Future Advances and Areas of Future Focus in the Treatment of Sport-Related Concussion

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KEYWORDS

- Sports concussion
- Athletic injuries
- Chronic traumatic encephalopathy
- Traumatic brain injury

THE END OF THE BEGINNING

The critical issues in the clinical management of sports concussion include confirming the diagnosis, differentiating concussion from other pathologies (particularly structural head injury), and determining when players have recovered so that they can be safely returned to competition. When expressed in this fashion, the management process seems simple. Yet the occurrence and management of this injury provokes more debate and concern than virtually all other sports injuries combined.

In the past 3 decades, clinicians have gone from mostly anecdotal strategies to an international consensus-based approach and the early evolution of evidence-based practice, particularly in the area of injury prevention.1–5 We have come far, but the situation in 2011 should be seen as the end of the beginning, not the beginning of the end.

The past 2 to 3 years have seen increasing engagement by mainstream neuroscientists in this field, which had previously been dominated by sports team physicians. This change has been useful in bringing a range of expertise (eg, neuropathology, neuroradiology) to the debate. However, it has been disappointing because the interchange has largely taken place in the media rather than through scientific journals. The
resultant media interest has caused significant alarm in the minds of the public about putative long-term risks and concern about how an acute injury should be managed, particularly in communities that currently lack access to quality medical resources.

Tragic stories of athletes who have not been managed according to current guidelines, or who have failed to fully disclose their injury to team medical staff, resulting in catastrophic outcomes, are regularly aired in the media and, at least in the United States, have caused legislators to propose regulatory measures that restrict medical management of concussion in ways that apply to no other medical condition. When last checked in 2009, 13 US states had bills either before their legislatures or passed related to sports concussion in addition to proposed national legislation. In many cases, the principle of the bills is primarily educative. However, in some states, mandatory preseason cognitive testing and other paradigms are included. The tragedy in this area is the replacement of scientific management by media anecdote. This is ironic given that the focus in sports concussion in the past 3 decades has been the opposite.

This paper examines some of the key areas that are likely to be the focus of research in the next few years. From the media perspective, the risk of long-term injury is paramount. However, from the sports perspectives globally, the major concern is how community athletes who may lack the resources available for elite athletes can safely be managed.

OPENING THE CHAMBER OF SECRETS

In many ways, elite sport has been its own worst enemy in this field. The sight of concussed professional athletes returning to play on the day of injury in many sports globally gives the public the wrong perception of the seriousness of this injury. Although it is broadly accepted that all athletes, regardless of their level of participation, should be managed using the same return-to-play paradigm, elite teams have far greater resources such as access to emergent neuroimaging, immediate neuropsychological assessment, as well as high-level expertise in concussion evaluation, which in turn means that the accurate assessment of recovery can occur in shorter time frames. However, the public never sees the back-office assessment, simply the rapid return of a concussed athlete to the field of play. The public assumes that similar rapid return is possible at lesser levels of competition. This lack of understanding makes the need for community education much more urgent, so that athletes, coaches, parents, trainers, and others involved in athlete care become aware of the significance of the injury and its appropriate management.

SAME-DAY RETURN TO PLAY

The basic management principles, namely full clinical and cognitive recovery before consideration of return to play, should be followed. This approach is supported by the major published guidelines such as the American Academy of Neurology, US Team Physician Consensus Statement, US National Athletic Trainers Association Position Statement, and the Zurich Consensus statement.1,3–5

There is published evidence that some professional American football players are able to return to play on the same day without a risk of concussion recurrence or sequelae.6 However, there are also data showing that, at the collegiate and high school level, some athletes allowed to return to play on the same day show neuropsychological deficits that may not be evident on the sidelines, and are more likely to have delayed onset of symptoms.7,8
This disparity in outcomes between elite and college/high school athletes highlights a key area in the debate, namely that any concussion management strategy needs to be tailored by age and possibly level of performance. A 'one-size-fits-all' strategy may not be possible unless one takes the ultraconservative view and simply has a policy of no return to play on the same day. Increasingly, research and clinical focus will be directed at managing different age groups with safe and appropriate guidelines. In many cases, this may involve no return on the day of injury, a strategy that may create concern, particularly at US collegiate levels.

