

Who should retire after repeated concussions?

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Introduction

The decision to medically retire an athlete following repeated concussions remains controversial. The issue has been reviewed by the recent Verma and Prange review.

Concussion is a complex phenomenon and the published guidelines have little or no scientific validity. The new law has reinforced by the recent Verma and Prange Concussion review, which emphasized the need to individualize clinical management and avoid decisions on anecdotal recommendations.

In situations in which the athlete has suffered a life-threatening severe brain injury, has persistent neurological deficits, or has a significant neurological deficit, the decision to retire is straightforward. In the vast majority of cases, however, the decision to retire is a judgment call. The athlete's performance, cognitive function, and overall health should be considered when making this decision.

Methodology

The relevant literature was searched by using searches (1986–2005) and SportDiscus (1975–2005) searches, hand searches of journals and reference lists, and discussions with experts and sporting organizations worldwide. In addition, a keyword search was carried out on the authors' Electronic database of over 6000 articles on sport-related concussions. The keywords and Medical Subject Headings (MeSH) terms used in all searches included concussion, brain injury, head injury, head trauma, brain trauma, sports injuries, and neurotrauma.

Background

There is no scientific evidence that sustaining several concussions over a sporting career will necessarily result in permanent damage. Part of the neurophysiology surrounding concussion is the "dose-response" model. If an athlete has three concussions, then he/she should be ruled out of competition for an arbitrary period of time. One concussion is the athlete's "spike" participation – permanently viable. This is the usual approach.

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originally attributed to Quigley in 1943 and subsequently adopted by Thomley, who suggested that any athlete suffering from concussions, which involved loss of consciousness for any period of time, the athlete should be removed from competition for the remainder of the season.¹⁰ This approach has no scientific validity. It is a contention that the level of neurological impairment must be assessed relative to the athlete's baseline.

The mainstay for behind this approach is that an athlete suffering repeated concussions will suffer cognitive impairment. However, the evidence is weak. The majority of studies on chronic traumatic encephalopathy have not shown any cognitive impairment. On the other hand, published evidence that has largely refuted this approach is that the athlete's performance is not impaired by repeated concussions. In fact, many athletes who have suffered repeated concussions have continued to play at a high level.

The evidence further confirms when staff know athletes suffering from repeated head trauma appear on the field – by gross in some cases, the impact is self to such extent that the athlete is unable to play. In some cases, the impact is self to such extent that the athlete is unable to play. In some cases, the impact is self to such extent that the athlete is unable to play. In some cases, the impact is self to such extent that the athlete is unable to play.

Adding to the difficulty is the fact that when professional athletes suffer repeated concussions, their baseline cognitive function is not as good as that of the general public. While it is true that many professional athletes are not as cognitively sharp as the general public, it is not clear that this is a result of repeated concussions. It is possible that this is a result of other factors, such as the athlete's lifestyle, which may be more stressful than that of the general public.

Most of the concern is related to the management of repeated concussions. The lack of scientific validity means that the athlete's performance is not impaired by repeated concussions. The lack of scientific validity means that the athlete's performance is not impaired by repeated concussions. The lack of scientific validity means that the athlete's performance is not impaired by repeated concussions.

Definition of concussion

Until recently, there was no universal agreement on the standard definition or nature of sports concussion.¹¹ Historically, the term has been used to refer to a transient disturbance of neurological function caused by the "blow" of the brain that accompanies low-velocity trauma.

The definition provided by the Commission on Head Injury Nomenclature of the Congress of Neurological Physicians was widely used to define traumatic injury until 2003. The definition states that concussion is a "clinical syndrome characterized by the immediate and transient post-traumatic impairment of neural function, such as alteration of consciousness, disturbance of vision or equilibrium, etc., due to traumatic injury to the brain." Over time, however, it had become clear that this definition really did not adequately define the clinical entity, and as a result an expert consensus conference on sports concussion was held in Vienna in 2001, with a second meeting held in Prague in 2004.¹² The Prague meeting established sports concussion as follows:

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It must be emphasized, however, that symptoms following concussion should not be deemed to be a sign of permanent damage. It is important to note that the athlete's performance is not impaired by repeated concussions. It is important to note that the athlete's performance is not impaired by repeated concussions.

It is only in the past few decades that there has been interest in studying the neurophysiological consequences of concussion, and particularly of those injuries seen in sports.¹³ While there is now acceptance that there is an organic basis to the problems associated with concussion, controversy remains regarding the nature of the concussive deficit, as well as the speed and extent of recovery from them.

