Consensus Statement on Concussion in Sport

The 3rd International Conference on concussion in sport, held in Zurich, November 2008 ☆

P. McCrory [a,*], W. Meeuwisse [b], K. Johnston [c], J. Dvorak [d], M. Aubry [e], M. Molloy [f], R. Cantu [g]

PREAMBLE

This paper is a revision and update of the recommendations developed following the 1st (Vienna) and 2nd (Prague) International Symposia on Concussion in Sport.[1,2] This Zurich Consensus Statement on Concussion in Sport (the ‘‘Zurich Consensus Statement”) is designed to build on the principles outlined in the original Vienna and Prague documents and to further develop conceptual understanding of this problem using a formal consensus-based approach. A detailed description of the consensus process is outlined in the Statement on Background to Consensus Process section (see Section 11). This document is developed for use by physicians, therapists, certified athletic trainers, health professionals, coaches and other people involved in the care of injured athletes, whether at the recreational, elite or professional level.

While agreement exists pertaining to principal messages conveyed within this document, the authors acknowledge that the science of concussion is evolving and therefore management and return to play (RTP) decisions remain in the realm of clinical judgment on an individualized basis. Readers are encouraged to copy and distribute freely the Zurich Consensus Statement and/or the Sports Concussion Assessment Tool (SCAT2) (Supplementary Figs. 1 and 2). Neither is subject to any copyright restriction. The authors request, however, that the Zurich Consensus Statement and/or the SCAT2 (Supplementary Figs. 1 and 2) be distributed in their full and complete format.

The following focus questions formed the foundation for the Zurich Consensus Document:

Acute simple concussion

- Which symptom scale and which sideline assessment tool is best for diagnosis and/or follow up?
- How extensive should the cognitive assessment be in elite athletes?
- How extensive should clinical and neuropsychological (NP) testing be at non-elite level?
- Who should do/interpret the cognitive assessment?
- Is there a gender difference in concussion incidence and outcomes?

Return to play issues

- Is provocative exercise testing useful in guiding RTP?
- What is the best RTP strategy for elite athletes?
- What is the best RTP strategy for non-elite athletes?
- Is protective equipment (e.g. mouthguards, helmets) useful in reducing concussion incidence and/or severity?

Complex concussion and long-term issues

- Is the Simple versus Complex classification a valid and useful differentiation?
- Are there specific patient populations at risk of long-term problems?
- Is there a role for additional tests (e.g. structural and/or functional MRI, balance testing, biomarkers)?
- Should athletes with persistent symptoms be screened for depression/anxiety?

Paediatric concussion

- Which symptoms scale is appropriate for this age group?
- Which tests are useful and how often should baseline testing be performed in this age group?
- What is the most appropriate RTP guideline for elite and nonelite child and adolescent athletes?

Future directions

- What is the best method of knowledge transfer and education?
- Is there evidence that new and novel injury prevention strategies work (e.g. changes to rules of the game, fair play strategies)?

☆ Consensus panelists in addition to the authors (in alphabetical order): S Broglio,G Davis, R Dick, R Echemendia, G Gioia, K Guskiewicz, S Herring, G Iverson, J Kelly, J Kissick, M Makdissi, M McCrea, A Ptito, L Purcell, M Putukian. Also invited but not in attendance: R Bahr, L Engebretsen, P Hamlyn, B Jordan, P Schamasch.

[a] Centre for Health, Exercise and Sports Medicine, University of Melbourne, 202 Berkeley Street, Victoria 3010, Australia
[b] Sport Medicine Centre, Faculty of Kinesiology and Department of Community Health Sciences, Faculty of Medicine, University of Calgary, Alberta, Canada
[c] Sport Concussion Clinic, Toronto Rehabilitation Institute, Toronto, Ontario, Canada
[d] FIFA Medical Assessment and Research Center (F-MARC) and Schulthess Clinic, Zurich, Switzerland
[e] Ottawa Sport Medicine Centre, Ottawa, Canada
[f] Huguenot House, Dublin, Ireland
[g] Emerson Hospital, Concord, Massachusets, USA

The Zurich Consensus Document additionally examines the management issues raised in the previous ‘‘Prague” and ‘‘Vienna” documents and applies the consensus questions to these areas.

