A STANDARDIZED CONCUSSION MANAGEMENT PROTOCOL

FOR CONCORDIA COLLEGE

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

ABSTRACT

Bogenreif, Michael James, M.S., Department of Health, Nutrition, and Exercise Sciences, College of Human Development and Education, North Dakota State University; April 2010. A Standardized Concussion Management Protocol for Concordia College. Major Professor: Dr. Pamela Hansen.

Sports-related concussion remains a diagnostic and management challenge for health care professionals. Numerous symptom scales and sideline assessment tools are available for team physicians and athletic trainers to objectively assess this difficult injury. Significant contributions of evidence-based research have led to a better understanding of this multifaceted but still often elusive injury. This information has transformed all aspects of concussion management, from on-field evaluation through return-to-play guidelines. A variety of approaches are currently available for the multi-dimensional management of sport-related concussion. Standardized protocols have been advocated by numerous consensus groups for the provision of uniform care and follow-up procedures for all concussive. The purpose of this paper was to review the literature of concussions, clarify why there is a need for a standardized concussion management protocol, and to develop a specific concussion protocol to be used by athletic trainers and athletic training students at Concordia College.

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CHAPTER I

INTRODUCTION

The incidence of sport-related concussion has acquired a position among topics of interest in athletic medicine today. Once thought of as an injury of little significance, or simply a part of sport, sport-related concussion has evolved into one of the most studied issues and is surrounded by the controversy of injury management as well as return-to-play guidelines. With each decade since the 1960s, the amount of literature published on concussions has increased significantly.

According to McCrory et al. (2009), concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathologic and biomechanical injury concepts that may be utilized in defining the nature of a concussive head injury include: (a) Concussion may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head; (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 a structural injury; (d) Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however, it is important to note that, in a small percentage of cases, post-concussive symptoms may be prolonged (McCrory et al., 2009).

The evaluation and management of concussions continues to be a controversial topic among certified athletic trainers and other sports medicine professionals. Choices about assessment protocol and return-to-play decisions have been based on poorly validated guidelines and clinical judgment. The difficulty in using the current grading scales for evaluating concussion is that most are based on loss of consciousness and the presence of posttraumatic amnesia, which occur very infrequently. The result is that athletic trainers and physicians have difficulty distinguishing among the various degrees of concussion. The confusion and frustration with the current scales have resulted in many sports medicine professionals not using the grading scales for evaluation purposes. According to Ferrara, McCrea, Peterson, and Guskiewicz (2001), up to 63% of athletic trainers reported not using any scale for evaluating concussion.

The establishment of a specific protocol in managing concussion is necessary to maintain the consistency of care and ensures that proper procedures are followed when making decisions about returning athletes to competition. The protocol should cover procedures for the less severe injuries, in which the athlete is permitted to return to the game, to the most severe injuries, involving the presence of a variety of symptoms lasting for days or weeks.

Statement of Purpose

The purpose of this paper was to review the literature of concussions, clarify why there was a need for a standardized concussion management protocol, and to develop a specific concussion protocol to be used by certified athletic trainers and athletic training students at Concordia College.

Objectives

1. Provided a brief overview of concussion in sports, including the incidence of sports-related concussion, and the effects of sports-related concussion.

2. Compared previous and current assessment and management strategies of concussions including neuropsychological assessment, medical diagnosis, symptom based assessment, and return to play assessment.
3. Developed a standardized concussion management protocol to be used by athletic trainers and athletic training students at Concordia College.

Definitions

Balance Error Scoring System (BESS) - developed as a standardized, objective assessment tool for the clinical sideline assessment of postural control. It utilizes six testing conditions under varying stances and surface conditions. (Riemann, Guskiewicz, & Shields, 1999)

Concussion - a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. (McCrory et al., 2009)

Diplopia - The condition in which a single object appears as two objects. Also called "double vision." (Beers, 2006)

Standardized Assessment of Concussion (SAC) - a standardized means of objectively documenting the presence and severity of neurocognitive impairment associated with concussion, thereby immediately providing additional information to athletic trainers and other medical personnel responsible for clinical decision making in care of athletes. (McCrea, Kelly, Kluge, Ackley, & Randolph, 1997).

Tinnitus - noise originating in the ear rather than in the environment. (Beers, 2006)

Organization of Chapters

Chapter I states an overview of the topic, statement of purpose, the objectives, and definitions. Chapter II discusses an overview of concussion in sports, the incidence of sports-related concussion, and the effects of concussion, including second impact syndrome and post-concussion syndrome. Chapter II also highlights the assessment of concussion in sports including neuropsychological assessment, postural stability, neuroimaging, symptom based assessment, and return-to-play assessment. Finally, Chapter II reviews the management of concussion in sports. Chapter III states the discussion and the concussion management protocol, which includes the purpose, signs and symptoms of concussion, and baseline assessment. Also in Chapter III are the concussion management and return-to-play guidelines, including sideline management of concussion, return-to-play guidelines, and the graduated return-to-play protocol.

CHAPTER II

REVEW OF LITERATURE

Overview of Concussion in Sports

Injuries in sports began to gain notoriety in 1904, when President Theodore Roosevelt threatened to ban American football. When this threat occurred, football came under great media and medical scrutiny as being a dangerous sport, for no other organized sport had been associated with as many deaths. Nineteen football players were paralyzed or killed in 1904 which spurred the birth of the National Collegiate Athletic Association (NCAA) to establish guidelines for safer athletic competition. In 1954, sports-related deaths reached an all time high in American football at 30 athletes. American football was associated with 819 deaths from concussion or cervical spine injury between 1931 and 1986. In the ten year span between 1973 and 1983, concussion related deaths in American football were greater in number than the combination of all other competitive sports (Cantu, 1997).

Rule changes, equipment standards, better conditioning, and better on-field medical care have dramatically reduced the number of concussion related deaths since the 1970's. In the course of this decade, the realization that more subtle forms of brain injury could follow concussion. While death or serious injury due to concussion has decreased significantly, spinal cord injuries causing quadriplegia has not been significantly reduced. This could possibly be attributed to a lack of equipment capable of preventing this type of injury (Cantu, 1997).

It wasn't until the mid 1980's that the perception of sports-related mild traumatic brain injury began to change and the potential severity of mild traumatic brain injury was truly discovered (Lovell, Echemendia, Barth, & Collins, 2004). The interest in sports-related brain injury rapidly emerged in the 1990's because sports concussion forced several prominent athletes into retirement, which in turn received media exposure. Consequently, the sports community began raising concerns about player safety. This caused professional leagues such as the National Hockey League (NHL) and National Football League (NFL) to take a serious interest in sports-related cerebral concussions. The interest at the professional level has cascaded down to the collegiate programs, high school programs, and even recreational programs (Echemendia, 2006).

In 1966, the Congress of Neurological Surgeons proposed the following consensus definition of concussion, subsequently endorsed by a variety of medical associations: ''Concussion is a clinical syndrome characterized by immediate and transient impairment of neural functions, such as alteration of consciousness, disturbance of vision and equilibrium, due to mechanical forces''(p. 387). Although the definition received widespread consensus in 1966, a more contemporary opinion (as concluded at the First International Conference on Concussion in Sport, Vienna, 2001) was that this definition fails to include many of the predominant clinical features of concussion, such as headache and nausea. 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" (p. 582). Along with this definition were a thorough list of signs and symptoms frequently present with concussion. In 2001, at the First International Conference on Concussion in Sport, concussion was defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.

In 2009, at the Third International Conference on Concussion in Sport, this definition still stands as the consensus among concussion experts.

Incidence of Sports-Related Concussion

Any athlete is potentially at risk for sustaining a concussion. In the United States alone, it is estimated that approximately 1.6 to 3.8 million cases of sports-related and recreation-related traumatic brain injury occur each year, (Langlois, Rutland-Brown, & Wald, 2006) which represents a significant health problem in active communities. According to the Center for Disease Control and Prevention (2010), each year, U.S. emergency departments treat an estimated 135,000 sports-related and recreation-related traumatic brain injuries, including concussions, among children ages five to 18.

