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Getting Your Head in the Game

A Position Stand on Sport Concussion and Return-to-Play Management

The purpose of this Position Stand is to provide background information specific to Sport Concussions in a context that will facilitate thoughtful discussion amongst athletes, coaches, parents, sport trainers and athletic support staff. We anticipate that this position stand will help to expand our clients, partners and friends in the training community, understanding of Sport Concussions, Symptom Management, and effective Return-to-Play screening, so that we may reduce the incidence and consequences of concussion in sport.

Performance Training Systems Inc. has developed this position stand paper in response to the growing frequency of Sport Concussion across all levels of sport, and out of our perceived need to educate the sport and athletic community on concussion definition, diagnosis, symptoms, treatment management, and return-to-sport protocol. This position stand has been developed following a thorough review of the published literature concerning sport concussion and is intended to be an educational resource. The opinions and recommendations included in this position should not be taken as expert medical opinion, and as always Performance Training Systems advises that all athletes seek diagnosis and medical consultation from their team or family Doctors, and a neuro-trauma specialist.

1.0 INTRODUCTION

In response to the growing concern of concussions in sport, international expert concussion symposia were held in Vienna (2001), Prague (2004), and Zurich (2008). These scientific meetings were jointly sponsored by the International Ice Hockey Federation (IIHF), the Federation International de Football (FIFA), and the International Olympic Committee (IOC) and resulted in the first, and currently most accepted broad, clearly defined definitions and guidelines concerning concussions in sport. The Vienna symposium led to the Consensus Statement on Concussion, it's Prague and Zurich revised versions, which have become regarded as the leading resource on sport concussion management.

In addition to these large-scale, International Sport Federation sponsored symposia, there has been a growth in the development of sport concussion based research centres and affiliated education projects and studies delivered and carried out at universities and sport organizations around the world. These initiatives have given the issue of sport concussions greater exposure to athletes, coaches, parents and allied health professionals, and have led to increased awareness, and better concussion diagnosis, treatment and Return-to-Play management. When looking at the epidemiological data, sport concussions are a wide-spread health issue that has significant physical, cognitive and financial consequences.

The statistics indicate that over 350,000 sports-related concussions occur annually in North America, and the likelihood of suffering a concussion while playing a contact sport is estimated to be as high as 19% per year of play. Data shows that males in particular, between the ages of 15-35 are twice as likely as women to sustain a sports related head injury¹. More than 62,000 concussions are sustained each year in high-school contact sports, and among college football players, 34% have had one concussion and 20%, multiple concussions. The data shows that the frequency rate is very similar for hockey players. The 2010 Hockey Concussion Education Project has recently revealed insight into the prevalence of concussion in adolescent hockey players⁵. This study reports that 'concussion rates are 7 times higher than previously reported'; reporting that 25% of subjects (male 15-21 yr old junior hockey players) suffered a concussion during a season, and that 29% of those concussed, suffered a 2nd concussion in the same season. The study further reveals that 69% of the concussions identified were the result of body-contact hits to the head, where 80% of the hits to the head were intentional. Dr. Echlin⁵, publicly commented that his expert opinion believes that 15,000-20,000 youth hockey players will suffer a concussion this hockey season (2010-2011) alone.

Dr. Cusimano⁵, a Toronto based Neurologist reports that 2% of rugby injuries are concussions. Spinal injuries account for 9% of time missed in English rugby, occurring at a rate of 10.9 per 1000 playing hours. The American Orthopaedic Society for Sports Medicine report in *Concussion (Mild Traumatic Brain Injury) and the Team Physician: A Consensus Statement*³ that 3-5% of all high school injuries are concussions. Data released by the IOC's Medical Commission following the 2010 Winter Olympic Games in Vancouver and Whistler reported 20 concussions at the games. While it is reported that 80% of reported head injuries are categorized as mild, a concussion is the result of an acute trauma-induced change in mental function, with or without preceding loss of consciousness that generally lasts less than 24 hours and usually has a patient recover within 2-3 weeks. It is reported that by 3 months 75% of patients will be symptom-free.

