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# Concussions: A Head-On Approach



Though not under the intense spotlight of the national media, most primary care physicians must nonetheless routinely evaluate patients who have sustained a concussion, and formulate an appropriate management plan.

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Over the past 10 years, much media attention has been focused on concussions and professional athletes. Both Troy Aikman and Steve Young have had to end their NFL careers prematurely, while Eric Lindros's return to the NHL was, in part, complicated by his concussion-history.

The word "concussion" comes from the Latin term *concutere*, or "to shake violently." A widely accepted definition comes from The Congress of Neurological

Surgeons (1966): "A clinical syndrome characterized by the immediate and transient post-traumatic impairment of neural function such as alterations of consciousness, disturbance of vision or equilibrium, *etc.* due to brain stem involvement."

Current estimates for concussion incidents in the U.S. secondary to contact sports is believed to be 250,000 to 300,000 per year.<sup>1</sup> Collision sports, such as football, hockey, soccer and wrestling, provide the greatest risk for participant concussion.<sup>2</sup>

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## Injury mechanism

Concussions are the product of an acceleration/deceleration moment to the brain, with the force vectors applied in a linear or angular/ rotational direction. Acceleration moments are most often produced by a sudden force to the stationary head, either through a direct blow to the head, jaw or “whiplash mechanism.” Deceleration moments are produced by the sudden ces-



sation of head movement, usually by head impact with the ground or other stationary object.<sup>3</sup> Put simply, concussion involves violent shaking of the head.

It should be emphasized that the force required to impart loss of consciousness (LOC) need not be reached to cause concussion.

## Pathophysiology

The pathophysiology of concussion is not known, however, most investigators believe that axonal injury secondary to sheering or stretching forces may lead to axonal dysfunction.<sup>4</sup> Other changes to the brain following injury may include neurochemical, metabolic or vascular alterations.



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Table 1

## Signs and symptoms of concussion

### *Memory or Orientation Problems*

- Unaware of time, date, place
- Unaware of period, opposition, score of game
- General confusion

### *Typical Symptoms*

- |                                   |                       |
|-----------------------------------|-----------------------|
| • Headache                        | • Feeling dazed       |
| • Dizziness                       | • Sleepiness          |
| • Feeling "dinged" or stunned     | • Double vision       |
| • "Having my bell rung"           | • Ringing in the ears |
| • Seeing stars or flashing lights | • Feeling "slow"      |
| • Loss of field of vision         | • Nausea              |

### *Physical Signs*

- |                            |                       |
|----------------------------|-----------------------|
| • Vacant stare/glassy eyed | • Vomiting            |
| • Slurred speech           | • Personality changes |
- Poor coordination or balance
  - Slow to answer questions or follow directions
  - Easily distracted, poor concentration
  - Displaying unusual or inappropriate emotions (*e.g.*, laughing, crying)
  - Inappropriate playing behaviour (*e.g.*, skating or running in the wrong direction)
  - Significantly decreased playing ability from earlier in the competition.

Guidelines for the Assessment and Management of Sport-Related Concussion.<sup>1</sup>

## Signs and symptoms

The clinical presentation of acute concussion includes a multitude of signs and symptoms (Table 1). Presentation can range from the overt with LOC, amnesia and confusion, to subtle changes with the athlete not "feeling right." It is not uncommon for a concussed athlete's teammate to note confusion or improperly executed plays.

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It should be stressed that many symptoms can be non-specific and may be secondary to non-concussion etiology (*e.g.*, headache, nausea).<sup>5</sup> In addition, physical findings, such as behavioural changes, co-ordination changes, and lethargy, are subjective and difficult to measure.

To date, validated signs and symptoms for the diagnosis of concussion include LOC, amnesia, headache, vertigo, blurred vision and attention deficit.<sup>5</sup> Over the past decade, much focus has been placed upon the neuropsychological (NP) findings of concussions. Neuropsychology deals with cognitive functions such as concentration, new information processing, motor dexterity and executive functioning.<sup>6</sup> Validated NP changes after concussion include difficulty with memory and new learning, attention deficits, and speed of information processing.<sup>7</sup> Many concussion assessment protocols now include elements of NP testing and return to play decisions are, in part, guided by comparative baseline/post-injury NP results.

