New developments in the management of sports concussion

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Purpose of review
Appropriate concussion management requires knowledge of the pathophysiologic, neurobehavioral, and neurocognitive changes that may occur with the injury, and of the commonly observed on-field markers. The purpose of this review is to assimilate new information regarding concussion management from publications released November 1, 2002, through November 15, 2003.

Recent findings
Recent findings suggest that concussion management is moving away from umbrella-type guideline systems, toward more individualized injury assessment and management. On-field markers such as amnesia and headache are often important indicators of outcome. Even very mild concussions can produce neurobehavioral or neurocognitive deficits that should be taken seriously. Neuropsychologic testing is a key component in identifying deficits and determining whether an athlete has fully recovered. The one unifying agreement among clinicians is that no athlete should return to play unless he or she is asymptomatic at rest and exertion.

Summary
Overall, physicians faced with the task of concussion management and return-to-play decision making should assess each case individually, noting symptom presentation and duration. Physicians should also be aware of the evolving research regarding concussion, management. Now such data is changing standards for clinical practice.

Keywords
concussion, mild traumatic brain injury, sports, computerized neuropsychologic testing, recovery

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Abbreviations

LOC loss of consciousness
NCAA National Collegiate Athletic Association

1041–9918

Introduction

One of the most challenging and controversial topics within sports medicine is the issue of making return-to-participation decisions after concussion (*ie*, mild traumatic brain injury) in athletes. For decades, the management of sports concussion has been predicated on expert opinion in the form of concussion management guidelines rather than on data-based management directives. Most clinicians are aware of guidelines, such as those by Cantu [1] and the American Academy of Neurology [2], the Colorado Guidelines [3], and potentially the 15 other guidelines that have been published since 1973 (see Collins *et al.* [4] and Johnston *et al.* [5] for a review of these issues). These guidelines have undoubtedly provided valuable assistance to sports medicine physicians and have generally led to increased awareness and caution in managing concussion. To date, none of the guideline systems have been scientifically evaluated, and there is continued controversy regarding the usefulness of these guidelines in predicting safe return to play.

The timing of the current review is optimal, because a paradigm shift of sorts is emerging in terms of the understanding and management of concussion and return-to-play decisions. In short, guidelines are being replaced with more individualized assessment protocols, and empirical studies of the concussive injury are emerging that will provide a foundation for decisions regarding management of injury that are evidence-based.

The purpose of the current review is to provide an overview of the latest developments in the understanding and management of sports concussion. The review first summarizes current information regarding the pathophysiology of concussion and then addresses how to recognize on-field signs and symptoms of injury. An understanding of these issues is essential for acute care for the concussed athlete. Next, the article assimilates new information and research regarding the issue of sports concussion from the most recent publications limited to November 1, 2002, through November 15, 2003.

Pathophysiology of sports concussion

Recent research has begun to shed light on the subtle effects and pathophysiology of concussive injury. Hovda *et al.* [6] have described a metabolic dysfunction in a rodent model that occurs when cells immediately injured

Table 1. Common on-field signs and symptoms of concussion

Signs observed by medical staff	Symptoms reported by athlete
Appears dazed	Headache
Staring, vacant facial expression	Nausea or vomiting
Confusion and/or mistakes during plays	Balance problems or dizziness
Disorientation to game, score, opposing team	Double or blurred vision
Inappropriate/labile emotions	Sensitivity to light or noise
Incoordination or clumsiness	Feeling "foggy," "hazy," or "out of it"
Slow to answer questions	Changes in sleep patterns
Loss of consciousness	Impaired concentration or short-term memory
Changes in behavior or personality	Irritability, emotionality, sadness

through concussive insult are exposed to dramatic changes in intracellular and extracellular environments. These changes are the result of excitatory amino acid-induced ionic shifts with increased sodium and potassium activation and resultant hyperglycolysis [7]. Thus, there is increased energy demand within the brain after concussive injury. This process is accompanied by decreased cerebral blood flow that is not well understood, although it may be secondary to accumulation of endothelial calcium, which is thought to cause widespread cerebral neurovascular constriction. The resulting metabolic mismatch between energy demand and energy supply within the brain has been postulated to propagate a cellular vulnerability that is particularly susceptible to even minor changes in cerebral blood flow, increases in intracranial pressure, and apnea. Animal models have indicated that this dysfunction can last as long as 2 weeks or, theoretically, longer in the human model [6].