The concern regarding these incidence rates lies in the association between concussions and psychosocial, physical, and behavioural problems, dementia, depression, amyotrophic lateral sclerosis (ALS) and suicide later in life. Researchers⁷ are now drawing convincing links between sport-related hits to the head, concussion, and brain disease aka Chronic Traumatic Encephalopathy (CTE), and quality of life markers.

The personal and applied drive to excel in competitive sport, a 'win-at-all-costs' and 'suck-it-up' attitude, and the 'competitive culture' in sport are contributing factors to the rise in concussion rates, and the hesitation to seek proper medical diagnosis and treatment. Athletes, coaches and parents are often reluctant to pull themselves or their players out of a game in favour of their desire to win, or the stigma of 'you're not tough enough if you don't play hurt'.

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It is the intention of this Position Stand to educate the greater sport and athletic community on the causes, risks and management protocols associated with Sport Concussions so that athletes are able to enjoy the games they love safely, and for their life-times.

2.0 WHAT IS A CONCUSSION?

The 2008 Consensus on Concussions⁸, drafted at the Zurich Symposium on Concussions in Sport, defines a Concussion as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. In lay terms, a concussion is caused by trauma to the head. The symposium delegates agreed that several common features that incorporate clinical, pathologic and biomechanical injury constructs may be utilized in defining the nature of a concussive head injury, and they include:

1. 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.
2. Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously.
3. Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury.
4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however, it is important to note that, in a small percentage of cases, post-concussive symptoms may be prolonged.
5. No abnormality on standard structural neuroimaging studies is seen in concussion.

Construct 1, as defined by the Sport Concussion Group identifies a single traumatic event as being the cause of concussions, however, new research is showing that multiple, frequent lower impact hits to the head, such as those sustained in football, rugby, and other contact-sports can cause concussion symptoms and associated brain tissue damage.

In addition to single or repetitive hits to the head, there is a reported link between whiplash type mechanisms of injury in causing concussion. Known as the 'Whiplash Effect', this mechanism of injury occurs when a rapid front-to-back or side-to-side snap takes place when the body or head is moved by a heavy force. The muscles of the neck function to support the head, and to control its movement. When a front-to-back, side-to-side, or rotational force is applied to the head or body that is stronger than the tensile or eccentric strength of the neck muscles, they lose their ability to decelerate, and control the movement of the head. While this is happening, the brain, anchored in the back by the brain stem, is moving inside the skull at a different speed from the rest of the head. When the head stops moving rapidly, as when it makes contact with the ice, field, fist, shoulder pad etc., it can shift causing strain on the brain stem and spinal cord, or result in the brain making contact with the inside of the skull. It is this contact or shearing that causes the tissue damage and impaired brain function.

2.1 Second Impact Syndrome

Second-impact syndrome (SIS) occurs when an athlete who sustains a head injury sustains a second head injury before symptoms associated with the first have cleared. Typically, the athlete suffers post-concussion signs and symptoms (Figure 4.1) after the first head injury, before these symptoms have cleared which may take minutes, hours, days or weeks, the athlete returns to competition and receives a second blow to the head.

The second blow may be unremarkable (a harmless looking hit), perhaps only involving a blow to the chest that jerks the athlete's head and indirectly sends accelerating forces to the brain. Affected athletes may appear stunned, but do not suffer loss of consciousness and often complete the play. They usually remain alert on their feet for 15 seconds to 1 minute or so but seem dazed. Often, affected athletes remain on the playing field or walk off under their own power. Usually within seconds to minutes of the second impact, the athlete - conscious but stunned - suddenly collapses to the ground, semi-conscious with rapidly dilating (widening) pupils and loss of eye movement, and in some reported cases, stops breathing.

The vast majority of victims are under the age of 18, and concussion experts agree that, in general, the younger the athlete, the longer it takes for the symptoms of a concussive event to clear. The brains of young athletes are still developing, making them particularly susceptible to catastrophic injury if the brain has not healed before a second blow to the head. Indeed, the vast majority of the victims of Second Impact Syndrome (95% by some estimates) are under the age of 18.

These broad definitions and mechanisms of injury make it difficult to specifically isolate when a concussion takes place, and makes it difficult to clearly diagnose. When watching a sporting event, and witnessing a traumatic blow to the head, a coach, parent, or team support person only needs to observe only 1 of these factors to assume a concussion has taken place, and has an obligation to remove the athlete from participation for further assessment.