SPECIFIC RESEARCH QUESTIONS AND CONSENSUS DISCUSSION

1. CONCUSSION

1.1. Definition of concussion

Panel discussion regarding the definition of concussion and its separation from mild traumatic brain injury (mTBI) was held. Although there was acknowledgement that the terms refer to different injury constructs and should not be used interchangeably, it was not felt that the panel would define mTBI for the purpose of this document. There was unanimous agreement, however, that concussion is defined as follows:

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 constructs that may be utilized in defining the nature of a concussive head injury include:

1. Concussion may be caused either by a direct blow to the head, face or neck or a blow 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. In a small percentage of cases, however, post-concussive symptoms may be prolonged.
5. No abnormality on standard structural neuroimaging studies is seen in concussion.

1.2. Classification of concussion

There was unanimous agreement to abandon the Simple versus Complex terminology that had been proposed in the Prague agreement statement as the panel felt that the terminology itself did not fully describe the entities. The panel, however, unanimously retained the concept that most (80–90%) concussions resolve in a short period (7–10 days), although the recovery time frame may be longer in children and adolescents.[2]

2. CONCUSSION EVALUATION

2.1. Symptoms and signs of acute concussion

The panel agreed that the diagnosis of acute concussion usually involves the assessment of a range of domains including clinical symptoms, physical signs, behavior, balance, sleep and cognition. 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 detailed clinical assessment of concussion is outlined in the SCAT2 form (Supplementary Fig. 1).

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

a) symptoms: somatic (e.g. headache), cognitive (e.g. feeling like in a fog) and/or emotional symptoms (e.g. lability)
b) physical signs (e.g. loss of consciousness, amnesia)
c) behavioral changes (e.g. irritability)
d) cognitive impairment (e.g. slowed reaction times)
e) sleep disturbance (e.g. drowsiness).

If any one or more of these components is present, a concussion should be suspected and the appropriate management strategy instituted.

2.2. On-field or sideline evaluation of acute concussion

When a player shows any features of a concussion:

a) The player should be medically evaluated onsite using standard emergency management principles and particular
b) attention should be given to excluding a cervical spine injury.
c) The appropriate disposition of the player must be determined by the treating healthcare provider in a timely manner. If no healthcare provider is available, the player should be safely removed from practice or play and urgent referral to a physician arranged.

d) Once the first aid issues are addressed, then an assessment of the concussive injury should be made using the SCAT2 (Supplementary Figs. 1 and 2) or other similar tool.
e) The player should not be left alone following the injury and serial monitoring for deterioration is essential over the initial few hours following injury.
f) A player with diagnosed concussion should generally not be allowed to RTP on the day of injury. Occasionally in adult athletes, there may be RTP on the same day as the injury (see Section 4.2).

It was unanimously agreed that sufficient time for assessment and adequate facilities should be provided for the appropriate medical assessment both on and off the field for all injured athletes. In some sports this may require a 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 NP test batteries that assess attention and memory function have been shown to be practical and effective. Such tests include the Maddocks questions[3,4] and the Standardized Assessment of Concussion (SAC).5–7 Standard orientation questions (e.g. time, place, person) have been shown to be unreliable in the sporting situation when compared with memory assessment.[4,8] It is recognized, however, that abbreviated testing paradigms are designed for rapid concussion screening on the sidelines and are not meant to replace comprehensive NP 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.

2.3. 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 include:

a) A medical assessment encompassing 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 eyewitnesses 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.

In large part, these points above are included in the SCAT2 assessment (Supplementary Figs. 1 and 2), which forms part of the Zurich Consensus Document.

3. CONCUSSION INVESTIGATIONS

A range of additional investigations may be utilized to assist in the diagnosis and/or exclusion of other injury. These include the following.

3.1. Neuroimaging

It was recognized by the panelists that conventional structural neuroimaging is normal in concussive injury. Given that caveat, the following suggestions are made: brain CT scans (or where available, brain MRI) contribute little to concussion evaluation but should be employed whenever suspicion of an intracerebral structural lesion exists. Examples of such situations may include a prolonged disturbance of the conscious state, a focal neurological deficit or worsening symptoms.

Newer structural MRI modalities including gradient echo, perfusion and diffusion imaging have greater sensitivity for structural abnormalities. However, the lack of published studies as well as absent pre-injury neuroimaging data limits the usefulness of this approach in clinical management. In addition, the predictive value of various MRI abnormalities that may be incidentally discovered is not established at the present time.