It has been postulated that the outlined metabolic dysfunction may be related to increased neurologic vulnerability in the event of any subsequent trauma. Metabolic dysfunction resulting from concussion is theoretically linked to the somewhat controversial second impact syndrome [8] and a less severe presentation known as postconcussion syndrome. Chronic deficits from postconcussion syndrome have been observed from a single concussive event. However, proper management of injury should most often lead to good prognosis without long-term deficits. Available information described above suggests that returning an athlete to play before he or she has completely recovered may significantly increase the risk of chronic effects of concussion or even increase the potential for catastrophic injury. Therefore, proper management of concussion is essentially the best form of prevention.

Because a concussive injury is metabolic rather than structural in nature, traditional neurodiagnostic techniques are not useful in detecting typical effects of concussion. Clinicians should be aware that CT scans, MRI scans, and electroencephalogram EEG, although invaluable in identifying more severe intracranial pathology (*eg*, skull fracture, intracerebral bleed, parenchymal lesion), are usually found unremarkable in cases of concussive injury. It is not uncommon for clinicians to deem an unremarkable scan indicative of a trivial or resolved concussive injury, although this assumption can clearly lead to concussion mismanagement.

On-field management of sports concussion

Table 1 provides a summary of common on-field signs and symptoms of concussion. Of paramount importance when considering on-field markers of concussion is that sideline presentation may vary widely from athlete to athlete depending on the biomechanical forces involved, the affected brain areas, the athlete's previous history of injury, and numerous other factors.

A concussed athlete may present with only one symptom of injury or a constellation of concussion-related difficulties. A thorough assessment of all common symptoms associated with concussion should be completed with the injured athlete. If the injured athlete displays or reports any signs or symptoms during the initial evaluation, this should preclude return to play and signal the necessity of a more comprehensive examination. All literature regarding concussion management recommends that symptomatic athletes (of any degree) be prohibited from return to play. Essentially, presence of any concussion symptom indicates impaired brain function, which certainly increases the risk for an athlete if subsequent injury occurs.

In addition to a careful symptom assessment, more formal mental status assessment helps determine the severity of injury or any presence of neurologic impairment. Table 2 outlines the University of Pittsburgh Concussion Card brief on-field mental status examination.

Before assessing mental status, the clinician should establish the presence of any loss of consciousness (LOC). By definition, LOC represents a state of brief coma in which the eyes are typically closed and the athlete is unresponsive to external stimuli. LOC is relatively rare and occurs in less than 10% of concussive injuries. Moreover, prolonged LOC (>1–2 minutes) in sports-related

Table 2. University of Pittsburgh Medical Center On-field Mental Status Screen

Orientation
What city is this?
What stadium is this?
What is the date of today (month/day/year)?
Who is the opposing team?
What is the score?
Anterograde amnesia
Repeat these words and try to remember them: girl, dog, green.
Concentration
Repeat the days of the week backward, starting with today.
Repeat these numbers backward: 63 (36); 419 (914).
Word list memory
Repeat the three words from earlier.

concussion is much less frequent [9••], and athletes with LOC are typically unresponsive for only a brief period. Obviously, any athlete with documented LOC should be managed conservatively, and return to play is contraindicated.

A more common mental status change after concussion involves confusion and amnesia. Confusion (*ie*, disorientation), by definition, represents impaired awareness and orientation to surroundings, although memory systems are not directly affected. A confused athlete is usually described as appearing stunned, dazed, or glassy-eyed on the sideline. Confusion is often initially detected when athletes have difficulty calling plays, answer questions slowly or inappropriately, are repetitive in conversation and evaluation, or have a combination of these symptoms. Often, teammates are the first to recognize that an athlete has been injured when he or she exhibits disorientation and difficulty in maintaining the flow of the game. Direct evaluation by the physician or athletic trainer may reveal extended response latencies. Confusion can be assessed using simple orientation questions (*eg*, name, current stadium, city, opposing team, current month and day).

A careful evaluation of amnesia is of paramount importance in the concussed athlete. Amnesia may be associated with loss of memory for events before or after injury. Specifically, posttraumatic amnesia or anterograde amnesia (synonymous terms) is typically represented by the length of time between trauma (*eg*, helmet-to-helmet contact) and the point at which the person regains normal continuous memory functioning (*eg*, standing on the sideline after the hit). As outlined in Table 1, on-field anterograde amnesia may be assessed through immediate and delayed (*eg*, 0, 5, 15 minutes) memory for three words (*eg*, girl, dog, green) and through interview questions concerning the course of the game after the concussive blow.