## Diagnosis and classification systems

The lack of a single validated concussion grading system can be a source of confusion for the health-care practitioner. Currently, approximately 25 sports related concussion classification and grading scales exist.<sup>5</sup> Unfortunately, these gradings are not validated by hard scientific evidence, relying more on expert opinion and being influenced by the current medico-legal views regarding concussions.

Most of the popular grading systems use LOC, post-traumatic amnesia (PTA) and post-concussive symptoms as their measure of severity. Examples include Cantu and

Table 2

### Sideline physical examination

- Inspection for evidence of skull fracture, namely Battle's sign, raccoon eyes, obvious otorrhea or rhinorrhea
- Cranial nerve exam, especially pupillary reflex
- Strength testing of major extremity myotomes
- Gross extremity sensation testing
- Quick assessment of gait and co-ordination (i.e., rapid alternating hand movements, etc.).
- Rhomberg
- Any other areas of concern, such as knee, shoulder or neck

Table 3

### Maddock's questions

- Which ground (field) are we at?
- Which team are we playing today?
- Who is your opponent at present?
- Which quarter is it?
- How far into the quarter is it?
- Which side scored the last goal?
- Which team did we play last week?
- Did we win last week?

Evidence-Based Review of Sport-Related Concussion.<sup>7</sup>

the Colorado Medical Society. (See Chart 1). Depending on which scale is used, the same clinical presentation may be rated as a Grade II or a Grade III concussion.

There is no one classification that is superior or that has been validated. Therefore, the physician should become familiar with the classification principles, choose one he/she is comfortable with, and use it in a consistent manner.

## Initial concussion management

Initial concussion management should start with ATLS protocols, namely airway with c-spine precautions, breathing, circulation and disability.

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C-spine concerns mandate immobilization with a spine board, leaving the athlete's helmet on. If the athlete has no c-spine concerns and no other primary survey concerns, he/she may be moved to the sideline for further evaluation.

Sideline evaluation should start with a focused history, noting signs of amnesia and ascertaining the following from the athlete:

- Event recall;
- LOC or "blackout";
- Areas of pain, sensory changes or weakness;
- Any concussive symptoms (*e.g.*, headache, nausea, vertigo, *etc.*).

The next step is a neurological/head injury examination, attempting to rule out evidence of a catastrophic head injury or focal neurological deficit. The sideline physical exam should consist of the tests from Table 2.

Table 4

## Criteria for concussion imaging

- Concern regarding other head injuries, such as subdural or epidural hematomas
- Focal neurological defects or symptoms
- Persistent or worsening post-concussion symptoms
- LOC greater than five minutes
- Post-traumatic seizures
- C-spine injury



Table 5

## Steps to return to play post-concussion

### Steps

- No activity, complete rest. Once asymptomatic, proceed to the next level (see below).
- Continue to proceed to the next level if asymptomatic. If symptoms occur, drop back to a level where there are no symptoms, and try to progress again.

### Levels

1. Light exercise, such as walking or stationary cycling.
2. Sport specific activity (*e.g.*, skating in hockey).
3. "On field" practice with body contact, once cleared to do so by a medical doctor. The time required to progress from full non-contact exercise to contact will vary with the severity of the concussion.
4. Game play.

CASM Position Statement "Guidelines for the Assessment and Management of Sports-Related Concussion."<sup>1</sup>

The last part of the exam is to determine if there is evidence of any NP deficits. Neuropsychological testing is important in evaluating mild concussions, especially when no LOC or obvious amnesia is present. Sideline testing focuses on memory, orientation and speed of information processing. Maddocks (1995) has developed eight questions, which have been proven sensitive in discerning between concussed and non-concussed individuals (Table 3).<sup>7</sup> Incorrect responses, or difficulty producing answers, indicates a probable concussion.

