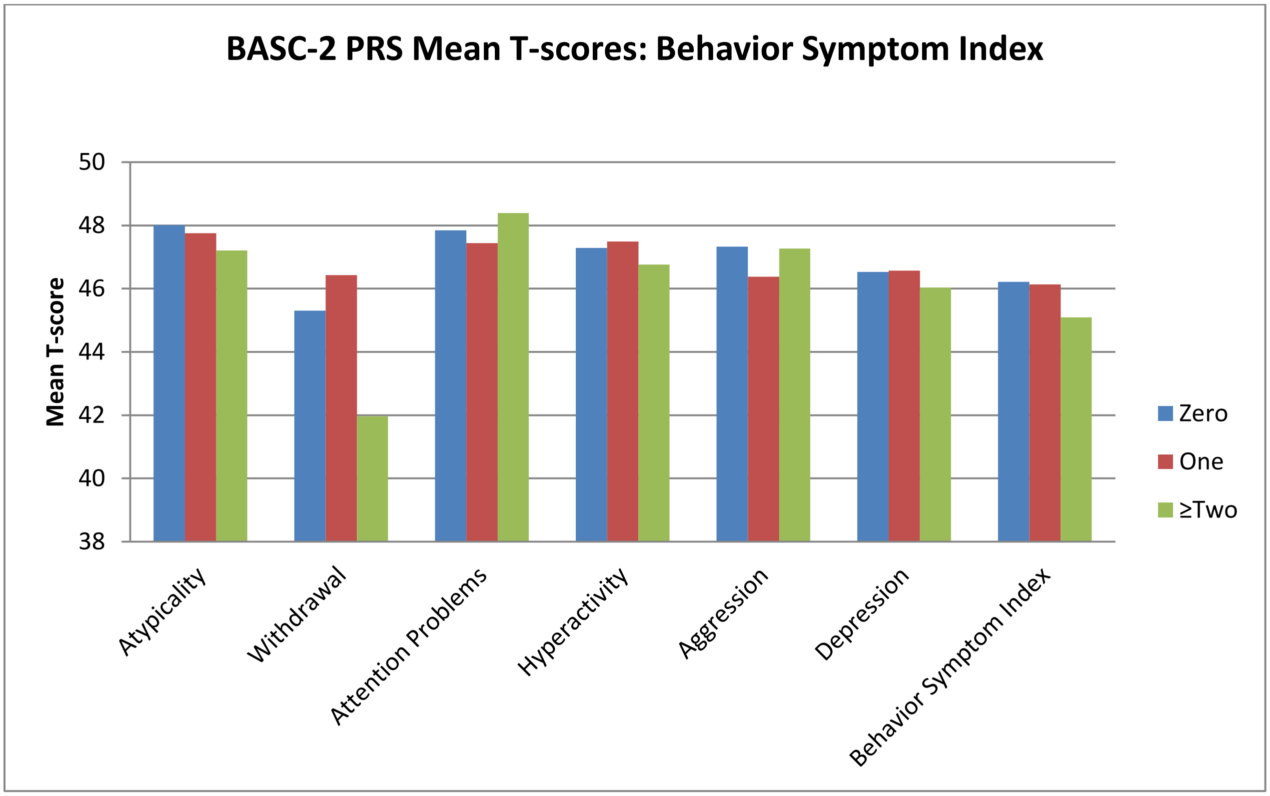

Figure 4. BASC-2 PRS Mean T-scores: Behavior Symptom Index

Note. Clinical Scale (Atypicality, Withdrawal, Attention Problems, Hyperactivity, Depression) scores of T> 60 are considered *At-Risk*.

Research Question 2

On average, do male youth hockey players with a medical history of one or more concussion(s) exhibit lower scores on the BASC-2 PRS adaptive composite and scales when compared to a non-injured control?

Based on previous research, it was hypothesized that athletes with a known history of concussion would exhibit lower scores on the BASC-2 PRS adaptive composite and scales when compared to a non-injured control. An ANCOVA analysis was conducted for the BASC-2 PRS adaptive composite score and scale scores in order to compare the results of the three concussion groups (no concussion, one concussion, two or more concussions). The adaptive composite score and scales are as follows: Adaptive Skills Composite (adaptability scale, social skills scale, leadership scale, activities of daily living scale, functional communication scale).

After controlling for age, the results indicated that the mean scores of the three concussion groups (no concussion, one concussion, two or more concussions) did not differ significantly on BASC-2 PRS adaptive composite: Adaptive Skills, $F(2, 390)=.083$, $p>.920$. Non-significant results were also found for all adaptive scale scores: adaptability scale $F(2, 390)=.388$, $p<.679$; social skills $F(2, 390)=.418$, $p>.659$; leadership $F(2, 390)=.120$, $p>.887$; activities of daily living scale $F(2, 390)=.050$, $p>.951$; and, functional communication scale $F(2, 390)=.615$, $p>.541$. Overall, the results do not provide support for the proposed hypothesis.

Table 6.

BASC-2 PRS Descriptive Statistics: Adaptive Composites & Scales

Clinical Composites & Scales	Number of Concussions								
	No concussion			One concussion			Two or more concussions		
	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
ADT-T score	54.5	8.3	45.0	55.0	7.2	35.0	53.8	6.3	28.0
SKL-T score	53.6	8.5	43.0	52.8	8.6	41.0	53.8	7.9	33.0
LED-T score	53.2	8.4	39.0	53.4	8.4	45.0	53.6	8.2	35.0
ADL-T score	50.8	8.5	48.0	51.0	8.8	43.0	51.0	9.7	41.0
FUN-T score	51.4	8.8	43.0	52.2	8.5	35.0	52.5	9.1	35.0
AKL-T score	53.2	8.4	39.0	53.3	7.9	40.0	53.5	8.4	32.0

Table 7.

BASC-2 PRS Mean T-scores: Adaptive Composites & Scales

BASC-2 PRS Composites & Scales	Zero	One	≥Two	*Sig.*
Adaptive Skills Composite	53.156	53.346	53.485	.920
Adaptability	54.489	54.971	53.818	.679
Social Skills	53.636	52.787	53.758	.659
Leadership	53.191	53.434	53.576	.887
Activities of Daily Living	50.800	50.971	51.000	.951
Functional Communication	51.409	52.191	52.545	.541

Note. Adaptive scale (Adaptive Skills Composite) scores of T<40 are considered *At-Risk*.