It should be noted that confusion and anterograde amnesia are not mutually exclusive and may be difficult to discriminate. To help clarify this issue, anterograde amnesia represents a loss in memory from the point of injury until the return of a full, ongoing memory process. Confusion in and of itself is not associated with memory loss. These two markers of injury may be properly assessed once the athlete's confusion and other mental status changes have resolved. At that point, the athlete should be asked to recall the specific events that occurred immediately after the trauma (*eg*, memory of returning to sideline, memory for subsequent plays, memory of later parts of contest, and so forth). Any failure to recall these events properly is indicative of anterograde amnesia. Any presence of amnesia, even in seconds, has been found to be highly predictive of postinjury neurocognitive and symptom deficit (see literature review).

Retrograde amnesia, although provided less coverage in the literature, is also an important injury severity marker of concussion. Retrograde amnesia is defined as the inability to recall events occurring during the period immediately preceding trauma. To properly assess on-field retrograde amnesia, the athlete may be interviewed to determine his or her memory of preconcussive events. As covered in Table 2, the athlete should be asked to recall details of the injury. From there, asking the athlete to recall the score of the game before the hit, events occurring in the plays preceding the injury, and events occurring in the first quarter or earlier is a practical assessment strategy. It should be noted that the length of retrograde amnesia will typically shrink over time. For example, as recovery occurs, the length of retrograde amnesia may contract from hours to several minutes or even seconds, although, by definition, a permanent loss of memory preceding injury occurs. Once again, even seconds of retrograde amnesia may be considered pathognomonic and predictive of outcome.

Recovery and return to play after concussion

In general, the outlined review regarding pathophysiology of concussion and on-field management of injury is well accepted and essentially the standard of practice. More controversial, however, is understanding of recovery from injury and decision making regarding return to play after concussion. As mentioned, the controversy involves opinion regarding the use of a guideline approach for managing concussion and what appears to be a paradigm shift resulting in a more data-driven and individualized approach to managing injury.

As a historical review, in 1997, the American Orthopaedic Society for Sports Medicine sponsored a workshop with the purpose of re-evaluating concussion guidelines and establishing practical alternatives [10]. This workshop started a trend away from the use of numeric grading systems for determination of return to play (*eg*, Cantu [1], American Academy of Neurology [2], Colorado [3]) and a call for ongoing research designed to clarify issues regarding severity of injury and return-to-play parameters. This group was the first to promote the use of neurocognitive testing in the clinical care of the athlete as a means of providing individualized data for management issues. Yet another important development took place in 2001 under the auspices of the Federation Internationale de Football Association in conjunction with the International Olympic Committee and the International Ice Hockey Federation. The organizers of this meeting assembled a group of physicians, neuropsychologists, and sports administrators in Vienna, Austria, to continue to explore methods of reducing morbidity secondary to sports-related concussion. The deliberations that took place during this meeting led to the publication of a document outlining recommendations for both the diagnosis and the management of concussion in sports [11••]. One of the most important conclusions of this meeting was that none of the previously published concussion management guidelines were adequate to assure proper management of every concussion. Although a complete discussion of these recommendations is beyond the scope of this chapter, the group emphasized the implementation of postinjury neurocognitive testing as the cornerstone of proper postinjury management and return-to-play decision making.

Moving forward: data-driven clinical practice for concussion management

Although a review of neurocognitive testing is beyond the scope of this article, clinical implementation of this approach to managing concussion is currently mandated within the National Hockey League [12], is used by approximately 29 of 31 teams in the National Football League [13], is practiced by hundreds of college programs, and is even used by hundreds of high school programs across the country. Since the advent of computerized neurocognitive testing [14], this approach to managing injury has been widely accepted for clinical use. Such programs are used to supplant a guideline approach to injury for a data-driven and individualized program that quantifies injury severity and tracks recovery to guide return-to-play decisions more safely. In addition to being a viable clinical protocol for managing concussion, neurocognitive testing serves as a sensitive dependent variable for researching germane areas of inquiry in understanding sports concussion.