Concentration and speed of information processing can be evaluated by serial-sevens (starting at 100 and counting backwards, in multiples of sevens, down to two) or naming the months of the year in reverse order. Our anecdotal observations demonstrate that most people can reach 50, with serial-sevens in 30 seconds, and can name the months backwards in less than 12 seconds. Other NP assessment tools include the Standardized Assessment of Concussion (SAC) which tests orientation, concentration, immediate memory and delayed recall. Though a valuable assessment tool, the five minutes

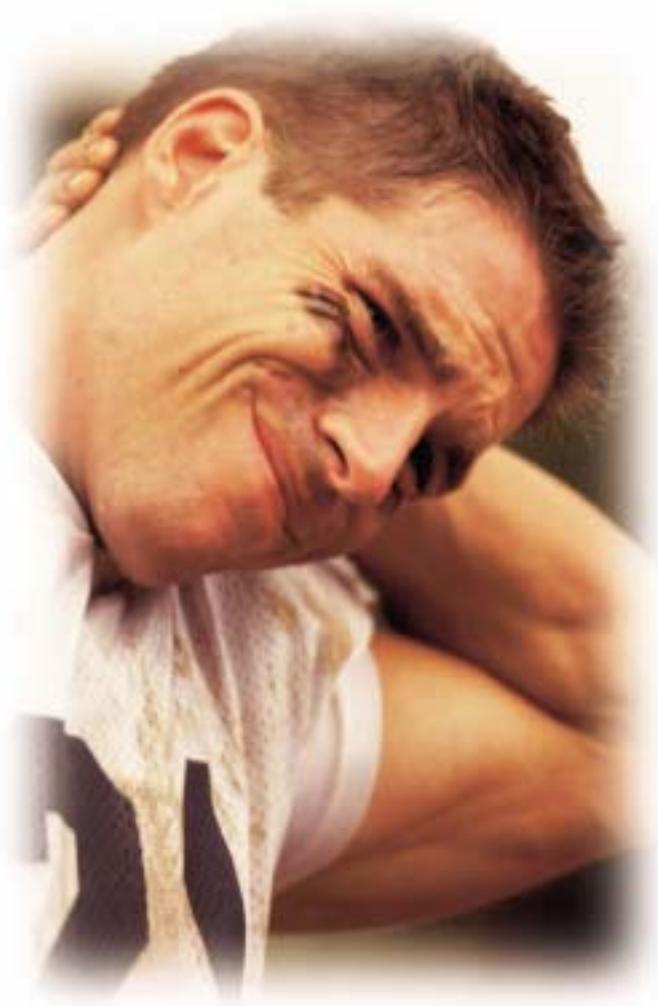
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needed to administer the test may prove cumbersome in some athletic situations, and, therefore, this instrument is more likely to be used in an emergency room or during an office visit assessment.

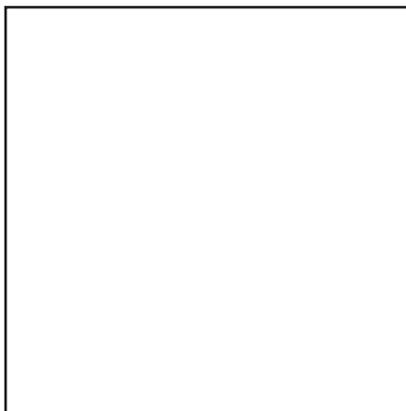
Once the initial assessment is complete, the athlete should be monitored for any deterioration in his or her condition. Either a member of the medical staff or a parent/guardian should observe the athlete, especially if return to play has been prohibited.

While the athlete is being observed on the sidelines, a practical piece of advice is to have a necessary piece of equipment, such as a helmet, to safeguard an ill-advised return to play. If there is evidence of a concussion with a skull fracture, persistent or worsening headache, nausea or vomiting, or lack of adult supervision following a concussion, hospital observation or admission is advised.



## Imaging

Routine imaging is not recommended for the diagnosis of concussion. Studies have shown no obvious pathology on plain film, computed tomography (CT) or magnetic resonance imaging (MRI) in the patient who was asymptomatic and neurologically intact following concussion. Imaging is generally done where more sinister conditions are suspected as per Table 4.