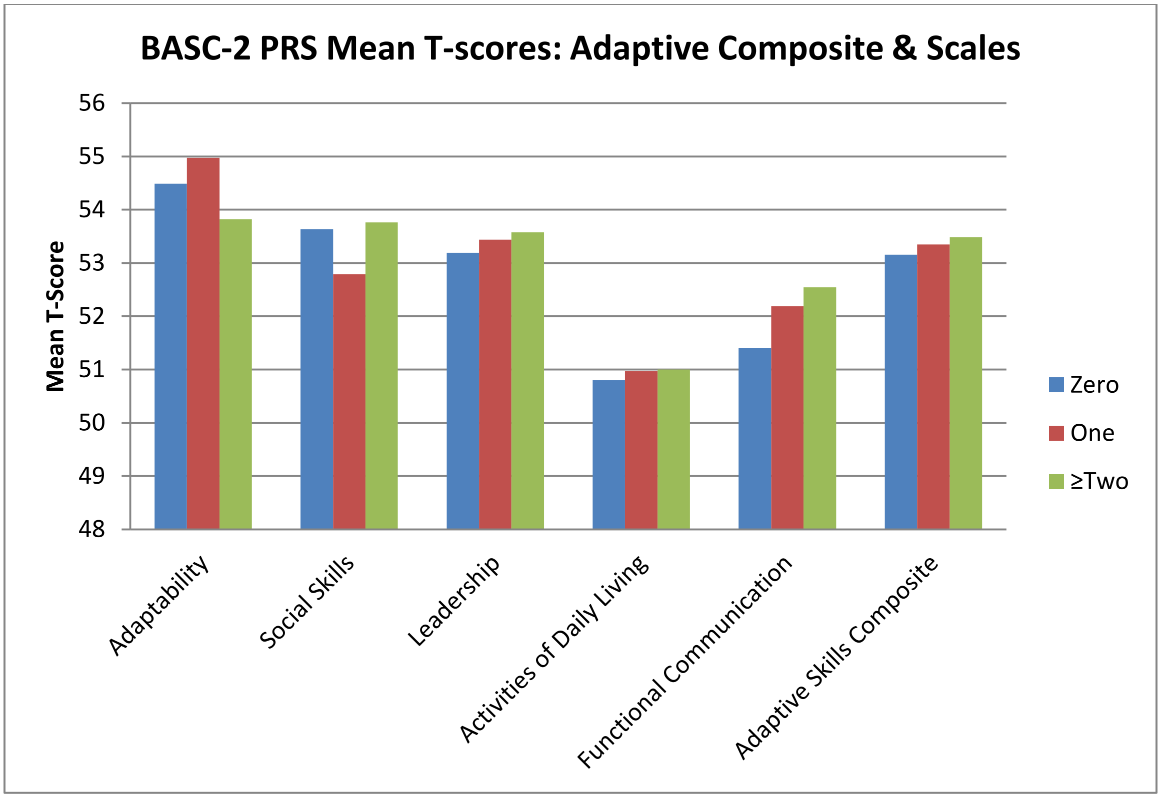

Figure 5. BASC-2 PRS Mean T-scores: Adaptive Composite and Scales

Note. Adaptive scale (Adaptability, Social Skills, Leadership, Activities of Daily Living, and Functional Communication) scores of T<40 are considered *At-Risk*.

Research Question 3

On average, do male youth hockey players with a known medical history of cumulative concussions (two or more) exhibit more profound deficits in psychosocial functioning, based on BASC-2 PRS results, than athletes who have previously sustained only one concussion?

It was hypothesized that participants with a history of cumulative concussions (two or more) would exhibit more profound deficits in psychosocial functioning when compared to athletes who have sustained only one prior concussive injury. The results did not substantiate this claim, and the hypothesis was subsequently refuted.

Research Question 4

Are there specific clinical or adaptive scales included within the BASC-2 PRS significantly more susceptible to sport-related concussion?

Non-significant results were found across concussion groups (no concussion, one concussion, two or more concussions) for each BASC-2 PRS composite and scale score with the exception of the withdrawal scale, $F(2, 390)=.4.768$, $p<.009$, $\eta^2=.024$. A Bonferroni post-hoc pairwise comparison was conducted to further examine the mean group differences. This procedure was chosen as it is considered to be "a good but relatively conservative post-hoc test" (Gamst, Meyers, & Guarino, 2008, p. 121). To address the familywise error, each pairwise comparison is made with a t test but statistical significance is evaluated by using an alpha level of .05 divided by the total number of multiple comparisons made (Gamst et al. 2008, p. 121). The results of this comparison are summarized in Table 10. Based on this analysis, it would seem that the BASC-2 PRS withdrawal scale is affected by SRC more so than other composite and scale scores. Furthermore, the results suggest that athletes having sustained two or more concussions tend to exhibit less overt signs of social withdrawal than those having sustained one previous concussion and a non-injured control based on parental evaluation. This finding is surprising as it runs contrary to what has been previously espoused within the research literature regarding the adverse effects of SRC on psychosocial functioning.

Table 8.

BASC-2 PRS Withdrawal Scale Univariate ANCOVA Results

SPSS Output Data	Sum of Squares	df	Mean Square	F	Partial Eta Squared
Contrast	533.789	2	266.894	4.768	.024
Error	21832.493	390	55.981		

Note. The F tests the effect of Concussion Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Table 9.

BASC-2 PRS Withdrawal Scale: Pairwise Comparisons

Concussion Group		Mean Difference	Std. Error	Sig.[b]
No concussion	One concussion	-1.088	.813	.546
	Two or more concussions	3.377*	1.395	.048
One concussion	No concussion	1.088	.813	.546
	Two or more concussions	4.464*	1.452	.007
Two or more concussions	No concussion	-3.377*	1.395	.048
	One concussion	-4.464*	1.452	.007

Note. Based on estimated marginal means*.The mean difference is significant at the .05 level. b. Adjustment for multiple comparisons: Bonferroni.

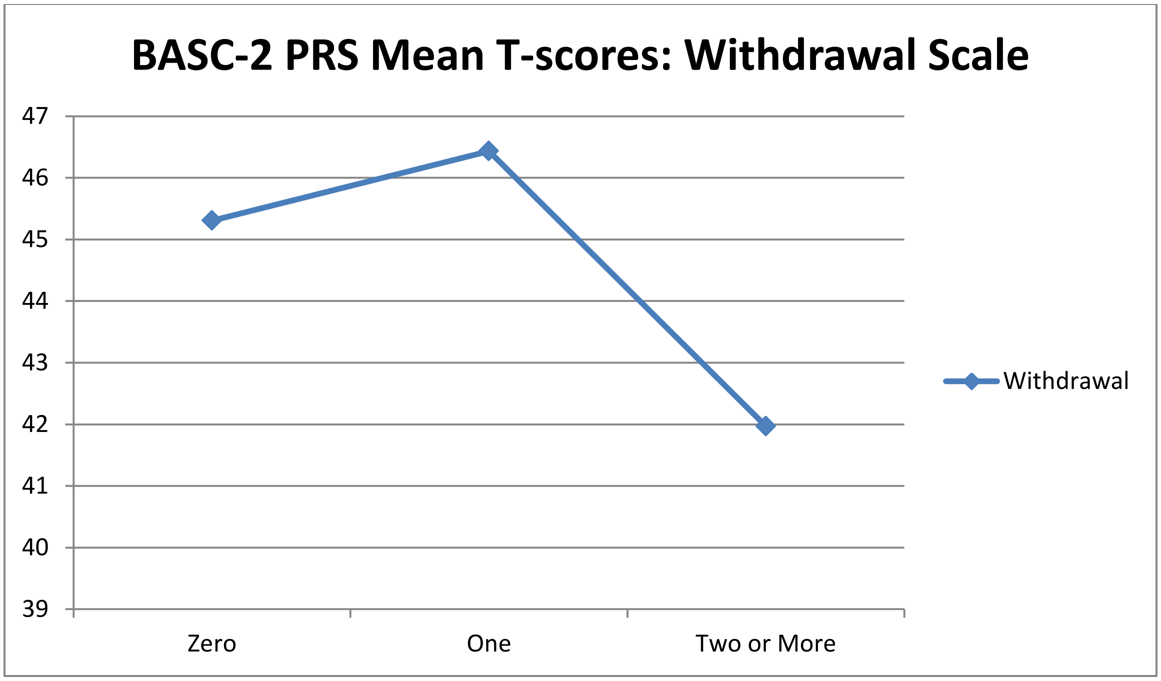

Figure 6. BASC-2 PRS Mean T-scores: Withdrawal Scale

Note. Withdrawal clinical scale scores of T>60 are considered *At-Risk*. Covariates appearing in the model are evaluated at the following values: Age=15.3649