Many studies demonstrating the utility of neuropsychologic testing in concussion management have been published in the past year. In addition, several other recently published studies provide new findings regarding the concussive injury and its management. The following literature review offers a summary of recent findings grouped into meaningful subunits.

Literature review: November 2002 to November 2003

Epidemiology of concussion

An Internet survey of division 1-A collegiate football players was undertaken to determine the incidence of concussion in the 2001 football season [15]. Over the course of the season, 373 concussions were reported, with almost 69% occurring during games and 31% occurring during practices. Injury rates were computed as 5.56 concussive experiences per 1000 athletic exposures during games and 0.25 concussions per 1000 athletic exposures during practices.

Another study involving National Collegiate Athletic Association (NCAA) football players reported an overall concussion injury rate of .81 per 1000 athletic exposures, which included contact practices and games [16•]. This group also found that 6.5% of concussed players sustained a repeat concussive injury within the same season, with most repeat concussions occurring within 10 days of the initial injury.

A Temple University study used 3 years of data from the NCAA Injury Surveillance System to determine the epidemiology of concussion [17]. Concussions accounted for 6.2% of reported sports-related injuries. Overall, female athletes were found to be at lower risk of suffering concussion during practice and at high risk of suffering concussions during games when compared with male athletes. Regarding risk of concussion during a game by sport, women's lacrosse reported the highest risk (11.4%), followed by women's soccer, men's ice hockey, men's lacrosse, football, women's basketball, field hockey, men's soccer, wrestling, men's basketball, baseball, and women's volleyball. The study also found the rate of concussion to increase over the 3-year study period in football, men's soccer, and men's and women's basketball.

Another survey of athletes, this time including athletes involved in sports participation at a university over a 5-year period, revealed that more than 30% of participants endorsed experiencing an insult to the head that caused dizziness. Almost 20% of athletes had received a formal diagnosis of concussion. Approximately 8% reported loss of consciousness. This same study reported occurrence of symptoms traditionally resulting from concussion. Of all surveyed athletes, 29% endorsed visual changes; 26% endorsed headache; 18% endorsed nausea, vomiting, or tinnitus; 8% reported confusion; and almost 5% reported cognitive difficulties, all resulting from a direct blow to the head [18].

Athletes' acknowledgment of concussion

After a suspected or certain concussive blow, the injured athlete should be removed from the practice or game to receive an appropriate evaluation and a professional opinion concerning return to play. However, because of athlete negligence, lack of knowledge, or lack of awareness regarding the concussive injury, this may not necessarily occur. In a recent survey of college athletes, 28% acknowledged experiencing dizziness as a result of a hit, yet continuing to play; 19% acknowledged failing to report dizziness to coaches or athletic trainers while playing; 30% stated that they continued to play with a headache induced by a blow to the head; and 3% failed to report next-day dizziness, headaches, or nausea [18].

Recent data on the biomechanics of concussion

In a study of National Football League players, Pellman *et al.* [19•] used videotapes of documented concussions to reconstruct game impacts and evaluate the biomechanics of concussion. Results revealed that evaluated concussions occurred at extremely high velocities (9.3 m/s), significant acceleration (98 g), and lengthy durations (15 ms). In addition, a concussive blow created a rapid change in head velocity (7.2 m/s) for the concussed athlete, which was much greater than velocity changes in the striking player or in uninjured struck players. The concussion injury was found to be related primarily to translational acceleration that occurred via insult to the facemask or side of the helmet, or from a strike of the back of the helmet to the ground.

Factors affecting recovery from concussion

Age differences

A study examining age differences in recovery from sports-related concussion revealed that recovery as measured by neuropsychologic performance occurred more slowly in high school versus college athletes [20•]. Baseline and postconcussion neurocognitive functioning was measured in a sample of 54 concussed athletes. Although the college sample had a greater previous incidence of concussion, high school athletes were found to take longer to recover from concussion. Specifically, concussed high school athletes demonstrated significant memory impairment at least 7 days after injury when compared with matched controls, whereas college athletes demonstrated impairment for only 24 hours after injury when compared with matched controls. This study suggests protracted recovery from concussion in younger (high school) athletes and calls for greater awareness that younger athletes may not bounce back as quickly as their older counterparts.

