chapter two

Concussion revisited: A historical perspective

How has the focus on concussion evolved over the years?

Paul McCrory

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Introduction

Concussion is a well-recognized clinical entity; however, the detailed understanding of its pathophysiologic basis is evolving. In the broadest clinical sense, concussion is often defined as representing the immediate and transient symptoms of traumatic brain injury; however, such operational definitions do not give an insight into the underlying processes through which the brain is impaired. This issue of understanding concussion and

mTBI is clouded not only by the lack of critical data but also by confusion in definition and terminology. For *over* 100 years, various definitions of concussion and mild traumatic brain injury (mTBI) have been proposed by individual authors as well as international bodies; however, these definitions do not concur with one another, which makes understanding the epidemiology of these injuries difficult and management complicated (Ruff and Jurica 1999).

One key unresolved issue is whether concussion is part of a TBI injury spectrum and thus associated with lesser degrees of diffuse structural change that are seen in severe traumatic brain injury, or whether the *concussive* injury is the result of reversible functional changes.

Newer technological advances have opened the possibility that now we not only can separate different patterns of injury presentation but give important insights into the underlying pathophysiology and ultimately provide a platform to develop a clear definition, which is underpinned by evidence. It is likely that head injury and concussion will ultimately be defined by the severity of clinical signs, as well as genetic, epigenetic, metabolomic, proteomic, advanced imaging findings, and blood/cerebrospinal fluid (CSF) biomarkers in the same way that cancer and other medical disease is diagnosed. At this stage, however, we have only the nonspecific clinical signs and symptoms to try and provide the beginnings of that framework and we lack sufficient certainty in aspects of physiology, metabolomics, proteomics, genetics, and epigenetics to enable a complete understanding of the entity.

Understanding the definition of concussion

Key elements of a clinical or operational definition of concussion must acknowledge that it is a subset of TBI and should include:

- Induced by direct or indirect trauma
- A defined physiological disruption of brain function
- An alteration in attention (mental state) at the time of the injury (e.g., confusion, disorientation, slowed thinking), alteration of consciousness, or mental state
- A period of post-traumatic amnesia (PTA)
- A range of resolving clinical symptoms that may or may not involve loss of consciousness (LOC)

Despite many publications and definitional attempts (McCrory et al. 2017a), these considerations leave several issues unresolved. Does being dazed, seeing stars, or feeling dizzy in the absence of unconsciousness constitute either concussion or mTBI? The millions of minor bumps to the head both in children and adults in which the victim is only momentarily dazed and is completely back to normal within a few seconds or minutes without later clinical sequelae, should remind us of the dangers of the overenthusiastic use of medical labels and their indiscriminate dissemination to the public.

Historical context

The clinical manifestations of concussion as a traumatic neurological syndrome without structural brain injury have been known since the tenth century AD when the Arabian physician Rhazes first defined the condition (Rhazes 1497; McCrory and Berkovic 2001). Larrificanus in 1506 taught that symptoms after a head injury could rapidly disappear and

were the results of a transient paralysis of cerebral function caused by the brain being shaken (Larrificanus 1506). De Carpi in the sixteenth century developed Larrificanus' concept of concussion, which he termed *cerebrum commotion* and was distinguished from more severe brain injuries, which he named *contusio* (bruising/hemorrhage) and *compressio* (brain swelling/oedema) (da Carpi 1535, Abbott 1961). In the sixteenth and seventeenth centuries, the term *commotio* (or *commotion*) of the brain was used interchangeably with *concussio* (or *concussion*), a term derived from the Latin verb *concutere*, which means to *shake violently* (McCrory and Berkovic 2001). In Europe, the term *brain commotion* (or *commotio cerebri*) is still used in place of concussion as well as in the current DSM5 criteria where concussion (S06.0) is still listed as commotio cerebri and there is no category for mTBI or any other descriptor of lesser severities of TBI. The historical evolution of the concepts surrounding brain injury and concussion and the development of theoretical models have been extensively reviewed elsewhere (Courtney 1944, 1982, McCrory and Berkovic 2001, Pearce 2007).