CHAPTER FIVE

Discussion

Overview

There has been an intensified need amongst medical practitioners and researchers to understand how SRC may affect an adolescent's long-term social, emotional and behavioral well-being (McCrory et al., 2009). The current study was designed to address this gap in the scientific literature by evaluating psychosocial outcomes in youth male hockey players (12 to 17 years old) as they have arisen in the years following concussive injury. More specifically, the following research questions were investigated: 1) Do male youth-athletes with a history of one or more concussions have more significant psychosocial impairments?; 2) Do male youth-athletes with a history of one or more concussions have more significant impairments in their adaptive functioning when compared to a normal control?; 3) Are these impairments more severe in youth-athletes who have sustained multiple concussions?; and finally, 4) Are there any clinical or adaptive scales included within the BASC-2 PRS that appear to be significantly more susceptible to SRC?

This chapter will begin with a discussion of the study's findings in relation to the research literature reviewed in Chapter Two. The implications of the findings for each of the proposed research questions will also be discussed. The Chapter will conclude with the study limitations and future directions. It is hoped that the findings of this study will encourage future research regarding the long-term effects of SRC on the psychosocial functioning of youth-athletes.

Implications

Sport-related concussion and BASC-2 clinical composite and scale scores.

SRC has been linked to deficits in behavioral functioning in children and adolescents (Valovich Mcleod & Register Mihalik, 2011). However, research investigating the prevalence rate of novel psychiatric disorders (NPD) amongst pediatric populations following a mTBI has produced mixed results. Depending on the study, researchers have found rates of NDP that were not significant, marginally elevated but not significant, or statistically significant (Lehmkuhl & Thuma, 1990; Massagli, Fann, Burington, et al., 2004; McKinlay, Dalrymple-Alford, Horwood, et al., 2002). The present study sought to provide further insight on this issue by examining the long-term behavioral and psychological outcomes of SRC in youth male hockey players.

Based on previous research, it was hypothesized that athletes with a known history of concussion would exhibit elevated scores on the BASC-2 PRS clinical composites and scales when compared to a non-injured control. After controlling for age, the results indicated that the mean scores of the three concussion groups (no concussion, one concussion, two or more concussions) did not differ significantly on any of the BASC-2 PRS clinical composites and scale scores with the exception of the withdrawal scale. Overall, the proposed hypothesis was not supported by the results obtained. In fact, the results do not support the existing literature that provides evidence of persisting psychological difficulties arising from mTBI.

To explain these results it is warranted to consider the psychological benefits of sport participation for youth-athletes in greater depth. The participants in this study were elite level hockey players who had played sports for many years. It is possible that sport participation itself, may have served as a protective or mitigating factor against the adverse behavioral and psychological outcomes that have been associated with SRC. In a study by Snyder et al. (2010), students participating in school and club sport were combined into a single ‘athletes’ category and compared to ‘non-athletes’ on health-related quality of life measures. Overall, those in the ‘athletes’ category endorsed higher scores on physical functioning, general health, social functioning, as well as mental health composite and scale scores than non-athletes. Research has also indicated that team sport participation can protect against feelings of hopelessness and suicidality (Taliaferro, Rienzo, Miller, Pigg & Dodd, 2008). A recent longitudinal study examining adolescents found that participation in a team sport served as a protective factor against depressed mood associated with school performance levels (Gore, Farrell, & Gordon, 2001).

According to Dunn (2014), “Sports participation, recreational physical activity, and/or being enrolled in a physical education class may be a possible method in which to prevent or delay substance use among adolescents” (p. 675). Additionally, participation on a team sport has been associated with overall higher life satisfaction (Valois, Zulig, Huebner, & Crane, 2004). In a study by Ferron and colleagues (1999), adolescents were classified as either ‘athletes’ or ‘non-athletic’ on the basis of sports club participation. They found that those who fell within the ‘athletes’ category had superior well-being when compared to ‘non-athletic’ peers. This included being better adjusted, feeling less nervous or anxious, being more often full of energy and happy about their life, feeling sad or depressed less often and having higher body image and fewer suicide attempts (Ferron, Narring, Cauderay, & Michaud, 1999; Eime, Young, Harvey, Charity, & Warren, 2013). Therefore, it may be reasonable to assert that sport participation may serve to protect against and mitigate the adverse behavioral and psychological outcomes associated with SRC injury in youth-athletes to a certain degree.

Sport-related concussion and BASC-2 adaptive composite and scale scores. Emerging research indicates that a concussion sustained during childhood or adolescence rather than in adulthood may have a more pronounced effect on the individual long term (Anderson & Moore, 2007). It has been suggested that well known skills are less vulnerable to head injury than skills that are in the process of being developed or have yet to emerge within the immature brain (Anderson & Moore, 2007; McKinlay, 2009). Therefore, a TBI incurred during one's early life has the potential to impede an individual's developmental trajectory across a variety of adaptive functional domains due to impaired skill acquisition. Based on previous research, it was hypothesized that athletes with a known history of concussion would exhibit lower scores on the BASC-2 PRS adaptive composite and scales when compared to a non-injured control. After controlling for age, the results indicated that the mean scores of the three concussion groups (no concussion, one concussion, two or more concussions) did not differ significantly on BASC-2 PRS adaptive composite or scale scores. Overall, the results did not provide support for the proposed hypothesis.

Again, it is important to consider the positive effects of sport participation on a youth's social development and acquisition of adaptive skills. The individuals included in this study were selected based on their participation in elite athletic play which often leads to increased parental involvement, more socialization with peers, increased opportunity for leadership, and more exposure to adults (coaching staff). A longitudinal study conducted by Findlay and Coplan (2008) found that sport participation was positively associated with positive adjustment including enhanced social skills and self-esteem. Furthermore, a recent qualitative study involving focus groups consisting of parents of youth-athletes found that social factors such as enhanced life skills and improved self-concept were perceived to be direct benefits of their child's participation in organized sport (Wiersma & Fifer, 2008). In general, sport participation has been associated with positive youth development (Eime, Young, Harvey, Charity, & Warren, 2013). Zarret et al. (2009) ascertained that the majority of youth participating in sports and youth development programs tended to have the highest positive youth development scores. The observed benefits of team sport participation have been attributed to positive experiences in coaching, skill development, and peer support that subsequently serve to enhance an individual's perceived social acceptance (Boone and Leadbeater, 2006). Due to the fact that sport participation appears to encourage the development of appropriate adaptive skills, it is likely it may act as a protective factor and mitigate adverse social outcomes following SRC injury in youth-athletes to a certain extent.

