University of Alberta

The Reporting of Concussion Symptoms in College Athletes

by

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Abstract

This study sought to investigate the differences in reporting of concussion symptoms among college athletes. Athletes ($n = 117$) were assigned to complete the Post-Concussion Symptom Scale (PCSS) as a self-administered questionnaire or as an interview. The study aims were to examine the effect of interviewer gender on the report of post-concussion symptoms (PCS) and, to examine whether athletes report a higher symptom score on a self-administered PCSS than in an interview. An independent sample *t*-test did not show a significant difference in symptom reporting across interviewer gender for male athletes, or female athletes ($p > .05$). Interviewer gender does not seem to influence symptom reporting. A two factor ANOVA revealed a significant difference in total symptom scores across administration mode for male athletes ($p \leq .05$). Male athletes reported a higher total symptom score in the self-administration condition than in the interview condition.

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Chapter One—Introduction

Cerebral concussion, or mild traumatic brain injury (MTBI), is a pervasive health concern affecting children, adolescents, and adults globally (Wrightson & Gronwall, 1999). Recent reports from the World Health Organization indicate that MTBI represents between 70% and 90% of all treated traumatic brain injury (TBI), and the rate of hospital-treated patients with MTBI ranges from 100 to 300/100,000 (Cassidy et al., 2004). It is therefore undeniable that MTBI places significant demands on health care services. Individuals suffering from MTBI often spend time in emergency departments; they may require expensive imaging procedures, the short term use of hospital beds, and in rare cases long term rehabilitative services (Wrightson & Gronwall, 1999).

Sports Related Mild Traumatic Brain Injury

With an ever-increasing involvement of individuals in athletic endeavors, sport-related concussion has received considerable attention over the last decade (Bailes & Cantu, 2001; Guskiewicz et al., 2004; Piland, Motl, Ferrara, & Peterson, 2003). MTBI is the most common form of head injury in recreational and competitive sports and has recently been identified as a major public health concern worldwide (Jantzen, Anderson, Steinberg, & Kelso, 2004; McCrea et al., 2003; Moser, 2007). Epidemiological studies have indicated that approximately 300,000 sports-related traumatic brain injuries or head injuries occur annually in the United States (Covassin, Swanik, & Sachs, 2003; Guskiewicz, Weaver, Padua, & Garrett, 2000). In a three year study conducted by Covassin, Swanik, and Sachs (2003), it was found that concussion among intercollegiate athletes accounted for 6.2% of all reported athletic injuries. Similarly, Powell and Barber-

Foss (1999) found that MTBI in high school athletes accounted for 5.5% of all injuries across ten different sports.

It is also likely that many MTBIs go unreported, underestimating the true incidence of these injuries (Kaut, DePompei, Kerr, & Congeni, 2003). Athletes represent a unique population who present with variables that influence their reporting of injuries. Several studies have delineated that athletes tend to fail to report their injuries or may be unaware of having experienced a concussion (Chen et al., 2007; Delaney, Lacroix, Leclerc, & Johnston, 2000; Kaut et al., 2003; Solomon, Johnston, & Lovell, 2006).

Due to the high incidence of head injuries in contact sports, proper identification, diagnosis, and management of concussion is of utmost importance for the health and welfare of athletes (Covassin et al., 2003; Johnston, Ptito, Chankowsky, & Chen, 2001). It is now known that concussed athletes who are not removed from play after injury are at an increased risk for impaired playing performance, further injury, and/or sustaining another impact before fully recovering (Johnston et al., 2001). Returning an athlete back to play too soon after a concussion can result in long-term neuropsychological dysfunction, or in rare circumstances severe disability or death (Lovell, Collins, Iverson, Johnston, & Bradley, 2004). Therefore, a key issue facing physicians, neuropsychologists, and other medical personnel is deciding when a concussed player is ready to return to play (Bailes & Cantu, 2001; Collins, Lovell, & Mckeag, 1999; Johnston et al., 2001).

Definition and Diagnosis of MTBI

Since the recognition of MTBI as a clinical diagnosis distinct from moderate and severe brain injury, many formal definitions of this injury have been created (Collins et al., 1999; K. M. Johnston, McCrory, Mohtadi, & Meeuwisse, 2001; R. S. Moser, 2007). The varying definitions of concussion proposed by neurosurgeons, neurologists, neuropsychologists and other multidisciplinary groups over time emphasize the complexity of MTBI and the conflicting opinions about it (Solomon et al., 2006). In 1966, the Congress of Neurological Surgeons defined concussion as, "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" (as cited in P. McCrory, 1999, p.136). In 1997, the American Academy of Neurology defined concussion as:

> A trauma-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 (as cited in Solomon et al., 2006, p.10).

Over time, the lack of uniformity in the definition and understanding of concussion led to an array of complexities in the identification, diagnosis, and management of this injury (Guskiewicz et al., 2006; Solomon et al., 2006). Advancement in the field of MTBI required a consensus definition of concussion and strict parameters for return to sport participation after injury (Aubry et al., 2002; P. McCrory et al., 2005). Therefore, in 2002, a multidisciplinary team of professionals formed the Concussion in Sport Group and created a consensus definition for MTBI (Aubry et al., 2002; P. McCrory et al., 2005). Their definition included the clinical, pathological, and biomechanical aspects of concussion to systematically diagnose and manage athletes with concussion. According to the Concussion in Sport Group:

Mild traumatic brain injury or concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathological, and biomechanical injury constructs that may be used in defining the nature of a concussive head injury include, (a) 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, (b) concussion typically results in the rapid onset of short lived impairment of neurological function that resolves spontaneously, (c) concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury, (d) concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course and, (e) concussion is typically associated with grossly normal structural neuroimaging studies (Aubry et al., 2002, p.6).

Historically, severity of concussion has been classified by a number of different grading systems (Asplund, McKeag, & Olsen, 2004; P. McCrory et al., 2005; R. S. Moser, 2007). However, most concussion grading systems are not derived from empirical evidence, and they base their return-to-play guidelines on mandatory exclusion policies (Chen et al., 2007; HintonBayre, Geffen, Geffen, McFarland, & Friis, 1999). Mandatory exclusion policies can be problematic given that they utilize arbitrary amounts of time for recovery, and they often under-estimate or over-estimate the recovery time required for athletes after concussion (Hinton-Bayre et al., 1999).

Without universal agreement on the classification of severity of concussive injury, the clinical management of sports related concussion has varied dramatically over time (K. M. Johnston et al., 2001; Solomon et al., 2006). However, at the most recent International Conference on Concussion in Sport, it was concluded that MTBI must be evaluated and treated on an individual basis (P. McCrory et al., 2005). As a result, concussion grading scales and their subsequent return-to-play guidelines are no longer recommended for the clinical management of MTBI (P. McCrory et al., 2005; Solomon et al., 2006).

One of the paramount developments outlined by the Concussion in Sport Group at the 2nd International Conference in Prague (2004) was a new classification system for concussion in sport (P. McCrory et al., 2005). In replacement of the previous concussion grading systems, MTBI is now classified as either simple or complex (P. McCrory et al., 2005). A simple concussion, which is the most common form of MTBI, is where an athlete suffers an injury that progressively resolves without complication over 7 to 10 days. Complex concussion is defined by persistent symptoms, specific sequelae, prolonged loss of consciousness, or prolonged cognitive impairment after injury.

The Problem at Hand

Currently, the science of concussion is in the early stages of development. Although extensive experimental research has drastically improved our understanding of the pathophysiology of brain injury, much remains unknown about what happens to the brain following minor concussive injuries and in particular, sports-related concussion (P. B. S. McCrory, Johnston, Mohtadi, & Meeuwisse, 2001). Therefore, as more and more evidence-based literature is published and disseminated, sports concussion management continues to evolve.

The identification, diagnosis, and management of concussion in sport relies heavily on the self-report of symptoms from injured athletes (Bailes & Cantu, 2001; Chen et al., 2007; Delaney et al., 2000; Van Kampen, Lovell, Pardini, Collins, & Fu, 2006). Physicians must rely on the self-report of symptoms from injured athletes because often physical, neurological, and radiological findings from computed tomography (CT) or magnetic resonance imaging (MRI) are unremarkable (Chen et al., 2004; Jantzen et al., 2004; K. M. Johnston et al., 2001). Although the present guidelines for returning athletes back to play after concussion require a complete resolution of symptoms, the self-report of symptoms by athletes is complex given the unique aspects of competitive sport. Many athletes' motivation to continue playing after injury may cause them to minimize or underreport their symptoms (Bruce & Echemendia, 2004; Covassin et al., 2003; Delaney et al., 2000). Furthermore, athletes may be reluctant to volunteer information about their symptoms because they do not want to be perceived as weak by their teammates or coaches and/or because they fear losing valuable playing time (Delaney et al., 2000). The under-reporting of post concussion symptoms in athletes is a phenomenon that has been observed and documented at all levels of competition (Delaney et al., 2000; Van Kampen et al., 2006).

At present, one of the most widely used tools to determine an athlete's clinical recovery from concussion is a self-report questionnaire examining the presence of post-concussive symptoms (PCS) (Bruce & Echemendia, 2004; Chen et al., 2007). To date, there has been no research examining self-report questionnaires and whether the mode of administration affects the results obtained from concussed athletes. Theories derived from the social psychology literature suggest that with face-to-face interviews an interviewer's personality, age, sex, and race may influence a respondent's reports (Moum, 1998). In addition, individuals may respond to self-report items in a manner that makes them look good rather than in an accurate and truthful manner. Interviewer effects and social desirability effects with self report inventories in concussion have never been examined in the scientific literature. Considering that the self-report of PCS is fundamental to the identification, diagnosis, and management of MTBI, it is imperative that coaches, physicians, athletic trainers, and neuropsychologists obtain the most accurate clinical information from injured athletes. With the recent emphasis on the safety and health of athletes who suffer concussive injuries, coupled with the reliance on self-report of symptoms for diagnosis and management, research examining different methods to collect clinical information from athletes is clearly warranted.

The Purpose of the Present Study

The aim of this study was to examine whether the medium in which athletes report their symptoms impacts the manner in which they disclose PCS. This study was developed to further enhance the research conducted by Chen et al. (2007), which found that self-reported PCS are associated with cerebral hemodynamic abnormality as well as with mild cognitive impairment. Due to the fact that research has identified that PCS are critical in the identification, assessment, and management of concussion (Chen et al., 2007), the present study attempted to identify different ways to collect self-report information from athletes. The specific aims of the study were (a) to examine whether interviewer gender influenced the reporting of PCS in athletes and (b) to examine the hypothesis that athletes will endorse more PCS in self-administered questionnaire completed independently compared than in an interview with a trained professional.