In 2005, approximately 135,901 U.S. collegiate athletes suffered a concussion according to data collected by the National Collegiate Athletic Association Injury Surveillance System. Since 1988, the NCAA Injury Surveillance System (ISS) has collected injury and exposure data from 15 sport activities: men's baseball, men's basketball, women's basketball, women's field hockey, men's fall football, men's spring football, women's gymnastics, men's ice hockey, men's lacrosse, women's lacrosse, men's soccer, women's soccer, women's softball, women's volleyball, and men's wrestling. Data collection for a 17th sport, women's ice hockey, began in the 2000–2001 season. Hootman, Dick and Agel (2007) summarized a 16 year sample of this data from 1988-1989 through 2003-2004. The incidence rate for concussion was specifically highlighted. More than 9100 concussions were reported over the 16 years, an average of 563 per year in this sample. Football had the highest number of reported concussions but women's ice hockey had the highest rate, significantly higher than for all other sports. However, the ISS has collected data from women's ice hockey for only four years, and therefore data must be interpreted with caution. Women's soccer, traditionally a noncontact sport, also had a relatively high rate of concussion (Hootman, Dick & Agel, 2007). The rate of concussion increased significantly by 7% on average over the 16 years covered in this report, despite sport-specific efforts to address the rising risk. This trend may reflect an actual increase in the numbers of concussions per unit of exposure, but is also attributable, at least in part, to improvements in the identification of concussion (better awareness and diagnosis) in recent years.

Worldwide, competitive sports participation has increased, and approximately 5-10% of athletes are sustaining concussions annually (Zillmer, Schneider, Tinker, & Kaminaris, 2006). Conversely, anyone associated with the athletic field knows that the "true" rate of concussion is much higher. Zillmer et al. (2006) found that when asked, 70% of athletes report having experienced concussion symptoms. The incidence of concussion is high in sports; however, risk factors such as history of concussion, gender, and field position are associated with higher rates of concussion.

Tommasone and McLeod (2006) also looked at contact sport concussion incidence by reviewing previous literature. Eight contact sports were included: American football, boxing, ice hockey, judo, karate, tae kwon do, rugby, and soccer. It was found that among high school males, ice hockey had the highest incidence (3.6 per 1000 athlete-exposures [AEs]), while soccer had the lowest (0.18 per 1000 AEs). At the professional level, similar concussion incidence rates were found in both ice hockey (6.5 per 1000 player-games) and rugby (9.05 per 1000 player-games). Tommasone and McLeod (2006) concluded that there were not many well-designed studies regarding the incidence of concussion and that very few studies address female athletes.

Effects of Concussion

Sports-related concussion can lead to acute psychological, cognitive, and motor difficulties. These impairments can be immediate or gradual in onset and may include confusion, amnesia, vacant stare, delayed verbal or motor responses, disorientation of time and place, uncoordination, incoherent speech, alteration of consciousness, deficits in memory, attention, concentration, reasoning, balance, and coordination (Collins et al., 2003; Covassin, Stearne, & Elbin, 2008; Majerske et al., 2008; Powell, 2001). Symptoms can persist for days, weeks, or even months if an athlete returns to play before the symptoms have subsided. Persistent symptoms can cause the athlete to have difficulty with academics, activities of daily living, and emotional well being. Complete recovery from concussion is possible if proper management occurs. However, some athletes experience persistent symptoms which include headaches, dizziness, lightheadedness, blurred vision, fatigue, irritability, depression, unusual sensitivity to environment, impaired concentration, and/or memory loss (Collins et al., 2003; Covassin, Stearne, & Elbin, 2008; Dodick, 2001; Majerske et al., 2008; Powell, 2001). Additionally, an athlete is more likely to sustain a second concussion in the first few days after the original injury (Shankar, Fields, Collins, Dick & Comstock, 2007)

The trauma induced to the brain from the mechanism of injury, causes a chain reaction on the cellular level. Maximum dysfunction in the brain is seen within the first three days following the impact and scores on neuropsychological tests are the lowest. The impact, or acceleration-deceleration forces, that cause the temporary displacement of the brain, begins the string of events known in literature as the cerebral metabolic cascade (Echemendia, Putukian, Mackin, Julian, & Shoss, 2001; Giza & Hovda, 2001). A disruption of numerous neurons and capillary damage has been seen in various studies (Bailes & Hudson, 2001). Axonal stretching as a result of the acceleration-deceleration forces triggers a release of neurotransmitters (Grindel, Lovell, & Collins, 2001). An immediate release of neurotransmitters, particularly acetylcholine, causes the depolarization of neurons. This depolarization causes an imbalance in the sodium-potassium pump. There is an outflow of potassium, caused by glutamate, and an inflow of calcium (Bailes & Hudson, 2001). This disruption of the sodium-potassium pump causes the cells to work twice as hard. An increase in ATP causes an increase in glucose which creates a hyper-metabolic state and diminished cerebral blood flow. Increased glucose levels can remain elevated for four hours in certain areas of the brain. Research has also demonstrated in animal models that cerebral blood flow remains diminished for up to ten days following concussion (Giza & Hovda, 2001). This coincides with the seven to ten day period of increased susceptibility to subsequent concussion following initial injury found in one study (Guskiewicz et al., 2003).

Second Impact Syndrome

Concussed athletes with unresolved symptoms, who try to return too soon, run the risk of second impact syndrome. Second impact syndrome (SIS) occurs when a second concussion is sustained before the signs and symptoms of the first have resolved. This is a rare, but potentially deadly syndrome. SIS occurs when the brain has already endured trauma and, therefore, has increased vulnerability (Bender, Barth, & Irby, 2004). Twenty-six documented deaths have resulted from SIS since 1984. Even the slight possibility of

SIS emphasizes the importance of conservative RTP criteria and neurocognitive assessment to be sure that full recovery has taken place (Bender et al., 2004).

The pathophysiology of SIS is not clearly understood. The limited evidence available suggests that the first impact results in subcortical edema and increased intracranial pressure, which make the brain susceptible to further injury. Significant intracranial pressure following the second impact hinders blood flow, causing severe tissue damage that leads to cognitive disability (Bender et al., 2004). Sports such as football, soccer, and hockey put players at an increased risk for sustaining multiple concussions (University of Pittsburgh, 2002). Athletes who return to play before completely recovering from the first concussion are at increased risk for sustaining a second concussion from even a minor collision. This second concussion can disturb blood supply to the brain causing cerebral swelling and deterioration of cells which leads to cognitive disability and even death (Kelly, 2000; McCrory & Berkovic, 1998).

Post-Concussion Syndrome

Another lasting effect of a concussion is post-concussion syndrome. Although most concussed individuals will recover completely within the seven to ten day period, approximately ten percent will display signs and symptoms of concussion past the usual period. After three weeks, patients begin to worry about when they will recover, and by six weeks, if symptoms persist, post-concussion syndrome (PCS) can alter how individuals live their lives. PCS is defined by the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM IV), as 1) cognitive deficits in attention or memory, and 2) at least three or more of the following symptoms: fatigue, sleep disturbance, headache, dizziness, irritability, affective disturbance, apathy, or personality change (American

Psychiatric Association, 2000). The DSM IV diagnostic criteria are quite conservative. Most patients with PCS have only a few symptoms, headache and fatigue being the most common. The fatigue is related to changes in cognitive function and is most evident for students (related to learning demands) and employees in whom work places demands for attention and concentration.

Post-concussion syndrome is characterized by the development of symptoms such as headache, dizziness, nausea, disorientation, and impaired motor control after an athlete sustains a concussion (Slobounov, Sebastianelli, & Simon, 2002). An estimated 50 to 80% of individuals who suffer a concussion can be affected by PCS at approximately three months post-injury. Many theories address the possible causes of PCS. The DSM-IV suggests that underlying cerebral dysfunction and structural anomaly are the causes of PCS, while other sources indicate psychosocial factors are the main contributors to the appearance of PCS (World Health Organization (ICD-10), 2007).

The effects of concussion can vary from a mild headache to the long lasting post concussion syndrome. It is important for athletes, parents, coaches, and medical personnel to recognize and understand these effects. Everyone involved in concussion management needs to be educated about the risks of returning from concussion before all symptoms have resolved to avoid more serious injury.

Assessment of Concussion in Sports

Neuropsychological Assessment

According to Merriam-Webster (2010) neuropsychology is defined as a science concerned with the integration of psychological observations on behavior and the mind with neurological observations on the brain and nervous system. During the past ten years, neuropsychology has become increasingly involved in the prevention and management of sports concussions. This has lead to the development of sports neuropsychology. Neuropsychological assessment has quickly become an integral component for the assessment and management of sports-related concussions. Professional leagues like the National Hockey League and the National Football League as well as many collegiate organizations such as the NCAA now use neuropsychological testing as the standard for concussion management. In view of the fact that recovery from concussion can occur before or after the athlete's clinical symptoms resolve, neuropsychological testing should play an important role in assessing return to play readiness (Aubry et al., 2002; Broglio & Puetz, 2008; Randolf, 2001; Randolf, McCrea, & Barr, 2005). Neuropsychological testing can provide information regarding an athlete's processing speed, planning, memory, and mental flexibility. Various forms of neuropsychological testing, ranging from paper tests and abbreviated batteries to computer-based tests and extensive neuropsychological batteries, are currently being used (Collins, Echemendia, & Lovell, 2004).