3.0 CONCUSSION PATHOPHYSIOLOGY

Recent research reveals that in both animals and humans, brain trauma, can alter the brain's physiology for hours to weeks, setting into motion a variety of pathological events. Though these events are thought to interfere with neuronal and brain function, the metabolic processes that follow concussion are reversed in a large majority of affected brain cells; however a few cells may die after the injury.

Included in the cascade of events unleashed in the brain by concussion is impaired neurotransmission, loss of regulation of ions, deregulation of energy use and cellular metabolism, and a reduction in cerebral blood flow. Excitatory neurotransmitters, chemicals such as glutamate that serve to stimulate nerve cells, are released in excessive amounts as the result of the injury. The resulting cellular excitation causes neurons to fire excessively. This creates an imbalance of ions such as potassium and calcium across the cell membranes of neurons. Since neuron firing involves a net influx of positively charged ions into the cell, the ionic imbalance causes cells to have a more positive membrane potential (i.e. it leads to neuronal depolarization). This depolarization in turn causes ion pumps that serve to restore resting potential within cells to work more than they normally would. This increased need for energy leads cells to require greater-than-usual amounts of glucose, which is made

into ATP. The brain may stay in this state of hypermetabolism for days or weeks. At the same time, cerebral blood flow is relatively reduced for unknown reasons, though the reduction in blood flow is not as severe as it is in ischemia. Thus cells get less glucose than they normally do, which causes an "energy crisis".

Concurrently with these processes, the activity of mitochondria may be reduced, which causes cells to rely on anaerobic metabolism to produce energy, which increases levels of the by-product lactate.

For a period of minutes to days after a concussion, the brain is especially vulnerable to changes in intracranial pressure, blood flow, and anoxia. According to studies performed on animals (which are not always applicable to humans), large numbers of neurons can die during this period in response to slight, normally innocuous changes in blood flow.

Concussion involves diffuse (as opposed to focal) brain injury, meaning that the dysfunction occurs over a widespread area of the brain rather than in a particular spot. Concussion is thought to be a milder type of diffuse axonal injury because axons may be injured to a minor extent due to stretching. Animal studies in which primates were concussed have revealed damage to brain tissues such as small petechial haemorrhages and axonal injury. Axonal damage has been found in the brains of concussion sufferers who died from other causes, but inadequate blood flow to the brain due to other injuries may have contributed to the damage. Findings from a study at Boston University's School of Medicine's Centre for the Study of Traumatic Encephalopathy that analyzed the brains of dead NFL athletes who received concussions suggest there is lasting damage to the brain after experiencing one. This damage was a form of brain disease called Chronic Traumatic Encephalopathy and is associated with behavioural, physical and cognitive problems.

The debate over whether concussion is a functional or structural phenomenon is ongoing. Structural damage has been found in the mildly traumatically injured brains of animals, but it is not clear whether these changes would be applicable to humans. Such changes in brain structure could be responsible for certain symptoms such as visual disturbances, but other sets of symptoms, especially those of a psychological nature, are more likely to be caused by reversible pathophysiological changes in cellular function that occur after concussion, such as alterations in neurons' biochemistry. These reversible changes could also explain why dysfunction is frequently temporary.

4.0 CONCUSSION EVALUATION

4.1 Symptoms and Signs of Acute Concussion

The diagnosis of acute concussion involves the assessment of a range of domains including clinical symptoms, physical signs, behaviour, balance; sleep and cognition (See a summary of signs and symptoms in *Figure 4.1*). Furthermore, a detailed concussion history is an important part of the evaluation both in the injured athlete and when conducting a pre-participation examination. The Sport Concussion Group, as described in the 2008 Sport Concussion Consensus, recommends that a detailed clinical assessment of concussion is outlined by using the Sport Concussion Assessment Tool 2nd Edition (SCAT2) form. *This form is an appendix to this document.*

The suspected diagnosis of concussion can include one or more of the following clinical domains:

Figure 4.1: Summary of Signs and Symptoms of Concussion³

Cognitive	Somatic	Affective
Confusion	Headache	Emotional lability
Post-traumatic amnesia	Fatigue	Irritability
Retrograde amnesia	Disequilibrium	
Loss of consciousness	Nausea / vomiting	
Disorientation	Visual disturbances	
Feeling 'in a fog', or 'zoned out'	Phonophobia	
Vacant stare		
Inability to focus		
Delayed verbal and motor responses		
Slurred / incoherent speech		
Excessive drowsiness		

It is strongly recommended, and the position of Performance Training Systems that a suspected concussed athlete must sit out 20 minutes and be reassessed before being allowed to resume physical activity. If any of the above symptoms persist or increase, a concussion should be suspected, the athlete should be sent to an emergency clinic and the appropriate management strategy should be instituted.