Since the 1970s, clinicians and scientists have begun to distinguish sport-related concussions (SRC) from other causes of concussion and mTBI, such as motor vehicle crashes, and so on. While this seems like an arbitrary separation from other forms of mTBI, which account for 80% of such injuries (Langlois and Sattin 2005, Langlois et al. 2006), it is largely driven by the need to have clear and practical guidelines to determine recovery and safe return to play for athletes suffering a SRC. In addition, SRC can be viewed as a research laboratory to study mTBI, given the detailed SRC phenotype data that is typically available in elite sports (Kelly and Rosenberg 1998). Having said that, it is critical to understand that the lessons derived from nonsporting mTBI research provides the understanding of SRC (and vice versa), and this arbitrary separation of sporting versus nonsporting TBI should not be viewed simply as a dichotomous or exclusive view of TBI.

This paper will focus on the evolution of SRC guidelines over the past 50 years. The author of this paper has been involved in the Concussion In Sport Group (CISG) consensus process.

Concussion guidelines pre-1974

A key development in the history of SRC was in 1905 when President Theodore Roosevelt drew attention to the American football death toll at that time, in 1905 alone, at least 18 people died and more than 330 were injured playing football. People were especially shaken by the November 1905 death of Union College halfback Harold Moore, who died of a cerebral hemorrhage after being kicked in the head while trying to tackle a New York University player. President Theodore Roosevelt summoned coaches and athletic advisers from Harvard University, Yale University, and Princeton University to the White House to discuss how to improve the game of football. Soon after, rules started to change to reduce the amount and severity of head injuries in football (Miller 2011). Up until 1980, the primary focus regarding concussions was to exclude a potentially fatal intracranial hemorrhage. While more recent studies have become increasingly aware of long-term consequences of concussions in some individuals, the perception over many decades was that virtually all concussions would *clear* with time and *rest* (Dunn et al. 2016, Stone et al. 2014, Maroon et al. 2014).

A number of neurosurgically driven laboratories or surgically oriented neurologists began to examine mTBI more specifically, in part because of the military research programs and clinical exposure to brain trauma seen in various conflicts (Russell 1932, Denny-Brown and Russell 1941, Russell 1973). After World War II, other neurosurgeons took up

the mantle, and a key figure during this period was Dr. Richard Schneider (1915–1986), a leading U.S. neurosurgeon, who published an influential book in 1973 examining head injuries in sport (Schneider 1973). This book did much to draw the focus of clinicians to the management of SRC.

At the same time, TBI researchers using primate models began to examine milder forms of brain injury to try and determine the pathophysiological basis of the clinical features (Ommaya et al. 1964, Ommaya and Gennarelli 1975, Gennarelli 1982).

Concussion severity grading scales and guidelines 1974–2001

From the 1970s until the early 2000s, numerous authors proposed injury severity scales and return to sport recommendations for the management of concussions that occurred during sport. Neurosurgeons were the various guidelines trying to be the same approach as was used in more severe TBI cases to SRC: published most of these scales.

Five published sport-related concussion severity grades can be broken down into a number of broad groupings. The details of these early scales have been reviewed elsewhere (Johnston et al. 2001). Table 2.1 gives illustrative examples of each category.

