

Evaluation and Management of Concussion in Athletes: Recommendations from the AAN

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Concussion is a clinical syndrome of biomechanically induced altered brain function that typically affects memory and orientation, and may involve loss of consciousness. An estimated 1.6 to 3.8 million sports-related concussions occur each year in the United States. The American Academy of Neurology (AAN) studied the incidence of concussion in high school and college athletes to address the following clinical questions:

- Which factors increase or decrease the risk of concussion in athletes?
- Which diagnostic tools are useful in identifying athletes with a concussion, and for identifying those at risk of severe or prolonged early impairment, catastrophic neurologic outcomes, or chronic neurobehavioral impairment after a concussion?
- Which clinical factors are useful in identifying athletes who are at risk of severe or prolonged early impairment, catastrophic neurologic outcomes, or chronic neurobehavioral impairment after a concussion?
- Which interventions enhance recovery and diminish long-term sequelae after a concussion, and reduce the risk of recurrent concussion?

Risk Factors

Because of the greater number of male athletes in the sports studied by the AAN, the total number of concussions is greater in males for all sports combined. However, the

relationship of concussion risk and sex varies among sports. Concussion risk is greater for females who play soccer or basketball. Concussion risk is also greater for football and rugby players, and lower for gymnasts and baseball, softball, and volleyball players. Body checking likely increases the risk of concussion in ice hockey players. Athletes with a body mass index greater than 27 kg per m² and those who train less than three hours per week are also at greater risk.

Headgear use likely has a protective effect in rugby, but it is unclear whether it affects concussion risk in soccer. There is no compelling evidence that mouth guards protect athletes from concussion, and there is insufficient evidence to determine whether one type of football helmet is superior to others in preventing concussions.

Among college football players, the risk of concussion is greater for linebackers, offensive linemen, and defensive backs, and lower for receivers. Data were insufficient for the AAN to determine concussion risk by position for any other sport. The AAN also could not determine whether age or level of competition affects the risk of concussion.

Diagnostic Tools

Table 1 compares tools commonly used to diagnose concussion. The reference standard by which the tests were compared was a concussion diagnosed by a physician or certified athletic trainer. A combination of these tests likely improves diagnostic accuracy, but there is not enough evidence to determine the best combination of specific tests. None of the tools are intended to rule out concussion or replace a thorough medical, neurologic, or neuropsychological evaluation.

Postconcussive Problems

In addition to confirming concussions, the tools listed in *Table 1* can be used to identify athletes with concussion-related early impairments, chronic neurobehavioral impairments, or catastrophic outcomes such as subdural hematoma. Elevated postconcussive symptoms, lower neuropsychological test scores, and deficits on the Balance Error Scoring System are associated with more severe or prolonged early impairments. Gait stability dual-task testing may help identify athletes with early postconcussive impairments.

Practice Guidelines

Risk factors for severe or prolonged early postconcussive impairments (e.g., persistent neurocognitive impairments, prolonged return to play) include ongoing clinical symptoms; a history of concussion or headaches; early posttraumatic headache; fatigue or fogging; early amnesia, altered mental status, or disorientation; dizziness; playing the quarterback position in football; and wearing a half-face shield in hockey. Younger age and level of play may also be risk factors for prolonged recovery. In football, playing on artificial turf may be a risk factor for more severe concussions.

Risk factors for recurrent concussions include a history of concussion, longer duration of sports participation, and playing the quarterback position in football. The risk may be highest in the 10 days after the initial concussion.

A history of concussion is a likely risk factor for chronic neurobehavioral impairment in a range of professional sports, and there seems to be a relationship with increasing exposure in football, soccer, boxing, and horse racing. There is insufficient evidence to determine whether a relationship exists between chronic cognitive impairment and heading in professional soccer, and whether a history of concussion is associated with chronic cognitive impairment in amateur athletes.

There is insufficient evidence to identify specific risk factors for catastrophic neurologic outcomes after a concussion. Because of a lack of good-quality studies, the AAN could not determine the effect of postconcussive activity level on recovery, or the likelihood of developing long-term complications.