While neuropsychological testing provides an abundance of information after an athlete sustains a concussion, the usefulness of such testing is enhanced with the presence of baseline data for each athlete. Baseline data provides a direct comparison for each athlete when he or she becomes injured. Athletes sustaining a concussion can be reassessed and monitored until his or her performance returns to the baseline. This comparison to baseline, along with the evaluation of symptoms, can provide useful information in the return-to-play decision. It is recommended that all sports organizations utilize the benefits of neuropsychological baseline and follow-up testing by setting up a concussion management program (Guskiewicz et al., 2004; McCrory et al., 2005; McCrory et al., 2009). Collecting baseline data for neuropsychological and post-concussion symptom scores provides an estimation of cognitive and psychosocial function that can then be used to determine the recovery from a concussion (Echemendia & Julian, 2001). While neuropsychological baseline assessment is helpful, empirical data have yet to determine how far above or below baseline a player should perform before returning to play (Echemendia & Cantu, 2003).

The extreme increase in interest in neuropsychological testing has resulted in the development of sophisticated neuropsychological test instruments. The traditional paper-and-pencil tests are fairly labor intensive and limit the widespread use of neuropsychological assessment. The development of computer-based neuropsychological testing instruments has expanded, and will continue to expand, the involvement of neuropsychology at all levels of competition (Lovell, 2006).

An effort to provide a mental status assessment tool that is not only succinct but objective and appropriate for sideline use has resulted in the Standardized Assessment of Concussion (SAC) test (McCrea, 2001). The SAC test is a condensed version of previously established tests that evaluate neurocognitive functions most vulnerable to change with a concussion. Included are measures of orientation, immediate memory, concentration, and delayed recall. The total test score also supplies a composite index for determining injury severity. The SAC involves an appraisal of strength, sensation, and coordination, entails approximately five minutes for administration, and is intended for use by individuals without prior expertise in psychometric testing (McCrea, 2001). Alternate versions of the SAC are allocated for follow-up assessment and may be employed for tracking injury recovery with minimal practice effects. Convenience predominates as the SAC is available on pocket-sized cards appropriate for sideline administration by athletic trainers or other medical professionals (McCrea, 2001).

Initial research focused on the application of the SAC has primarily involved high school and college football players due to the high incidence of injury among these sports participants (Shuttleworth-Edwards, 2002). To date, normative data exist for more than 2,500 athletes of both genders and at multiple levels of competition. Cumulatively, the data suggest that the instrument is suitable for use at a variety of competitive and educational levels, consistent over repeated administrations, and free of significant gender effects (McCrea, 2001).

Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT™) is currently the most widely used of the computerized neuropsychological assessments. It was developed during the late 1990's to address some of the limitations of traditional neuropsychological testing. The development of ImPACT™ allows for randomization of stimuli, accurate and reliable measures of variables such as reaction time and processing speed, and fast, reliable scoring. ImPACT™ contains five sections: demographics and history, concussion symptom inventory, computerized neuropsychological testing modules, current concussion details, and a comment section. All of these sections take approximately 30 minutes to administer (Lovell, 2006). The ImPACT™ test battery has undergône extensive validation through multiple studies and is currently used throughout professional and amateur sports (Iverson, Gaetz, Lovell, & Collins, 2004; Iverson, Lovell & Collins, 2003; Iverson, Lovell & Collins, 2005; Lovell, Collins, Iverson, Johnston & Bradley, 2004).

Bigler and Orrison (2004) claim that even the best neuroimaging methods may result in a false negative concussion diagnosis and neuropsychological testing is used because of its sensitivity to the outward manifestation of the actual underlying neuropathology. Imaging techniques such as CT scans and MRI are typically insensitive in measuring the subtle effects of concussion. However, neuropsychological testing has been shown to be 89.5% effective in detecting injury in athletes 24 hours post-injury (Collins et al., 1999). Neuropsychological testing is not used to diagnose concussion. Instead, it shows the effects of the concussion by highlighting the neurocognitive changes present in an athlete following concussion (Echemendia & Cantu, 2003).

Neuropsychological testing is a vital instrument for concussion management, but one of the problems associated with it is the possibility of learning effects as a result of serial testing. Players who learn the test may return to baseline scores even if symptoms of the concussion persist and full recovery has not been made. Tests such as the Trail Making Test (TMT), Digit Span, and Grooved Pegboard have been found to be subject to the practice effect (Lovell & Collins, 1998).

Researchers have examined the sensitivity of specific tests in the neuropsychological battery. Collins et al. (1999) reported that TMT and the Symbol Digits Modalities Test (SDMT) were both sensitive to those athletes with a history of two or more concussions. Likewise, Echemendia et al. (2001) found significant differences between concussed athletes and athletes involved in noncontact sports, such as swimming (used as a control), at two hours and 48 hours post-injury when evaluated by the Hopkins Verbal Learning Test (HVLT), SDMT, Controlled Oral Word Association Test (COWAT), and the TMT. The concussed group of athletes continued to have significantly different scores than the control group on the SDMT at one month post-injury. Macciocchi, Barth, Alves, Rimel, and Jane (1996) noted the TMT was sensitive to the mild effects of concussion, as it denoted subtle impairments in injured athletes.

One study contradicted the research cited above, reporting no differences between the scores of injured athletes and controls at one day, three days, five days, and ten days post-injury on the TMT, Digit Span, and the HVLT (Guskiewicz, Riemann, Perrin, & Nashner, 1997). Similarly, no differences were observed at any interval post-injury between contact and non-contact sport athletes and the control group, regardless of concussion history, on COWAT or digit span. Aubry et al. (2002) discovered no differences at any interval post-injury between concussed and non-injured Australian football players on the TMT. It can be speculated that the severity of concussions tested could have differed in these studies, producing different results. It is also likely that some subjects had experienced the learning effect, therefore creating an inconsistency among the studies.

Postural Stability

The implementation of balance testing within concussion management has dramatically increased, as diminished postural stability following concussion has been shown to occur for as many as three days post-injury (Broglio & Puetz, 2008). Postural stability testing has been advocated as a valid component of concussion assessment (Aubry et al., 2002; Guskiewicz et al., 2001; Guskiewicz et al., 2004; McCrory et al., 2005; McCrory et al., 2009; Riemann et al., 1999). Postural tests provide a glimpse of the concussed athlete's motor domain and may be executed with a force-plate or with simple clinical tests such as the Balance Error Scoring System (BESS) (Guskiewicz, Ross & Marshall, 2001; Oliaro, Anderson, & Hooker, 2001).

The BESS (Appendix A) incorporates three 20-second balance tests completed on varying surfaces (Oliaro et al., 2001). Tasks include standing with feet close together with eyes closed, a single-leg stance executed on the non-dominant foot, and finally a single-leg stance performed in a heel-toe position with the non-dominant foot behind. Athletes are observed during each of these challenges and assigned points based on present balance errors. Errors are comprised of eye opening, removal of hands from the hips, taking a step, abduction of the hips greater than thirty degrees, a forefoot or heel lift, and remaining out of the test position for more than five seconds. The points for each of the errors are totaled for all of the tests and amount to the overall BESS score (Oliaro et al., 2001).