A range of neurophysiological deficits has been reported after mild concussive injury. The major areas of deficit include:

- Disorientation of time and space
- Fluctuating and delayed speed of information processing
- Reduced attention and reduced speed of information processing

There have also been related reports suggesting that impairments may be evident in tasks involving visuospatial construction ability, language, and sensorimotor function.¹⁴

Recovery of neurophysiological function after concussion in sport

In general terms, there appears to be clear evidence of neurophysiological deficits relating to the first week after mild concussive injury, but notable findings tend to develop after that period.^{15,16}

There are a number of methodological issues that may affect the responsiveness reported between studies – including task selection, different mechanisms of injury, and varying levels of control. In addition, the athlete's baseline cognitive function has been included under the rubric of concussion, ranging from no loss of consciousness (LOC) through LOC for 1 week or more, and missing of the season for a few weeks through to patients with post-traumatic stress disorder for 6 months.

In addition, concussive injuries may result from a number of different causes, such as motor vehicle accidents, sporting injuries, falls, and domestic violence. This heterogeneity may account for some of the differences between studies, using the magnitude of the head impact as a measure of the severity of the injury.

With regard to the various neurophysiological test instruments used in the different studies, a number of methodological issues arise, including task selection, lack of consistency of various tests, practice effects, inadequate identification of premorbid characteristics influencing task results, and the use of different tests for testing high-velocity control groups, small sample sizes, and compensation issues.

The postconcussion syndrome

The onset of the constellation of physical and cognitive symptoms that have been labeled as "postconcussion syndrome" (PCS) is controversial today as when it was first proposed in the 1960s.¹⁷ The term PCS was used to describe a group of symptoms that were not clearly defined.

PCS may include symptoms such as headache, vertigo, dizziness, tinnitus, memory complaints, blurred vision, sensory and light intolerance, irritability, concentration, fatigue, depression, sleep disturbance, loss of appetite, anxiety, incoordination, and hallucinations.^{18,19}

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Published guidelines for return to sport after concussion

The published guidelines recommending termination of all contact sport following three concussions during the season of an athlete, women need to be considered. Concussions are a leading cause of injury in contact sports. The athlete's performance is not impaired by repeated concussions. The athlete's performance is not impaired by repeated concussions. The athlete's performance is not impaired by repeated concussions.

The main guidelines on returning to sport after repeated concussive injury are those published by Cantu²⁰ and the Colorado Medical Society.²¹ The American Academy of Neurology guidelines²² are also relevant for this purpose.

It is not known that there are many reported limitations between the two scales systems. Although the criteria for the severity of injury differ, the guidelines recommend that the athlete should be ruled out of competition for a period of time following a concussion. The athlete's performance is not impaired by repeated concussions.

The physiology of concussion

At present, there is no existing animal model or other experimental model that accurately reflects a sporting concussive injury. It has been noted in experimental models of acute severe injury that a complex cascade of biochemical, metabolic, and membrane homeostasis changes occur. Whether similar metabolic changes occur to sports concussions however is still currently unclear.

Table 6.1 Return to sport guidelines: Cantu system (adapted from Cantu 1998)²⁰

Severity grade	1st concussion	2nd concussion	3rd concussion
Grade 1 LOC: 0-5 min PTA: >30 min	Return to sport after 1 week If asymptomatic	Return to sport after 2 weeks If asymptomatic	Return to sport after 3 weeks If asymptomatic
Grade 2 LOC: 6-30 min PTA: >30 min	Return to sport after 2 weeks If asymptomatic	Return to sport after 4 weeks If asymptomatic	Return to sport after 6 weeks If asymptomatic
Grade 3 LOC: >30 min PTA: >24 h	Return to sport after 4 weeks If asymptomatic	Return to sport after 6 weeks If asymptomatic	Return to sport after 8 weeks If asymptomatic

LOC, loss of consciousness; PTA, post-traumatic amnesia; RTP, return to play.

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Table 6.2 Postconcussion symptoms scale (adapted from Lovell and Collins 1998)²³

None	Rating			
	Mild/moderate	Severe	Very severe	
Headache	0	1	2	4
Nausea	0	1	2	4
Vomiting	0	1	2	4
Appetite loss	0	1	2	4
Sleeping more than usual	0	1	2	4
Memory loss	0	1	2	4
Sensitivity to noise	0	1	2	4
Feeling like "a fog"	0	1	2	4
Difficulty concentrating	0	1	2	4
Difficulty remembering	0	1	2	4
Double vision	0	1	2	4
Double hearing	0	1	2	4
Double feeling	0	1	2	4
Neurotama	0	1	2	4
	0	1	2	4

Various PCS scales are widely used in sports-concussion assessment (Table 6.3). Although different definitions of PCS exist, the most commonly used is that of Lovell and Collins.²³ The problem includes a lack of pre-injury data, which makes it difficult to determine the true prevalence of PCS in athletes. The athlete's performance is not impaired by repeated concussions.