THE BLACK DOG OF DEPRESSION

Mental health issues (such as depression) have been reported as a long-term consequence of sports-related concussion, occurring in approximately 11%, with a possible association with recurrent concussion. It is important to examine the wider perspective, because depression and anxiety symptoms occur in 15% to 60% of patients following traumatic brain injury from any cause. Neuroimaging studies using functional magnetic resonance imaging and other neuroimaging modalities suggest that a depressed mood following brain injury may reflect an underlying pathophysiologic abnormality consistent with a limbic-frontal model of depression.

Although this issue highlights the need to be vigilant for all mental health problems in all current and retired athletes, it seems that sport per se is not the concern here, but rather the presence of a traumatic brain injury, which in itself carries an inherent risk of depression, suicide, and other mental health issues. In addition to awareness, psychological approaches may have potential applications in this injury and remain an underused resource in sports medicine. Caregivers are also encouraged to evaluate for affective symptoms such as depression, not only in the concussed athlete but also in healthy athletes during preparticipation screenings to prevent future problems.

PUNCH-DRUNK ATHLETES?

Recent cross-sectional descriptive epidemiologic studies have suggested an association between repeated sports concussions during a career and late-life cognitive impairment. Similarly, case reports have noted anecdotal cases in which possible neuropathologic evidence of chronic traumatic encephalopathy was observed in retired football players as well as other sportsmen, such as boxers.

Major methodological flaws exist in these observational studies, and the putative associations may be spurious. Much of the debate in this regard has been in the media rather than in the scientific literature, and many of the cases proposed are easily explained by mechanisms other than participation in sport, with or without recognized head injury. Even the recent cases reported with neuropathologic features (such as tau positive neurofibrillary tangles) have other possible causes and, of more concern, differ in their microscopic features from the older cases of punch-drunk syndrome (which also have β amyloid deposition) in boxers, which were the basis for the current understanding of this condition. At the present time, the classification and neuropathologic understanding of this condition still needs resolution.

One particular concern is raised by clinicians is that, if this condition is a potential risk for all athletes (even reported in footballers never diagnosed with concussion during their career), then why are there not more cases of retired footballers with dementia? Sports such as Australian football have a risk of concussion 15 times that of American football, yet long-term follow-up studies do not show similar findings. More importantly, prospective cohort studies using neuropsychological assessment in athletes have been available since the late 1980s, and these published studies do not
conclusively support evidence of deteriorating cognitive function during an athletic career following recurrent concussions. However, they do suggest that having 1 concussion may increase the risk and/or severity of subsequent concussions.\textsuperscript{30–32}

In many ways, this parallels the debate about the small percentage of boxers who seem disproportionately affected by chronic traumatic encephalopathy. However, most boxers, many of whom have had substantial head trauma during their careers, remain unaffected.\textsuperscript{33} The data from the original work by Corsellis and Roberts\textsuperscript{25,26} suggest that extremes of head injury exposure are a risk factor for chronic traumatic encephalopathy in boxers. However, such levels are simply not seen in other sports. It seems that there is likely to be an alternative explanation, such as a particular genetic factor that puts these athletes at greater risk. The significance of apolipoprotein (Apo) E\textsubscript{4}, ApoE promoter gene, tau polymerase, and other genetic markers in the risk of sports concussion or injury outcome is unclear at this time.\textsuperscript{34–36} Additional concerns are the role of risk-taking behavior, alcohol use, and drug use by elite athletes, which in turn may have adverse neuropathologic consequences.\textsuperscript{37,38}

At this time, the frequency or risk, if any, of long-term consequences of sports concussion are unknown. However, ongoing monitoring during and after an athletic career is a reasonable approach. Clinicians need to be mindful of the potential for long-term problems in the management of all athletes.