4.2 On-field or Sideline Evaluation of Acute Concussion

When a player shows ANY features of a concussion it is recommended that the coach, parents, or team support staff follow the protocol outlined in Figure 4.2.

Figure 4.2.1: On-Field or Sideline Evaluation of Acute Concussion⁸

On-Field or Sideline Evaluation of Acute Concussion
When a player shows any sign of a concussion
a) The player should be medically evaluated onsite using standard emergency management principles and particular attention should be given to excluding a cervical spine injury.
b) The appropriate disposition of the player must be determined by the treating healthcare provider in a timely manner. If no health care provider is available, the player should be safely removed from practice or play and urgent referral to a physician arranged.
c) Once first aid issues are addressed, than an assessment of the concussive injury should be made using the SCAT2 form.
d) The player should not be left alone following the injury and serial monitoring for deterioration is essential over the initial few hours following injury.
e) A player with diagnosed concussion should generally not be allowed to return to play on the day of injury.

It is strongly recommended that sufficient time for assessment and adequate facilities be provided for the appropriate medical assessment both on and off the field for all injured athletes. In some sports this may require rule change to allow an off-field medical assessment to occur without affecting the flow of the game or unduly penalizing the injured player's team.

Sideline evaluation of cognitive function is an essential component in the assessment of this injury. Brief neuropsychological test batteries that assess attention and memory function have been shown to be practical and effective. Such tests include the Maddock's questions (Figure 4.2.2) and the SCAT2 form. It is worth noting that standard orientation questions (eg. time, place, person) have been shown to be unreliable in the sporting situation when compared with memory assessment.

Figure 4.2.3: Maddock's Questions On-Field Cognitive Assessment

Maddocks Questions
Which field are we at / on?
Who are we playing?
Who is your opponent at present?
What half / period is it?
How far into the half?
Who scored last?
Who did we / you play last week?
Did we / you win last week?

It is recognized, however, that abbreviated testing protocols are designed for rapid concussion screening on the sidelines and are not meant to replace comprehensive neuropsychological testing which is sensitive to detect subtle deficits that may exist beyond the acute episode. Nor should they be used as a stand-alone tool for the ongoing management of sports concussions. It should also be recognized that the appearance of symptoms might be delayed several hours following a concussive episode.

4.3 Evaluation in Emergency Room or Office by Medical Personnel

An athlete with concussion may be evaluated in the emergency room or doctor's office as a point of first contact following injury or may have been referred from another care provider. In addition to the points outlined above, the key features of this exam should encompass:

Figure 4.3: In-Office Medical Exam⁸

In-Office Medical Exam should include the following	
a)	A medical assessment including a comprehensive history and detailed neurological examination including a thorough assessment of mental status, cognitive functioning and gait and balance.
b)	A determination of the clinical status of the patient including whether there has been improvement or deterioration since the time of injury. This may involve seeking additional information from parents, coaches, teammates and eyewitness to the injury.
c)	A determination of the need for emergent neuroimaging in order to exclude a more severe brain injury involving a structural abnormality.

4.4 Concussion Grading System

While concussion diagnosis is the responsibility of trained medical personnel, the reality is that many head injuries and concussions go unreported, or are determined without consult by a medical person. Many young athletes are self-diagnosed by themselves, their coaches, or their parents. While there is some criticism over the appropriateness and validity of grading concussions on a scale, a 3 point grading scale is used for evaluation measures. Figure 4.4 identifies the a 3 point grading scale based on the length of time unconscious following the moment of injury.