1. *Surrogate head injury scales*: Whereas the practical needs in the majority of concussions are for a scale which is biased toward distinguishing the margins clinical injury from normal or nonsevere injury, most of the scales are biased toward the higher severity injuries. In some cases these include coma, persistent cognitive state, and death, far beyond the historical understanding of concussion (Ommaya and Gennarelli 1974, Ommaya 1990, Torg 1991, Gerwell 1991). The aim of these types of injury scales is to avoid missing the more severe brain injuries (e.g., cerebral hemorrhage) that may mimic concussion in their early stages. There is no evidence that these scales improve this goal.
2. *Neuroanatomical scales*: Traditional neuroanatomical thinking is evident in the complexities of each of these scales (Maroon et al. 1980, Hagerthofte and Richard 1982, Cantu 1986, Wilberger and Maroon 1989, Kelly et al. 1991, Roberts 1992, Pollen et al. 1996). While the anatomical focus of these scales has important conceptual problems (e.g., the extrapolation of such clinical features to milder grades of brain injury remains speculative), much of the focus of the recommendations regarding the various concussion grades of concussion injury.
3. *Sport-specific scales*: Various organizations throughout the world have responded to the needs of injury management within their given sport by the development of their own severity scales (Lorrer 1976). In most cases these have been developed by an aggregated medical subcommittee within the sport and reflect the specific logistics and practicalities inherent within a particular sport. Most have not been published formally but exist as part of the medical regulations for the sport. As a result, these specific scales have not been subjected to peer review.
4. *Sporting injury scales*: In these cases the stated aim of the injury scales is to distinguish the mild injuries from more severe injuries (Aubrey et al. 1992, Nelson et al. 1994, Kelly 1989, Schneider 1973, Saul 1991, American Academy of Neurology 1997). In some cases these have been made to stratify injuries for clinical decisions within this framework but in general these types of scales are largely symptoms-driven. Often terminology is used loosely (e.g., *extended* LOC or *prolonged retrograde amnesia*), which makes interpretation of the arbitrary subdivisions difficult. Although this approach is more in keeping with the typical management

problems faced by sports medicine clinicians, no scientific validation has been attempted with any of these scales.
5. *Unclassifiable scales*: In this category, the scaling systems proposed is none reflective of pathophysiological constructs than clinical management (Parkinson 1977).

At the First International Conference on Concussion in Sport, held in Vienna in 2001, one of the key *outcomes* was the *magnum* by the *expert* panel that none of the numerous concussion scales then published was scientifically valid. For this reason a seminal recommendation was made to assess individual *recovery* using a multimodality assessment upon which to determine safe return to play rather than rely on invalidated recommendations.

Concussion consensus and agreement statements 2001–present

Since 2001, a variety of SRC guidelines have been published. These include:

1. Global initiatives with a formal consensus process and guidelines or recommendations (Aubry et al. 2002, McCrory et al. 2005, 2009, 2013, 2017b)
2. Sport-specific meetings with outcome papers (Smith et al. 2015, 2011)
3. Organization (Guskiewicz et al. 2004, Herring et al. 2006, Harmon et al. 2013, Giza et al. 2013, Broglio et al. 2014) or institutional (Collins et al. 2016) conferences that have led to systematic reviews, guidelines, and/or recommendations
4. Reports of various conferences or position statements

In many cases, the authors of various papers overlap; however, it is worth observing that the majority of sport-specific and institutional guidelines derive from North America and reflect the sports played on that continent.

The methodology for various guidelines differs substantially, which in turn means that the published outcomes need to be considered in that context. In the case of the formal consensus meetings (Aubry et al. 2002, McCrory et al. 2005, 2009, 2013, 2017b) although the lead author is often cited, the opinions represent the agreed consensus view of the expert panel that are named in the paper. The consensus process attempts to define a more transparent method through which outcomes are developed. In the case of the CISG meetings, in addition to the summary paper, the group publishes formal systematic reviews on each of the questions under discussion (and meta-analyses where possible) upon which the summary recommendations are based and these should be read in conjunction with the summary papers.

Formal consensus meetings

CISG guidelines

One of the most significant developments in SRC over the past two decades has been the establishment of the Concussion In Sport Group (CISG). This group has organized five consensus meetings to date and has published the guidelines and assessment tools that have become globally adopted. The outcome documents from the meetings are first and foremost, intended to guide clinical practice; however, they also help form the agenda for SRC research. All outcome papers and assessment tools have been made available copyright free to encourage dissemination. The first two meetings (2001 and 2004) were expert panel meetings but from 2008 onwards these meetings have adopted a U.S. National Institutes of Health Consensus meeting format with background systematic reviews of

each of the topics under discussion published in conjunction with the summary paper of each meeting. The methodology of the meetings is described in detail in conjunction with each summary paper (Aubry et al. 2002, McCrory et al. 2005, 2009, 2013, 2017b, Meeuwisse et al. 2017).