## Return to play

Perhaps the most difficult decision facing the physician once an athlete has suffered a concussion is whether to allow a return to athletic endeavours. As with concussion-severity scales, return to play (RTP) guidelines are numerous and they differ in their recommen-

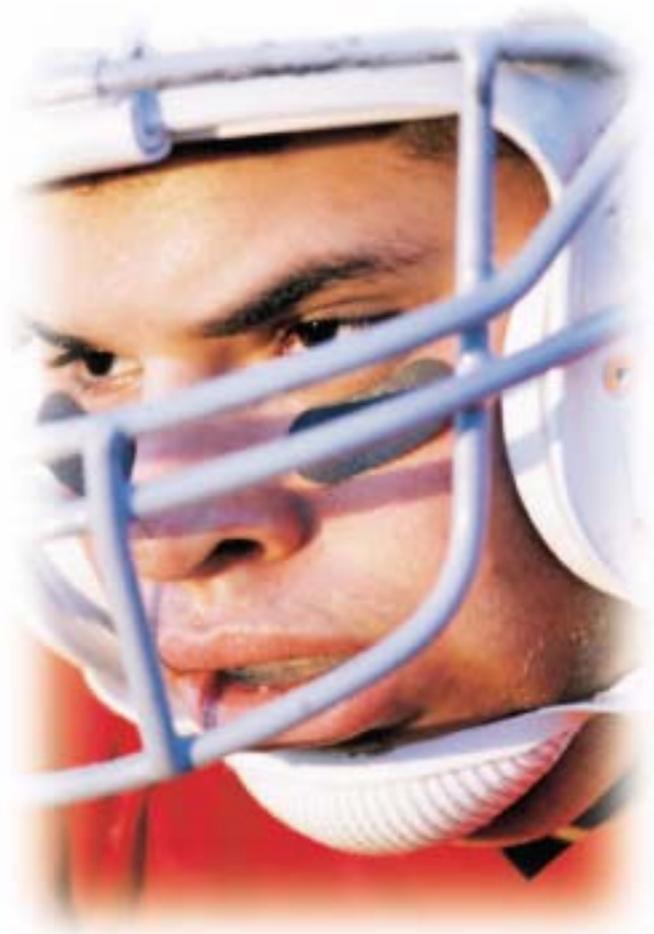
datations. They are based upon expert opinion and general consensus, and have not been scientifically validated.

One of the three most widely used RTP guidelines is listed in Chart 2. Return to play guidelines make recommendations based upon the severity of the concussion, and the number of concussions preceding the current one. Traditionally, most guidelines allow an athlete who has suffered a concussion without loss of consciousness or amnesia to return to play after fifteen to 30 minutes, provided there is a total resolution of signs and symptoms at rest and upon exertion.

Exertional testing usually consists of five push-ups, five sit-ups, five squats, and five wind-sprints or other sport-specific maneuvers in an attempt to provoke symptoms under conditions similar to full competitive situations.

In general, those suffering concussions with minimal amnesia or a LOC of less than five minutes have been treated by withholding participation for one week, starting from the first day without any post-concussive signs and symptoms. A second similar concussion has often led to restrictions from play anywhere from two weeks after the resolution of symptoms up to the termination of a season.

Concussions with prolonged amnesia or a LOC greater than five minutes have usually been managed with longer restrictions from play, and earlier consideration for season termination.



## Return to play algorithm

Once it has been agreed that a patient should temporarily refrain from athletic participation, use of a gradual return to play algorithm can be applied. An algorithm has been developed by the Canadian Association of Sports Medicine (CASM) (Table 5).

A slow reintroduction of increasingly strenuous activity is used to elicit possible post-concussive symptoms and allow the athlete and his/her physician to gauge progress. It

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Table 6

## Digital Symbol Substitution Test (DSST) administration

- The patient attempts to substitute a given symbol for assorted numerals as many times as possible over a 90-second period.
- The score (point total) is the total number of correct substitutions and is compared to a baseline total, which is the patient's score at the beginning of the season, when asymptomatic.
- Scores not compared to a baseline value should be interpreted with caution, if used at all.
- Ideally, the DSST should be administered at least five days post-concussion, to ensure that gross concentration and attention deficits are not present.
- A DSST score four to five points or lower than baseline, should alert the physician of continuing neuropsychological deficits and post-concussion symptoms.

also requires that every patient have a clinical follow-up before full medical clearance is granted.

## Digital symbol substitution test

Neuropsychological testing, in particular the Digital Symbol Substitution Test (DSST), is a useful method of assessing concussion resolution. It also supplies the physician with further objective information data on the patient; namely speed of information processing, which will assist in making a return-to-play decision.