Figure 4.4: 3 Point Concussion Grading Scale

Grade I	Grade II	Grade III
No loss of consciousness, confusion, post-traumatic amnesia for < 15-30 minutes.	Loss of consciousness for <5 minutes or no loss of consciousness, with post-traumatic amnesia for 30minutes – 24 hours.	Loss of consciousness for >5 minutes.

5.0 CONCUSSION MANAGEMENT & RETURN-to-PLAY

The foundation of concussion management is physical and cognitive rest until symptoms resolve, followed by a progressive, exertion based exercise program, to medical clearance and return-to-play. Following the on-field concussion evaluation, the coaches, parents, or team support staff should follow the Acute Management Guidelines (Figure 6.0) as defined at the Vienna (2001) Symposium on Sport Concussions. These guidelines represent the 1st step in effective concussion management.

Figure 5.0: Guidelines for Acute Management of a Sports Concussion as defined at the Vienna (2001) Symposium²

Guidelines for Acute Management of a Sports Related Concussion	
When a player shows any symptoms or signs of a concussion:	
1.	The player should not be allowed to return to play in the current game or practice
2.	The player should not be left alone; regular monitoring for deterioration is essential
3.	The player should be medically evaluated after the injury.
4.	Return to play must follow a medically supervised step-wise process.

The majority of head injuries and concussion 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 (eg, school 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.

5.1 Graduated Return-to-Play Protocol

Return to play protocol following a concussion follows a stepwise process as outlined in Figure 5.1. With this stepwise progression, the athlete should continue to proceed to the next level if they are asymptomatic at the current level. Generally, each step should take 24 hours so that an athlete would take approximately one week to proceed through the full rehabilitation protocol once they are asymptomatic at rest and with provocative exercise. If any post-concussion symptoms occur while in the stepwise program, then the patient should drop back to the previous asymptomatic level and try to progress again after a further 24-hour period of rest has passed.

Most athletes recover within several days. To ensure a gradual and safe progression for athletes to return to play, the panel recommended a specific progression of activities. The progression levels begin with complete rest and progress through to return to play. Each level should take 24 hours with the athlete asymptomatic (symptom free) before moving to the next level in the progression. If any symptoms occur during the progression, the athlete should drop back to the previous level and try to complete that level after a 24 hour rest period. The progression levels are listed below:

Figure 5.1: Return-to-Play Protocol as Identified in 3rd International Symposium on Concussions in Sport, Zurich (2008)⁸

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% HRmax. No resistance training.	Increase Heart Rate
3. Sport-Specific Exercise	Skating drills in ice hockey, running drills in soccer etc.	Add movement
4. Non-Contact training drills	Progression to more complex training drills (passing etc.). May begin progressive resistance training.	Exercise, coordination, cognitive load
5. Full-Contact practice	Following medical clearance, participate in normal training activities.	Restore confidence, assessment of functional skills by coaching staff.
6. Return-to-play	Normal game play	

Ideally, the progression should take about one week from asymptomatic rest to full competition. The challenge for coaches, parents and sport administrators is going to be in implementing this program in the world of competitive athletics. Convincing coaches and athletic administrators that this type of progression is necessary for the protection and health of the athlete is going to be a difficult task. Historically, coaches are used to having athletes with concussions return to play within 24 hours (if that long) of being asymptomatic. Holding every athlete who shows signs and symptoms of concussion out of play for one week is going to cause tension among the athlete, the medical staff, and the athletic staff. The new progression is a step in the right direction for protecting athletes. The challenge is going to be getting buy-in from the athletes, their parents, their coaches, and their athletic staff. A coach, parent, and sport administrator must never forget that their responsibility is athlete safety first, competition second.

5.2 Same Day Return-to-Play

With adult athletes, in some settings, where there are team physicians experienced in concussion management and sufficient resources (eg, access to neuropsychologists, consultants, neuroimaging, etc.), as well as access to immediate (ie, sideline) neuro-cognitive assessment, return to play management may be more rapid. The return-to-play strategy must still follow the same basic management principles, namely, full clinical and cognitive recovery before consideration of return-to-play. This approach is supported by published guidelines, such as the American Academy of Neurology, US Team Physician Consensus Statement, and US National Athletic Trainers' Association Position Statement. This issue has been extensively discussed among concussion experts and it has been acknowledged that there is evidence that some professional American football players are able to return-to-play more quickly, with even same day return-to-play supported by NFL studies without a risk of recurrence or sequel. There is data, however, demonstrating that, at the collegiate and high school level, athletes allowed to return-to-play on the same day may demonstrate neuropsychological deficits post-injury that may not be evident on the sidelines and are more likely to have delayed onset of symptoms. It should be emphasized, however, that the young (<18) elite athlete should be treated more conservatively even though the resources may be the same as an older professional athlete.