\section*{LITTLE ADULTS OR DIFFERENT MANAGEMENT STRATEGIES FOR CHILDREN?}

It was accepted by the Zurich international consensus group that the adult athlete evaluation and management recommendations could be applied to children and adolescents down to the age of 10 years with a few important differences.\textsuperscript{1} Younger than that age, children report different concussion symptoms than adults and require age-appropriate symptom checklists as a part of the assessment. When assessing the child or adolescent athlete with a concussion, the health care professional needs to consider input from parents, teachers, and other school personnel.\textsuperscript{39–42}

Although neuropsychological assessment is widely used following symptom resolution in adult concussion, its timing differs in children, because it may be used to assist planning for school and home management while the patient is still symptomatic. If cognitive testing is performed, then it must be developmentally sensitive through the late teen years. It is particularly important to consider the use of trained neuropsychologists to interpret data, particularly in children with learning disorders and/or attention-deficit hyperactivity disorder who may need more sophisticated assessment strategies.\textsuperscript{39,43,44}

Because of the different physiologic response, longer recovery after concussion, and specific risks (eg, diffuse cerebral swelling) related to head impact during childhood and adolescence, a more conservative return-to-play approach is usually recommended for children and adolescents. It is not appropriate for a child or adolescent athlete with concussion to return to play on the same day as the injury, regardless of the level of athletic performance.

\section*{PREVENTION IS BETTER THAN CURE}

Consideration of rule changes to reduce the head injury risk may be appropriate if a specific mechanism is implicated. An example of this is in football (soccer), for which published studies show that upper limb to head contact in heading contests accounted for approximately 50\% of concussions.\textsuperscript{45} By penalizing such contact and enforcing the rules, the risk of injury has been substantially reduced.\textsuperscript{46,47}
There is no good clinical evidence that currently available protective equipment (especially soft-shell helmets) prevents concussion. However, mouthguards have a definite role in preventing dental and orofacial injury.\textsuperscript{48,49} For skiing and snowboarding, there are several studies to suggest that helmets provide protection against soft tissue head (not brain) and facial injury. Hence, they may be recommended for participants in alpine sports.\textsuperscript{50–52} In specific sports such as cycling, motor sports, and equestrian sports, protective helmets may prevent other forms of head injury (eg, skull fracture) that are related to falling on hard surfaces. These may be important injury prevention issues for those sports.\textsuperscript{53–59}

**EDUCATING THE MASSES**

Because the ability to reduce the effects of concussive injury after the event is minimal, the education of athletes, colleagues, and the general public is a mainstay of progress in this field. All people involved in athlete care, including referees, administrators, parents, coaches, as well as the athletes themselves, must be educated regarding the importance of injury and the principles of safe return to play. However, in spite of the efforts by sports to promulgate such information, evidence that these educational strategies are effectively reaching their target groups is lacking.\textsuperscript{60–63}

Methods to improve education, including Web-based resources, are important in delivering the message and providing peer support.\textsuperscript{64,65} In addition, enlightened bodies, such as Fédération Internationale de Football Association (FIFA), the International Olympic Committee, the International Rugby Board, and the International Ice Hockey Federation, are to be congratulated for their support because their efforts reach a global audience.

**WHERE TO NOW?**

There are several areas of focus at the present time that require resolution. The role of the Concussion in Sport group as an international forum for research exchange and in the development of consensus guidelines cannot be underestimated. In specific countries, such as the US, local guidelines have had a similarly important role in educating medical staff but have yet to translate into mainstream community education. The engagement of mainstream neuroscience is important, but, rather than conducting the debate through the media, the issues raised need to be tested by scientific peer review. We must remember that the plural of anecdotes is not data.

**REFERENCES**