Summary

Chapter I discussed the need for physicians, coaches, neuropsychologists, athletic trainers and other medical personnel to obtain the most accurate clinical information from concussed athletes after injury. The identification, diagnosis, and management of cerebral concussion currently relies on the self-report of symptoms from the injured athletes. However, many athletes either minimize or underreport their symptoms for fear of losing valuable playing time or being perceived as weak by their teammates or coaches. To date, there is minimal research examining different methods of collecting subjective clinical information from injured athletes.

Chapter II will present a review of relevant literature on sports-related concussion and on the identification, assessment, and management of this injury. The discussion will appraise what is currently known about sports-related concussion, and then will introduce 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 a discussion of the findings.

Chapter Two—Literature Review

Through an examination of related research, this chapter will provide a context for the study at hand. The chapter will begin with a historical review of mild traumatic brain injury as well as review some of the challenges inherent in the identification, diagnosis, and management of sports related concussion. The most recent model used in the management of sport-related concussions will be outlined and discussed. In addition, emphasis will be placed on reviewing the literature regarding the assessment of concussion and the collection and utilization of subjectively reported post-concussion symptoms. This chapter will also review relevant aspects of the social psychology literature pertaining to interviewer effects and the collection of subjective data. The chapter concludes with proposed hypotheses for the current study.

MTBI: A Brief History

MTBI was first discussed in myth and legend as well as in non-medical literature in the 10th centrury A.D. (P.R. McCrory & Berkovic, 2001; Solomon et al., 2006). However, at that time, mild head injury was not differentiated from moderate or severe head injury. It was not until the year 900 when Rhazes, a renowned Muslim physician, recognized concussion as an abnormal physiological condition rather than as a severe brain injury. From the tenth century forward, the clinical features of MTBI were recognized and studied, and the understanding of concussion began to develop. In the 16th century, writers began to propose the idea that the acute symptoms of concussion manifest from brain shaking or brain movement (P.R. McCrory & Berkovic, 2001; Wrightson & Gronwall, 1999). To date, debate still remains as to whether or not this injury produces permanent pathologic change (P.R.McCrory & Berkovic, 2001; Solomon et al., 2006). Although there has been a recent explosion of scientific investigation around cerebral concussion, research aimed at the diagnosis, assessment, and management of this injury is still required.

In sports, head injuries began to receive prominent notice in the early 1900's (Bailes & Cantu, 2001). An excessive number of deaths and injuries associated with brutality in football led to the recognition of head injury and the creation of the National Collegiate Athletic Association (Bailes & Cantu, 2001; Kelly & Rosenberg, 1997). The responsibilities of the organization were to implement safety rules and guidelines for play in college sports to help reduce injury (Bailes & Cantu, 2001). In subsequent years, additional organizations were introduced to help further reduce the incidence of head injury attributed to sports (Bailes & Cantu, 2001; Solomon et al., 2006).

In the 1960's, a significant reduction of head injuries in football was noted. These changes were attributed to alterations in helmet design, helmet usage, and associated rule changes (Bailes & Cantu, 2001; Kelly & Rosenberg, 1997). However, even despite recognition of MTBI in sports, concussion was viewed primarily as a transient, routine event that occurred regularly in athletic contests (Solomon et al., 2006). MTBI was commonly referred to as a *ding* or *bell ringer,* and the injury was rarely taken seriously (Guskiewicz et al., 2004; Solomon et al., 2006). A recent report published by Guskiewicz et al. (2004) called for the eradication of the term ding to describe sports concussion because it diminishes the seriousness of this injury (Guskiewicz et al., 2004). It has only been within the last few years that concussion has been viewed by the public as a serious injury with potential deleterious effects (Solomon et al., 2006).

Challenges in the Identification of Concussion

Sport- related concussion is a challenging injury to identify and evaluate (Chen, Johnston, Collie, McCrory, & Ptito, 2007; Notebaert & Guskiewicz, 2005). This is partially attributable to the fact that over 90% of athletes with sustained head injury show no objective signs or symptoms of concussion, such as loss of consciousness or amnesia (Guskiewicz, Weaver, Padua, & Garrett, 2000; McCrea, 2001a; McCrea, 2001b). Similarly, unlike for many other athletic injuries, clinicians do not have easy access to sophisticated tools or methods with which to immediately identify, evaluate, and diagnose concussive injuries (Notebaert & Guskiewicz, 2005). Although computed tomography (CT) and magnetic resonance imaging (MRI) can detect the presence of more severe brain injury, the subtle pathology associated with concussion is much more difficult to recognize (Collins et al., 2003; Solomon, Johnston, & Lovell, 2006). Current imaging techniques are unable to capture the microscopic axonal damage and the subsequent cellular dysfunction that underlies the pathology of concussion (Echemendia, Putukian, Mackin, Julian, & Shoss, 2001). Therefore, clinical information must be gathered from a variety of sources and from multiple diagnostic elements in order to determine the presence and severity of a concussive injury (Lovell et al., 2006; Notebaert & Guskiewicz, 2005). However, due to the cost and impracticality of many of the current diagnostic tools, many athletes are not privy to such investigation and are managed solely on clinical examination and symptomatology (Maroon et al., 2000; Notebaert & Guskiewicz, 2005). Unfortunately, the effects of concussion can be subtle and difficult to identify through clinical examination, and the self-report of symptoms can be problematic given an athlete's motivation to continue playing after injury (Bruce & Echemendia, 2004; T. Covassin, Swanik, & Sachs, 2003; Delaney, Lacroix, Leclerc, & Johnston, 2000; McCrea, 2001a).

Another inherent challenge in the identification of concussion has been the lack of a standard definition and diagnostic criteria (Cassidy et al., 2004; P. R. McCrory, Ariens, & Berkovic, 2000; Ruchinskas, Francis, & Barth, 1997). Prior to the formation of the Concussion in Sport Group in 2001, there was no definitive classification of concussion in sport, and the term concussion was sometimes used in confusing and contradictory ways (Aubry et al., 2002; Collins et al., 2003; P. R. McCrory & Berkovic, 2001). Research conducted prior to 2002 utilized a diverse range of criteria to evaluate the severity of a concussion (Cassidy et al., 2004). For example, whereas conservative methods identified concussion based on subjective feelings of being *dazed*, other approaches used indicators such as loss of consciousness or post-traumatic amnesia (Cassidy et al., 2004). The previous lack of agreement over the definition of sport concussion has led to an abundance of literature that is heterogeneous in nature and thus difficult to evaluate and compare (Cassidy et al., 2004; Solomon et al., 2006).

Similarly, prior to the creation of the Concussion in Sport Group there was also incongruity in concussion classification (Asplund, McKeag, & Olsen, 2004; Johnston, McCrory, Mohtadi, & Meeuwisse, 2001; P. McCrory, 1999). At that time, over 25 different concussion grading systems were being utilized to classify the severity of an injury and provide prognostic information (i.e. return-to-play criteria) (Asplund et al., 2004; Johnston et al., 2001; P. McCrory, 1999). Most of the 25 different concussion grading scales were derived from clinical expertise and consensus opinion rather than evidence based research (Johnston et al., 2001; Solomon et al., 2006). The abundance of concussion grading systems available for use encouraged doctors, coaches, and team personnel to choose injury scales based upon their sporting needs rather than for optimal medical management (Johnston et al., 2001). Recently, injury grading systems have been abandoned and replaced with more individualized methods of concussion assessment and evaluation (P. McCrory et al., 2005). The newest model of concussion evaluation formed by the Concussion in Sport Group will be reviewed below.

New Model of Concussion Evaluation

In 2001, the first international symposium on concussion in sport was held to establish guidelines and recommendations for athletes after concussive injury. Experts in this field discussed different aspects of concussive injury in sport including epidemiology, clinical and basic science, injury grading systems, cognitive assessment, new research methods, protective equipment, management, prevention, and long term outcome (Aubry et al., 2002). At the conclusion of the conference, a working document with the most current concussion management guidelines was published and disseminated for public use. In 2004, the second international symposium was held and the original concussion recommendations established in 2001 were up-dated and revised. Concussion evaluation and management guidelines accepted as most current have been derived from the second international symposium.

One of the paramount developments arising out of the second international symposium was a new classification system for concussive injury in sport (P. McCrory et al., 2005). Concussive injury in sport is now classified as either simple or complex, and grading scales are no longer recommended for use in clinical practice. Management considerations vary according to the classification of the injury, and recovery is guided by a stepwise process. In cases of simple concussion, an athlete's symptoms progressively improve within 7 to 10 days. The athlete is removed from play until the complete resolution of symptoms. Formal neuropsychological testing is not required for simple concussions, and an athlete can return to sport participation when all symptoms have dissipated both at rest and with exertion. In cases of complex concussion, an athlete experiences persistent symptoms, specific sequelae, prolonged loss of consciousness, or prolonged cognitive impairment. Complex concussions entail added management considerations that may include formal neuropsychological testing, balance testing, neuroimaging, and the expertise of a multidisciplinary team.

Current evaluation procedures for concussion encourage a preparticipation medical examination of all athletes (P. McCrory et al., 2005). This examination includes obtaining an athlete's history of concussion injury, a baseline cognitive assessment, and, if possible, a formal baseline neuropsychological test. A thorough baseline evaluation is valuable for medical personnel to identify those individuals with a high-risk concussion profile (Guskiewicz, Bruce, Cantu, Ferrara, Kelly, McCrea, Putukian et al., 2004; P. McCrory et al., 2005; Solomon et al., 2006).

In the event of a concussion, a detailed evaluation process for both simple and complex concussion is suggested. To begin, an injured athlete who presents with any of the following clinical symptoms (e.g. headache, balance problems dizziness, nausea etc.), physical signs (e.g. poor coordination or balance, seizure, vomiting, personality changes), cognitive impairment (e.g. confusion, amnesia), and/or loss of consciousness should be managed with the appropriate concussion strategies as outlined by the Concussion in Sport Group (P. McCrory et al., 2005). These strategies stipulate that:

a) A concussed athlete must not be returned to play in the current game or practice, b) the player should not be left alone over the initial few hours after injury and should be monitored regularly for signs of deterioration, c) the player should be medically evaluated after the injury, d) return-to-play must follow a medically supervised stepwise process (P. McCrory et al., 2005, p. 201-202.).