Cumulative concussion and psychosocial functioning. Elevated susceptibility for repeated injuries is a palpable aspect of SRC (Giza & Kutcher, 2014). According to Noble and Hesdorffer (2013) severe and repeated concussions can lead to decidedly poorer cognitive outcomes including slower recovery, persistent cognitive impairment and acute and chronic neuropsychiatric symptoms including late-life depression (Gardner, Shores, & Batchelor 2010; Guskiewicz, Marshall, Bailes, et al., 2005; Guskiewicz, Marshall, Bailes, et al., 2007; Guskiewicz, McCrea, Marshall, et al., 2003). Perhaps a more alarming reason why repeated injury following a SRC is of concern to all those involved in the player's recovery, is the unknown probability of second impact syndrome and the more controversial, chronic traumatic encephalopathy (CTE) (Cantu, 1998).

It was hypothesized that participants with a history of cumulative concussions (two or more) would exhibit more profound deficits in psychosocial functioning when compared to athletes who have sustained only one prior concussive injury. The results did not substantiate this claim, and the hypothesis was subsequently refuted. A potential explanation for these results may again lie within the protective factors inherent in sport participation. However, this assertion has yet to be established within the research literature. It is also worth mentioning that information pertaining to the severity of injury, recovery time, and total elapsed time between SRC injuries was not analyzed in this study. Including this information may have served to provide further insight into the observed results.

Vulnerable psychological constructs. Two of the most commonly self-reported behavioral issues associated with SRC are depression and anxiety (Giza, 2014). Other commonly reported sequelae of mTBI include disinhibition, irritability, aggression, reduced anger control, impaired social perception, low mood and social withdrawal (Taylor, Barrett, McLellan, & McKinlay, 2015). Non-significant results were found across concussion groups (no concussion, one concussion, two or more concussions) for each BASC-2 PRS clinical and adaptive composite and scale scores with the exception of the withdrawal scale, $F(2, 390)=.4.768$, $p<.009$, $\eta^2=.024$. Based on this analysis, it would seem that the BASC-2 PRS withdrawal scale is affected by SRC more so than other composite and scale scores. Furthermore, the results suggest that athletes having sustained two or more concussions tend to exhibit less overt signs of social withdrawal than those having sustained one previous concussion and a non-injured control based on parental evaluation. This finding is surprising as it runs contrary to what has been previously espoused within the research literature regarding the adverse effects of SRC on psychosocial functioning.

To shed some light on this finding, research regarding the effect of sport participation and social isolation were examined. For example, a longitudinal study conducted over a span of 12 years found that participation in team sport when compared with other activities defined as prosocial, arts, and school-based, correlated with lower social isolation later in life (Barber, Eccles, & Stone, 2001). Another study found that sport participation played a distinct protective role for shy children. More specifically, participation in sport led shy children to report significant decreases in anxiety (Findlay & Coplan, 2008). Although this can explain why clinically insignificant levels of withdrawal are generally found amongst youth-athletes, it fails to explain why those who have sustained multiple concussions exhibit significantly less withdrawal. Perhaps baseline testing would reveal that individuals who are at heightened risk for multiple concussive injuries tend to be less withdrawn than their same-aged peers. At this point in time, this theory remains speculative and further research regarding specific psychological traits that predispose athletes to SRC injury is warranted.

Limitations and Future Research Directions

Participant sample. The participant sample used for the purposes of this study included elite youth male hockey players. Therefore, the results may not be generalizable to other sports or non-athlete populations. Given that female athletes represent a sizable portion of youth participating within organized hockey in the province of Alberta, an obvious limitation of the current study is the fact that female athletes were not accounted for within the sample population. With that being said, the results are not generalizable to youth female hockey players. Including a female sample in future studies would allow researchers to determine whether differences in psychosocial functioning exist across genders. Furthermore, acquiring data from an organized contact sport other than hockey, in which there is a more equitable rate of participation across genders as well as consistent rules regarding use of contact in play, is advisable. This would allow for a larger sample of female youth-athletes with a history of concussion to be acquired and allow for valid comparisons across genders to be conducted.

Preseason Questionnaire. It is probable that the PSQ may underestimate the precise number of concussions previously sustained by each participant. This is partially due to the under-reporting of concussions within organized competitive sports in general (Lovell, 2008). It is estimated that one third of athletes lack the ability to correctly identify the immediate signs and symptoms associated with a concussion injury and therefore fail to report it to coaching staff (Gerberich, Priest, Boen, Straub, & Maxwell, 1983). In a more recent study involving Canadian university football and soccer players, researchers found that nearly 70% of athletes reported symptoms suggestive of a concussion, but only 20% actually realized that they had sustained a concussion (Delaney, Lacroix, Leclerc, & Johnstone, 2002). Therefore, it would be safe to conclude that the participants in this study may have sustained a concussion earlier in their life without even knowing it and may have subsequently failed to report this on the PSQ. In addition, athletes at all levels of competition have been found to minimize or hide symptoms in an attempt to prevent their removal from the game (Lovell, 2008). The participant may also choose to withhold information for fear of compromising his or her athletic career.

Research has found that a significant proportion of parents continue to fail to identify key components of a concussion, such as difficulty with sleep, disorientation symptoms, and emotional irritability (Coghlin, Myles, & Howitt, 2009). Subsequently, even though the participant may have sustained a concussion earlier in life, his or her parent may have no knowledge of the incident ever occurring and may have failed to report the injury on the PSQ. In addition, an individual's memory is subject to inconsistencies, especially when asked to recall events that occurred in early childhood. It is reasonable to assume that families may not keep accurate records of concussion injury throughout the youth-athlete's early-life.

McKay and colleagues (2014) recently compared PSQ and ImPACT data acquired from the same participant sample used in this study. The researchers found notable disagreement in self-reported learning disorders and concussion history (McKay, Schneider, Brooks, Mrazik, & Emery, 2014). With regards to concussion history, the largest disagreements existed for those reporting 1 or 2 previous concussions, and more of those players reported fewer concussions on the ImPACT compared to the PSQ. The authors acknowledged that the study's results may be partially attributed to discrepancies in the level of parental input provided during the completion of the PSQ. However, they argued that it was highly unlikely that more than a few players completed the PSQ independently given their young age and the detailed nature of the survey questions.

McKay et al. (2014) speculated that parental input may have resulted in a more sensitive self-reported history, especially for those with few previous concussions. This may be due to the fact that parents tend to have a more accurate recall of prior medical injuries and occasionally maintain records. Parents may also employ a broader definition of concussion when assessing an injury than a player, resulting in a higher overall estimate of prior concussions. On the other hand, results indicated that a high number of players had a larger estimate of their concussion history on the ImPACT compared to the PSQ. With this in mind, the authors argued that, "it is equally probable that players included on-ice events that their parents were unaware of because they were not formally diagnosed as concussions" (McKay et al., 2014, p. 322). Consequently, the date of injury, the number of concussions, and the estimated severity of injury may only be rough approximations. Future studies should consider collecting relevant concussion data directly from players, parents, and coaching staff over time for more accurate results.