First CISG meeting Vienna, November 2001 (Aubry et al. 2002). The Vienna conference was held in November 2001 and was supported and organized by the International Ice Hockey Federation (IIHF), Fédération Internationale de Football Association (FIFA), and the IOC Medical Commission, with a stated objective of providing recommendations for the improvement of the safety and health of athletes who suffer concussive injuries in ice hockey, soccer, and other sports. Part of the drive by sporting organizations to organize a specific meeting was the lack of a practical and valid management paradigm to diagnose and treat concussions seen in a sporting context. One particular catalyst for the meeting was the need for SRC guidelines leading into the 2002 Winter Olympic Games and, paradoxically, this occurred at a time when concussion in sport was not topical. Although consensus definitions for mTBI already existed, they were not related to the type of injuries seen in sport and did not provide practical guidance in regard to recovery and return to sport (ACRM 1993). For this reason, experts were invited to address issues involving epidemiology, basic and clinical science, grading systems, cognitive assessment, new research methods, protective equipment, management, prevention, and long-term outcome from SRC. At the conclusion of the conference, a small group of the experts was given the mandate to draft the summary paper (Aubry et al. 2002) that was subsequently co-published in three sports medicine journals.

The key recommendations from the Vienna meeting were:

1. A new consensus definition of SRC (see the previous section)
2. The participants agreed that the various guidelines differs substantially, which in turn means that the published outcomes need to be considered in that context. In the case of the formal consensus meetings (Aubry et al. 2002, McCrory et al. 2005, 2009, 2013, 2017b) although the lead author is often cited, the opinions represent the agreed consensus view of the expert panel that are named in the paper. The consensus process attempts to define a more transparent method through which outcomes are developed. In the case of the CISG meetings, in addition to the summary paper, the group publishes formal systematic reviews on each of the questions under discussion (and meta-analyses where possible) upon which the summary recommendations are based and these should be read in conjunction with the summary papers.

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4. That cognitive rest may be an important management strategy where cognitive activities intensify or prolong post-concussion symptoms
5. That the number and duration of post-concussion symptoms were most important in determining concussion severity
6. The development of a new sideline concussion assessment tool (SCAT) for use by clinicians
7. The separation of SRC into simple concussion (symptoms < 10 days) and complex concussion (symptoms > 10 days or where the patient lost consciousness for longer than 1 min, had a convulsive concussion, or had repeated concussions involving diminishing force)
8. Described the motor phenomena of SRC (e.g., tonic posturing, convulsions) as benign but dramatic in presentation
9. Whenever a player shows any symptoms or signs of concussion, he or she should not be allowed to return to play in the current game or practice, should not be left alone, and should undergo serial reassessment for deterioration

At the conclusion of the conference, a small group of the experts was given the mandate to draft the summary document that was subsequently co-published in three sports medicine journals (McCrory et al. 2005).

Third CISG meeting Zurich, November 2008 (McCrory et al. 2009). The third International Conference on Concussion in Sport was held in Zurich, Switzerland, on October 29th and 30th, 2008 and was designed as a consensus meeting broadly following the organizational guidelines set forth by the U.S. National Institutes of Health (details of the consensus methodology can be obtained at: http://consensus.nih.gov/ABOUTCDP.htm). The principles governing the conduct of a consensus development conference include: a broad-based expert panel with full disclosure of conflicts of interest; development of specific questions to be addressed with a systematic review paper on each topic circulated to the panel in advance of the meeting; presentation of the data in an open public session followed by an executive session to prepare the summary statement, which serves as a scientific record of the meeting and is then disseminated.