A recent examination of recovery in concussed NCAA football players revealed that recovery in the sample tended to take as long as 7 days to resolve [21]. Specifically, symptom complaints and cognitive impairment resolved by day 7 for almost all participants, and balance difficulties tended to resolve by day 5.

Sequelae of “bell-ringers” or mild concussion

Another recently published study [22••] reveals apparent heightened vulnerability to concussion in the high school athlete. Specifically, the issue of “bell-ringers” or very mild concussions was examined in high school athletes age 13 to 17 years. This study revealed that high school athletes with fewer than 15 minutes of on-field symptoms required at least 7 days before full neurocognitive recovery and at least 4 days before becoming asymptomatic. Closer examination of this mildly concussed group indicated that those with postinjury anterograde amnesia, retrograde amnesia, or disorientation lasting longer than 5 minutes did not fully recover by day 7. Those with less than 5 minutes of these on-field symptoms had typically returned to baseline by day 4. Overall, findings from this particular study suggest that computerized neuropsychologic test data provide unique information to the sports medicine practitioner, allowing more accurate follow-up of concussion recovery and more informed return-to-play decisions.

A follow-up study also examined neurobehavioral and neurocognitive deficits resulting from mild or “ding” concussions in high school athletes, although within a more acute time frame [23•]. Consistent with findings in the previously described study, results revealed significant declines in memory functioning and significant increases in symptom reporting at 36 hours postinjury. Taken together, these two studies examining the effects of mild concussion call into question the validity of the grading systems for management of mild concussion. These findings are suggestive that all high school athletes diagnosed with concussion be removed from play during that contest.

On-field predictors of outcome

Collins *et al.* [9••] also recently investigated the relation between on-field markers of concussion severity and postinjury immediate post-concussion assessment and cognitive functioning neurocognitive performance and symptom presentation in a group of 78 concussed high school and college athletes. Data from this study revealed that the presence of amnesia, not brief loss of consciousness, was most predictive of postinjury difficulties at 3 days postinjury. For example, athletes demonstrating poor presentation (notable cognitive deficits and high degree of symptoms) were more than 10 times more likely to have exhibited any degree of retrograde amnesia after concussion when compared with athletes with good postinjury presentation (no cognitive deficits and no reported symptoms at 3 days postinjury). Similarly, athletes with poor presentation were more than four times more likely to have exhibited any degree of anterograde amnesia. Interestingly, loss of consciousness was not predictive of deficits after sports-related concussion.

Similarly, a second outcome study using a computerized test battery [24] found that athletes reporting memory problems at follow-up examinations had significantly higher numbers of symptoms, increased duration of symptoms, and significant declines on neuropsychologic testing. In addition, athletes endorsing loss of consciousness, dizziness, nausea, or headache at sideline evaluation tended to endorse a higher number of overall symptoms. Data from these two studies directly contradict most existing grading systems of concussion, which delineate severity of injury and length of time until return to play on the LOC construct. The outlined data suggest that amnesia, and in particular retrograde amnesia, may be much more predictive in this regard.

Headache

Headache is the most commonly reported symptom of concussion and may be seen in as many as 70% of concussed athletes [25•]. A survey of college athletes at one university in a 5-year period revealed that 26% of respondents (with and without concussive history) reported experiencing at least one headache the week after a blow to the head, and 30% of respondents played through a headache [18]. Although it is true that musculoskeletal headaches and other pre-existing headache syndromes may complicate the clinical picture, any presentation of headache after a blow to the head or body should be managed conservatively.

In an investigation of the significance of endorsed symptoms in concussion recovery, the University of Pittsburgh Medical Center research group discovered a relation between headache presentation and neurocognitive impairment on ImPACT in concussed high school athletes [25•]. Any endorsement of headache at 1 week after concussive injury was associated with continued adverse neurocognitive and neurobehavioral events. Specifically, concussed athletes with headache (when compared with concussed athletes without headache) endorsed significantly more postconcussion symptoms. Concussed athletes with headaches at day 7 also demonstrated significant attenuation in reaction time and memory performance. In addition, headache was associated with more severe concussion, because athletes with headaches at day 7 were four times more likely to evidence three to four on-field markers of injury and were five times more likely to demonstrate sideline-assessed mental status changes with a duration of greater than 5 minutes. The presence of anterograde amnesia was also associated with the presence of headaches at day 7. Clearly, headache, even when endorsed at mild levels, is a concussion symptom that should be taken seriously and monitored closely.