Neuroimaging

Concussion implies a mild brain injury, in general, with normal neuroimaging findings. For sports-related concussion, neuroimaging of any type is typically not performed; rather medical decisions are made by the athlete's clinical presentation (Bigler & Orrison, 2004). There are some situations in which neuroimaging is recommended for athletes, and that is those in which there is extended loss of consciousness, seizures, or persistent symptoms that suggest a structural cerebral lesion (McCrory et al., 2009). While neuroimaging is not used routinely to diagnose a concussion, new brain-imaging technologies such as gradient echo, perfusion, and diffusion weighted imaging, which all have greater sensitivity for structural abnormalities, are on the horizon and could revolutionize the diagnosis, care, and management of sports-related concussion (Bigler & Orrison, 2004; McCrory et al., 2005)

Symptom Based Assessment

The use of symptoms as an assessment tool can be problematic as symptoms may not occur consistently across all situations and environments. Symptoms may also be delayed in onset and therefore not begin until the return to play decision has already been made. There are four general symptom categories in identifying a concussion: typical symptoms, cognitive symptoms, physical symptoms, and medical symptoms. Typical symptoms of concussion include headache, dizziness, nausea, loss of balance, tinnitus, diplopia, sleepiness, or sleep disturbance. If any of these symptoms are present following an impact, concussion is suspected (McCrory et al., 2009). Cognitive symptoms indicating concussion include periods of confusion or amnesia, loss of consciousness for any length of time, poor concentration, slow processing time, and/or an inability to answer questions regarding orientation such as the date, time, or location. Psychological symptoms of a concussion encompass laughing and crying inappropriately and/or personality changes (McCrory et al., 2009). Physical signs of concussion can be mild or severe in nature and can include different aspects of cognitive, psychological, medical, and motor functioning. Physical symptoms include loss of consciousness, slowness in answering questions or following directions, and inappropriate playing behavior such as running the wrong direction on the playing field. Motor deficits often considered to be physical signs of concussion are poor coordination, unsteady walking, and slurred speech (McCrory et al., 2009). Medical symptoms of a concussion include concussive convulsions, nausea, vomiting, and vacant stare (McCrory et al., 2009).

The different clusters of symptoms can suggest a location in the brain in which an injury occurred. Symptoms such as loss of consciousness, tinnitus, lightheadedness, poor muscle coordination, headache, nausea, and vomiting can be indicative of brainstem dysfunction. Damage to the cerebral cortex can produce symptoms such as confusion, disorientation, amnesia, decreased ability to process information, and memory impairment (Maroon et al., 2000).

Return-to-Play Assessment

The return-to-play (RTP) decision is not a simple one; rather it is a complex and dynamic decision-making process. While this decision is a difficult one, there is a possibility that this process could be made easier with knowledge of the major risk factors for incidence rate and recovery patterns. For example if a concussed athlete has a high risk for sustaining another concussion or is “at risk” for a longer recovery period, the RTP decision should be a more conservative one.

The team physician typically manages the RTP decision, but it is a collaborative and cooperative decision-making process that includes an entire concussion management team. It is the role of the physician to evaluate the athlete and talk with certified athletic trainers and other professionals, including a neuropsychologist if available, and then make a decision based on the comprehensive information. Frequently, certified athletic trainers make the immediate RTP decision on the sidelines. The athletic trainers should have extensive training in recognition of the signs and symptoms of concussion, so that they are able to make the RTP decision on the spot (Echemendia, 2006).

The goal of the RTP decision is to return the player to competition at a point when it is most safe for the player, but not to restrict the player from competition unnecessarily. Historically, this decision has been based on a series of guidelines that were developed to match classification schemes used to rate the severity of the concussion. Collins et al.

(1999) documented 14 different classification systems. Although they were useful in standardizing RTP, these guidelines lacked empirical support (Echemendia, 2006).

In 1986, Cantu proposed one of the first sport-based concussion severity grading scales. This grading scale was based on the presence and duration of LOC and/or retrograde or post-traumatic amnesia (Cantu, 1992; Cantu, 1998). In 1991, the Colorado Medical Society published Guidelines for the Management of Concussion in Sports as a response to team physicians' call for consistency in the management of concussion in young athletes (Kelly & Rosenberg, 1998). This first attempt to build a consensus among experts with regard to sport concussion management was well received as these guidelines were endorsed by the American Academy of Pediatrics, the American Academy of Sports Physicians, and the American College of Surgeons Committee on Trauma (Kelly & Rosenberg, 1998). However, the need for a broader consensus was identified and the involvement of the Quality Standards Subcommittee of the American Academy of Neurology emerged.

In 1996, a panel of experts responsible for the treatment of athletes who have sustained a concussion met twice to clarify issues regarding the identification and grading of concussions and criteria for return to play (Kelly & Rosenberg, 1997). The result of these meetings was the development of the American Academy of Neurology practice parameter regarding the management of concussion in sport. Their definition of concussion, a traumatically induced alteration in mental status that may or may not involve loss of consciousness, is commonly utilized today. This model advocates the recognition of observable features of concussion and self-reportable symptoms that may present initially or develop days to weeks after the traumatic incident (Kelly & Rosenberg, 1997).

The primary concern with previous grading scales is that they are frequently based on subjectively assessed symptomology (Guskiewicz, Weaver, Padua, & Garrett, 2000; McCrory, 1998; Ruff, Wylie, & Tennant, 1993; Sturmi, Smith, & Lombardo, 1998; Yuan, Prough, Smith, & Dewitt, 1988) and time periods of LOC and post-traumatic amnesia (Esselman & Uomoto, 1995; McCrory, Ariens, & Berkovic, 2000). However, while these are recognizable signs of concussion, they do not need to be present in order for an injury to be classified a concussion. Guskiewicz et al. (2000) reporting on 1003 injuries, found only 8.9% of concussions are associated with a LOC and 27.7% with amnesia. Interestingly, many national and international sport governing bodies have adopted their own concussion grading scales which are primarily based on LOC (Johnston, McCrory, Mohtadi, & Meeuwisse, 2001). The symptoms of headache, dizziness, confusion, disorientation and blurred vision actually occur more often with concussion than do LOC or post-traumatic amnesia (Guskiewicz, 2001; Guskiewicz et al., 2000). Lovell, Iverson, Collins, McKeag and Maroon (1999) demonstrated that LOC is not an important predictor of cognitive impairment following injury. Limited research on the importance of post-traumatic amnesia following mild injury indicates that it is not as important of a prognostic measure in mild brain injury as it is in severe brain injury (McCrory, 1998). Many athletes demonstrate motor and cognitive impairment as well as confusion in a concussed state, but do not demonstrate post-traumatic amnesia (Guskiewicz et al., 2000).

In November 2001, the First International Symposium on Concussion in Sport was held in Vienna, Austria. This symposium was organized by the International Ice Hockey Federation (IIHF), the Federation Internationale de Football Association Medical Assessment and Research Centre (FIFA, F-MARC), and the International Olympic

Committee (IOC) Medical Commission. The aim of the symposium was to provide recommendations addressing this important topic for the improvement of safety and health of athletes who suffer concussive injuries in ice hockey, football (soccer), and other sports. A range of experts were invited to address specific issues of epidemiology, basic and clinical science, grading systems, cognitive assessment, new research methods, protective equipment, management, prevention, and long-term outcome, and to discuss a unitary model for understanding concussive injury. The summary and agreement statement published after the First International Symposium on Concussion in Sport recommended that the existing RTP guidelines be abandoned in favor of individualized RTP decisions (Aubry et al., 2002). Further, despite at least three of the panel members previously publishing concussion grading scales, they hesitated to endorse any particular one thus reflecting current understanding of the strengths and weaknesses of these scales. Instead, the group recommended combined measures of recovery with individual consideration regarding return to play decisions. This statement further recommended that a concussed athlete should rest with no activity until post-concussion symptoms are not present, and neurological and cognitive evaluations return to normal. Once asymptomatic, the athlete should begin a graded, medically supervised process beginning with light aerobic exercise, eventually progressing to full-contact training and game play (Echemendia, 2006).

The summary and agreement statement published after the Second International Conference of Concussion in Sports (McCrory et al., 2005), endorsed the use of individually tailored RTP, but also downplayed the role of neuropsychology in managing simple concussions. The summary and agreement statement also provided a useful tool for evaluating the signs and symptoms of concussion. It is a two-sided card that is referred to as the Sport Concussion Assessment Tool (SCAT). The SCAT contains basic concussion information, the Post-concussion Symptom Scale, and a sideline evaluation protocol that assesses orientation, symptoms, five-item word recall, reverse digits (or months in reverse), and neurological screening. The SCAT was revised in the Third International Conference of Concussion in Sports, and the SCAT2 (Appendix B) was developed. A useful guideline of the graded return-to-play process was also included (Table 1). It is stated that athletes should not be returned to play the same day of injury. When returning athletes to play, they should follow a stepwise symptom-limited program, with stages of progression. There should be approximately 24 hours (or longer) for each stage and the athlete should return to stage one if symptoms recur (McCrory et al., 2009).

The RTP decision is a complex and dynamic one. Although there has been an exponential increase of research in the diagnosis and management of sports-related concussions during the past decade, the RTP decision remains a largely clinical venture without firm empirically based guidelines (Echemendia, 2006). What professionals do recognize is that the RTP decision should be individualized to each athlete and that the decision needs to be a collaborative one. The RTP decision is significant because of the detrimental effects a second concussion can have on an athlete who prematurely returns to play.