The risk of repeat concussion in sport

It has been widely held belief that after sustaining a concussive injury, one is three times more likely to sustain a second concussive injury. The evidence for this is limited at best. The athlete's performance is not impaired by repeated concussions.

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There is a genetic susceptibility to brain injury in sports?

Recent research has been suggested that chronic traumatic encephalopathy (CTE) is the so-called "punch-drunk syndrome" is more likely associated with a particular genetic profile.

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In addition, genetic factors have been suggested that may affect the athlete's susceptibility to CTE. The athlete's performance is not impaired by repeated concussions. The athlete's performance is not impaired by repeated concussions.

Does repeat concussion result in cumulative damage?

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Return to sport after life-threatening head injury

The return to sport following a severe or potentially life-threatening brain injury is controversial, and there are few guidelines for the clinician to follow. There are some situations in which the athlete might play on the field at an unacceptably high risk of sustaining further injury and hence should be considered against participating in contact sports. In such situations, common sense should prevail.

Although severe physical trauma does not mean that meaningful neurological recovery from severe brain injury, it is nevertheless recommended that at least 12 months should elapse before the athlete is considered for return to sport.

Thorough deliberation and analysis of all the available medical evidence should occur when such decisions are being made. It is also recommended that the athlete's performance is not impaired by repeated concussions.

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Table 6.3 Return to sport guidelines: the Colorado guidelines (adapted from Kelly et al. 1997)²⁴

Severity grade	1st concussion	2nd concussion	3rd concussion
Grade 1 LOC: none no amnesia	RTP after 24 hours If asymptomatic	RTP after 48 hours If asymptomatic	RTP after 72 hours If asymptomatic
Grade 2 LOC: 1-5 min no amnesia	RTP after a minimum of 1 week with no symptoms	RTP after a minimum of 2 weeks with no symptoms	RTP after a minimum of 3 weeks with no symptoms
Grade 3 LOC: >5 min no amnesia	RTP after a minimum of 2 weeks with no symptoms	RTP after a minimum of 4 weeks with no symptoms	RTP after a minimum of 6 weeks with no symptoms

LOC, loss of consciousness; RTP, return to play.

Although experimental research has enhanced our understanding of the physiological changes to the brain following severe head trauma, there is still uncertainty as to what is happening to the human brain following minor concussive injuries, and in particular in sport-related concussion.

The neurophysiology of concussion

The nature of transient loss of cerebral function following a blow to the head has excited much speculation over the centuries regarding whether microscopic neurophysiological changes occur, or whether other cerebral neurophysiological processes manifest the clinical symptoms of concussion. At this stage, these important issues remain unresolved. In general terms, although it is well accepted that minor neurophysiological changes may occur following concussive brain injury, the clinical symptoms are due to functional disturbances, presumably at the cell membrane level, rather than due to any underlying structural injury. This is supported by evidence demonstrating that the cellular stress can produce a marked neuronal depolarization followed by a point of nerve cell membrane failure in the absence of structural injury.²⁵

Human models of concussion are necessarily limited, given that virtually all patients recover within discrete periods of time. It is not clear whether the athlete's performance is not impaired by repeated concussions.

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Table 6.4 Conditions contraindicating a return to contact sport (adapted from Cantu 1998)²⁰

• Persistent postconcussive or post-injury symptoms
• Persistent neurological symptoms: headache, visual deficit, dementia or cognitive impairment
• Hydrocephalus with or without shunting
• Significant subdural hematoma from any cause
• Epilepsy: neurologic or post-traumatic etiology should be treated before return to contact sport
• Chronic injury of any structure of the skull

Conclusions

Who should retire after recurrent concussive injury? It appears self-evident that athletes with persistent cognitive or neurological symptoms should be withheld from contact sports until such time as they symptom fully resolve. There are some situations in which the athlete might play on the field at an unacceptably high risk of sustaining further injury and hence should be considered against participating in contact sports. In such situations, common sense should prevail.

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Key messages

- No evidence-based guidelines exist in relation to the return to sport after repeated concussions.
- Persistent neurological symptoms or cognitive impairment should preclude a return to sport, but there are few exceptions. There is no evidence that an athlete at risk of long-term sequelae from concussive injury.

Sample examination questions

- Multiple-choice questions** (answers on page 602)
1. In relation to the presence of a April phenomenon (AP) has been demonstrated to:
 - A. Confer a severe prognosis following traumatic brain injury
 - B. Be associated with chronic traumatic encephalopathy ("punch-drunk syndrome") in boxers

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