5.3 Psychological Management and Mental Health Issues

In addition, psychological approaches may have potential application in this injury, particularly with the modifiers *Figure 6.0*. Care givers are also encouraged to evaluate the concussed athlete for affective symptoms *Figure 4*. Issues such as depression, as these symptoms may be common in concussed athletes.

5.4 The Role of Pharmacological Therapy

Pharmacological therapy in sports concussion may be applied in two distinct situations. The first of these situations is the management of specific prolonged symptoms (eg, sleep disturbance, anxiety, etc.). The second situation is where drug therapy is used to modify the underlying pathophysiology of the condition with the aim of shortening the duration of the concussion symptoms. In broad terms, this approach to management should be only considered by clinicians experienced in concussion management.

An important consideration in return-to-play is that concussed athletes should not only be symptom free but also should not be taking any pharmacological agents/medications that may mask or modify the symptoms of concussion. Where antidepressant therapy may be commenced during the management of a concussion, the decision to return-to-play while still on such medication must be considered carefully by the treating clinician.

5.5 The Role of Pre-participation Concussion Evaluation

Recognizing the importance of a concussion history, and appreciating the fact that many athletes will not recognize all the concussions they may have suffered in the past, a detailed concussion history is of value. Such a history may pre-identify athletes that fit into a high risk category and provides an opportunity for the healthcare provider to educate the athlete in regard to the significance of concussive injury. A structured concussion history should include specific questions as to previous symptoms of a concussion, not just the perceived number of past concussions. It is also worth noting that dependence upon the recall of concussive injuries by teammates or coaches has been demonstrated to be unreliable. The clinical history should also include information about all previous head, face or cervical spine injuries, as these may also have clinical relevance. It is worth emphasizing that, in the setting of maxillofacial and cervical spine injuries, co-existent concussive injuries may be missed unless specifically assessed. Questions pertaining to disproportionate impact versus symptom severity matching may alert the clinician to a progressively increasing vulnerability to injury. As part of the clinical history it is advised that details regarding protective equipment employed at time of injury be sought, both for recent and remote injuries. The benefit a comprehensive pre-participation concussion evaluation allows for modification and optimization of protective behaviour and is an opportunity for education.

6.0 MODIFYING FACTORS IN CONCUSSION MANAGEMENT

A range of 'modifying' factors may influence the investigation and management of concussion and in some cases may predict the potential for prolonged or persistent symptoms. These modifiers would also be important to consider in a detailed concussion history and are outlined in *Figure 6.0: Modifying Factors in Concussion Management*.

In this setting, there may be additional management considerations beyond simple return-to-play advice. There may be a more important role for additional investigations including formal neuropsychological testing, balance assessment, and neuroimaging. It is recommended that athletes with such modifying features would be managed through a multidisciplinary approach, one that is coordinated by a physician with specific expertise in the management of concussive injury.

There has been the suggestion among experts that the 'role of female gender as a possible modifier in the management of concussion' requires special management. However, there was not unanimous agreement that the current published research evidence is conclusive that this should be included as a modifying factor, although it was accepted that gender may be a risk factor for injury and/or influence injury severity.