Management of Concussion in Sports

Management of concussion in sports should include three basic elements: an educational component, a program of cognitive rehabilitation, and a common set of management rules that should be followed for each player (Covassin, Elbin, Stiller-Ostrowski, 2009). The

Table 1
Graduated Return to Play Protocol

Rehabilitation Stage	**Functional Exercise at Each Stage of Rehabilitation**	**Objective of Each Stage**
1. No activity	Complete physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity ,70% MPHR; no resistance training	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer; no head impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, e.g., passing drills in football and ice hockey; may start progressive resistance training	Exercise, coordination, and cognitive load
5. Full-contact practice	Following medical clearance, participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

educational component should address the athlete's knowledge of physical, cognitive, and emotional symptoms that he or she is likely to encounter after sustaining a concussion. The athlete's family and team should also be educated about the possible symptoms the athlete could experience. A cognitive rehabilitation program should include areas such as memory training, organizational training, and attention training. This rehabilitation should be implemented for athletes who have persistent cognitive deficits beyond the expected recovery time period. Emotional and psychological effects of sports-related concussion should also be addressed and dealt with appropriately as many of the athletes who are in this position are devastated at the prospect of not being able to participate in his or her sport (Echemendia & Julian, 2001).

Proper identification of sports-related concussion is essential for assessing readiness for return to play, preventing unfavorable consequences, and avoiding the potential long-term effects of frequent brain injury. Return-to-play decisions are often difficult without baseline testing. While neuropsychological tests have been determined to be sensitive to subtle cognitive changes after concussion, the effectiveness of such tests is thoroughly enhanced with established baseline data. Repeated testing can follow an injury to determine when the player returns to baseline and therefore can be used as a factor to determine readiness to return to play (Ravdin, Barr, Jordan, Lathan, & Relkin, 2003).

The use of symptoms as an assessment tool can be problematic as symptoms may not occur consistently across all situations and environments. Symptoms may also be delayed in onset and therefore not begin until the return to play decision has already been made. In addition, many individuals associated with competitive sports believe that symptoms of concussion will eventually subside even if the athlete continues to play while experiencing the post-concussive symptoms. This furthers the evidence that making return to play decisions based on reported symptoms is not the most effective or safe route to take for the best interests of the injured athlete (Lovell & Collins, 1998).

With the incidence of sports related concussion reaching over 300,000 cases per year (Thurman, Branche, & Sniezek, 1998), an agreement on assessment and guidelines for management of this potentially life threatening injury is necessary. A variety of approaches are currently available for the multi-dimensional management of sport-related concussion. Standardized protocols have been advocated for the provision of uniform care and follow-up procedures for all who have concussions.

According to Ferrara et al. (2001), more clinicians appear to be using a multidimensional approach to concussion assessment and management, which incorporates clinical examination findings, concussion grading scale criteria, symptom checklist information, return-to-play guidelines, standardized tests, and neuroimaging studies. Similarly, Notebaert and Guskiewicz (2005) established an increase in these trends. They found that more than 95% of athletic trainers used the clinical examination, 85% used a symptom checklist, 48% used the Standardized Assessment for Concussion (SAC), 16% used the Balance Error Scoring System (BESS), and 18% used neuropsychological testing. These results help to describe the current trends in concussion management when compared with the findings of Ferrara et al. (2001) that 33% used the clinical examination, 35% used symptom checklists, 10% used the SAC, 5% used the BESS, and 15% used neuropsychological testing. It can safely be said that more athletic trainers are looking to standardized cognitive assessment, postural stability testing, and formal neuropsychological testing to guide their clinical decision making compared with several years ago.

CHAPTER III

DISCUSSION AND PROTOCOL

The purpose of this paper was to review the literature of concussions, clarify why there was a need for a standardized concussion management protocol, and to develop a specific concussion protocol to be used by certified athletic trainers and athletic training students at Concordia College. The specific objectives were to: 1) Provide a brief overview of concussion in sports, including the incidence of sports-related concussion, and the effects of sports-related concussion; 2) Compare previous and current assessment and management strategies of concussions including neuropsychological assessment, medical diagnosis, symptom based assessment, and return to play assessment; 3) To develop a standardized concussion management protocol to be used by athletic trainers and athletic training students at Concordia College.

Discussion

Concussions do not appear with easily measured, objective assessment criteria, such as a positive finding on an x-ray or pain with palpation, and often two similar presenting cases can result in two completely different outcomes. Evaluation and subsequent return-to-play decisions are some of the most difficult challenges faced by physicians and certified athletic trainers. Concussions are commonly graded according to the presence or absence of symptoms and abnormal behavioral responses while return-to-play decisions are then based on the severity of the injury and persistence of subjectively assessed symptoms and behaviors.

The focus of the initial concussion assessment has shifted from severity grading to injury detection and characterization. A multifaceted approach should be taken to concussion assessment and management, involving an assessment of symptoms, neurological findings, including postural stability, and cognition. While many concussion symptom scales and sideline assessment tools exist, there is no single agreed upon "best" concussion symptom scale or sideline assessment tool. Recent guidelines suggest a multifaceted approach to concussion assessment to capture the variety of deficits following injury (Aubry et al., 2002; Guskiewicz et al., 2004; McCrory et al., 2005; McCrory et al., 2009). These guidelines are accompanied by the suggestion of baseline testing for all athletes before the competitive season to compare preseason function with that of post-injury.

Each concussion is as individual as the athletes that sustain them, and moreover, every return-to-play criteria varies from institution to institution. The variation typically depends on the training of the medical staff, the tools available to the medical staff, and the relationship that members of the staff have with their athletes, coaches, and administration. A sound plan between all members of the medical team should be agreed upon before any competitive season. The team physician should drive the protocol through a collaborative decision-making process with everyone involved. The team physician should lead this team of professionals by providing information and concurring with the plan of action to ensure continuity of management following a concussive injury.

Ultimately, it is up to each institution to decide which assessment tools to include in their standardized concussion management protocol. The assessment tools used will be based on number of staff available, time needed for baseline testing, and cost of neuropsychological testing. Regardless of what tools are used, everyone involved in the management of the concussed athlete needs to be educated in the recognition of concussion and how to administer assessment tests, and be in agreement on return-to-play protocols.

Concussion Management Protocol

The following policy and procedures on neuropsychological baseline testing, assessment and management of concussions, as well as return to play guidelines, have been developed to provide quality healthcare services and assure the well-being of student-athletes at Concordia College.

Purpose

The Concordia College Department of Athletics recognizes that sport induced concussions pose a significant health risk for those student-athletes participating in athletics. With this in mind, the Department of Athletics has implemented policies and procedures to assess and identify those student-athletes who have suffered a concussion. The Department also recognizes that baseline neuropsychological testing on student-athletes who participate in sports which have been identified as collision, and/or contact sports, will provide significant data for return to competition decisions. This baseline data, along with physical examination, and/or further diagnostic testing, will be used in conjunction in determining when it is safe for a student athlete to return to competition.

Signs and Symptoms of Concussion

Certified athletic trainers and athletic training students all need to be aware of the signs and symptoms of concussion (Table 2) to properly recognize and intervene on behalf of the student-athlete.

Table 2.
Signs and Symptoms of Concussion

Physical Symptoms	**Cognitive Symptoms**	**Emotional Symptoms**
Loss of Consciousness	Memory Loss	Irritability
Headache	Attention Disorders	Sadness
Vision Difficulty	Reasoning Difficulty	Nervousness
Dizziness		Sleep Disturbances
Balance Difficulty		
Light/Sound Sensitivity		
Fatigue		
Slurred Speech		
Nausea		
Feeling “Dinged”, “Foggy”, “Stunned” or “Dazed”		

Baseline Assessment

All incoming freshman and transfer student-athletes participating in sports classified as contact or collision at Concordia College will have a baseline neuropsychological test and a Sport Concussion Assessment Tool 2 (SCAT2) performed as part of their athletic medical screening. For the neuropsychological testing, currently the Concordia College Department of Athletics utilizes the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) concussion management system. The system is a Windows-based user-friendly computer program which consists of 10 modules designed to test cognitive functioning. The SCAT2 is tool that represents a standardized method of evaluating injured athletes for concussion and can be used in athletes aged from 10 years and older. This tool has been produced as part of the Summary and Agreement Statement of the Third International Symposium on Concussion in Sport (McCrory et al., 2009). It supersedes the original SCAT published in 2005 (McCrory et al., 2005). This tool also enables the calculation of the Standardized Assessment of Concussion (SAC), score and the Maddocks questions (Maddocks et al., 1995) for sideline concussion assessment. High risk/impact sports which currently undergo baseline neurocognitve testing are listed in Table 3.