The DSST (Figure 1) is a practical NP test for the medical practitioner, as it is quick to administer and does not need the interpretation of a neuropsychologist (Table 6). It helps assess the athlete's psychomotor speed

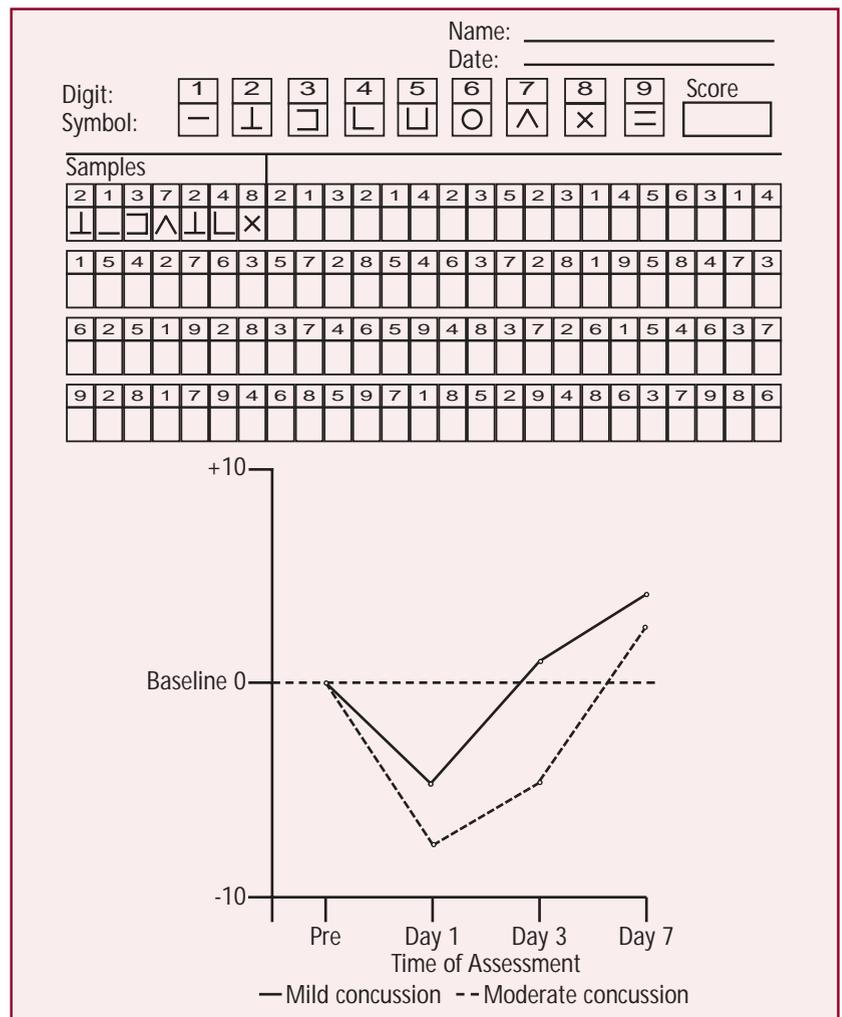


Figure 1. Digital symbol substitution test. Adapted from Maddocks D, Saling M: Neuropsychological deficits following concussion. *Brain Inj* 1996; 10(2):100.

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and visual short-term memory in addition to allowing the comparison with a pre-event normal scale, which is very helpful.

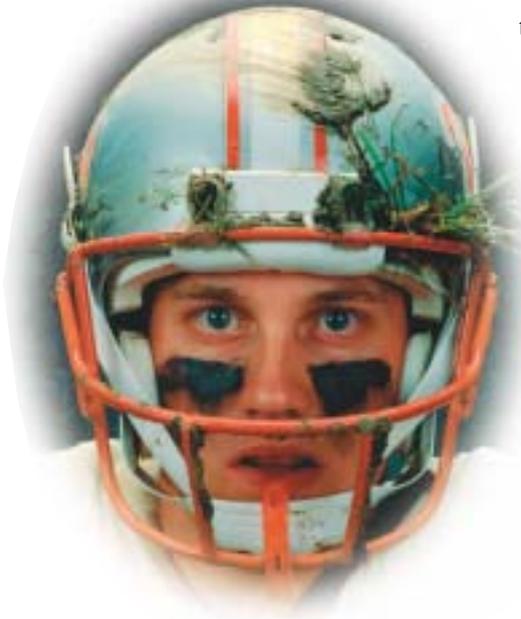
## Return to play risks

Theoretical risks involved with return to play following concussion include an increased risk for subsequent concussions, and cumulative effects such as chronic traumatic brain injury (CTBI) and second impact syndrome (SIS).