Other imaging modalities such as functional MRI (fMRI) demonstrate activation patterns that correlate with symptom severity and recovery in concussion.[9–13] While not part of routine assessment at the present time, they nevertheless provide additional insight into pathophysiological mechanisms. Alternative imaging technologies (e.g. positron emission tomography, diffusion tensor imaging, magnetic resonance spectroscopy, functional connectivity), while demonstrating some compelling findings, are still in the early stages of development and cannot be recommended other than in a research setting.

3.2. Objective balance assessment

Published studies, using both sophisticated force plate technology, as well as those using less sophisticated clinical balance tests (e.g. the Balance Error Scoring System), have identified postural stability deficits lasting approximately 72 hours following a sport-related concussion. It appears that postural stability testing provides a useful tool for objectively assessing the motor domain of neurologic functioning, and should be considered a reliable and valid addition to the assessment of athletes suffering from concussion, particularly where symptoms or signs indicate a balance component.[14–20]

3.3. Neuropsychological assessment

The application of NP testing in concussion has been shown to be of clinical value and continues to contribute significant information in concussion evaluation.[21–26] Although in most cases cognitive recovery largely overlaps with the time course of symptom recovery, it has been demonstrated that cognitive recovery may occasionally precede or more commonly follow clinical symptom resolution, which suggests that the assessment of cognitive function should be an important component in any RTP protocol.[27,28] It must be emphasized, however, that NP assessment should not be the sole basis of management decisions; rather it should be seen as an aid to the clinical decision-making process in conjunction with a range of clinical domains and investigational results.

Neuropsychologists are in the best position to interpret NP tests by virtue of their background and training. However, there may be situations where neuropsychologists are not available and other medical professionals may perform or interpret NP screening tests. The ultimate RTP decision should remain a medical one in which a multidisciplinary approach, when possible, has been taken. In the absence of NP and other testing (e.g. formal balance assessment), a more conservative RTP approach may be appropriate.

In most cases, NP testing will be used to assist RTP decisions and will not be done until the patient is symptom free.[29,30] There may be situations (e.g. child and adolescent athletes) where testing may be performed early, while the patient is still symptomatic, to assist in determining management. This will normally be determined best in consultation with a trained neuropsychologist.[31,32]

3.4. Genetic testing

The significance of apolipoprotein (Apo) E4, ApoE promotor gene, Tau polymerase and other genetic markers in the management of sports concussion risk or injury outcome is unclear at this time.[33,34] Evidence from human and animal studies in more severe traumatic brain injury demonstrates induction of a variety of genetic and cytokine factors such as: insulin-like growth factor-1 (IGF-1), IGF binding protein-2, fibroblast growth factor, copper–zinc superoxide dismutase-1 (SOD-1), nerve growth factor, glial fibrillary acidic protein (GFAP) and S-100. Whether such factors are affected in sporting concussion is not known at this stage.[35–42]

3.5. Experimental concussion assessment modalities

Different electrophysiological recording techniques (e.g. evoked response potential, cortical magnetic stimulation and electroencephalography) have demonstrated reproducible abnormalities in the post-concussive state; however, not all studies reliably differentiated concussed athletes from controls.[43–49] The clinical significance of these changes remains to be established.

In addition, biochemical serum and cerebrospinal fluid markers of brain injury (including S-100, neuron specific enolase, myelin basic protein, GFAP, tau) have been proposed as means by which cellular damage may be detected if present.[50–56] There is insufficient evidence, however, to justify the routine use of these biomarkers clinically.

4. CONCUSSION MANAGEMENT

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 RTP. The recovery and outcome of this injury may be modified by a number of factors that may require more sophisticated management strategies. These are outlined in the section on modifiers (see Section 5).

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 RTP strategy. [57] During this period of recovery while symptomatic 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, video games, text messaging) 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.

4.1. Graduated return to play protocol

The RTP protocol following a concussion follows a stepwise process as outlined in Table 1. With this stepwise progression, the athlete should continue to proceed to the next level if 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.

4.2. Same day return to play

With adult athletes, in some settings, where there are team physicians experienced in concussion management and sufficient resources (e.g. access to neuropsychologists, consultants, neuroimaging) as well as access to immediate (i.e. sideline) neurocognitive assessment, RTP management may be more rapid. The RTP strategy must still follow the same basic management principles; namely, full clinical and cognitive recovery before consideration of RTP.