Subsequent return-to-play decisions will vary according to the classification of the injury (simple versus complex), but the following step-wise protocol should be employed in all cases:

a) no activity, complete rest. Once asymptomatic, proceed to level two, b) light aerobic exercise such as walking or stationary cycling, no resistance training, c) sport specific exercise- for example skating in hockey, running in soccer; progressive addition of resistance training at steps three or four, d) non contact training skills, e) full contact training drills, f) game play (P. McCrory et al., 2005, p. 202).

This step-wise recovery process stipulates that an athlete must be symptom free before progressing to the next level. If post-concussion symptoms occur at any point in the step-wise recovery process, the athlete must drop back to the previous asymptomatic level and rest for 24 hours before beginning again.

Sports concussion management continues to evolve as more evidence-based research is conducted and disseminated. Although concussion management has advanced dramatically in the last decade, clinicians are still searching for more reliable and systematic ways to evaluate and manage mild head injury in athletes. This research study sought to enhance the growing body of literature that addresses the optimal way to identify and manage concussion in athletes.

Why is it Important to Identify Concussion?

The importance of early identification and proper management of concussion in sport has stemmed from a plethora of literature suggesting that there may be life threatening or long-term, deleterious consequences from this injury (R. S. Moser, 2007; Solomon et al., 2006). Although the literature is just beginning to highlight some of the long term effects of sport concussion, it is clear that management strategies for this injury are of paramount importance for the health and well-being of injured athletes (HintonBayre & Geffen, 2002; P. R. McCrory & Berkovic, 1998).

Second impact syndrome (SIS) is one of the most commonly feared complications of traumatic brain injury (P. McCrory, 2001). SIS occurrs when, "…an athlete who has sustained an initial head injury, most often a concussion, sustains a second head injury before symptoms associated with the first have fully cleared" (P. McCrory, 2001, p. 144). It is postulated that a second impact causes cerebral vascular congestion resulting in increased intracranial pressure. The consequences of SIS can be catastrophic, resulting in either death or permanent disability (P. R. McCrory & Berkovic, 1998). According to Maroon et al. (2000), 26 cases of SIS related deaths have been documented and confirmed in the United States since 1984. Although SIS happens infrequently and the scientific literature for its existence is lacking, the potential catastrophic outcomes of this injury demand rigorous management strategies for concussion (P. McCrory, 2001; P. B. S. McCrory, Johnston, Mohtadi, & Meeuwisse, 2001; P. R. McCrory & Berkovic, 1998; Solomon et al., 2006). Until scientific evidence can disprove the existence of SIS, management strategies must embrace guidelines that restrict injured athletes from return-to-sport participation until complete resolution of post-concussive symptoms (P. R. McCrory & Berkovic, 1998; Solomon et al., 2006).

The Assessment of Concussion

Within the last decade there has been an explosion of research and scientific investigation exploring the topic of sport concussion (Ferrara, McCrea, Peterson, & Guskiewicz, 2001; Piland, Motl, Ferrara, & Peterson, 2003). Consequently, several evaluation methods, assessment tools, and return-to-play guidelines for concussion in sport have been formulated and implemented (Piland et al., 2003). Although a plethora of information has enabled team physicians, athletic trainers, coaches, and neuropsychologists to develop their understanding of concussion, many questions concerning the validity and practicality of concussion evaluation methods and diagnostic tools remain (Piland et al., 2003). Concussion in athletes after injury has been identified through neuropsychological evaluation, balance testing, neuro-imaging, and the self-report of symptoms (Guskiewicz, Bruce, Cantu, Ferrara, Kelly, McCrea, Putukinan et al., 2004). Each of these assessment methods, which examine different components of concussive injury, will be discussed in more detail below.

Neuropsychological testing. Neuropsychological testing in athletes provides an assessment and quantification of brain function by measuring different components of cognitive performance after concussive injury (Echemendia et al., 2001). Neuropsychological assessment objectively measures an individual's memory recall, attention, concentration, problem solving abilities, visual tracking, reaction time, speed of information processing, and other cognitive functions that can be affected after minor head injury (Collins et al., 1999; Echemendia et al., 2001; Solomon et al., 2006). A large body of literature supports and encourages the use of neuropsychological testing because it contributes significantly to concussion evaluation in athletes (Collins et al., 1999; Lovell et al., 2003; P. McCrory et al., 2005). More specifically, research has revealed that formal neuropsychological testing can delineate the subtle cognitive changes associated with concussion that are undetectable with other assessment techniques (Collins, Lovell, & Mckeag, 1999; Johnston et al., 2001). In fact, in one study it was found that in some cases cognitive performance deficits in concussed athletes persisted up to 14 days, long after the resolution of post concussion symptoms (McClincy, Lovell, Pardini, Collins, & Spore, 2006). Subtle cognitive dysfunction may be an indicator that an athlete's brain has not fully recovered after injury, and thus, return to play decisions must be made cautiously. Assessment of cognitive function has become an especially vital component in the management of complex concussion or in cases of multiple concussion (Bleiberg et al., 2004; Maroon et al., 2000; P. McCrory et al., 2005). Neuropsychological testing has been shown to provide the most sensitive guide to on-going or cumulative problems following minor head injury and has been particularly helpful to medical personnel making return to play decisions (Maroon et al., 2000). Given the value of neuropsychological testing in the individualized management of concussion, researchers and clinicians are hopeful that these tests will become more widely implemented at all levels of athletic competition.

Balance testing. One of the biggest challenges facing clinicians in the management of concussion is the lack of objective and quantifiable information available to make precise return-to-play decisions (Guskiewicz, 2001). Although neuropsychological testing is critical for the evaluation of cognitive functioning after concussion, postural stability assessment is gaining credence for its ability to evaluate motor function abnormalities after injury (Guskiewicz, 2001). Many athletes commonly report problems with dizziness and balance after concussion, and therefore, tests of postural stability are one more way to objectively measure injury in athletes (Guskiewicz, 2001; Guskiewicz, Bruce, Cantu, Ferrara, Kelly, McCrea, Putukinan et al., 2004; Solomon et al., 2006). Researchers have stated that, "postural stability testing can provide clinicians with an additional piece of the *concussion puzzle* and assist them in determining readiness to return safely to participation" (Guskiewicz, 2001, p.182). A prospective study conducted by McCrea et al. (2003), which sought to measure the immediate effects and natural recovery course of sport related concussion, found pronounced balance deficits in concussed athletes at 24 hours after injury. Results from this study also found that, in many cases, balance deficits in injured athletes resolve within five days post-injury (M. McCrea et al., 2003; Solomon et al., 2006). These results emphasize the utility of balance testing in the acute recovery of concussion. Although balance testing may not be applicable in the assessment of every injured athlete, the Concussion in Sport Group and the National Collegiate Athletic Association recommend its use in the clinical evaluation of acute concussion when appropriate. The additional information balance testing can provide after concussion renders it a valuable and useful tool for clinicians making return to play decisions (Guskiewicz, 2001; P. McCrory et al., 2005). However, as with most other sophisticated medical tools, costs associated with balance testing prohibit its clinical use.

Neuroimaging. A recent growing body of literature has highlighted the value of different neuroimaging techniques to study and identify the physiological changes in the brain associated with concussion (Lovell et al., 2007; Solomon et al., 2006). Although structural scans of the brain, including magnetic resonance imaging (MRI) and computed tomography (CT), generally reveal normal results after concussion, functional imaging scans examining brain activity have provided clinicians with invaluable information. More specifically, research has shown that athletes have reduced brain activation after concussive injury that tends to resolve in synchrony with post concussive symptoms and cognitive dysfunction (Chen et al., 2004; Solomon et al., 2006). Although neuroimaging techniques examining concussion are exclusively used for research purposes, many hope that functional brain imaging tests will be used to clinically assess concussion in the future (Solomon et al., 2006).

Self-Report of symptoms. Despite the recent influx of more sophisticated, objective measures (i.e. neuropsychological tests, postural stability tests and, neuroimaging techniques) to identify, assess, and manage concussion in sport, the subjective self-report of symptoms after injury remains a central component of concussion evaluation (Ferrara et al., 2001; Lovell et al., 2006; Piland et al., 2003). Although an abundance of literature highlights the benefits of these sophisticated measures and encourages their use in the evaluation of concussion, their cost and impracticality have limited their widespread application (Piland et al., 2003). There are several issues related to neuropsychological testing, neuroimaging, and postural stability testing that limit their use in concussion assessment: lengthy tests, which are not feasible in a sports medicine setting; proper training and expertise needed to administer and interpret them; acquisition of parental consent for minors; and the cost of implementation (Piland et al., 2003).

In a study examining the common practice patterns in concussion assessment and management, researchers found that even though athletic trainers found the results from standardized sideline assessment methods and neuropsychological testing to be valuable, they placed more emphasis on their own clinical examination and the symptoms reported by the injured player (Ferrara et al., 2001). Self-reported symptoms are a practical way to identify and monitor concussive injury in sport, and at present, they remain a primary factor in the management guidelines outlined by the Concussion in Sport Group (Piland et al., 2003; Piland et al., 2003). More specifically, after an acute concussive injury in sport, current guidelines stipulate that the presence of symptoms preclude an athlete's participation in sport. Similarly, the stepwise progression of recovery relies on the presence of reported symptoms. That is, post-concussive symptoms reported at any time through the stepwise recovery process prohibit continuation and mandates rest for 24 hours (P. McCrory et al., 2005). Former concussion management guidelines were based on arbitrary exclusion policies whereby concussed athletes were removed from play for a fixed period of time. Today, concussion management guidelines utilize an individualized approach to assessment, recognizing that the speed of symptom resolution can vary from individual to individual. Recovery and subsequent return to play decisions are now largely based on the presence of post concussion symptoms in addition to the clinical judgment of an attending physician (P. McCrory et al., 2005).

Although there are some inherent challenges in using self-report methods to identify and manage concussive injuries, research continues to highlight the value of post-concussive symptoms in the assessment of concussion and in understanding the acute and long term effects of this injury. The most compelling of these studies will be discussed in more depth below and will provide a context for the study at hand.

Post-Concussion Symptoms, Neuroimaging, and Recovery

In an effort to better understand concussive injury in athletes, recent scientific investigation has turned to functional Magnetic Resonance Imaging (fMRI) techniques to explore brain activation patterns and brain physiology after mild head injury (Chen et al., 2004; Chen et al., 2007; Lovell et al., 2007). Even though the use of fMRI in concussion research is still in its infancy, a handful of studies have shown promising results with links between cerebral activity and post-concussive symptoms (Chen et al., 2004; Chen et al., 2007; Lovell et al., 2007).