Figure 6.0: Modifying Factors in Concussion Management⁸

FACTOR	MODIFIER
Symptoms Signs	Number, duration (>10 days), severity. Prolonged Loss of Consciousness (>1min), amnesia.
Sequelae Temporal	Concussive convulsions. Frequency, Timing (injuries close together), 'Recency' (recent concussions).
Threshold	Repeated concussions occurring with progressively less impact force or slower recovery after each concussion.
Age Co- and Pre-morbidities	Child & Adolescent (<18yrs old). Migraine, depression, attention deficit hyperactivity disorder (ADHD), learning disorders, sleep disturbances.
Medication Behaviour	Psychoactive drugs, anticoagulants. Dangerous style of play.
Sport	High-risk activity collision / contact

7.0 INJURY PREVENTION

7.1 Protective Equipment - Mouthguards and Helmets

Contrary to popular belief and manufacturer claims, there is no good clinical evidence currently available that supports the contention that protective equipment will prevent concussion, although mouthguards have a definite role in preventing dental and oro-facial injury. Biomechanical studies have shown a reduction in impact forces to the brain with the use of head gear and helmets, but these findings have not been translated to show a reduction in concussion incidence. For skiing and snowboarding, there are a number of studies to suggest that helmets provide protection against head and facial injury and hence should be recommended for participants in alpine sports. In specific sports such as cycling, motor and equestrian sports, protective helmets may prevent other forms of head injury (eg, skull fracture) that are related to falling on hard road surfaces, and these may be an important injury prevention issue for those sports. As this document reveals, concussion injury mechanisms do not require high impact compression forces. Helmets and mouthguards may reduce head trauma forces, but do not prevent concussions.

7.2 Rule Change

Consideration of rule changes to reduce head injury incidence or severity may be appropriate where a clear-cut mechanism is implicated in a particular sport. Rule changes also may be needed in some sports to allow an effective off-field medical assessment to occur without compromising the athlete's welfare, affecting the flow of the game or unduly penalizing the player's team. Another example can be found in

International Rugby, where many concussions go un-reported due to the International Rugby Board's rule that a player must sit-out 3 weeks and receive clearance from a neurologist before returning-to-play following a concussion diagnosis. It is important to note that rule enforcement may be a critical aspect of modifying injury risk in these settings, sport administrators and referees play an important role in this regard.

7.3 Risk Compensation

An important consideration in the use of protective equipment is the concept of risk compensation. This is where the use of protective equipment results in behavioural change such as the adoption of more dangerous playing techniques, which can result in a paradoxical increase in injury rates. This may be a particular concern in child and adolescent athletes where head injury rates are often higher than in adult athletes.

7.4 Aggression vs. Violence in Sport

The competitive/aggressive nature of sport which makes it fun to play and watch should not be discouraged. However, sporting organizations should be encouraged to address violence that may increase concussion risk. Fair play and respect should be supported as key elements of sport.

8.0 KNOWLEDGE TRANSFER

As the ability to treat or reduce the effects of concussive injury after the event is minimal, education of athletes, colleagues and the general public needs to be, and is the required foundation for progress in this field. Athletes, referees, administrators, parents, coaches and health care providers must be educated regarding the detection of concussion, its clinical features, assessment techniques and principles of safe return-to-play. Methods to improve education including web-based resources, educational videos and international outreach programs are important in delivering the message. In addition, concussion working groups, plus the support and endorsement of enlightened sport groups such as Fédération Internationale de Football Association (FIFA), International Olympic Commission (IOC), International Rugby Board (IRB) and International Ice Hockey Federation (IIHF) who initiated the first 3 International Symposiums on Concussion in Sport; Vienna (2001), Prague (2004), and Zurich (2008), and the various sport organizations and research groups around the world, have enormous value and must be pursued vigorously. Fair play and respect for opponents are ethical values that should be encouraged in all sports and sporting associations. Similarly, coaches, parents and managers play an important part in ensuring these values are implemented on the field of play.

9.0 CONCUSSION MANAGEMENT RESOURCES TO CONSULT

ThinkFirst – a Canadian Non-Profit organization dedicated to the prevention of brain and spinal cord injuries that focuses on injury prevention through education, research and policy.

<http://www.thinkfirst.ca/index.aspx>

Hockey Neurotrauma and Concussion Initiative (HNCI) – A Canadian based initiative involving multi-disciplined, international sport concussion experts and sporting organizations. The HNCI holds regular, well attended research-focused collaborative teleconferences.

<http://playitcoolhockey.com/home/coach.html>

Ontario Neurotrauma Foundation – www.onf.org

Consensus Statement on Concussion – Written at the 2008 Zurich symposium on concussions in sport, held jointly by FIFA, IIHF, and the IOC.

http://journals.lww.com/cjsportsmed/Fulltext/2009/05000/Consensus_Statement_on_Concussion_in_Sport_3rd.1.aspx

Sports Legacy Institute - The mission of the Sports Legacy Institute is to advance the study, treatment and prevention of the effects of brain trauma in athletes and other at-risk groups.