Table 3.
High Risk/Impact Sports

Football	M/W Ice Hockey	Fastpitch Softball
M/W Basketball	Wrestling	Volleyball
M/W Soccer	Baseball	Swimming & Diving
M/W Pole Vaulters		

Concussion Management and Return-to-Play Guidelines

In any circumstance where a concussion is suspected in an athlete, the first priority is to remove the athlete from further competition until a thorough sideline assessment can be made. Furthermore, if there is any question about the mental state of the athlete, it is best to proceed conservatively and withhold the athlete from further competition until a physician assessment can be arranged. The recommendations in this document for the management of concussion are based on a thorough review of literature as well as the resources available at Concordia College.

Sideline Management of Concussion

When an athlete shows ANY signs of a concussion:

(a) The athlete should be medically evaluated onsite using standard emergency management principles, and particular attention should be given to ruling out a cervical spine injury. If the athlete remains unconscious or a head, neck or back injury is suspected, he/she should undergo cervical spine immobilization and EMS should be activated. In all situations where a concussion is suspected, the first step is to remove the athlete from competition.

(b) The appropriate disposition of the athlete must be determined by the treating healthcare provider in a timely manner. If no healthcare provider is available, the athlete should be safely removed from practice or play and urgent referral to a physician arranged.

(c) Once the first aid issues are addressed, an assessment of the concussive injury should be made using the SCAT2 assessment protocol. This will include a symptom checklist, and cognitive and balance assessments. Proper documentation should be kept of all findings.

(d) The athlete should not be left alone following the injury, and serial monitoring for deterioration is essential over the initial few hours following injury.

(e) An athlete with a suspected concussion should not be allowed to return to play on the day of injury. The athlete should be referred for neuropsychological testing and physician evaluation within 24 hours of the injury.

The Department of Athletics recognizes that it may not be possible for neuropsychological testing to take place within a 24 hour time frame due to team travel and other difficulties. With that in mind, it is necessary to plan for neuropsychological testing as soon as possible for the student-athlete, when they return to campus and for an evaluation with the team physician.

Return-to-Play Guidelines

The cornerstone of concussion management is physical and cognitive rest until symptoms resolve and then a graded program of exertion prior to medical clearance and return to play. As described above, the majority of injuries will recover spontaneously over several days. In these situations, it is expected that an athlete will proceed progressively through a stepwise return to play strategy. During this period of recovery, while symptomatically following an injury, it is important to emphasize to the athlete that physical AND cognitive rest is required. Activities that require concentration and attention (e.g., scholastic work, videogames, text messaging, etc.) may exacerbate symptoms and possibly delay recovery. In such cases, apart from limiting relevant physical and cognitive activities (and other risk-taking opportunities for re-injury), while symptomatic, no further intervention is required during the period of recovery, and the athlete typically resumes sport without further problem.

Graduated Return-to-Play Protocol

1. Rest until asymptomatic (physical and mental rest)
2. Light aerobic exercise (e.g. stationary cycle, walking, and swimming)
3. Sport-specific training (no head impact activities)
4. Non-contact training drills (start light resistance training)
5. Full contact training AFTER medical clearance
6. Return to competition (game play)

There should be approximately 24 hours (or longer) for each stage and the athlete should return to stage one if symptoms recur.

Neuropsychological testing, the team physician's physical exam, and additional diagnostic tests as needed, will determine when a student-athlete will return to activity. Neuropsychological testing will be scheduled for 24 hours post initial injury and again once asymptomatic, until the student-athlete scores at their baseline level, or an equivalent that is acceptable by team physician. Continued post-concussive symptoms, prior concussion history, diagnostic testing results, and neuropsychological testing and physical exam, will be utilized by the team physician in establishing a timeline for an athlete's return to activity. It is important to note that this timeline could last over a period of days to weeks or months, or potential medical disqualification. All concussions will be handled on a case-by-case basis.

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APPENDIX A

BALANCE ERROR SCORING SYSTEM

Balance Error Scoring System (BESS)

Developed by researchers and clinicians at the University of North Carolina's Sports Medicine Research Laboratory, Chapel Hill, NC 27599-8700

The Balance Error Scoring System provides a portable, cost-effective, and objective method of assessing static postural stability. In the absence of expensive, sophisticated postural stability assessment tools, the BESS can be used to assess the effects of mild head injury on static postural stability. Information obtained from this clinical balance tool can be used to assist clinicians in making return to play decisions following mild head injury.

The BESS can be performed in nearly any environment and takes approximately 10 minutes to conduct.

Materials

1) Testing surfaces
   -two testing surfaces are need to complete the BESS test: floor/ground and foam pad.

   1a) Floor/Ground: Any level surface is appropriate.

   1b) Foam Pad (Power Systems Airex Balance Pad 81000)
   Address = PO Box 31709 Knoxville, TN 37930 tel = 1-800-321-6975
   Web Address = www.power-systems.com

   Dimensions: Length: 10"
   Width: 10"
   Height: 2.5"

   The purpose of the foam pad is to create an unstable surface and a more challenging balance task, which varies by body weight. It has been hypothesized that as body weight increases the foam will deform to a greater degree around the foot. The heavier the person the more the foam will deform. As the foam deforms around the foot, there is an increase in support on the lateral surfaces of the foot. The increased contact area between the foot and foam has also been theorized to increase the tactile sense of the foot, also helping to increase postural stability. The increase in tactile sense will cause additional sensory information to be sent to the CNS. As the brain processes this information it can make better decisions when responding to the unstable foam surface.

2) Stop watch
   -necessary for timing the subjects during the 6, twenty second trials

3) An assistant to act as a spotter
   -the spotter is necessary to assist the subject should they become unstable and begin to fall. The spotter's attention is especially important during the foam surface.

4) BESS Testing Protocol
   -these instructions should be read to the subject during administration of the BESS

5) BESS Score Card

(the Testing Protocol and a sample Score Card are located at the end of this document)

BESS Test Administration

1) Before administering the BESS, the following materials should be present:
   - -foam pad
   - -stop watch
   - -spotter
   - -BESS Testing Protocol
   - -BESS Score Card
2) Before testing, instruct the individual to remove shoes and any ankle taping if necessary. Socks may be worn if desired.
3) Read the instructions to the subject as they are written in the BESS Testing Protocol.
4) Record errors on the BESS Score Card as they are described below.

Scoring the BESS

Each of the twenty-second trials is scored by counting the errors, or deviations from the proper stance, accumulated by the subject. The examiner will begin counting errors only after the individual has assumed the proper testing position.

Errors: An error is credited to the subject when any of the following occur:

- ♦ moving the hands off of the iliac crests
- ♦ opening the eyes
- ♦ step stumble or fall
- ♦ abduction or flexion of the hip beyond 30°
- ♦ lifting the forefoot or heel off of the testing surface
- ♦ remaining out of the proper testing position for greater than 5 seconds

-The maximum total number of errors for any single condition is 10.

Normal Scores for Each Possible Testing Surface

	Firm Surface	Foam Surface	
Double Leg Stance	.009 ± .12	.33 ± .90	
Single Leg Stance	2.45 ± 2.33	5.06 ± 2.80	
Tandem Stance	.91 ± 1.36	3.26 ± 2.62	
Surface Total	3.37 ± 3.10	8.65 ± 5.13	
BESS Total Score			12.03 ± 7.34

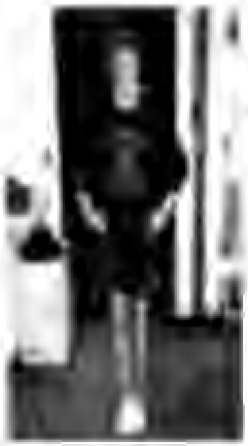
Maximum Number of Errors Possible for Each Testing Surface

	Firm Surface	Foam Surface
Double Leg Stance	10	10
Single Leg Stance	10	10
Tandem Stance	10	10
Surface Total	30	30

-if a subject commits multiple errors simultaneously, only one error is recorded. For example, if an individual steps or stumbles, opens their eyes, and removes their hands from their hips simultaneously, then they are credited with only **one error**.

-subjects that are unable to maintain the testing procedure for a minimum of **five seconds** are assigned the highest possible score, ten, for that testing condition.

FIRM / GROUND TESTING POSITIONS



Double leg stance: Standing on a firm surface with feet side by side (touching), hands on the hips and eyes closed

Single leg stance: Standing on a firm surface on the non-dominant foot (defined below), the hip is flexed to approximately 30° and knee flexed to approximately 45°. Hands are on the hips and eyes closed.