One of the first studies to explicate these findings was conducted by Chen et al. (2004), in which changes in brain activation were quantified in concussed athletes and compared to normal control participants. In this study, regional brain activations were obtained from 15 symptomatic concussed athletes, 1 asymptomatic concussed athlete, and 8 matched control subjects while performing a working memory task. Overall, results demonstrated that symptomatic concussed athletes had different task-related physiological responses in comparison to the normal control group. Furthermore, the findings revealed that the one asymptomatic concussed athlete was the only individual who revealed brain activation patterns similar to the control group. In other words, areas of abnormal brain activation appear to dissipate and return to normal with the resolution of post-concussion symptoms (Solomon et al., 2006). Additionally, results showed that brain activation patterns were negatively associated with the severity of post-concussive symptoms. Taken together, these results highlight the value of post-concussion symptoms in the acute and long term care of concussed athletes. As Chen et al. (2004) assert, "the presence of post-concussive symptoms can be an important, if not the most important, indicator for the diagnosis and prognosis of concussive injury" (p.80).

Following this publication, researchers aspired to explore the relationship between self-reported post concussive symptoms (PCS), brain activation patterns, and cognitive functioning (Chen et al., 2007). Moreover, the goal of this research was to validate a commonly used self-report measure, the post-concussion symptom scale (PCSS), with the results obtained from objective neuropsychological assessment and fMRI testing (Chen et al., 2007). Participants included 28 male athletes from recreational, amateur, and professional contact sports who had sustained a complex concussion and had reported PCS. Athletes were divided into two groups (low PCS or moderate PCS) based on the severity of their symptoms. The moderate PCS group showed slower performance on aspects of neuropsychological testing in addition to reduced activation patterns on fMRI. For the low PCS group, although athletes showed normal neuropsychological test performance, they continued to demonstrate reduced activation patterns on fMRI. These results supported the notion that the mildest form of brain injury could still produce atypical brain activity (Chen et al., 2007). Furthermore, this study provided evidence that that PCS closely mimic both neuro-cognitive deficits and abnormal brain activations. In the clinical assessment of concussion, these results have confirmed that PCS are useful for guiding diagnostic and management decisions.

Research endeavours continue to highlight the importance of PCS in the identification, diagnosis, and management of concussion in athletes, and in 2007 an additional study examining functional brain abnormalities and clinical recovery was published (Lovell et al., 2007). The results from this research reaffirmed previous findings demonstrating that post-concussive symptoms are associated with changes in brain activation. Similarly, changes in brain physiology following concussion are linked to changes in neuropsychological test results and the self-report of symptoms (Lovell et al., 2007). Although fMRI technology shows potential in the evaluation of concussion, it is impractical in a clinical setting and unlikely to be available for public use. However, even despite its barriers for widespread use, the implications derived from fMRI research have been invaluable to the study of concussive injuries. Although medical personnel involved in the care of concussed athletes are still encouraged to use a multifaceted approach to the diagnosis and management of this injury, the current research findings highlight the value post-concussion symptoms can have in this process.

Post-Concussion Symptoms, Cognitive Impairment, and Recovery

Given that the measurement of symptoms is a prominent piece in the assessment and evaluation of concussion in sport, additional research has explored the value that individual symptoms may have in predicting outcome and recovery after injury (Cantu, 2001; Collins et al., 2003; Iverson, Gaetz, Lovell, & Collins, 2004; Lovell, Collins, Iverson, Johnston, & Bradley, 2004). Initially, this research was inspired because many concussion grading systems arbitrarily assigned more importance to the presence/absence and duration of particular post concussion symptoms. For example, in the most commonly utilized grading systems, loss or non-loss of consciousness and posttraumatic amnesia were the hallmarks of the concussion grading schemes and subsequent return-to-play guidelines (Cantu, 2001). More recently, management guidelines have abandoned the use of grading systems, and all signs and symptoms of concussion are now regarded as important in the identification, assessment, and management of this injury. Scientific evidence supports the use of post-concussion symptoms as clinical markers for injury severity and outcome. This section will outline some of the most prominent of these studies.

In an attempt to identify the relevance of headache to outcome after sports related concussion, Collins et al. (2003), studied a group of high school athletes after concussive injury to examine whether or not the presence of post concussion headache would be related to poor performance on neuropsychological testing and overall higher symptom reporting. Participants in this study included 109 high school athletes who had sustained concussion. The athletes were divided into two groups, those who reported post-concussion headache seven days post-injury and those who did not report post-concussion headache. Results revealed that athletes who reported post-concussion headache had considerably poorer performance on the reaction time and memory composites of neuropsychological testing, reported overall more post-concussion symptoms, and were more likely to exhibit anterograde amnesia at the time of injury. Although there has been much controversy over the utility of post-concussion headache as a clinical marker of injury, these results have established that post-concussion headache is significantly associated with incomplete recovery after injury (Collins et al., 2003). Athletes reporting post concussion headache one week after injury should be managed conservatively as they are likely to be suffering from the lingering effects of a concussive injury (Collins et al., 2003). Overall, this study lends support to the new concussion management guidelines established by the Concussion in Sport group, which mandate complete rest until resolution of all symptoms.

Similar to the aforementioned study, a study by Iverson, Gaetz, Lovell, and Collins (2004b) sought to determine the relationship between post-concussion fogginess at one week following injury and neuropsychological test performance. In this study 110 high-school athletes with sustained concussion were evaluated 5 to 10 days after injury. Athletes were divided into two groups, those without self-reported fogginess and those with self-reported fogginess. Results revealed that athletes with fogginess after injury experienced more post concussion symptoms; they had slower reaction times, reduced memory performance, and slower processing speed on neuropsychological testing than athletes without reported fogginess. In congruence with the study examining post concussion headache, persistent fogginess after injury is also indicative of incomplete recovery. These results further validate the usefulness of post-concussion symptoms in the identification, assessment, and management of sports concussion.

Challenges With Subjective Symptom Reporting

It is apparent that the self-report of post concussion symptoms remains a vital component of concussion evaluation in sport (Aubry et al., 2002; P. McCrory et al., 2005). Although an abundance of literature has highlighted the value of post concussion symptoms in the identification, assessment, and management of sports concussion, the undeniable challenges with using clinical self-report information from athletes must be addressed.

To begin, the self-report of symptoms from athletes after concussion is not always presented accurately to team medical personnel (M. McCrea, 2001; Van Kampen, Lovell, Pardini, Collins, & Fu, 2006). A body of literature demonstrates that athletes often minimize their symptoms for fear of removal from a game or for fear of losing their position on a team (Van Kampen et al., 2006). Furthermore, athletes may be reluctant to volunteer information about their symptoms because they do not want to be perceived as weak by their teammates or coaches (Delaney et al., 2000). The under-reporting of symptoms after concussion in sport is a phenomenon that has been documented at all levels of athletic competition (Van Kampen et al., 2006). Therefore, it is imperative that coaches, physicians, and other medical personnel involved in the care of concussed athletes recognize these issues when making management decisions, so as not to return an athlete back to play prematurely and risk further injury.

Factors That Affect Self-Reports

Presently, one of the most extensively used tools in the assessment of concussion is a self-report questionnaire examining the presence of post-concussive symptoms (Bruce & Echemendia, 2004; Chen et al., 2007). To date, there has been no research examining whether the mode of administration (self-report administration vs. interview) affects the symptoms reported by concussed athletes. A body of literature derived from social psychology has provided insight into variables that may influence the way an athlete subjectively reports post-concussion symptoms after injury. This section will provide an overview of this literature, providing a context for the study at hand.

Social desirability is the inclination for an individual to respond to questions in a manner that will be viewed favorably by others (Holtgraves, 2004). For example, research has demonstrated that people often over-report engaging in socially desirable activities such as attending religious services and voting (Holtgraves, 2004). Likewise, individuals under-report engaging in socially undesirable behaviour such as sexual activity, drug use, and alcohol intake (Holtgraves, 2004). An abundance of literature has suggested that information obtained via interviews may be subject to *interviewer effects*, whereby the quality of the responses and the rate of responding are affected by the presence and the characteristics of an interviewer (Tourangeau & Smith, 1996). Interviewer effects are thought to occur as a result of self-presentation or social desirability issues (Bradburn & Sudman, 1979; Tourangeau & Smith, 1996). In some cases, the mere presence of an interviewer may distort or limit the information revealed by a respondent (Hyman, 1954). In other cases, the specific characteristics of an interviewer may alter the way an individual responds (Hyman, 1954). Although several interviewer characteristics such as age, gender, educational background, experience, race, and socio-economic status are known to have an impact on the quality of the responses obtained in interviews (Bradburn & Sudman, 1979; Kane & Macaulay, 1993), for purposes of this study, only the effects of gender were examined.

Interviewer gender. Gender-of-interviewer effects have been studied at length in several different contexts (Carpenter, Andrykowski, Cordova, Cunningham, & Studts, 1999; Kane & Macaulay, 1993; Moum, 1998). However, the research on this topic has produced results that vary across research contexts and studies (Groves & Fultz, 1985; Kane & Macaulay, 1993; Lueptow, Moser, & Pendleton, 1990). To date, no research has examined this issue with concussive injury in sports. However, given the importance of self-report measures for the identification and management of concussion, gender-of-interviewer effects in this context must be appraised.

Although there is a scarcity of research that specifically examines gender-of-interviewer effects with athletes in competitive sport, other research has provided us with some insight into this issue. A recent study conducted at the University of Alberta sought to determine collegiate athletes' preference for the gender of their team physician (Wesner & Vallance, 2007). Overall, results showed that for general medical issues, athletes did not express a preference for the gender of their team physician. However, for medical issues of a sexual nature, both male and female athletes showed preference for a female physician. Male athletes attributed their increased comfort with female physicians to their caring and sympathetic disposition. These results show that female physicians may be viewed as more nurturing and thus more favorable for the revelation of medical issues (Wesner & Vallance, 2007). Although the aforementioned study did not examine interviewer effects with athlete and physician, the results suggest there may be a possible gender bias when athletes are disclosing personal medical information. These results emphasize the need for more research into this issue.