BASC-2. According to Reynolds and Kamphaus (2004), parents may produce invalid responses on the PRS if they lack English or Spanish proficiency, linguistic differences, reading disability, or lack of education. Data pertaining to these areas of concern were not attained for the purposes of this study. In the future, collecting relevant information with regards to parental background would ensure the validity of item responses. In addition, because the participant's parent and/or legal guardian were permitted to complete the BASC-2 PRS in the privacy of their home, the examiner was unable to observe the completion of the form first hand or provide further clarification as needed. Therefore, it is likely that some parents may have provided some invalid responses due to a lack of comprehension.

The participant was also only provided with one copy of the BASC-2 PRS form, which eliminates the option of comparing the results between parents or legal guardian(s) in an effort to check for potential inconsistencies. The validity of the study could also be strengthened by having the participant's teacher complete the BASC-2 Teacher Rating Scale (TRS). This would allow the researcher to better understand the individual's behavior across social contexts and within an academic setting. However, due to the fact that the study consists of a participant pool of considerable size, these were not deemed to be feasible options due for the current study due to constraints on time and resources.

Conclusion

Research examining the psychosocial outcomes at the mild end of the TBI spectrum, including SRC, have produced mixed findings, with some research suggesting full recovery within weeks of injury while other research suggests youth can encounter significant, persistent, and long-term adverse injury outcomes. While the findings drawn from this study failed to support the hypotheses originally proposed based on the current literature, they have nonetheless added to the growing body of research regarding the potential long-term psychosocial effects of

SRC in youth-athletes. It is hoped that the study has drawn attention to some of the developmental considerations unique to this vulnerable population and will encourage more research to be conducted in this area.

In accordance with statements previously put forth by Lazar and Menaldino (1995), it is important that clinicians continue to endeavor to take a developmental perspective when working with youth who have suffered a TBI. This involves expressly recognizing that the recovery process exists within the context of maturational and developmental changes (Lazar & Menaldino 1995; McKinlay, 2009). Although SRC represents a tangible health concern for youth-athletes, the risk of injury must be weighed against the potential benefits of sport participation with regards to one's development and overall well-being.

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Appendix A

Parent and/or Legal Guardian Consent Form

Consent Form

TITLE: Elite Youth Ice Hockey Concussion Study

Funding: Alberta Children's Hospital Research Institute, Max Bell Foundation

INVESTIGATORS:

Principal Investigator: Dr. Carolyn Emery, University of Calgary

Co-Investigators (University of Calgary): Dr. Willem Meeuwisse, Dr. Brian Brooks, Dr. Karen Barlow, Dr. Tish Doyle-Baker, Dr. Jian Kang, Kathryn Schneider (PhD Student), Tracy Blake, Kirsten Taylor

Co-Investigators (University of Alberta): Dr. Martin Mrazik, Dr. Connie Lebrun, Andrea Krol (PhD Student)

This consent form is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. For further details about this study, or to have your questions addressed please contact us. Please take the time to read this carefully and to understand any accompanying information. If you choose to participate, please keep your copy of this form and return the study copy (signed and witnessed) to your team designate.

BACKGROUND

Concussions are the most common injury type in elite youth ice hockey. Concussions can lead to long term sequelae including prolonged symptoms (i.e. headache, dizziness, neck pain) and neurocognitive deficits. The SCAT2 is a standardized evaluation of concussion used on the bench and in clinical return-to-play decisions in elite levels of play (i.e. major junior, NHL). The validity of the SCAT2 and the added value of the ImPACT in return to play decisions in youth elite ice hockey is unknown. This study will evaluate the validity of baseline neurocognitive testing (i.e. SCAT2 and ImPACT) and examine the utility of these tools in medical return to play decisions and in predicting prolonged recovery from concussion.

In addition to neurocognitive changes that may occur with concussion, we will also be looking at other functional changes in the body that may occur with concussion. Behavioral, emotional and social changes have also been shown to occur after concussion in some individuals. We will be using a behavioural questionnaire to assess for any changes before and after concussion. Currently there is little research that has been conducted in this area.

A number of Alberta Bantam, Minor Midget and Midget Hockey Teams have agreed to take part in this research project. We would like to invite your child to participate. Your child's team has been randomly selected to participate in this survey. There are expected to be more than 1000 hockey players in this study.

WHAT IS THE PURPOSE OF THE STUDY?

The primary purpose of this study is to evaluate two neurocognitive tools (SCAT2 and ImPACT computerized neurocognitive test) in the assessment of neurocognitive function (i.e. reaction time, memory, concentration, attention and processing speed) both during the pre-season and following a concussion.

WHAT WOULD MY CHILD HAVE TO DO?

We will be recruiting 12 teams in Edmonton (and 30 teams in Calgary) from Bantam and Midget AAA and AA Quadrant Hockey and Female AAA Bantam and Midget. Pre-season testing will be completed at the Sport medicine Centre, University of Calgary in September 2011. Testing will occur after team rosters have been finalized but before regular season games begin. This will provide a baseline to evaluate neurocognitive changes that may occur following a concussion and throughout recovery. This testing is not the current standard of practice in elite youth ice hockey but more typical in elite adult leagues (i.e. major junior, NHL). Baseline testing will take approximately 90 minutes.

Before baseline testing, there will be an information package sent home that includes a consent form, a preseason medical questionnaire and a behavioural questionnaire. On the day of testing, each participant will complete the SCAT2 (which is completed with a research assistant on an iPad) and one ImPACT test on a computer.

During the season:

During the season, if a team trainer suspects that a player has sustained a concussion, they will have the opportunity to follow-up with the study sport medicine physician at the Glen Sather Sport Medicine Centre within a week following the injury. At this time, the player will also repeat the baseline tests. Athletes will be assessed weekly until return to play and at three months following concussion. The same measures will be repeated at each visit.

ARE THERE ANY BENEFITS FOR MY CHILD?

If you agree to participate in this study there may or may not be a direct medical benefit to your child. His/her injury risk may be decreased during the study but there is no guarantee that this research will help him/her. If your child experiences a sports injury during the study duration, the team therapist (who will be attending every practice and game) will be assessing for injuries and making recommendations for follow-up treatment. The information we get from this study may help us to provide better sport injury prevention in future adolescent sport activities.

DOES MY CHILD HAVE TO PARTICIPATE?

No, your child does not have to participate.

WILL THERE BE FINANCIAL COMPENSATION, OR WILL THERE BE COSTS FOR THE PARTICIPANT?

There will be no financial compensation to the child or costs to the child as a participant in this study.

WILL MY CHILD'S RECORDS BE KEPT PRIVATE?

All of the information collected from the survey will be anonymous and will remain strictly confidential. Only the investigators responsible for this study, the research assistants who will be doing the baseline assessments, the statistician who will analyze the data and the University of Alberta Human Research Ethics Board (HREB) will have access to this information. Confidentiality will be protected by using a study identification number in the database. Any results of the study, which are reported, will in no way identify study participants.

IF MY CHILD SUFFERS A RESEARCH RELATED INJURY, WILL WE BE COMPENSATED?

In the event that your child suffers an injury because of participating in this research, the University of Alberta, Alberta Health Services or the researchers, will provide no compensation.

You still have all your legal rights. Nothing said here will in any way alter your right to seek damages.