Non-Dominant Leg: The non-dominant leg is defined as the opposite leg of the preferred kicking leg

Tandem Stance: Standing heel to toe on a firm surface with the non-dominate foot (defined above) in the back. Heel of the dominant foot should be touching the toe of the non-dominant foot. Hands are on the hips and their eyes are closed.

FOAM TESTING POSITIONS

Double leg stance: Standing on a foam surface with feet side by side (touching), with hands on the hips and eyes closed

Single leg stance: Standing on a foam surface on the non-dominant foot (defined below), with hip flexed to approximately 30° and knee flexed to approximately 45°. Hands are on the hips and eyes closed.

Non-Dominant Leg: The non-dominant leg is defined as the leg opposite of the preferred kicking leg

Tandem Stance: Standing heel to toe on a foam surface with the non-dominant foot (defined above) in the back. Heel of the dominant foot should be touching the toe of the non-dominant foot. Hands are on the hips and their eyes are closed.

WARNING: Trained personnel should always be present when administering the BESS protocol. Improper use of the foam could result in injury to the test subject.

Script for the BESS Testing Protocol

Direction to the subject: *I am now going to test your balance.*

Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable).

This test will consist of 6 - twenty second tests with three different stances on two different surfaces. I will describe the stances as we go along.

DOUBLE LEG STANCE:

Direction to the subject: *The first stance is standing with your feet together like this* [administrator demonstrates two-legged stance]

You will be standing with your hands on your hips with your eyes closed. You should try to maintain stability in that position for entire 20 seconds. I will be counting the number of times you move out of this position. For example: if you take your hands off your hips, open your eyes, take a step, lift your toes or your heels. If you do move out of the testing stance, simply open your eyes, regain your balance, get back into the testing position as quickly as possible, and close your eyes again.

There will be a person positioned by you to help you get into the testing stance and to help if you lose your balance.

Direction to the spotter: *You are to assist the subject if they fall during the test and to help them get back into the position.*

Direction to the subject: *Put your feet together, put your hands on your hips and when you close your eyes the testing time will begin*

[Start timer when subject closes their eyes]

SINGLE LEG STANCE:

Direction to subject: *If you were to kick a ball, which foot would you use?* [This will be the **dominant** foot]

Now stand on your ***non-dominant*** *foot.*

[Before continuing the test assess the position of the dominant leg as such: the dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion]

Again, you should try to maintain stability for 20 seconds with your eyes closed. I will be counting the number of times you move out of this position.

Place your hands on your hips. When you close your eyes the testing time will begin.

[Start timer when subject closes their eyes]

Direction to the spotter: *You are to assist the subject if they fall during the test and to help them get back into the position.*

TANDEM STANCE:

Directions to the subject: *Now stand heel-to-toe with your* **non-dominant** *foot in back. Your weight should be evenly distributed across both feet.*

Again, you should try to maintain stability for 20 seconds with your eyes closed. I will be counting the number of times you move out of this position.

Place your hands on your hips. When you close your eyes the testing time will begin.

[Start timer when subject closes their eyes]

Direction to the spotter: *You are to assist the subject if they fall during the test and to help them get back into the position.*

***** Repeat each set of instructions for the foam pad**

Score Card

Balance Error Scoring System (BESS)
(Guskiewicz)

Balance Error Scoring System – Types of Errors
1. Hands lifted off iliac crest 2. Opening eyes 3. Step, stumble, or fall 4. Moving hip into > 30 degrees abduction 5. Lifting forefoot or heel 6. Remaining out of test position >5 sec
The BESS is calculated by adding one error point for each error during the 6 20-second tests.

SCORE CARD: (# errors)	FIRM Surface	FOAM Surface
Double Leg Stance (feet together)		
Single Leg Stance (non-dominant foot)		
Tandem Stance (non-dom foot in back)		
Total Scores:		
BESS TOTAL:		

Which **foot** was tested: ☐ Left ☐ Right
(i.e. which is the **non-dominant** foot)

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APPENDIX B

SPORT CONCUSSION ASSESSMENT TOOL 2

SCAT2

FIFA

Sport Concussion Assessment Tool 2

Name

Sport/team

Date/time of injury

Date/time of assessment

Age Gender M F

Years of education completed

Examiner

What is the SCAT2?[1]

This tool represents a standardized method of evaluating injured athletes for concussion and can be used in athletes aged from 10 years and older. It supersedes the original SCAT published in 2005[2]. This tool also enables the calculation of the Standardized Assessment of Concussion (SAC)[3,4] score and the Maddocks questions[5] for sideline concussion assessment.

Instructions for using the SCAT2

The SCAT2 is designed for the use of medical and health professionals. Preseason baseline testing with the SCAT2 can be helpful for interpreting post-injury test scores. Words in Italics throughout the SCAT2 are the instructions given to the athlete by the tester.

This tool may be freely copied for distribtion to individuals, teams, groups and organizations.

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific symptoms (like those listed below) and often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (such as headache), or
- Physical signs (such as unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour.

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle.

Symptom Evaluation

How do you feel?

You should score yourself on the following symptoms, based on how you feel now.

	none	mild		moderate		severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep (if applicable)	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22)

Symptom severity score

(Add all scores in table, maximum possible: 22 x 6 = 132)

Do the symptoms get worse with physical activity? Y N

Do the symptoms get worse with mental activity? Y N

Overall rating

If you know the athlete well prior to the injury, how different is the athlete acting compared to his / her usual self? Please circle one response.

no different very different unsure

Cognitive & Physical Evaluation

1 Symptom score (from page 1)

22 **minus** number of symptoms | of 22

2 Physical signs score

Was there loss of consciousness or unresponsiveness? Y N
If yes, how long? ____ minutes
Was there a balance problem/unsteadiness? Y N

Physical signs score (1 point for each negative response) | of 2

3 Glasgow coma scale (GCS)

Best eye response (E)	
No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4
Best verbal response (V)	
No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5
Best motor response (M)	
No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion/Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6
Glasgow Coma score (E + V + M)	of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

4 Sideline Assessment – Maddocks Score

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

At what venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week/game?	0	1
Did your team win the last game?	0	1
Maddocks score		of 5

Maddocks score is validated for sideline diagnosis of concussion only and is not included in SCAT 2 summary score for serial testing.

5 Cognitive assessment

Standardized Assessment of Concussion (SAC)

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score		of 5

Immediate memory

"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order."

Trials 2 & 3:
"I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before."

Complete all 3 trials regardless of score on trial 1 & 2. Read the words at a rate of one per second. Score 1 pt. for each correct response. Total score equals sum across all 3 trials. Do not inform the athlete that delayed recall will be tested.

List	Trial 1	Trial 2	Trial 3	Alternative word list		
elbow	0 1	0 1	0 1	candle	baby	finger
apple	0 1	0 1	0 1	paper	monkey	penny
carpet	0 1	0 1	0 1	sugar	perfume	blanket
saddle	0 1	0 1	0 1	sandwich	sunset	lemon
bubble	0 1	0 1	0 1	wagon	iron	insect
Total						

Immediate memory score | of 15

Concentration

Digits Backward:
"I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7."

If correct, go to next string length. If incorrect, read trial 2. One point possible for each string length. Stop after incorrect on both trials. The digits should be read at the rate of one per second.

			Alternative digit lists		
4-9-3	0	1	6-2-9	5-2-6	4-1-5
3-8-1-4	0	1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0	1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0	1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6

Months in Reverse Order:
"Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November ... Go ahead"

1 pt. for entire sequence correct

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan | 0 | 1

Concentration score | of 5

[1] This tool has been developed by a group of international experts at the 3rd International Consensus meeting on Concussion in Sport held in Zurich, Switzerland in November 2008. The full details of the conference outcomes and the authors of the tool are published in British Journal of Sports Medicine, 2009, volume 43, supplement 1.
The outcome paper will also be simultaneously co-published in the May 2009 issues of Clinical Journal of Sports Medicine, Physical Medicine & Rehabilitation, Journal of Athletic Training, Journal of Clinical Neuroscience, Journal of Science & Medicine in Sport, Neurosurgery, Scandinavian Journal of Science & Medicine in Sport and the Journal of Clinical Sports Medicine.

[2] McCrory P et al. Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. British Journal of Sports Medicine. 2005; 39: 196-204

[3] McCrea M. Standardized mental status testing of acute concussion. Clinical Journal of Sports Medicine. 2001; 11: 176-181

[4] McCrea M, Randolph C, Kelly J. Standardized Assessment of Concussion: Manual for administration, scoring and interpretation. Waukesha, Wisconsin, USA.