Although the results on gender-of-interviewer effects are varied, the prevailing view is that when the topic of the interview is closely related to the observable characteristics of the interviewer (i.e. gender of interviewer for gender-role attitudes), interviewer characteristics are more likely to influence individual responses (Kane & Macaulay, 1993; Lueptow et al., 1990). Research conducted by Lueptow, Moser, and Pendleton (1990) examined gender-of-interviewer effects with gender related issues (i.e. sex role orientations). In this study, the effects of the interviewer's gender and/or sex role attitude on individual responses are referred to as *response effects*. Overall the study found that, "a) male interviewers elicited more response effects than female interviewers, especially from females, b) respondents, especially females, disclosed liberal orientations more to female than to male interviewers and, c) females show desirability effects to a greater degree than males" (Lueptow et al., 1990, p. 33). These results support the premise that when the interview content is related to salient characteristics of the interviewer, response effects are likely to occur (Lueptow et al., 1990).

In addition, research has suggested that the gender of an interviewer can affect the disclosure of personal information (Pollner, 1998). In a study examining interviewer gender in mental health interviews, it was found that both male and female respondents interviewed by women reported more symptoms of depression, substance abuse, and conduct disorders than those interviewed by men (Pollner, 1998). The authors suggest that the results lend support to the notion that women may be perceived as more sympathetic and thus more favorable to disclose personal information to than men (Pollner, 1998). On the other hand, additional studies have shown that interviewer gender has had no impact on the disclosure of women's reports of sexual abuse (Fry, Rozewicz, & Crisp, 1996), or with patient reports of physical, psychological, or menopausal symptoms (Carpenter et al., 1999).

Taken together, these results suggest that interviewer gender effects likely vary in relation to both the type and content of the questions being asked. This literature reinforces the need for interviewer effects to be examined in the context of concussion assessment and evaluation.

Mode of administration. Literature has also suggested that the mode of administration or the method of data collection can affect the responses obtained on surveys and questionnaires (Locander, Sudman, & Bradburn, 1976; Tourangeau & Smith, 1996). In the context of threatening or sensitive questions, data collection methods that increase respondent anonymity are generally thought to be the most effective (Bradburn & Sudman, 1979; Locander et al., 1976). One of the earliest studies to investigate this relationship was conducted by Locander, Sudman, and Bradburn (1976), when they sought to determine the effect of four different methods of administration on the reporting of five types of behavior. Overall, results demonstrated that self-administered questionnaires were the most effective in reducing the over-reporting of socially desirable behavior (Locander et al., 1976). However, results also established that no data collection methods were superior for all types of threatening or sensitive questions.

Following this research, many other studies have provided evidence that self-administered paper and pencil questionnaires yield higher rates of responding for undesirable behavior than interview administered questionnaires. To illustrate this, a study conducted by Aquilio and Losciuto (1990) examined whether or not there was a difference in reporting of tobacco, alcohol, marijuana, and cocaine use across different modes of data collection: face-to-face interviews, self administered questionnaires, and telephone interviews. Results concluded that self-administered questionnaires yield higher reporting for alcohol consumption and illicit drug use compared to face-to-face interviews and telephone interviews (Aquilino & Leonard A. Losciuto, 1990). Similar results have been found in other studies that have examined different modes of administration with the reporting of abortion (Tourangeau & Smith, 1996), drinking and driving (Locander et al., 1976), alcohol consumption, and illicit drug use (Aquilino, 1994).

Taken together, the results from the aforementioned studies suggest that in some cases self-report questionnaires may increase the disclosure of sensitive information. Currently, it is unknown whether the mode of administration of a post-concussion symptom questionnaire will affect the symptoms disclosed by athletes. Although the context of reporting symptoms in concussion is substantially different from the existing research done in this field, these results support the inclusion of mode of administration as a variable in this study.

Post-Concussion Symptom Scale

Background. The Post-Concussion Symptom Scale (PCSS) is a commonly used concussion symptom inventory to measure an individual's baseline functioning as well as the severity of symptoms after concussive injury (Lovell et al., 2006). The scale was first created in the late 1980's for the Pittsburgh Steelers concussion management program and has since been adopted by many different athletic leagues (Lovell et al., 2006). For example, reports indicate that the PCSS is being utilized by the National Football League, the National Hockey League, numerous college and high-school athletic programs, and different automobile racing leagues (Lovell et al., 2006). The PCSS is a standardized scale used as a formal way to document the self-reported symptoms of concussion by athletes prior to and after injury. Because symptom reports are highly subjective, the PCSS assigns a numeric value to the symptoms reported as a means to objectively measure this construct (Lovell et al., 2006).

As previously highlighted, the recent guidelines for concussion management established by the Concussion in Sport Group emphasize an individualized approach to assessment (P. McCrory et al., 2005). Following these guidelines, the recommended concussion management strategy for athletes is to obtain a PCSS score at baseline, prior to concussive injury. This is due to the fact that many post-concussion symptoms are endorsed by healthy individuals without brain injury. Therefore, obtaining a score on the PCSS at baseline informs medical personnel about an individual's level of functioning prior to injury. In the event of a concussive injury, medical personnel can re-administer the PCSS and compare an injured athlete's scores with baseline scores to assess for any adverse effects of the presumed concussion (Solomon et al., 2006). Baseline PCSS scores used in conjunction with post-concussion PCSS scores provides medical personnel with additional clinical information with which to map an individuals' injury course and recovery. It is now recommended that preseason medical evaluations include a concussion assessment whereby an athletes' concussion history, scores on the PCSS, and neuropsychological testing results are obtained.

Structure and administration. The PCSS contains 21 concussion related symptoms that are rated on a seven point scale with anchors ranging from none, to mild, to moderate, to severe. The individualized scale items were created to reflect an athlete's actual report of symptoms rather than medical terminology (Lovell & Collins, 1998; Lovell et al., 2006). For example, fogginess was incorporated into the PCSS based on the frequent reporting of this symptom by athletes after injury (Lovell et al., 2006). Symptom items were created based upon data gathered from thousands of amateur and professional athletes (Lovell & Collins, 1998; Lovell et al., 2006).

For administration of the PCSS, individuals respond to items asking whether or not they experience a particular symptom. If an athlete experiences a particular symptom, they rate the severity of it on a scale ranging from 0 (*no symptom reported*), and 1 (*very* *mild*) to 6 (*very severe*). The scale has been made available for widespread use and is offered in both paper format and through ImPACT, a computerized neuropsychological test (Lovell et al., 2006).

Psychometric properties: reliability. In a study examining the reliability and normative data for the PCSS, a sample of 1,746 healthy and 260 concussed high school and university athletes were examined. The internal consistency reliabilities for the PCSS were found to be high and ranged from 0.88 to 0.94 across the sample of healthy high-school and university students (Lovell et al., 2006). Similarly, the internal consistency reliabilities for concussed athletes were equally high at 0.93. The standard error of measurement (SEM), or the estimate of measurement error in an individual's observed test scores ranged from 2.7 in healthy men to 3.5 in healthy women. In the sample of concussed athletes the SEM was 5.3. Overall, these results suggest that the internal consistency reliability of the PCS is very high in healthy and concussed adolescents and young adults (Lovell et al., 2006)

Individual symptom reporting. For the group of concussed athletes, the frequencies of symptoms endorsed were examined. Overall, it was found that the most frequently reported symptoms with a severity of mild or greater were (a) headaches, (b) fatigue, (c) feeling slowed down, (d) drowsiness, (e) difficulty concentrating, (f) feeling mentally foggy, and (g) dizziness. These symptoms were reported by 60-79% of the sample. On the other hand, symptoms that were the least endorsed were, a) nervousness, b) feeling more emotional, c) sadness, d) numbness or tingling and, e) vomiting. These symptoms were reported by less than 25% of the sample.

Validity. Several studies have examined the validity of the PCSS. In one study conducted by Iverson, Lovell, & Collins (2002), 120 college level athletes were evaluated using ImPACT neuropsychological testing and the PCSS at baseline and 72 hours post-concussion. Results indicated that concussed athletes reported significantly more symptoms on the PCSS after concussion compared to baseline and they performed worse on the memory and reaction time indices of the neuropsychological testing. Similarly, in another study conducted by Iverson et al. (2004b), it was found that athletes with post-concussive symptoms had slower reaction times, reduced memory performance, and slower processing speed on neuropsychological testing than athletes without reported post-concussion symptoms.

Furthermore, recent research with fMRI has provided evidence of a relationship between cerebral activity and post-concussion symptoms. A study conducted by Chen et al. (2007) examined the self-report of symptoms on the PCSS with cognitive testing and functional magnetic resonance imaging (fMRI). Overall, the results of the study found that the report of PCS was directly linked to both cognitive abnormalities and abnormal brain activation patterns. The findings from the aforementioned studies highlight the validity of the PCSS, that is, symptoms reported by athletes after injury reflect changes occurring as a result of concussion.

These studies provide evidence for the value of the PCSS as a clinical tool for the identification and management of concussive injury in sport. Although the PCSS is useful as a measure to quantify symptoms prior to and after concussion, it should be used in conjunction with other assessment tools and a thorough clinical evaluation to aid in return-to-play decisions.

Summary

Concussion in sport has received increased awareness over the last decade as research continues to draw attention to the major health implications and long ranging effects of this injury (Solomon et al., 2006). With the escalating involvement of individuals in athletic endeavours, researchers and clinicians are searching for the most reliable and systematic way to assess concussive injury in sport. Although there has been a trend towards more sophisticated approaches to managing this injury, the lack of feasibility of these strategies has limited their widespread use. Neuropsychological testing, postural stability, and neuro-imaging techniques can provide clinicians with an objective measure to examine concussion but these techniques are costly, time consuming and often unavailable. At this time, the self-report of post-concussion symptoms remains a prominent piece in the concussion evaluation process.

As evidenced in the above literature review, post-concussion symptoms are important in the clinical assessment and management of concussive injury in sports. Research with athletes has indicated that underlying cognitive and neuro-physiological impairments after concussive injury often resolve synonymously with post-concussion symptoms. This body of literature has highlighted the value of post-concussion symptoms in the identification, assessment, and management of this injury. However, it has also been shown that the subjective reporting of concussive symptoms by athletes can be erroneous given the unique pressures of competitive sport. Athletes' motivation to continue playing after injury may lead them to underreport their symptoms for fear of removal from a game, or losing their position on a team.