SIGNATURES

If you agree to allow your child to participate, we require you to sign and return this form to your designated team study personnel. Two copies of the form are provided. Please keep one for your records. Please have another adult witness your signature on the copy that you return to us. Your signature on this form indicates that you have understood to your satisfaction, the information regarding participation in this research project and agree to allow your child participate as a subject. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. Your child is free to withdraw from the study at any time without jeopardizing your health care. Continued participation should be as informed as your initial consent, so you should feel free to ask for clarification throughout your child's participation. You will be informed if there is new information available through this study period. If you have further questions concerning matters related to this research, please contact:

Dr. Martin Mrazik (Principal Investigator) (780) 492-8052

If you have any questions concerning your rights as a possible participant in this research, please contact the Research Ethics Office (REO), University of Alberta, (780)-492-0459.

CONSENT FOR ELITE YOUTH ICE HOCKEY CONCUSSION STUDY

Parent/Guardian's Name (Printed)	Signature and Date
Child's Name (Printed)	Signature and Date
Investigator/Delegate's Name (Printed)	Signature and Date
Witness Name (Printed)	Signature and Date

The University of Alberta Human Research Ethics Board has approved this research study.

PLEASE SIGN THIS PAGE AND RETURN THE <u>FULL</u> DOCUMENT TO YOUR TEAM DESIGNATE.

KEEP THE OTHER COPY FOR YOUR RECORDS

Appendix B

Participant Assent Form

Assent Form for Players (under 18 yrs)

TITLE: Elite Youth Ice Hockey Concussion Study

INVESTIGATORS

Principal Investigator: Dr. Carolyn Emery

Co-Investigators (University of Calgary): Dr. Willem Meeuwisse, Dr. Brian Brooks, Dr. Karen Barlow, Dr. Tish Doyle-Baker, Dr. Jian Kang, Kathryn Schneider (PhD Student), Tracy Blake, Kirsten Taylor

Co-Investigators (University of Alberta): Dr. Martin Mrazik, Dr. Connie Lebrun, Andrea Krol (PhD Student)

This consent form is only one part of agreeing to be in this study. It should give you the basic idea of what the research is about and what being a part of it will mean. Please, take the time to read and understand the information. If you have questions or need more information about this study, please let us know. ***If you choose to participate, please keep a copy of this form and return the other copy (signed and witnessed) to your team designate.***

BACKGROUND

A concussion is a mild brain injury. It is the most common injury in elite youth ice hockey. Concussions can lead long lasting problems like headache, dizziness, and neck pain as well as problems with concentration and memory. The SCAT2 is a standardized test for those who have had concussions. It is used to help doctors to make return-to-play decisions. ImPACT is a test that checks reaction time, how fast your brain makes sense of information, and memory. We do not know how important the SCAT2 and the ImPACT are in return-to-play decisions in youth elite ice hockey. This study will look at the validity of the SCAT2 and ImPACT; how helpful they are in making choices about returning to sport; and predicting who will take longer to get better after a concussion.

Concussions can also change how other parts of your body works, like your heart, your neck, how well you can balance, and how you act, think and feel. Part of this study will look at if your heart works differently after a concussion by measuring your heart rate and the time in between heartbeats. We do not have a good understanding about how these change after a concussion.

Many people have dizziness and problems balancing after a concussion. The inner ear plays a big part in balance and is important in order to have clear vision when the head is moving quickly. We do not have a good understanding about these things change after a concussion.

Headaches and neck pain are also common after a concussion. In this study, we will test balance, how the neck moves and how strong the neck muscles are before and after a concussion and to see if there is a difference.

Concussions can make some people think, feel and act differently. We will ask you to answer some questions that will help us see if any changes happen after a concussion.

Your team has been randomly selected to participate in this study. We would like to invite you to be involved. More than 1000 hockey players are expected to take part in this study.

WHAT IS THE PURPOSE OF THE STUDY?

The purpose of this study is to look at how well the SCAT2 and ImPACT work for testing how hockey players 13-17 years old think, react, remember and focus before and after a concussion.

WHAT WOULD I HAVE TO DO?

We will be asking 30 teams in Calgary (and 12 teams in Edmonton) from Bantam and Midget AAA and AA Quadrant Hockey and Female Bantam and Midget AAA teams to be in the study. Pre-season testing will take place at the Sport Medicine Centre, University of Calgary in September 2011. Testing will be done after team rosters are set but before the regular season starts. This will give us information that we can look back on so we can see any changes that may happen after a concussion. This testing is not currently done in every elite youth hockey league, but is used regularly in major junior hockey and the NHL. Pre-season testing will take about 90 minutes.

Before pre-season testing, there will be an information package sent home that you and your parents will fill out. It includes this consent form, questions about your medical and injury history and questions about how you think, act and feel. These forms must be returned to your team designate BEFORE you are allowed to take part in the study. The name of your team designate will given to you when you receive your package. On pre-season test day, you will do the SCAT2 on the iPad and one ImPACT test on a computer. You will also be wearing a heart rate monitor and will do tests for neck function and balance.

During the season:

During the season, if your team trainer thinks that you have had a concussion, you will be able to see the study sport medicine doctor at the Sport Medicine Centre at the University of Calgary within a week. You will see the doctor every week until you are back to sport as well as three months after your concussion. You will repeat the pre-season tests at each visit.

If one of your teammates has a concussion, you might be asked to act as a healthy control. This will involve coming into the Sport Medicine Centre and repeating the baseline tests at the same time as your teammate.

If you get injured and have to miss more than one week of hockey (practices and/or games), you will have the chance to see the study sport medicine doctor at the Sport Medicine Centre at the University of Calgary.

ARE THERE ANY BENEFITS FOR ME?

If you agree to be in this study there may or may not be a direct medical benefits. You may have less risk of injury during the study but there is no guarantee that this research will help you. If you have a sports injury during the study, your team therapist will assess you and give you advice about any treatment they think would help you.

DO I HAVE TO BE IN THE STUDY?

If you agree to be in the study, we need you to sign and return one copy of this form to your volunteer team designate. Please have another adult witness your signature on the copy that you return to us. Please keep the other copy for your records.

Taking part in this study is voluntary. You may leave the study at any time by telling the Research Coordinator, Maria Romiti, by phone (403-220-8949) or by email (maromiti@ucalgary.ca). Your involvement and registration in the club/team will not change if you do not want to be in the study. Your coaching staff will know who is or is not in the study. This knowledge will not have any effect on how your relationship with your coaches or on the coaches' decisions about playing time. Please feel free to ask any questions you have that come up during the study that you think will help your understanding. You will be told of any new information that is available during the study.

WILL I BE PAID FOR BEING IN THE STUDY, OR DO I HAVE TO PAY FOR ANYTHING?

You will not get paid for being a part of this study. You will not have to pay for anything.

WILL MY RECORDS BE KEPT PRIVATE?

All of the information collected throughout the study period will have the names taken off and will remain private. Only the investigators responsible for this study, the research coordinator who will be doing the pre and post season testing, the statistician who will analyze the data and the University of Calgary, and the Conjoint Health Research Ethics Board will have access to this information. Using only a study identification number in the database will protect privacy. The reported results of the study will not identify you in any way.