Cumulative concussions in high school athletes

Based on the likelihood of protracted recovery time in high school students and research on older populations demonstrating the risks associated with multiple concussions, the authors' group examined the sequelae of multiple concussions in high school athletes [26]. Results indicated that high school athletes with a history of three previous concussions were more than nine times more likely than athletes without history of previous concussion to exhibit three or four on-field markers of injury (*eg*, loss of consciousness, amnesia, confusion) with a subsequent concussion. This study demonstrates that sustaining multiple concussions does place high school athletes at greater risk for worse neurobehavioral outcomes. A smaller study [24] did not find that history of concussion was predictive of the number of on-field symptoms with subsequent concussion.

Guskiewicz *et al.* [16•] examined repeated concussion in collegiate football players and found an association between self-reported history of previous concussion and subsequent concussion. In addition, players with a history of at least three concussions were three times more likely than those without previous concussion history to sustain an additional injury. Having a history of one or two previous concussions also elevated concussion risk. History of multiple concussions was associated with a protracted course of recovery. Loss of consciousness and amnesia were not associated with concussion history, although both were associated with prolonged recovery periods.

Symptom status

Recent research in the high school and college populations indicates that neuropsychologic testing can provide unique information to the sports medicine practitioner and assist in making return-to-play decisions safer for the recovered athlete. Specifically, studies have demonstrated that athletes typically report symptom resolution several days before their cognitive functions return to baseline [22••]. Additionally, new research using the ImPACT computerized test battery demonstrates that athletes who are asymptomatic after a concussive injury have impairments in visual memory, verbal memory, processing speed, and reaction time that tend to be less severe than those of symptomatic concussed athletes, but significantly more impaired than unconcussed controls [26a].

Balance problems

A postural stability study revealed that concussed athletes showed significant decrements in measures of composite balance and the vestibular ratio from a sensory organization test [27]. McCrea *et al.* [21] found balance scores to be significantly lower in concussed subjects when compared with controls as well.

Conclusion

Over the past 12 months, several empirical studies of the concussive injury and concussive management have been released. The tone of these articles generally reflects a paradigm shift in concussion management from a guideline approach to data-driven management at the individual level. Every concussion is a unique event and should be handled as such. Perhaps the greatest breakthrough in mild traumatic brain injury research is a realization among researchers and clinicians that there is no single formula that can handle an injury so complex and multifaceted. From current research, many important considerations that should have a direct impact on clinical practice and thinking emerge:

- Concussion is a frequently occurring injury among athletes. In the United States, between 50,000 and 300,000 athletes sustain a concussion each season.
- Even mild "ding" or "bell-ringer" concussions can have significant and longer-lasting cognitive and symptomatic impairment than previously thought.

This calls for more conservative management of mild concussion (especially in younger athletes) and demonstrates the shortcomings of mild concussion guidelines.

- Multiple studies suggest that concussion may have cumulative effects, especially if the athlete returns to play before complete recovery. There is no definite number of previous concussions that should undoubtedly lead to permanent removal from play. Rather, individualized assessment and decision making via the use of neurocognitive testing and symptom assessment appear to be the best standard of care. Such an evaluation should be conducted by a professional well trained in the area of concussion assessment.
- A heightened vulnerability to concussion appears to exist in younger athletes. Recent data suggest a need for more conservative management of younger athletes.
- The on-field marker of amnesia appears to be a more important marker than brief LOC in terms of outcome prediction. Confusion and amnesia are the hallmarks of the concussive injury in terms of outcome prediction. An athlete without LOC may still have sustained a significant concussion, may still need to be removed from play, and may still have a protracted recovery period.
- Headache is a common symptom of concussion that has been linked with protracted recovery in athletes.
- Good concussion management involves not allowing the athlete to return to play until he or she has returned to baseline cognitive functioning and is symptom-free both at rest and during exertion. In addition, it is important to be aware that symptoms may resolve before concussion-related cognitive deficits resolve.
- Neuropsychologic testing offers unique information about cognitive recovery and is a useful tool in making sound return-to-play decisions.
- Computerized neuropsychologic testing is a time-efficient, cost-efficient, valid, sensitive, and data-rich method of providing baseline assessments and post-concussion evaluations.
- The practice of concussion management is moving from a grading or guideline system toward individualized management, based on evidence of varied symptom presentations and recovery courses.

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