The key recommendations from this meeting included:

1. A minor change to the definition noting that SRC symptoms could be persistent or prolonged
2. Abandoning the simple versus complex SRC terminology
3. Reinforcing the need for a multidimensional SRC assessment
4. Reinforcing the *no same day return to play* approach
5. Highlighting the role of balance assessment in concussion management
6. Emphasizing the role of physical and cognitive rest in the acute stages after concussion followed by the graduated symptom limited rehabilitation protocol
7. Developing a list of modifying factors that may influence the investigation and management of SRC
8. Highlighting the issue of mental health sequelae following SRC
9. Highlighting the role of management of SRC in children and adolescents
10. Noting the developing literature on cognitive impairment in retired athletes but no consensus was reached of the significance of these observations
11. Updating the sideline concussion assessment tools—SCAT2 and pocket SCAT

At the conclusion of the conference, the summary document was co-published in seven sports medicine journals (McCrory et al. 2005, 2009).

Fourth CISG meeting Zurich, November 2012 (McCrory et al. 2013). The fourth International Conference On Concussion In Sport was held in Zurich, Switzerland, in November 2012. This meeting was designed to build on the principles outlined in the previous meetings and to develop further conceptual understanding of this problem using the formal consensus-based approach previously described.

The key recommendations included:

1. The agreement that SRC was an evolving injury in the early stages with rapidly changing clinical signs and symptoms. This in turn makes the exclusion of the diagnosis on the sidelines problematic. For that reason it was recommended that all athletes who have transient neurological symptoms should be removed from play for a detailed assessment
2. No single sideline tool has sufficient sensitivity or specificity to make or exclude the diagnosis of SRC.
3. A revision of the SCAT3 tools and publishing a new Child SCAT3 for assessment of young (<13 years) individuals
4. Emphasizing the role of trained neuropsychologists in the assessment of cognitive dysfunction in SRC.
5. Acknowledging the developing literature on vestibular and cervical physiotherapy in the rehabilitation of symptomatic individuals
6. Highlighting the *difficult* concussion patient and the appropriate management
7. Reviewing the modifiers from the previous meeting in terms of strength of evidence
8. Discussing about the literature on chronic traumatic encephalopathy and noting the lack of prospective studies in this area
9. Highlighting the role of knowledge translation

At the conclusion of the conference, the summary document was co-published in seven sports medicine journals (McCrory et al. 2013).

Fifth CISG meeting Berlin, October 2016 (McCrory et al. 2017b). The fifth International Conference On Concussion In Sport was held in Berlin, Germany, on October 27–29, 2016. Once again, the meeting utilized a formal consensus approach to build on the principles outlined in the previous meetings and to develop further conceptual understanding of SRC. The details of the meeting and the consensus process have been published in a separate paper (Meeuwisse et al. 2017). It is worth noting that approximately 40,000 published articles were screened by the expert panels for the Berlin meeting as part of the review process. The meeting itself engaged more formally with experts from TBI research, dementia and neurodegenerative disease, genetics and biomarker research, as well as a range of peak sporting bodies.

The key outcomes from the meeting include:

1. A revision of the SRC definition highlighting that concussion should be seen as a subset of TBI and that the features of the injury cannot be explained by drug, alcohol, medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction etc.), or other comorbilities (e.g., psychological factors or coexisting medical conditions)

2. The limited clinical role of helmet-based or other sensor systems to clinically diagnose or assess SRC
3. A revision of the SCAT tools
4. Emphasizing the importance of a multidimensional assessment of SRC
5. Removal from play of an athlete with SRC and the importance of allowing adequate time for the medical assessment
6. Noting that advanced neuroimaging, fluid biomarkers, and genetic testing are important research tools, but require further validation to determine their clinical utility in evaluation of SRC
7. The role of symptom limited physical and cognitive rest (rather than complete rest) in the recovery phase
8. Recognizing the role of rehabilitation strategies in the recovery phase including: controlled aerobic exercise, vestibular rehabilitation, submaximal exercise programs, as well as psychological, cervical, and vestibular rehabilitation
9. Discussing of the different management strategies for persistent symptoms
10. Reviewing the evidence for concussion modifiers
11. Noting that medication will not significantly alter recovery after SRC, while *useful* as research tools, are not ready for clinical management
12. Reviewing the graduated return to sport paradigm
13. Highlighting the importance of the correct management of children and adolescents with SRC
14. Reviewing the literature on neurobehavioral sequalae and long-term consequences of exposure to recurrent head trauma and noting that this is largely inconclusive at this stage
15. Reviewing injury prevention strategies

The outcome papers will be co-published in a number of journals (McCrory et al. 2017b).