[5] Maddocks, DL; Dicker, GD; Saling, MM. The assessment of orientation following concussion in athletes. Clin J Sport Med. 1995;5(1):32-3

[6] Guskiewicz KM. Assessment of postural stability following sport-related concussion. Current Sports Medicine Reports. 2003; 2: 24-30

6 Balance examination

This balance testing is based on a modified version of the Balance Error Scoring System (BESS)[6]. A stopwatch or watch with a second hand is required for this testing.

Balance testing

"I am now going to test your balance. Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of three twenty second tests with different stances."

(a) Double leg stance:
"The first stance is standing with your feet together with your hands on your hips and with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. I will start timing when you are set and have closed your eyes."

(b) Single leg stance:
"If you were to kick a ball, which foot would you use? [This will be the dominant foot] *Now stand on your non-dominant foot. The dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

(c) Tandem stance:
*"Now stand heel-to-toe with your **non-dominant foot** in back. Your weight should be evenly distributed across both feet. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

Balance testing – types of errors

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

Each of the 20-second trials is scored by counting the errors, or deviations from the proper stance, accumulated by the athlete. The examiner will begin counting errors only after the individual has assumed the proper start position. **The modified BESS is calculated by adding one error point for each error during the three 20-second tests. The maximum total number of errors for any single condition is 10.** If a athlete commits multiple errors simultaneously, only one error is recorded but the athlete should quickly return to the testing position, and counting should resume once subject is set. Subjects that are unable to maintain the testing procedure for a minimum of **five seconds** at the start are assigned the highest possible score, ten, for that testing condition.

Which foot was tested: ☐ Left ☐ Right
(i.e. which is the **non-dominant** foot)

Condition	Total errors
Double Leg Stance (feet together)	of 10
Single leg stance (non-dominant foot)	of 10
Tandem stance (non-dominant foot at back)	of 10
Balance examination score (30 **minus** total errors)	of 30

7 Coordination examination

Upper limb coordination

Finger-to-nose (FTN) task: *"I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm (either right or left) outstretched (shoulder flexed to 90 degrees and elbow and fingers extended). When I give a start signal, I would like you to perform five successive finger to nose repetitions using your index finger to touch the tip of the nose as quickly and as accurately as possible."*

Which arm was tested: ☐ Left ☐ Right

Scoring: 5 correct repetitions in < 4 seconds = 1

Note for testers: Athletes fail the test if they do not touch their nose, do not fully extend their elbow or do not perform five repetitions. Failure should be scored as 0.

Coordination score of 1

8 Cognitive assessment

Standardized Assessment of Concussion (SAC)

Delayed recall

"Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."

Circle each word correctly recalled. Total score equals number of words recalled.

List	Alternative word list		
elbow	candle	baby	finger
apple	paper	monkey	penny
carpet	sugar	perfume	blanket
saddle	sandwich	sunset	lemon
bubble	wagon	iron	insect

Delayed recall score of 5

Overall score

Test domain	Score
Symptom score	of 22
Physical signs score	of 2
Glasgow Coma score (E + V + M)	of 15
Balance examination score	of 30
Coordination score	of 1
Subtotal	**of 70**
Orientation score	of 5
Immediate memory score	of 5
Concentration score	of 15
Delayed recall score	of 5
SAC subtotal	**of 30**
SCAT2 total	**of 100**
Maddocks Score	**of 5**

Definitive normative data for a SCAT2 "cut-off" score is not available at this time and will be developed in prospective studies. Embedded within the SCAT2 is the SAC score that can be utilized separately in concussion management. The scoring system also takes on particular clinical significance during serial assessment where it can be used to document either a decline or an improvement in neurological functioning.

Scoring data from the SCAT2 or SAC should not be used as a stand alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion.

Athlete Information

Any athlete suspected of having a concussion should be removed from play, and then seek medical evaluation.

Signs to watch for

Problems could arise over the first 24-48 hours. You should not be left alone and must go to a hospital at once if you:

- Have a headache that gets worse
- Are very drowsy or can't be awakened (woken up)
- Can't recognize people or places
- Have repeated vomiting
- Behave unusually or seem confused; are very irritable
- Have seizures (arms and legs jerk uncontrollably)
- Have weak or numb arms or legs
- Are unsteady on your feet; have slurred speech

Remember, it is better to be safe.
Consult your doctor after a suspected concussion.

Return to play

Athletes should not be returned to play the same day of injury. When returning athletes to play, they should follow a stepwise symptom-limited program, with stages of progression. For example:

1. rest until asymptomatic (physical and mental rest)
2. light aerobic exercise (e.g. stationary cycle)
3. sport-specific exercise
4. non-contact training drills (start light resistance training)
5. full contact training after medical clearance
6. return to competition (game play)

There should be approximately 24 hours (or longer) for each stage and the athlete should return to stage 1 if symptoms recur. Resistance training should only be added in the later stages.
Medical clearance should be given before return to play.

Tool	Test domain		Time	Score			
		Date tested					
		Days post injury					
SCAT2	Symptom score						
	Physical signs score						
	Glasgow Coma score (E + V + M)						
	Balance examination score						
	Coordination score						
SAC	Orientation score						
	Immediate memory score						
	Concentration score						
	Delayed recall score						
	SAC Score						
Total	**SCAT2**						
Symptom severity score (max possible 132)							
Return to play				Y N	Y N	Y N	Y N

Additional comments

Concussion injury advice (To be given to concussed athlete)

This patient has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. It is expected that recovery will be rapid, but the patient will need monitoring for a further period by a responsible adult. Your treating physician will provide guidance as to this timeframe.

If you notice any change in behaviour, vomiting, dizziness, worsening headache, double vision or excessive drowsiness, please telephone the clinic or the nearest hospital emergency department immediately.

Other important points:

- **Rest and avoid strenuous activity for at least 24 hours**
- **No alcohol**
- **No sleeping tablets**
- **Use paracetamol or codeine for headache. Do not use aspirin or anti-inflammatory medication**
- **Do not drive until medically cleared**
- **Do not train or play sport until medically cleared**

Clinic phone number

Patient's name

Date/time of injury

Date/time of medical review

Treating physician

Contact details or stamp

SCAT2 SPORT CONCUSSION ASSESMENT TOOL 2 | **PAGE 4**

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APPENDIX C

CONCORDIA COLLEGE CONCUSSION MANAGEMENT PROTOCOL

Signs and Symptoms of Concussion

Physical Symptoms	**Cognitive Symptoms**	**Emotional Symptoms**
Loss of Consciousness	Memory Loss	Irritability
Headache	Attention Disorders	Sadness
Vision Difficulty	Reasoning Difficulty	Nervousness
Dizziness		Sleep Disturbances
Balance Difficulty		
Light/Sound Sensitivity		
Fatigue		
Slurred Speech		
Nausea		
Feeling "Dinged", "Foggy", "Stunned" or "Dazed"		

Sideline Management of Concussion

When an athlete shows ANY signs of a concussion:

(a) The athlete should be medically evaluated onsite using standard emergency management principles, and particular attention should be given to ruling out a cervical spine injury. If the athlete remains unconscious or a head, neck or back injury is suspected, he/she should undergo cervical spine immobilization and EMS should be activated. In all situations where a concussion is suspected, the first step is to remove the athlete from competition.

(b) The appropriate disposition of the athlete must be determined by the treating healthcare provider in a timely manner. If no healthcare provider is available, the athlete should be safely removed from practice or play and urgent referral to a physician arranged.

(c) Once the first aid issues are addressed, an assessment of the concussive injury should be made using the SCAT2 assessment protocol. This will include a symptom checklist, and cognitive and balance assessments. Proper documentation should be kept of all findings.

(d) The athlete should not be left alone following the injury, and serial monitoring for deterioration is essential over the initial few hours following injury.

(e) An athlete with a suspected concussion should **NOT** be allowed to return to play on the day of injury. The athlete should be referred for neuropsychological testing and physician evaluation within 24 hours of the injury.

Return-to-Play Guidelines

Graduated Return to Play Protocol

Rehabilitation Stage	Functional Exercise at Each Stage of Rehabilitation	Objective of Each Stage
1. No activity	Complete physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity ,70% MPHR; no resistance training	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer; no head impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, e.g., passing drills in football and ice hockey; may start progressive resistance training	Exercise, coordination, and cognitive load
5. Full-contact practice	Following medical clearance, participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

Consensus Statement on Concussion in Sport, 3rd International Conference on Concussion in Sport, (McCrory et al., 2009)