IF I SUFFER A RESEARCH RELATED INJURY, WILL WE BE COMPENSATED?

If you are injured from participating in this research, the University of Calgary, Alberta Health Services and the researchers will not provide compensation. You still have all your legal rights. Nothing said here will in any way alter your right to seek damages.

SIGNATURES

Your signature on this form means that you have understand the information about taking part in the research project and agree to be a subject. This does not waive your legal rights nor release the investigators, or involved institutions from their legal and professional responsibilities. You are free to leave the study at any time without jeopardizing your health care. If you have more questions related to this research, please contact:

Ms. Maria Romiti (Research Coordinator)	(403) 220-8949
Dr. Carolyn Emery (Principle Investigator)	(403) 220-4608

If you have any questions concerning your rights as a possible participant in this research, please contact The Director, Office of Medical Bioethics, University of Calgary, at 403-220-7990.

Player´s Name (Print) ____________________ Signature and Date ____________________

Contact Information

Address:

Phone:

Witness' Name (Print) ____________________ Signature and Date ____________________

Dr. Carolyn Emery

Investigator/Delegate's Name

The University of Calgary Conjoint Health Research Ethics Board has approved this research study.

PLEASE SIGN THIS PAGE AND KEEP ONE COPY FOR YOUR RECORDS

Appendix C

Preseason Baseline Questionnaire

Study Subject ID# ____

(to be completed by study coordinator):

HOCKEY STUDY 2011-2012

UNIVERSITY OF CALGARY

Sport Injury Prevention Research Centre

UNIVERSITY OF CALGARY

Preseason Baseline Questionnaire

Name:

Today's Date: / / (Day Month Year)

Gender: ☐ Male ☐ Female

Age:

City:

Phone #: ( ) -

Height: ______ feet ____ inches **or** ______ cm

Date of Birth: / / (Day Month Year)

Weight: (lbs) **or** (kg)

Dominant Hand (for writing): ☐ Right ☐ Left

Age Group: ☐ Bantam ☐ Minor Midget ☐ Midget

Association:

Division: ☐ AAA ☐ AA ☐ A

Position: ☐ Forward ☐ Defense ☐ Goalie

Team Name:

Please check off how many years of organized hockey you have played prior to this season (check only one):

☐ 0 years	☐ 5 years	☐ 10 years
☐ 1 year	☐ 6 years	☐ 11 years
☐ 2 years	☐ 7 years	☐ 12 years
☐ 3 years	☐ 8 years	☐ 13 years
☐ 4 years	☐ 9 years	☐ Other: ________

EQUIPMENT (check all that apply):

a) Mouthguard:

At games: ☐ always ☐ less than 75% ☐ never

At practices: ☐ always ☐ less than 75% ☐ never

Type of mouthguard worn: ☐ Dentist custom-fit ☐ off the shelf

b) Helmet:

Make: ☐ Bauer ☐ CCM ☐ Itech ☐ Jofa ☐ Mission ☐ Nike ☐ RBK ☐ Other: ________

Type: ☐ full clear visor ☐ full wire cage ☐ combination visor/cage

Age: ☐ new this season ☐ new last season ☐ 2-3 years old ☐ >3 years old

INJURY AND MEDICAL HISTORY:

1. Have you ever had a concussion or been "knocked out" or had your "bell rung"?

☐ Yes ☐ No *If **yes**, please list:*

Date:	Activity at the time	Time unconscious		Memory loss (yes or no)	Time loss before FULL return to sport
eg. (DD/MM/YY)	*hockey, skateboarding, etc.*	*0min*	*30sec*	*no*	*1day, 10 days, etc*

If you answered **yes** to Question 1, please indicate whether you have any persistent problems with:

a) memory ☐ Yes ☐ No

b) dizziness ☐ Yes ☐ No

c) headaches ☐ Yes ☐ No

2. In the past **6 weeks,** have you had an injury requiring medical attention AND at least one day of time lost from physical activity?

☐ Yes ☐ No

*If **yes**, please describe this injury or these injuries to the best of your ability:*

Injury Date	Injury Type	Body Part	Sport of Occurrence	Treatment description	Estimated time loss from sport (days/wks)
eg. (DD/MM/YY)	*sprain, bruise, etc.*	*knee, nose, etc.*	*soccer, wakeboarding, etc.*	*first aid, physio, etc.*	*1day, 3 weeks, etc*

questionnaire continues (over) →

Preseason Baseline Questionnaire Page 2
HOCKEY STUDY 2011-2012

3. In addition to any injury described in questions 2, have you had any other injury requiring medical attention AND at least one day of time lost from physical activity in the past **ONE YEAR**?

☐ Yes ☐ No

*If **yes** , please describe this injury or these injuries to the best of your ability:*

Injury Date	Injury Type	Body Part	Sport of Occurrence	Treatment description	Estimated time loss from sport (days/wks)

4a. Do you have any incompletely healed injuries?

☐ Yes ☐ No

*If **yes** , describe this injury to the best of your ability:* ______

4b. Are you currently receiving treatment for this injury/these injuries?

☐ Yes ☐ No

*If **yes** , describe this injury to the best of your ability:* ______

5. Are you currently taking any medication **for injuries**? (Please check all the apply)

☐ Advil
☐ Tylenol
☐ Other If Other, please list: ______

6. Do you take any medications (asthma inhaler, advil, tylenol, etc) on a regular basis ?

☐ Yes ☐ No

*If **yes** , please list:* ______

7. Are you currently taking any supplements (Vitamins, Minerals, Protein Powder, etc) ?

☐ Yes ☐ No

*If **yes** , please list:* ______

8. Have you been diagnosed by a physician with a bone fracture, arthritis, or other muscle or bone related condition?

☐ Yes ☐ No Year: ______

*If **yes** , describe this condition(s) to the best of your ability:* ______

9. Have you been diagnosed by a physician with a systemic disease (ie. cancer, thyroid disease, heart disease)?

☐ Yes ☐ No Year: ______

*If **yes** , describe this condition(s) to the best of your ability:* ______

questionnaire continues →

Preseason Baseline Questionnaire Page 3
HOCKEY STUDY 2011-2012

10. Have you ever been diagnosed by a physician with a circulation or heart-related problem (ie. heart murmur, irregular heart beat, congenital deformity of the heart)?

☐ Yes ☐ No Year: ______________

*If **yes** , describe this condition(s) to the best of your ability:* ______________________

11. Have you been diagnosed by a physician with a neurological disorder (ie. Brain injury, cerebral palsy, pinched nerve, "stinger", multiple sclerosis, etc)?

☐ Yes ☐ No Year: ______________

*If **yes** , describe this condition(s) to the best of your ability:* ______________________

12a. Have you ever experienced headaches?

☐ Yes ☐ No

12b. If yes, are they associated with (please check all that apply):

☐ Nausea
☐ Vomiting
☐ Sensitivity to Light
☐ Sensitivity to Noise

12c. Does anyone else in your family experience headaches?

☐ Yes ☐ No

*If **yes** , please list:* ______________________

13a. Have you ever been concerned that you have an attention or learning issue?

☐ Yes ☐ No

*If **yes** , describe to the best of your ability:* ______________________

13b. Have you ever been formally diagnosed by a health care professional (physician, psychologist, etc) as having an attention or learning issue?