<http://www.sportslegacy.org/>

Sports Concussion Institute - <http://www.concussiontreatment.com/>

10. REFERENCES

1. Anderson, Tim., et al. Concussion and Mild Head Injury. *Practical Neurology*. 2006; 6:342-357.
2. Aubrey, M et al. Summary and Agreement Statement of the First International Conference on Concussion in Sport, Vienna 2001. Recommendations for the improved safety of athletes who may suffer concussive injuries. *British Journal of Sports Medicine*. 2002; 36:6-10.
3. Concussion (Mild Traumatic Brain Injury) and the Team Physician: A Consensus Statement. *The American Orthopaedic Society for Sports Medicine*. www.sportsmed.org.
4. Echlin et al. A prospective study of physician-observed concussions during junior ice hockey: implications for incidence rates. *Neurosurg Focus*. 29 (5): E4 2010
5. Echlin et al. Return to play after an initial or recurrent concussion in a prospective study of physician-observed junior ice hockey concussions: implications for return to play after a concussion. *Neurosurg Focus*. 29 (5): E5 2010
6. Echlin et al. A Prospective Study of Concussion Education in 2 junior ice hockey teams: Implications for Sports Concussion Education. *Neurosurg Focus*. 29 (5): E6 2010
7. King, Peter. Concussions: The Hits that are Changing Football. *Sports Illustrated*. November 1, 2010.
8. McCrory, Paul et al. Consensus Statement on Concussion in Sport 3rd International Conference on Concussion in Sport Held in Zurich, *Clinical Journal of Sport Medicine*: May 2009 - Volume 19 - Issue 3 - pp 185-200

11.0 Appendix

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 2005². This tool also enables the calculation of the Standardized Assessment of Concussion (SAC)³,⁴ score and the Maddocks questions⁵ 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 distribution 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?	<input type="checkbox"/> 0 <input type="checkbox"/> 1
Which half is it now?	<input type="checkbox"/> 0 <input type="checkbox"/> 1
Who scored last in this match?	<input type="checkbox"/> 0 <input type="checkbox"/> 1
What team did you play last week/game?	<input type="checkbox"/> 0 <input type="checkbox"/> 1
Did your team win the last game?	<input type="checkbox"/> 0 <input type="checkbox"/> 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?	<input type="checkbox"/> 0 <input type="checkbox"/> 1
What is the date today?	<input type="checkbox"/> 0 <input type="checkbox"/> 1
What is the day of the week?	<input type="checkbox"/> 0 <input type="checkbox"/> 1
What year is it?	<input type="checkbox"/> 0 <input type="checkbox"/> 1
What time is it right now? (within 1 hour)	<input type="checkbox"/> 0 <input type="checkbox"/> 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	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 1	candle baby finger
apple	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 1	paper monkey penny
carpet	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 1	sugar perfume blanket
saddle	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 1	sandwich sunset lemon
bubble	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 1	<input type="checkbox"/> 0 <input type="checkbox"/> 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	<input type="checkbox"/> 0 <input type="checkbox"/> 1 6-2-9 5-2-6 4-1-5
3-8-1-4	<input type="checkbox"/> 0 <input type="checkbox"/> 1 3-2-7-9 1-7-9-5 4-9-6-8
6-2-9-7-1	<input type="checkbox"/> 0 <input type="checkbox"/> 1 1-5-2-8-6 3-8-5-2-7 6-1-8-4-3
7-1-8-4-6-2	<input type="checkbox"/> 0 <input type="checkbox"/> 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	<input type="checkbox"/> 0 <input type="checkbox"/> 1
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Concentration score of 5

¹ This tool has been developed by a group of international experts at the 2nd 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)[®]. 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			<input type="checkbox"/> Y <input type="checkbox"/> N	<input type="checkbox"/> Y <input type="checkbox"/> N	<input type="checkbox"/> Y <input type="checkbox"/> N	<input type="checkbox"/> Y <input type="checkbox"/> 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