Recommendations

Athletes, their families, and coaches should be counseled about risk factors for concussion by a licensed health

care professional (LHCP) experienced in the diagnosis and management of sports concussions. Inexperienced LHCPs should be instructed in the administration of standardized validated sideline assessment tools, emphasizing that these tools are only a supplement to the evaluation of the athlete and should not be used alone to diagnose concussion.

SCREENING AND DIAGNOSIS

Athletes with a suspected concussion should be removed from play immediately, and should not be allowed to return until they have been assessed by an LHCP with training in the diagnosis and management of concussions and in the recognition of more severe traumatic brain injury.

Diagnostic tools should be used by sideline LHCPs, and the results should be made available to other health care professionals who evaluate the athlete in the clinical setting. Physicians caring for athletes may use individual baseline scores on concussion assessment tools, especially in younger athletes, those with previous concussions, and those with preexisting learning disabilities or attention-deficit/hyperactivity disorder.

Computed tomography should not be used to diagnose concussions, but may be necessary to rule out serious traumatic brain injury, such as intracranial hemorrhage, in athletes with suspected concussions who have loss of consciousness, posttraumatic amnesia, persistently altered mental status, focal neurologic deficit, evidence of skull fracture, or signs of clinical deterioration.

COGNITIVE RESTRUCTURING

Cognitive restructuring is a form of brief psychological counseling that consists of education, reassurance,

Table 1. Diagnostic Tools Used to Evaluate for Concussion

<i>Test</i>	<i>Description</i>	<i>Sensitivity (%)</i>	<i>Specificity (%)</i>
Balance Error Scoring System	Balance test; can be completed in five minutes	34 to 64	91
Neuropsychological testing	Paper- or computer-based tests that measure memory, reaction time, and cognition; generally require a neuropsychologist for accurate interpretation	71 to 88	—
Post-Concussion Symptom Scale or Graded Symptom Checklist	Symptom checklists; can be self-reported or administered by trained personnel, psychologists, nurses, or physicians	64 to 89	91 to 100
Sensory Organization Test	Uses a force plate to measure the athlete's ability to maintain equilibrium while it alters orientation information available to the somatosensory and/or visual inputs	48 to 61	85 to 90
Standardized Assessment of Concussion	Administered on sidelines by nonphysicians in the early stages after an injury; can be completed in six minutes	80 to 94	76 to 91

and reattribution of symptoms. Although no studies have examined the use of cognitive restructuring specifically in sports concussions, several studies that used this intervention in persons with mild traumatic brain injury demonstrated decreased rates of postconcussion syndrome. Therefore, physicians may consider cognitive restructuring for athletes with concussion to shorten the duration of subjective symptoms and reduce the risk of postconcussion syndrome.

RETURN TO PLAY

To reduce the risk of recurrent injury, athletes with concussions should be prohibited from returning to play or practice until they are asymptomatic without medication and an LHCP has determined that the concussion is resolved. Supplemental information, such as results from neurocognitive testing, may be used to assist in determining concussion resolution. Return-to-play decisions for athletes who are high school-aged or younger should be made more conservatively than those for older athletes. Individualized graded plans may be used

for return to physical and cognitive activity; these plans should be developed using a monitored, clinically based approach to minimize exacerbation of early postconcussive impairments.

RETIREMENT FROM PLAY

Referral for neurologic and neuropsychological assessment may be considered for professional athletes with a history of multiple concussions and subjective persistent neurobehavioral impairments. Formal neurologic/cognitive assessment can help guide retirement decisions for amateur athletes with similar histories and symptoms. These athletes should be counseled about risk factors for permanent neurobehavioral or cognitive impairments. To minimize the risk and severity of chronic neurobehavioral impairments, physicians who treat professional contact sport athletes should recommend retirement from the sport for athletes who have objective evidence of chronic or persistent neurologic or cognitive deficits.

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