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.[58–60] This issue was extensively discussed by the consensus panelists and it was acknowledged that there is evidence that some professional American football players are able to return to play more quickly, with even same day RTP supported by National Football League studies without a risk of recurrence or sequelae.[61] There are data, however, demonstrating that at the collegiate and high school level, athletes allowed to RTP on the same day may demonstrate NP deficits post-injury that may not be evident on the sidelines and are more likely to have delayed onset of symptoms.[62–68] It should be emphasized, however, that the young (<18 years) elite athlete should be treated more conservatively even though the resources may be the same as for an older professional athlete (see Section 6.1).

4.3. Psychological management and mental health issues

In addition, psychological approaches may have potential application in this injury, particularly with the modifiers listed in Section 5.[69,70] Care givers are also encouraged to evaluate the concussed athlete for affective symptoms such as depression as these symptoms may be common in concussed athletes.[57]

4.4. 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 (e.g. sleep disturbance, anxiety). 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 concussion symptoms.[71] In broad terms, this approach to management should be considered only by clinicians experienced in concussion management.

An important consideration in RTP is that concussed athletes should not be only 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

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.	Recovery
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, 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	

HR = heart rate, MPHR = maximum predicted heart rate.

of a concussion, the decision to RTP while still on such medication must be considered carefully by the treating clinician.

4.4. The role of pre-participation concussion evaluation

Recognizing the importance of a concussion history, and appreciating that many athletes will not recognize all the concussions that they may have suffered, a detailed concussion history is of value.[72–75] Such a history may pre-identify athletes who 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.[72]

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, coexistent 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 the time of injury be sought, both for recent and remote injuries. The benefit of a comprehensive pre-participation concussion evaluation is that it allows for modification and optimization of protective behavior and an opportunity for education.

5. MODIFYING FACTORS IN CONCUSSION MANAGEMENT

The consensus panel agreed that 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 Table 2.

In this setting, there may be additional management considerations beyond simple RTP advice. There may be a more important role for additional investigations including: formal NP testing, balance assessment, and neuroimaging. It is envisioned that athletes with such modifying features would be managed in a multidisciplinary manner coordinated by a physician with specific expertise in the management of concussive injury.

Table 2 – Concussion modifiers

Factors	Modifier
Symptoms	Number Duration (>10 days) Severity
Signs	Prolonged LOC (>1 minute), amnesia
Sequelae Temporal	Concussive convulsions Frequency – repeated concussions over time Timing - injuries close together in time ‘‘Recency” – recent concussion or TBI
Threshold	Repeated concussions occurring with progressively less impact force or slower recovery after each successive concussion
Age	Child and adolescent (<18 years old)
Comorbidity and premorbidity	Migraine, depression or other mental health disorders, ADHD, LD, sleep disorders
Medication	Psychoactive drugs, anticoagulants
Behavior	Dangerous style of play
Sport	High-risk activity, contact and collision sport, high sporting level

ADHD = attention deficit hyperactivity disorder, LD = learning disabilities, LOC = loss of consciousness, TBI = traumatic brain injury.

The role of female gender as a possible modifier in the management of concussion was discussed at length by the panel. There was not unanimous agreement that the 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.[76–78]

5.1. The significance of loss of consciousness

In the overall management of moderate to severe TBI, duration of loss of consciousness (LOC) is an acknowledged predictor of outcome. [79] While published findings in concussion describe LOC associated with specific early cognitive deficits, it has not been noted as a measure of injury severity.[80,81] Consensus discussion determined that prolonged (>1 minute duration) LOC would be considered as a factor that may modify management.