The Post Concussion Symptom Scale (PCSS) is often used in the clinical assessment of concussion and is important for assessing baseline functioning and injury recovery. The current literature, which suggests that athletes minimize their symptoms after injury, has been the impetus for the present study, which examined whether the mode of administration for the PCSS will affect symptom reporting by athletes. Previous literature has suggested that the mode of administration of a survey can influence the subjective reporting of symptoms. More specifically, information obtained via interviews may be subject to interviewer effects, whereby an individual's responses may be affected by the presence and the characteristics of an interviewer (Tourangeau & Smith, 1996). Since concussion management remains largely in the realm of clinical judgment, the main objective of this research is to identify an effective way to obtain subjective information from injured athletes.

Hypotheses

Previous research has highlighted the inherent challenges in identifying, assessing, and managing concussive injuries in sport. The self-report of symptoms by athletes remains a vital component to concussion evaluation and management. Based on my review of the literature, two hypotheses are investigated in the current study. Research findings have established that male and female respondents report more symptoms when interviewed by women than by men (Pollner, 1998). Therefore, it was hypothesized that athletes at baseline would report more post-concussion symptoms to a female interviewer than to a male interviewer. In addition, research findings have found self-report questionnaires to increase the disclosure of sensitive or personal information (Aquilino & Leonard A. Losciuto, 1990; Aquilino, 1994). Therefore, the second hypothesis was that athletes at baseline will endorse more post concussion symptoms on the PCSS completed independently than on the PCSS during an interview with a trained professional.

Chapter Three—Method

Using two different reporting techniques (self-administration vs. interview), differences in symptom disclosure at baseline were examined among collegiate athletes. The relationship between symptom disclosure and interviewer gender was explored. In addition, the symptoms reported by the self-administration group were compared to the symptoms reported by the interview group. This chapter presents an overview of the method used in this study, including the participants, ethical considerations, procedure, and instrumentation. Strategies used in organizing and analyzing the data are also described.

Participants

Data for this study were obtained at preseason from a group of 118 University of Alberta athletes playing football, hockey, or rugby during the 2007-2008 school year. One athlete's data were discarded from this study because of a chronic heart condition. Therefore, 117 athletes' data were analyzed. Overall, there were 59 male football players, 28 male hockey players, and 30 female rugby players (see Table 1). There were no female football or hockey players, and no male rugby players. Participants ranged in age from 18 to 27 years (mean = 20.6). All athletes were enrolled in university classes at the time of participation. Educational level ranged from grade 12 to seven years post-secondary education (mean = 2.80 years post secondary). The sample was predominantly male (n = 87). All rugby players were female (n = 30). At the time of the study all participants were non-concussed athletes. The PCSS was administered prior to concussive injury in order to obtain baseline information about an athletes' functioning. Additional demographic information was not collected for the present study.

Table 1

Participants According to Sport, Gender, and Administration Mode

Sport	Self-administered	Interviewed	
		Female interviewer	Male interviewer
Football			
Female	0	0	0
Male	34	25	0
Hockey			
Female	0	0	0
Male	13	3	12
Rugby			
Female	15	8	7
Male	0	0	0

Ethical Considerations

The current study was approved by the Faculties of Education, Extension, and Augustana Research Ethics Board (EEA REB) in August 2007. Those athletes over the age of 18 who were selected to play for the University of Alberta football, hockey, or rugby teams were recruited to participate at the beginning of their competitive seasons. A researcher met with each participant to explain the nature and the details of the research study. Participants were ensured that their decision to participate would be kept confidential. All subjects were informed of the voluntary nature of their participation and they received an information letter outlining the research project (see Appendix B).

Written informed consent was obtained from all subjects prior to their participation (see Appendix C).

Procedure

In August and September 2007, prior to the start of the competitive seasons, and prior to concussive injury, I conducted a meeting with each team (football, hockey, and rugby) to discuss the details of the current research study. These teams were chosen based upon the nature of the sport and the likelihood of concussive injury. At that time, those athletes willing to participate in the study signed a consent form. Each team was evaluated separately, and data collection was completed on three separate occasions. Football players were evaluated on August 26th, 2007, hockey players on September 3rd, 2007, and rugby players on September 14th, 2007.

Due to the fact that the athletes were seated in an auditorium at the time of the meeting, those athletes sitting on one side of the auditorium were assigned at random to one testing condition and the remaining athletes were assigned to the other testing condition. Athletes completed the post-concussion symptom scale (PCSS) in one of two ways. Approximately, one half of the athletes completed the PCSS independently in a separate room. The remaining athletes completed the PCSS as a one-on-one interview with one of the researchers, or trained assistants. In the latter format, the athletes lined up and one-by-one they were interviewed by one of the researchers or trained assistants. The questionnaire was read aloud to the athlete one item at a time. The athletes were asked to report their symptoms as they experienced them on a typical day-to-day basis. In the presence of a particular symptom, the athlete then rated the severity of it on a scale ranging from 0 (*no symptom reported*), and 1 (*very mild*) to 6 (*very severe*). If an athlete endorsed a severity of 4 or higher on any of the symptoms, the interviewer queried the response to find out why they were rating the severity of the symptom so high in the absence of a concussive injury. The interviewers in this study consisted of one male professional neuropsychologist specializing in concussive injury, one female University of Alberta educational psychology graduate student, one male team coach, and five female athletic trainers. Overall, there were two male interviewers (neuropsychologist and team coach) and six female interviewers (graduate student and athletic trainers). Although the ratio of female to male interviewers was disproportionate in this study, in collegiate sports, athletic trainers are predominantly female. Therefore, the composition of the groups in this study reflects reality for most college level teams. In total, 25 male football players were interviewed by a female, and no male football players were interviewed by a male (see Table 1). Three male hockey players were interviewed by a female, and 12 male hockey players were interviewed by a male (see Table 1). Eight female rugby players were interviewed by a female, and 7 female rugby players were interviewed by a male (see Table 1). Athletes in the interview condition were not equally assigned to male and female interviewers due to the availability of team personnel (athletic trainers) on the day of testing. All interviewers were trained prior to the administration of the PCSS by the lead researcher.

Those athletes who completed the questionnaire independently were given instruction by the researcher (neuropsychologist) beforehand. The athletes were asked to read each item on the questionnaire and report the symptoms they experience on a typical day-to-day basis. In the presence of a particular symptom, the athlete was asked to rate the severity of it on a scale ranging from 0 (*no symptom reported*), and 1 (*very mild*) to 6 (*very severe*). The athletes recorded their responses on the questionnaire without discussing their symptoms with the researcher or trained assistants. All athletes were asymptomatic at the time of the study and they were unaware of having been assigned to one of two different reporting groups.

Instrumentation

Athletes' symptoms were assessed with the Post-Concussion Symptom Scale (PCSS), by Lovell and Collins (1998). The PCSS consists of 21 post-concussion symptoms that are commonly experienced by athletes after concussion (see Appendix A). The scale is based on a seven point scale with 0 and 6 reflecting the anchor points. Zero represents the *absence of a symptom*, 1 represents *very mild severity* and 6 represents *very severe severity*. Participants in the current study rated themselves on the PCSS prior to the start of their competitive seasons and prior to concussive injury to indicate the frequency with which they experience typical post-concussion symptoms on a day-to-day basis. The severity of the symptoms were added (0 to 6) for each item to obtain a total symptom score.

A baseline evaluation using the PCSS was conducted in order to obtain information about an athletes' functioning prior to injury. The purpose in obtaining a baseline score on the PCSS is for medical personnel to compare baseline (pre-season) scores to post-concussion scores in the event of a concussive injury. The comparison of baseline and post-injury scores on the PCSS allows medical personnel to assess for any possible adverse effects from a presumed concussion.

In a study examining the reliability of the PCSS, Lovell and his colleagues report high internal consistency for this measure (Lovell et al., 2006). The Cronbach's alpha coefficient for a sample of 1746 normal, healthy high-school and college athletes ranged from $\alpha = 0.88$ to $\alpha = 0.94$. Similarly, for a sample of 260 concussed athletes, the Cronbach alpha was equally high at $\alpha = 0.93$.

Data Analyses

Hypothesis 1 was tested twice using two different groups of athletes. In the first analysis, an independent sample t-test was used to analyze male athletes (football and hockey players) interviewed with the PCSS. This analysis tested the differences in total symptom score between athletes interviewed by a female and athletes interviewed by a male. In the second analysis, an independent sample t-test was used to test whether there was a difference in total symptom score for female athletes (rugby players) across male and female interviewers.

Hypothesis 2 was also tested twice using two different groups of athletes. In the first analysis, a two-way Analysis of Variance (ANOVA) using an a-priori ordering approach was conducted with male athletes. A two-way ANOVA was chosen to simultaneously assess the effects of the two independent variables (sport and mode of administration) on the dependent variable (total symptom score). In the second analysis, an independent sample t-test was used to assess whether there was a difference in administration mode across female athletes playing rugby. SPSS version 16.0 was used for the statistical analyses of these data.

Chapter Four—Results

This chapter will review the study results organized according to the hypotheses outlined in chapter two. First, the hypothesis that athletes would report more post-concussion symptoms to a female interviewer than a male interviewer will be considered. Then, the hypothesis that at baseline, athletes would endorse more post concussion symptoms on the PCSS completed independently than on the PCSS completed as an interview will be examined. An alpha level of .05 was used for all statistical tests.

Gender of Interviewer

My first hypothesis was that athletes will endorse more post-concussion symptoms on the PCSS to a female interviewer than to a male interviewer.

First, the data of the male athletes in the interview group ($n = 40$) were analyzed to determine whether male athletes report more symptoms to a female interviewer than a male interviewer. Overall, there were 12 male athletes interviewed by a male and 28 male athletes interviewed by a female. The data were analyzed using an independent sample t-test. Levene's test for the equality of variances was not significant $F = 0.32, p > .05$, so the t calculation assumed equal variances. Contrary to what was hypothesized, there was no statistically significant difference in reporting of symptoms across interviewer gender $t\ (38) = -1.41, p > .05$. Those athletes interviewed by a male did not report significantly more symptoms ($M = 4.42$, $SD = 5.25$) than those athletes interviewed by a female ($M = 7.43$, $SD = 6.52$).

Second, in a separate analysis, the data of female athletes in the interview group ($n = 15$) were analyzed to determine whether female athletes report more symptoms to a female interviewer than a male interviewer. Overall, there were 7 female athletes interviewed by a male and 8 female athletes interviewed by a female. The data were analyzed using an independent sample t-test. Levene's test for the equality of variances was not significant $F = 0.49, p > .05$, so the t calculation assumed equal variances. Contrary to what was hypothesized, there was no statistically significant difference in reporting of symptoms across interviewer gender $t\ (13) = -0.62, p > .05$. Female athletes interviewed by a male did not report significantly more symptoms ($M = 10.29$, $SD = 10.18$) than female athletes interviewed by a female ($M = 13.75$, $SD = 11.20$).