☐ Yes ☐ No

*If **yes** , describe to the best of your ability:* ______________________

13c. Have you ever been formally diagnosed by a health care profession (physician, psychologist, etc) with any of the following: (please check all that apply)

☐ Cognitive Delay	☐ Disruptive Behaviour Disorder:
☐ Communication Disorder	☐ Oppositional Defiant Disorder
☐ Pervasive Developmental Disorder	☐ Conduct Disorder
☐ ADHD	☐ Mood Disorder:
☐ Learning Disability	☐ Depression
☐ Anxiety Disorder	☐ Bi-Polar
☐ Other: ______________	

questionnaire continues →

Preseason Baseline Questionnaire Page 4
HOCKEY STUDY 2011-2012

14. Have you had surgery in the past year?

☐ Yes ☐ No Date: ____________

*If **yes**, describe this condition(s) to the best of your ability:* ____________

15. In the past **6 weeks**, how many weeks and how many hours per week (on average) did you participate in a school PE class?

____________ *number of weeks* ____________ *hours per week*

16. Based on the past **6 weeks** of activity, did you participate in any sports on a weekly basis **(NOT including PE class)**?

☐ Yes ☐ No

*If **yes**, please estimate the average number of hours per week you participated in each sport:*

SPORT	hrs/week	SPORT	hrs/week	SPORT	hrs/week
Aerobics		Floor hockey		Skateboarding	
Alpine skiing		Football		Snowboarding	
Badminton		Golf		Soccer	
Baseball		Gymnastics		Squash	
Basketball		Hiking/ Scrambling		Speed skating	
Boxing (incl. kick)		Hockey		Swimming	
Cross-country skiing		Horse riding		Tennis	
Cycling (road or mtn)		Lacrosse		Track and field	
Dance		Martial arts		Volleyball	
Dirt biking		Rock climbing		Waterpolo	
Diving		Rollerblading		Weight training	
Field hockey		Rugby		Wrestling	
Figure skating		Running		*Other:	
				**Please describe:*	

Appendix D

BASC-2 Parent Rating Scales- Adolescent

Parent Rating Scales– Adolescent

Computer-Entry Form

PRS–A
Ages 12–21

BASC™-2

Behavior Assessment System for Children, Second Edition

Cecil R. Reynolds, PhD, and Randy W. Kamphaus, PhD

Child's Name ______________________ (First / Middle / Last)

Date ____________ (Month / Day / Year) Birth Date ____________ (Month / Day / Year)

School ______________________ Grade __________

Sex: ☐ Female ☐ Male Age __________

Other Data ______________________

Your Name ______________________ (First / Middle / Last)

Sex: ☐ Female ☐ Male

Relationship to Child: ☐ Mother ☐ Father

☐ Guardian ☐ Other ______________

Instructions:

On the pages that follow are phrases that describe how children may act. Please read each phrase, and mark the response that describes how this child has behaved recently (in the last several months).

Circle **N** if the behavior **never** occurs.

Circle **S** if the behavior **sometimes** occurs.

Circle **O** if the behavior **often** occurs.

Circle **A** if the behavior **almost always** occurs.

Please mark every item. If you don't know or are unsure of your response to an item, give your best estimate.

How to Mark Your Responses

Be certain to **circle** completely the letter you choose, like this:

N (S) O A

If you wish to change a response, mark an X through it, and circle your new choice, like this:

N (X) (O) A

Before starting, be sure to complete the information in the boxes above these instructions.

PEARSON

PsychCorp

Product Number 30035

Remember: N – Never S – Sometimes O – Often A – Almost always

1. Adjusts well to new teachers. .... N S O A
2. Accurately takes down messages. .... N S O A
3. Volunteers to help clean up around the house. .... N S O A
4. Calls other adolescents names. ...... N S O A
5. Pays attention. .... N S O A
6. Compliments others. .... N S O A
7. Is creative. .... N S O A
8. Cries easily. .... N S O A
9. Complains of being sick when nothing is wrong. .... N S O A
10. Annoys others on purpose. .... N S O A
11. Has eye problems. .... N S O A
12. Worries about making mistakes. ..... N S O A
13. Uses foul language. .... N S O A
14. Makes friends easily. .... N S O A
15. Cannot wait to take turn. .... N S O A
16. Has stomach problems. .... N S O A
17. Joins clubs or social groups. .... N S O A
18. Adjusts well to changes in plans. .... N S O A
19. Steals. .... N S O A
20. Acts without thinking. .... N S O A
21. Seems unaware of others. .... N S O A
22. Complains about being teased. ...... N S O A
23. Is nervous. .... N S O A
24. Encourages others to do their best. .. N S O A
25. Is cruel to animals. .... N S O A
26. Is unclear when presenting ideas. ... N S O A
27. Sees things that are not there. .... N S O A
28. Says, "I'm not very good at this." ..... N S O A
29. Drinks alcoholic beverages. .... N S O A
30. Says, "Nobody understands me." ..... N S O A
31. Adjusts well to changes in routine. ... N S O A
32. Communicates clearly. .... N S O A
33. Acts in a safe manner. .... N S O A
34. Teases others. .... N S O A
35. Has a short attention span. .... N S O A
36. Congratulates others when good things happen to them. .... N S O A
37. Is good at getting people to work together. .... N S O A
38. Is negative about things. .... N S O A
39. Complains of shortness of breath. ... N S O A
40. Threatens to hurt others. .... N S O A
41. Has a hearing problem. .... N S O A
42. Worries about what teachers think. .. N S O A
43. Sneaks around. .... N S O A
44. Refuses to join group activities. ...... N S O A
45. Has poor self-control. .... N S O A
46. Says, "I think I'm sick." .... N S O A
47. Will speak up if the situation calls for it. .... N S O A
48. Is a "good sport." .... N S O A
49. Smokes or chews tobacco. .... N S O A
50. Interrupts parents when they are talking on the phone. .... N S O A
51. Stares blankly. .... N S O A
52. Says, "I hate myself." .... N S O A
53. Tries too hard to please others. ...... N S O A
54. Says, "please" and "thank you." ...... N S O A
55. Has headaches. .... N S O A
56. Tracks down information when needed. .... N S O A
57. Has strange ideas. .... N S O A
58. Says, "I get nervous during tests" or "Tests make me nervous." .... N S O A
59. Is in trouble with the police. .... N S O A
60. Says, "I want to kill myself." .... N S O A
61. Recovers quickly after a setback. .... N S O A
62. Is effective when presenting information to a group. .... N S O A
63. Needs help from others to get up on time. .... N S O A
64. Argues when denied own way. ...... N S O A
65. Listens to directions. .... N S O A
66. Tries to bring out the best in other people. .... N S O A
67. Works well under pressure. .... N S O A
68. Changes moods quickly. .... N S O A
69. Complains about health. .... N S O A
70. Hits other adolescents. .... N S O A
71. Repeats one activity over and over. .. N S O A
72. Worries about things that cannot be changed. .... N S O A
73. Breaks the rules. .... N S O A
74. Is shy with other adolescents. .... N S O A
75. Acts out of control. .... N S O A
76. Pays attention when being spoken to. .... N S O A