5.2. The significance of amnesia and other symptoms

There is renewed interest in the role of post-traumatic amnesia and its role as a surrogate measure of injury severity.[67,82,83] Published evidence suggests that the nature, burden and duration of clinical post-concussive symptoms may be more important than the presence or duration of amnesia alone.[80,84,85] Further, it must be noted that retrograde amnesia varies with the time of measurement post-injury and hence is poorly reflective of injury severity.[86,87]

5.3. Motor and convulsive phenomena

A variety of immediate motor phenomena (e.g. tonic posturing) or convulsive movements may accompany a concussion. Although dramatic, these clinical features are generally benign and require no specific management beyond the standard treatment of the underlying concussive injury.[88,89]

5.4. Depression

Mental health issues (e.g. depression) have been reported as a long-term consequence of TBI including sports-related concussion. Neuroimaging studies using fMRI suggest that a depressed mood following concussion may reflect an underlying pathophysiological abnormality consistent with a limbic-frontal model of depression.[52,90–100]

6. SPECIAL POPULATIONS

6.1. The child and adolescent athlete

There was unanimous agreement by the panel that the evaluation and management recommendations contained herein could be applied to children and adolescents down to the age of 10 years. Below that age children report concussion symptoms different from adults and would require age-appropriate symptom checklists as a component of assessment. An additional consideration in assessing the child or adolescent athlete with a concussion is that in the clinical evaluation by the healthcare professional there may be the need to include both patient and parent input, as well as teacher and school input, when appropriate.[101–107]

The decision to use NP testing is broadly the same as the same as the adult assessment paradigm. However, timing of testing may differ in order to assist planning in school and home management (and may be performed while the patient is still symptomatic). If cognitive testing is performed then it must be developmentally sensitive until the late teen years due to the ongoing cognitive maturation that occurs during this period which, in turn, makes the utility of comparison to either the person's own baseline performance or to population norms limited.20 In this age group it is more important to consider the use of trained neuropsychologists to interpret assessment data, particularly in children with learning disorders and/or attention deficit hyperactivity disorder who may need more sophisticated assessment strategies.[31,32,101]

The panel strongly endorsed the view that children should not be returned to practice or play until clinically completely symptom free, which may require a longer time frame than for adults. In addition, the concept of ‘‘cognitive rest" was highlighted with special reference to a child's need to limit exertion with activities of daily living and to limit scholastic and other cognitive stressors (e.g text messaging, video games) while symptomatic. School attendance and activities may also need to be modified to avoid provocation of symptoms.

Because of the different physiological response and longer recovery after concussion and specific risks (e.g. diffuse cerebral swelling) related to head impact during childhood and adolescence, a more conservative RTP approach is recommended. It is appropriate to extend the amount of time of asymptomatic rest and/or the length of the graded exertion in children and adolescents. It is not appropriate for a child or adolescent athlete with concussion to RTP on the same day as the injury regardless of the level of athletic performance. Concussion modifiers apply even more to this population than adults and may mandate more cautious RTP advice.

6.2. Elite vs. non-elite athletes

The panel unanimously agreed that all athletes regardless of level of participation should be managed using the same treatment and RTP paradigm. A more useful construct was agreed whereby the available resources and expertise in concussion evaluation were of more importance in determining management than a separation between elite and non-elite athlete management. Although formal baseline NP screening may be beyond the resources of many sports or individuals, it is recommended that in all organized high-risk sports consideration be given to having this cognitive evaluation regardless of the age or level of performance.

6.3. Chronic traumatic brain injury

Epidemiological studies have suggested an association between repeated sports concussions during a career and late-life cognitive impairment. Similarly, case reports have noted anecdotal cases where neuropathological evidence of chronic traumatic encephalopathy was observed in retired football players.[108–112] A panel discussion was held and no consensus was reached on the significance of such observations at this stage. Clinicians need to be mindful of the potential for long-term problems in the management of all athletes.

7. INJURY PREVENTION

7.1. Protective equipment – mouthguards and helmets

There is no good clinical evidence that currently available protective equipment will prevent concussion, although mouth guards have a definite role in preventing dental and orofacial 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 studies to suggest that helmets provide protection against head and facial injury and hence should be recommended for participants in alpine sports.[113–116] In specific sports such as cycling, motor and equestrian sports, protective helmets may prevent other forms of head injury (e.g. skull fracture) that are related to falling on hard road surfaces and these may be an important injury prevention issue for those sports.[116–128]

7.2. Rule change

Consideration of rule changes to reduce the head injury incidence or severity may be appropriate where a clear-cut mechanism is implicated in a particular sport. An example of this is in football (soccer) where research studies demonstrated that upper limb-to-head contact in heading contests accounted for approximately 50% of concussions.[129] As noted earlier, 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. It is important to note that rule enforcement may be a critical aspect of modifying injury risk in these settings 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.[130] This is where the use of protective equipment results in behavioral 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.[131–133]

7.4. Aggression versus violence in sport

The competitive/aggressive nature of sport that 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.[134,135] Fair play and respect should be supported as key elements of sport.