Mode

My second hypothesis was that at baseline, athletes will endorse more post concussion symptoms on the PCSS completed independently than on the PCSS during an interview with a trained professional.

To test this hypothesis, the data from male athletes playing hockey and football were analyzed. Because the analysis of the first hypothesis showed no statistical difference in total symptom score across interviewer gender, the data from male athletes interviewed by a female, and the data from male athletes interviewed by a male were pooled together for this analysis.

Female athletes' data were not included in this analysis due to the fact that all female athletes play rugby and thus, the variables of sport and gender are confounded. A separate analysis examining this hypothesis with female athletes will follow.

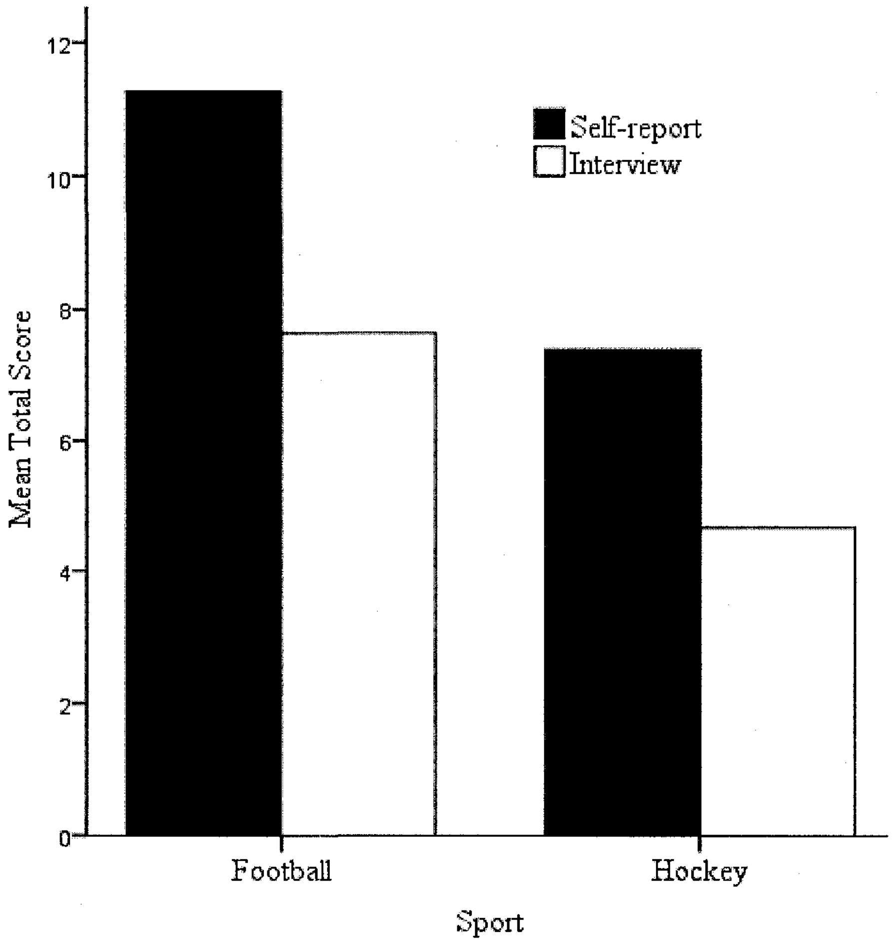
This hypothesis was tested using a 2 factor ANOVA. A two-way ANOVA was chosen to simultaneously assess the effects of the two independent variables (sport and mode of administration) on the dependent variable (total symptom score). Due to the fact that the numbers of subjects in each of the cells were neither equal nor proportional, the three sources of systematic variance overlap in the 2 factor ANOVA. Stated differently, sources of variability due to sport of athlete, mode of administration, and the interaction between athlete and response mode have shared variance. In order to disentangle the sources of variability in this unbalanced design, an ANOVA with a type 1 or, *a-priori* ordering approach was taken. Mode of administration was the factor that was given priority in this design followed by sport of athlete, and lastly, the interaction.

A 2 (sport) x 2 (administration mode) factorial analysis of variance (ANOVA), with type 1 sums of squares was employed. Levene's test of equality of error variances was applied. Levene's test for equality of variances was not significant, $F = 1.51, p > 0.05$ and thus, the homogeneity of variance assumption was met.

Results indicated there was a statistically significant difference in mean total PCSS score by mode of administration, $F(1, 83) = 4.88, p \leq 0.05$. As predicted, male athletes in the self-administration group reported a higher total symptom score ($M = 10.19$, $SD = 8.90$) than those male athletes in the interview group ($M = 6.52$, $SD = 6.26$). The factorial ANOVA did not reveal a significant main effect of sport ($F(1, 83) = 3.70, p > 0.05$). Male athletes playing football ($M = 9.73$, $SD = 8.49$) did not report a significantly higher total symptom score than male athletes playing hockey ($M = 5.93$, $SD = 6.09$). The mean symptom scores for athletes in each of the four conditions are shown in Figure 1. Although the absolute difference in mean total symptom score between the self-administration and the interview group ($M = 3.67$) was similar to the difference in mean total symptom score between the hockey and football players ($M = 3.8$), the difference in statistical significance was attributed to the a-priori ordering approach used.

Figure Captions

Figure 1. Mean total symptom scores for male athletes by sport and administration mode.



The results did not show a significant interaction between sport and mode of administration, $F(1, 83) = 0.07, p > .05$. That is, the mean difference across mode of administration (self-administration vs. interview) was not significantly different across sport (hockey and football).

In a separate analysis, the data from the female rugby players were analyzed using an independent sample *t*-test. Levene's test for the equality of variances was not significant $F = 0.51, p > .05$, so the *t* calculation assumed equal variances. Contrary to what was hypothesized, there was no statistically significant difference in reporting of symptoms across administration mode for female rugby players, $t(28) = 0.80, p > .05$. Female athletes in the self-administration group did not report a significantly higher total symptom score ($M = 15.60$, $SD = 13.11$) than female athletes in the interview group ($M = 12.13$, $SD = 10.50$).

Chapter Five—Discussion

The focus of this study was to determine whether or not college athletes report subjective clinical concussion information differently across two data collection methods, self-report and interview. This research was conducted in order to add to the growing body of literature that seeks to accurately identify and manage concussion in sport. It is hoped that the findings of this study will inform physicians, coaches, neuropsychologists, athletic trainers, and other medical personnel about ways to obtain clinical information from concussed athletes. This chapter will begin with a discussion of the study's findings in relation to the two hypotheses proposed and the literature reviewed in chapter two. The implications of the findings for each hypothesis will also be discussed. The chapter will conclude with the study limitations and future directions.

Gender of Interviewer

Although gender-of-interviewer effects have been explored in many different contexts, this was the first study to examine this issue with concussion in sport. Therefore, the first hypothesis examined was the assertion that in the interview group, both female and male athletes would report more post-concussion symptoms to female interviewers than male interviewers. This hypothesis was derived from research that found male and female respondents to report more symptoms to a female interviewer than a male interviewer (Pollner, 1998). Results of the current study did not uphold these previous research findings as there was not a significant difference in an athlete's disclosure of symptoms across male and female interviewers.

There are several possible explanations for the current results. To begin, the literature examining gender-of-interviewer effects has generally dealt with sensitive and personal topics such as mental health, sexuality, and drug and alcohol use. However, the disclosure of concussive symptoms is a topic very different from those discussed in previous research. Athletes may experience unique pressures from competitive sport that influence the reporting of concussive symptoms but the nature of the information collected on the PCSS is not generally considered personal and sensitive. Therefore, the absence of gender-of-interviewer effects in the current study may be attributed to the nature of the questions on the PCSS. As demonstrated by Wesner and Vallance (2007), when athletes discuss general medical issues they do not demonstrate a preference for the gender of their physician. However, when medical issues of a personal and sensitive nature are discussed, athletes show a preference for a female physician. The findings from the aforementioned study can be used to provide a possible explanation for the current results. That is, the gender of interviewer in the present study may not have had an effect on athlete responses due to the fact that concussion is a general medical topic that is often not considered to be sensitive and personal.

Implications for concussion management can be derived from the results of the current study. More explicitly, because athletes endorsed concussive symptoms similarly across male and female interviewers, the differences in symptom reporting across the self-administration group and the interview group can be attributed to the mere presence of an interviewer regardless of the interviewer gender. However, it should be noted that in the current study only the issue of gender was examined. Many other interviewer characteristics such as race, age, education, familiarity, and status may have an impact on the quality of the responses obtained and should be examined in future research.

Mode of Administration

Symptoms after concussion in sport are not always presented accurately to team medical personnel (McCrea, 2001; Van Kampen, Lovell, Pardini, Collins, & Fu, 2006). Literature from social psychology suggests that the mode of administration or the method of data collection for surveys and questionnaires can affect the responses obtained (Locander, Sudman, & Bradburn, 1976; Tourangeau & Smith, 1996). Therefore, the second objective of this study was to explore how the mode of administration of the PCSS could affect symptom reporting in athletes.

While concussion management has developed considerably over the last decade, current assessment tools to identify acute concussion in sport still remain imperfect. At present, management guidelines for concussion in sport rely heavily on the self-report of symptoms from injured athletes. Data from the present study provided evidence of variability in how athletes endorse common concussion symptoms, even prior to injury. The results from the current study suggest that male athletes endorse a higher symptom score when they complete the PCSS independently compared to when they complete the PCSS as an interview. Taken together, these results suggest that male athletes may feel more comfortable disclosing medical information in an environment where there is increased anonymity. Although the athletes in this study were not completely anonymous, the self administration group had increased privacy compared to those athletes in the interview group. Athletes in the self-administration group did not discuss their symptoms with an interviewer and were only identifiable by name. Conversely, those athletes in the interview group were asked to disclose their symptoms verbally to researchers or trained assistants.