At present, the length of time the brain remains vulnerable following concussion is unknown.<sup>8</sup> The widely held notion that an athlete who has suffered a concussion is at a greater risk for future concussive injury has come under recent criticism. Alternative reasons for increased subsequent concussion risk may include the athlete's style of play, such as poor or illegal techniques.<sup>8</sup> It is believed that the risk for sustaining further injury is increased for an athlete who participates while symptomatic of a concussion in a collision or high-risk sport.

This is due to the fact that the athlete may not process information in a quick enough fashion to protect himself/herself in dangerous situations.

CTBI injury, also known as *dementia pugilistica*, is a syndrome representing the long-term damage of repetitive concussive blows to the head that has been primarily described in professional boxers. It has been theorized that such sports as hockey, football, and soccer may mimic the findings found in boxing. To date, no study has shown con-



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<b>CONCUSSION GRADING SCALE</b>		
	<i>Canto, 1986</i>	<i>Colorado, 1991</i>
<b>Grade 1</b>	No LOC PTA <30 minutes No amnesia	No LOC, Confusion
<b>Grade 2</b>	LOC <five minutes PTA >30 minutes Amnesia	No LOC, Confusion
<b>Grade 3</b>	LOC >five minutes PTA >24 hours	LOC

Chart 1

*Evidence-based review of sport-related concussion.*<sup>6</sup>

<b>COLORADO MEDICAL SOCIETY</b>			
	<i>First injury</i>	<i>Second injury</i>	<i>Third injury</i>
<b>Grade 1</b>	20-minutes of observation with re-evaluation every five minutes. If there is no amnesia, the athlete may return to play.	Out of play for 24 hours after symptoms resolve	Season terminated. No contact sports for three months
<b>Grade 2</b>	Out of play for one full week after symptoms resolve.	Out of play for one full month after symptoms resolve; consider terminating the season	Season terminated Season terminated
<b>Grade 3</b>	Out of play for one month with at least two weeks symptom free.	Season terminated	Season terminated

Chart 2

*Adapted from the Colorado Medical Society: The Sports Medicine Committee. Guidelines for the Management of Concussion in Sports (rev). Denver: Colorado Medical Society, 1991.*

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clusive evidence in finding the same cumulative effects in other contact sports.

SIS, a major concern in the area of concussions, occurs when an athlete (usually child or adolescent) receives a second head injury before the symptoms of the previous head injury have cleared, inciting cerebral vascular changes which lead to a sudden, rapid increase in intra-cranial pressure and subsequent brainstem herniation. A risk factor for this rare condition is believed to be repeat-concussions, though the scientific evidence is not compelling.<sup>9</sup>

What is agreed upon is that any single minor head trauma may rarely be followed by generalized cerebral swelling and its complications. Therefore, any athlete still symptomatic from a concussion is not advised to return to play because of an increased risk of sustaining any injury (*i.e.*, minor head injury, ankle sprain or concussion).

## What is really behind the guidelines?

The majority of the return-to-play guidelines are influenced by medical-legal concerns regarding concussions. Fear of increased concussion risk, cumulative effects of repeat injury and the SIS have prompted return-to-play recommendations to be conservative in nature. Most well designed studies indicate that athletes are safe to return to sports in a five to seven-day period, provided they are symptom free and have a normal neurological exam.<sup>10</sup>

Guidelines are simply such; guidelines. Therefore, the guidelines should not be used in isolation, nor should they override clinical judgment. Ideally, return-to-play decisions

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should encompass individual factors, including the athlete's goals and expectations, the hazards of the sport, past medical and concussive history, and physician experience. Always remember, however, that no athlete should ever return to competition while symptomatic.

## Prevention

Effort must be placed on reducing the incidence of concussions. Key prevention strategies include rule changes to reduce hitting from behind and spearing with the head, in addition to the use of proper equipment. Athlete, coach and parent-education regarding concussions should be instituted.

## Conclusion

Concussions are an important health-care concern in the athletic population. All practitioners must have a solid understanding of the diagnosis and all aspects of the return-to-play guidelines in order to make the best treatment decisions for their patients. 

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