8. 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 is a mainstay of progress in this field. Athletes, referees, administrators, parents, coaches and healthcare providers must be educated regarding the detection of concussion, its clinical features, assessment techniques and principles of safe RTP. 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 sports groups such as Fédération Internationale de Football Association (FIFA), International Ice Hockey Federation (IIHF), International Olympic Commission (IOC) and the International Rugby Board (IRB) who initiated this endeavor 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.[57,136–148]

9. FUTURE DIRECTIONS

The consensus panelists recognize that research is needed across a range of areas in order to answer some critical research questions. The key areas for research identified include:

- validation of the SCAT2 (see Supplementary Figs. 1 and 2)
- gender effects on injury risk, severity and outcome
- pediatric injury and management paradigms
- virtual reality tools in the assessment of injury
- rehabilitation strategies (e.g. exercise therapy)
- novel imaging modalities and their role in clinical assessment
- concussion surveillance using consistent definitions and outcome measures
- clinical assessment where no baseline assessment has been performed

- ‘‘best-practice” NP testing
- long-term outcomes
- on-field injury severity predictors.

10. MEDICAL LEGAL CONSIDERATIONS

This consensus document reflects the current state of knowledge and will need to be modified according to the development of new knowledge. It provides an overview of issues that may be of importance to healthcare providers involved in the management of sports-related concussion. It is not intended as a standard of care, and should not be interpreted as such. This document is only a guide, and is of a general nature, consistent with the reasonable practice of a healthcare professional. Individual treatment will depend on the facts and circumstances specific to each individual case. It is intended that this document will be formally reviewed and updated prior to 1 December 2012.

11. STATEMENT ON BACKGROUND TO THE CONSENSUS PROCESS

In November 2001, the 1st International Conference on Concussion in Sport was held in Vienna, Austria. This meeting was organized by the IIHF in partnership with FIFA and the Medical Commission of the IOC. As part of the resulting mandate for the future, the need for leadership and future updates were identified. The 2nd International Conference on Concussion in Sport was organized by the same group with the additional involvement of the IRB and was held in Prague, Czech Republic, in November 2004.

The original aims of the symposia were to provide recommendations for the improvement of safety and health of athletes who suffer concussive injuries in ice hockey, rugby, football (soccer) as well as other sports. To this end, a range of experts were invited to both meetings to address specific issues of epidemiology, basic and clinical science, injury grading systems, cognitive assessment, new research methods, protective equipment, management, prevention and long-term outcome.[1,2]

The 3rd International Conference on Concussion in Sport was held in Zurich, Switzerland, on 29 October to 2 November 2008 and was designed as a formal consensus meeting following the organizational guidelines set forth by the US National Institutes of Health. (Details of the consensus methodology can be obtained at http://consensus.nih.gov/ABOUTCDP.htm>).

The basic principles governing the conduct of a consensus development conference are summarized below.

1. A broad based non-government, non-advocacy panel was assembled to give balanced, objective and knowledgeable attention to the topic. Panel members excluded anyone with scientific or commercial conflicts of interest and included researchers in clinical medicine, sports medicine, neuroscience, neuroimaging, athletic training and sports science.

2. These experts presented data in a public session, followed by inquiry and discussion. The panel then met in an executive session to prepare the consensus statement.

3. Specific questions were prepared and posed in advance to define the scope and guide the direction of the conference. The principle task of the panel was to elucidate responses to these questions. These questions are outlined in the preamble.

4. A systematic literature review was prepared and circulated in advance for use by the panel in addressing the conference questions.

5. The Consensus statement is intended to serve as the scientific record of the conference.

6. The Consensus statement will be widely disseminated to achieve maximum impact on both current healthcare practice and future medical research.

The panel chairperson (WM) did not identify with any advocacy position. The chairperson was responsible for directing the consensus session and guiding the panel’s deliberations. Panelists were drawn from clinical practice, academic and research in the field of sports related concussion. They do not represent organizations per se but were selected for their expertise, experience and understanding of this field.

APPENDIX A. SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jocn.2009.02.002.

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