The results from this study can also be explained with the notion that information obtained via interviews are subject to *interviewer effects*. That is, the responses obtained in this study may have been affected by the presence or characteristics of the interviewer (Tourangeau & Smith, 1996). In fact, research has shown that even the mere presence of an interviewer may distort or limit the information revealed by a respondent (Hyman, 1954). Therefore, a likely explanation for the significant difference in symptoms between the two groups of male athletes (self-administration versus interview) is that an athlete's disclosure of concussive symptoms was influenced by the presence of an interviewer. Given that this study was conducted prior to the start of competitive seasons, athletes may have been reluctant to disclose personal medical information to interviewers for fear of removal from a team, or disapproval from teammates and/or coaches. Athletes may have responded in a socially desirable manner in order to be viewed favorably by others. Future research may consider examining the effect of symptom reporting at different times throughout a competitive season to determine whether interviewer effects and socially desirable responding are more likely to occur at particular times in the athletic season.

From a clinical perspective, the results may suggest that less emphasis should be placed on interviewing a male athlete about their concussive symptoms, with more emphasis on a private, more anonymous approach. Given that previous research has found athletes to down-play, or under-report concussion symptoms, clinicians and medical personnel should consider administering the PCSS in a manner where athletes are known to report a higher total symptom score. In the management of an injury that has potential deleterious effects, a conservative approach to concussion assessment should be adopted. This study is the first to examine this issue with concussion in sport. Although the results are still preliminary, this study has shown that clinicians and medical personnel need to be cognizant in how they administer the PCSS, as male athletes may report symptoms differently depending on how they are asked.

Although a significant difference in total symptom score was found across administration mode for male athletes, these results were not upheld with female athletes. Female athletes did not report symptoms differently across interview and self-administration modes. There are a few possibilities in interpreting these results. First, the insignificant result could be due to the fact that the sample size of female athletes in this study was small ($n = 30$). In future research, an increased sample size of female athletes may change the findings. However, these results could also suggest that male and female college athletes report symptoms differently. For example, it could be possible that male athletes are more prone to interviewer effects than female athletes. Male athletes may also feel more pressure from their teammates and/or coaches and may be reluctant to volunteer information about their symptoms in order to avoid being perceived as weak. However, since all the females in the present study play rugby, a different sport from all the male athletes, this relationship cannot be discerned. That is, the variables of gender and sport are confounded. The current results cannot determine whether a difference in symptom reporting would be due to gender differences among athletes or due to sport differences among athletes. However, since the implementation of individualized assessment after concussion, the gender of the athlete has become an important component to consider in the management of sport concussion. In fact, previous research has proposed that patient gender may be one variable that influences symptom reporting and differentially affects recovery after concussion (Broshek et al., 2005). Because the issue of gender differences in sport is becoming increasingly important as more and more females are becoming involved in contact sports, the relationship between symptom reporting and athlete gender should be explored in future research.

Limitations and Directions for Future Research

Although the present research has provided clinicians with important implications for the management of concussion in sport, the limitations of this study must be addressed. First, this study evaluated athletes at baseline, prior to any concussive injury. It is unknown how results may have differed for athletes after concussive injury. Future research examining similar characteristics after concussive injury would be informative. Second, this study did not screen athletes for preexisting medical conditions (i.e. previous concussions) prior to participation in the study. Pre-existing medical conditions would have likely impacted the reporting of common concussive symptoms in athletes in addition to familiarizing athletes with reporting their symptoms to health care professionals. Future research should address this issue and ensure that any pre-existing medical conditions are controlled for. Third, the current study only evaluated a subset of college athletes. Since the characteristics of this sample are unique (i.e. all athletes are university students), the following results can not be generalized to all athletes involved in contact sport. Future research is needed to examine symptom reporting with elite professional athletes, high-school athletes and athletes in recreational sport.

Another variable that was not taken into consideration at the time of the study was the athlete's affective disposition at the time of the study. Since data collection commenced prior to the start of competitive seasons when anxiety levels were high, athletes may have been inclined to report more symptoms. Similarly, an athlete's motivation to participate in the study prior to the start of their competitive season may have been minimal. Future research may consider examining an athlete's anxiety and motivation at different times throughout the competitive season to see if this variable correlates with overall symptom reporting.

Additionally, the interviewer-interviewee relationship was not accounted for in the present study. Overall, there were eight different interviewers who had different levels of familiarity with the interviewed athletes. For example, the coach on the men's hockey team and some of the athletic trainers were familiar to the athletes evaluated. In the present study, data on familiarity between athlete and interviewer was not known and thus, not recorded. This relationship between interviewer and interviewee should be examined in future research. That is, do athletes report more symptoms to interviewers with whom they have an established relationship with compared to unfamiliar interviewers?

Lastly, due to the unequal sample sizes in this study, the variables of gender of interviewer and sport are confounding. More explicitly, there were no football players interviewed by males and 80 percent of the hockey players were interviewed by males. Future research should therefore re-examine the topic of interviewer gender in the reporting of symptoms on the PCSS.

Conclusion

The self-report of symptoms is vital for the identification, diagnosis, and management of concussion in sport (Bailes & Cantu, 2001; Chen et al., 2007; Delaney et al., 2000; Van Kampen, Lovell, Pardini, Collins, & Fu, 2006). However, it is known that the self-report of symptoms by athletes is complex given the unique aspects of competitive sport. Many athletes under-report their symptoms in order to avoid being perceived as weak by their teammates or coaches and/or losing valuable playing time (Delaney et al., 2000). The current study was the first to examine different ways to collect symptom information from athletes using the PCSS. Overall, important implications for sports concussion management have been derived from the study findings. First, the higher symptom score on the PCSS administered as a self-report compared to an interview for male athletes can be attributed to the mere presence of an interviewer rather than the gender of the interviewer. Second, because college male athletes report fewer symptoms on the PCSS when the questionnaire is administered by an interviewer, emphasis should be placed on using an evaluation method that is private and more anonymous. It is hoped that the findings from the current research study can be applied to current concussion management schemes to help increase the accuracy of symptom reporting by athletes and reduce further injury.

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Appendix A

Post - Concussion Symptoms Scale

Name:______________Team:______________Date of Concussion:______________

None Moderate Severe

0 1 2 3 4 5 6

Symptoms	**Date/Time**	**Date/Time**	**Date/Time**	**Date/Time**	**Date/Time**
Dizziness					
Headache					
Nausea					
Vomiting					
Balance problems					
Trouble falling asleep					
Sleeping more than usual					
Drowsiness					
Low Energy					
Sensitivity to light					
Sensitivity to noise					
More emotional than usual					
Irritability					
Sadness					
Nervous / Anxious					
Numbness or tingling					
Feeling slowed down					
Feeling like "in a fog"					
Difficulty concentrating					
Feeling "Pressure" in head					
Difficulty remembering					
Other:					
Total score					

Appendix B

Project Title: Assessment of symptoms following concussions in college athletes.

Researcher: Dr. Martin Mrazik, Department of Educational Psychology, University of Alberta (780) 492-8052, (mrazik@ualberta.ca)
Co-investigators: Dr. Dhiren Naidu, Physical Medicine and Rehabilitation, University of Alberta (780) 492-4752, and Andrea Krol, Department of Educational Psychology, University of Alberta (780)289-5738.

Purpose/Background

In this study, we will be looking at the symptoms associated with concussions sustained in sports. We are asking your permission for you to participate in this project. If you agree, you will be asked to complete several questionnaires during this study.

What we are asking you to do

If you agree to take part in this study, please fill out the consent form. During your pre-season medicals, you will be asked by one of the researchers (Dr. Martin Mrazik, Dr. Dhiren Naidu or Andrea Krol) to complete the Post Concussion Symptom Scale. If you happen to experience a concussion at any point during your participation in sports, you will be asked by one of the researchers to again complete this questionnaire in addition to a second questionnaire. In total, these questionnaires will take a *maximum* of 5 minutes.

Risks and Benefits

This study will help us to understand the typical symptoms experienced by athletes who have sustained a concussion. In addition, it will also help us understand the impact this injury might have on the day-to-day activities of a student athlete. This information will help inform medical practitioners about how to treat symptoms after concussions as well as provide supports and services that concussed student athletes might need. You will have the experience of volunteering to help others, as well as the experience taking part in a research project There are no foreseeable risks to this study, but if any risks should arise, the researcher will inform the participants immediately. Any athlete who sustains a concussion will be monitored and treated by the attending team physician.

Freedom to Withdraw

Your decision to participate in this study is entirely voluntary and you may decide at any time to withdraw from the study with no penalty. Your participation in this study will be kept confidential. If you choose to participate, you may skip any items on the questionnaires that you do not wish to answer. Responses made by individual participants will remain confidential.

Confidentiality

The information you provide will be kept private and confidential, and will be given a code number and your name will be removed. The information will always be kept in a locked and secure location only accessible to the research team members. Researchers are required to comply with the University of Alberta Standards for research participation regarding any issues of confidentiality. Your consent form will also be kept separate from any information you provide. Your name will never be used in any presentations or publications about the study results. The information collected will be kept for a minimum of five years in a secure place. Although we will not be able to give you your test results, we will send you a summary of the overall findings from this study when it is finished.

The plan for this study has been reviewed for its adherence to ethical guidelines and approved by the Faculties of Education, Extension and Augustana Research Ethics Board (EEA REB) at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Chair of the EEA REB at (780) 492-3751.

Please keep this letter for your own information, in case you would like to contact us later.

- If you have any questions please contact **Dr. Martin Mrazik**
  Phone: 780-492-8052. E-mail: mrazik@ualberta.ca

Appendix C

CONSENT FORM

Project Title: Assessment of symptoms following concussions in college athletes.

Researcher: Dr. Martin Mrazik, Department of Educational Psychology, University of Alberta (780) 492-8052, (mrazik@ualberta.ca)
Co-investigators: Dr. Dhiren Naidu, Physical Medicine and Rehabilitation, University of Alberta (780) 492-4752, and Andrea Krol, Department of Educational Psychology, University of Alberta (780)289-5738.

Please answer the following questions:

Name: ________________ Age as of September 1, 2007 ________________

Year in University: _______ Sport: ____________________

E-mail address: ________________________

	Yes	**No**
Have you received and read a copy of an attached information sheet?	___	___
Do you understand the benefits and risks in taking part in this research study?	___	___
Have you had an opportunity to ask questions and discuss this study?	___	___
Do you understand that you are free to leave the study at any time without having to give a reason?	___	___
Do you understand the issue of confidentiality?	___	___

I agree to take part in this study: ☐ Yes ☐ No

Signature of Participant______________________________ Date_______________

Printed name of Participant______________________________

Signature of Investigator or Designee____________________Date___________