Sport-specific meetings with outcome papers (Smith et al. 2015, 2011)

While numerous sporting bodies have held conferences and symposia on SRC in their sport, few have published outcome or recommendation papers. In most cases, these meetings are didactic rather than consensus driven; however, one sport that has attempted to prioritize prevention strategies using a form of consensus is ice hockey.

Two conferences on SRC in ice hockey occurred in 2011 and 2013 and a third meeting is planned for September 2017. These meetings were an attempt to integrate the research on SRC in ice hockey and develop an action plan to reduce the risk, incidence, severity, and consequences of SRC in that sport. Topics for discussion were circulated in advance of the meetings and breakout groups formed to present the literature related to those topics. At the meeting, attendees voted using an *audience response system* to prioritize areas for future action planning. At the second meeting in 2013, progress in each of these action areas was reviewed and new developments identified. Brief summaries of each topic were presented to the audience for prioritization. While commendable in terms of knowledge translation, the outcome papers did not discuss how the literature was searched and the comprehensiveness of the process.

Organization (Guskiewicz et al. 2004, Herring et al. 2006, Harmon et al. 2013, Giza et al. 2013, Broglio et al. 2014) *and institutional* (Collins et al. 2016) *guidelines*

National athletic trainers' association position statement: Management of sport-related concussion 2004 & 2014 (Guskiewicz et al. 2004, Broglio et al. 2014)

This position statement, which was published in 2004 (Guskiewicz et al. 2004) and revised and updated in 2014 (Broglio et al. 2014) is a detailed and extensive narrative review of the published literature and intends to provide athletic trainers with best practice guidelines for SRC management based on an up-to-date research. The statement lists 36 specific recommendations and grades the strength of the recommendation using the strength of recommendation taxonomy (SORT) (Ebell et al. 2004). The recommendations cover areas such as recognizing concussion; making return-to-play decisions; and assessment tools, cognitive screening, postural assessment, and neuropsychological testing. It also contains sections on when to refer an athlete to a physician after a concussion and when it is appropriate to consult athletic, as well as sections on special considerations for the young athlete, home care, and equipment issues.

Concussion (Mild Traumatic Brain Injury) and the team physician: A consensus statement 2006 & 2011 (Herring et al. 2006, 2011)

In 2006, the American College of Sports Medicine published a consensus statement on SRC and specifically on the role of the team physician in this setting and focusing on the on-field and sideline management of SRC (Herring et al. 2006). This statement was updated in 2011 (Herring et al. 2011). The statement represented the collaborative effort of six major professional associations, including the American Academy of Family Physicians, the American Academy of Orthopedic Surgeons, the American College of Sports Medicine, the American Medical Society for Sports Medicine (AMSSM), the American Orthopedic Society for Sports Medicine, and the American Osteopathic Academy for Sports Medicine, and was endorsed by a number of additional organizations, including the American Osteopathic Association, the National Athletic Trainers' Association, the North American Spine Society, the National Collegiate Athletic Association, the National Youth Sports Safety Foundation, the American Academy of Pediatric Sports Medicine, and the American Kinesiotherapy Association.

The areas covered within the narrative review include: epidemiology, biomechanics, and pathophysiology, preseason planning and assessment, same day evaluation and treatment, post same day evaluation, diagnostic testing, return-to-play decisions, complications, prevention, as well as legislation and governance issues. Each section of the document includes the panel's consensus view on what is *essential* and what is *desirable* for the team physician to know and understand.

This statement was similar to the CISG statements in that it emphasized that concussion severity should be determined by the duration and number of post-concussion symptoms, not by whether there was brief LOC or even whether amnesia alone was one of the symptoms.

American Medical Society for sports medicine position statement: Concussion in sport 2013 (Harmon et al. 2013)

The purpose of this statement was to provide an evidence-based, best practice summary to assist physicians in the evaluation and management of SRC and to establish the level of evidence, knowledge gaps, and areas requiring additional research. The focus of the statement was for nonsurgical sports medicine physician with additional training in sports medicine. The recommendations derived from this narrative review were graded according to the strength of the recommendation using the SORT criteria (Ebell et al. 2004).

American Academy of Neurology—evaluation and management of concussion in sport—1997 & 2013 (American Academy of Neurology 1997, Giza et al. 2013)

This evidence-based guideline (Giza et al. 2013) replaced the 1997 American Academy of Neurology (AAN) practice parameter on the management of sports concussion (American Academy of Neurology 1997). This is one of the most comprehensive documents on SRC available. The multidisciplinary authors very clearly describe the systematic review process that was followed to search and extract data. The strength of the evidence was assessed according to the GRADE scale (Guyatt et al. 2011). The writing panel formulated recommendations on the basis of the evidence systematically reviewed and when evidence directly related to sports concussion was unavailable, from strong evidence derived from nonsport-related mTBI, similar to the CISG approach. The clinician level of obligation of recommendations was assigned using a modified Delphi process. The summary document is accompanied by extensive online data supplement (available at www.neurology.org).

This guideline addressed the following clinical questions: (1) For athletes, what factors increase or decrease SRC risk? (2) For athletes suspected of having sustained an SRC, what diagnostic tools are useful in identifying those with SRC? (3) For athletes suspected of having an SRC, what diagnostic tools are useful in identifying those at increased risk for severe or prolonged early impairments, neurologic catastrophe, or chronic neurobehavioral impairment? and (4) For athletes with SRC, what interventions enhance recovery, reduce the risk of recurrent concussion, or diminish long-term sequelae?

Statements of agreement from the targeted evaluation and active management approaches to treating concussion (Collins et al. 2016)

A group of concussion experts was convened in Pittsburgh, Pennsylvania, on October 14–16, 2015, to determine areas of agreement regarding the current state of concussion treatment. The outcome document (Collins et al. 2016) presents the results of the meeting, which was designed to foster an understanding among clinicians, scientists, and lay people that concussion symptoms and impairment are treatable with more active and targeted approaches than prescribed rest alone. In contrast to meetings such as the CISG meetings, which used formal consensus meeting guidelines, the targeted evaluation and active management (TEAM) meeting used a majority voting approach to determining agreement on each statement similar to that used by ice hockey summit described earlier (Smith et al. 2011, 2015).

Thirty-seven concussion experts from neuropsychology, neurology, neurosurgery, sports medicine, physical medicine and rehabilitation, physical therapy, athletic training, and research and 12 individuals representing sport, military, and public health organizations attended the meeting. A total of 16 statements of agreement were supported covering (1) summary of the current approach to treating concussion, (2) heterogeneity

and evolving clinical profiles of concussion, (3) team approach to concussion treatment: specific strategies, and (4) future directions: a call to research.

Reports of various conferences or position statements

Numerous organizations have published position statements or statements of practice with varying degrees of scientific rigor, stating how the data was derived upon which recommendations are based (Halstead et al. 2010, Echemendia et al. 2012, NCAA 2014, Moreau et al. 2015). While this list is not exhaustive, it highlights the need for organizations to develop methodologies that describe the process by which position/summary statements are developed and the strength of evidence of any recommendations provided.

Conclusion

It is important to consider that all SRC need to be medically assessed given the potential for adverse outcomes. Embedded in that approach is the concept that diagnosing concussion is often not a *point in time* event but rather one that requires observation over time and exclusion of other conditions that may mimic a concussion. The role of evidence-based guidelines has evolved over the past 50 years driven by various sporting, cultural, political, and scientific agendas from a *neurosurgical one* of trying to rule out severe TBI to an SRC *one* of trying to diagnose the minimal injury and manage these using best practice strategies. The future challenge will be to unify the various groups and bodies who publish individual guideline statements in a global initiative.

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