



American  
Association of  
Neurological  
Surgeons

# CONCUSSION

## PATIENT INFORMATION

This resource, developed by neurosurgeons, provides patients and their families trustworthy information on neurosurgical conditions and treatments.

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A concussion is an injury to the brain that results in temporary loss of normal brain function. It usually is caused by a blow to the head. In many cases, there are no external signs of head trauma. Many people assume that concussions involve a loss of consciousness, but that is not true. In many cases, a person with a concussion never loses consciousness.

The formal medical definition of concussion is a clinical syndrome characterized by immediate and transient alteration in brain function, including alteration of mental status and level of consciousness, resulting from mechanical force or trauma.

People with concussions often cannot remember what happened immediately before or after the injury and may act confused. A concussion can affect memory, judgment, reflexes, speech, balance and muscle coordination. Paramedics and athletic trainers who suspect a person has suffered a concussion may ask the injured person if they know their name, what month/year it is and where they are.

Even mild concussions should not be taken lightly. Neurosurgeons and other brain-injury experts emphasize that although some concussions are less serious than others, there is no such thing as a "minor concussion." In most cases, a single concussion should not cause permanent damage. A second concussion soon after the first one does not have to be very strong for its effects to be permanently disabling or deadly.

## Prevalence and Incidence

According to the **University of Pittsburgh's Brain Trauma Research Center**, more than 300,000 sports-related concussions occur annually in the U.S., and the likelihood of suffering a concussion while playing a contact sport is estimated to be as high as 19 percent per year of play. More than 62,000 concussions are sustained each year in high school contact sports and, among college football players, 34 percent have had one concussion and 20 percent have endured multiple concussions. Estimates show that between four and 20 percent of college and high school football players will sustain a brain injury over the course of one season. The risk of concussion in football is three to six times higher in players who have had a previous concussion.

A study conducted by McGill University in Montreal found that 60 percent of college soccer players reported symptoms of a concussion at least once during the season. The study also revealed that concussion rates in soccer players were comparable to those in football. According to this study, athletes who suffered a concussion were four to six times more likely to suffer a second concussion. Research such as this has led to greater interest in developing protective headgear for soccer participants but it is not clear that such headgear would actually reduce the risk of concussion.

During the 2014 World Cup, head injuries sustained by the participating soccer players reignited the debate over concussion management after one of Germany's players took a major hit to the head and continued to play, only to be helped away from the field shortly after. Major League Soccer created a concussion committee in 2010 and instituted a mandatory baseline neuropsychological testing for players. Now, players must be removed from a game immediately if they show signs of a head injury. If a series of cognitive tests are failed, the player must see a team specialist before returning to play and must be symptom free for 24 hours before being allowed to play. However, many worry that the rules are not as strictly enforced as they should be. Dr. Riley Williams, the team physician for the New York Red Bulls, noted, "There's always a differential between what policy says and what the actual application of the policy is on the field." FIFA, the international league that governs the World Cup, leaves decisions up to the team.

## Symptoms

Like concussions, mild injuries to the brain may not be observable in routine neurological examinations. Diagnostic tests typically will not show any changes. Therefore, diagnosis is based on the nature of the incident and the presence of specific symptoms, confusion being a primary one.

The three principal features of confusion are:

- Inability to maintain a coherent stream of thought
- A disturbance of awareness with heightened distractibility
- Inability to carry out a sequence of goal-directed movements

The following are concussion symptoms:

- Prolonged headache
- Vision disturbances
- Dizziness
- Nausea or vomiting
- Impaired balance
- Confusion
- Memory loss
- Ringing ears
- Difficulty concentrating
- Sensitivity to light
- Loss of smell or taste

If any of these occur after a blow to the head, a health-care professional should be consulted as soon as possible.

## Concussions and Head Injuries

The skull protects the brain against penetrating trauma, but does not absorb all the impact of a violent force. The brain is cushioned inside the skull by the surrounding cerebrospinal fluid. Despite this, an abrupt blow to the head, or even a rapid deceleration, can cause the brain to contact the inner side of the skull. There is a potential for tearing of blood vessels, pulling of nerve fibers and bruising of the brain substance.

Sometimes the blow can result in microscopic damage to the brain cells without obvious structural damage visible on a CT scan. In severe cases, the brain tissue can begin to swell. Since the brain cannot escape the rigid confines of the skull, severe swelling can compress the brain and its blood vessels, limiting the flow of blood. Without adequate blood flow, the brain does not receive the necessary flow of oxygen and glucose. A stroke can occur. Brain swelling after a concussion has the potential to amplify the severity of the injury.

A blow to the head can cause a more serious initial injury to the brain. A contusion is a bruise of the brain tissue involving bleeding and swelling in the brain. A skull fracture occurs when the bone of the skull breaks. A skull fracture by itself may not necessarily be a serious injury. Sometimes, however, the broken skull bones cause bleeding or other damage by cutting into the brain or its coverings.

A hematoma is a blood clot that collects in or around the brain. If active bleeding persists, hematomas can rapidly enlarge. Like brain swelling, the increasing pressure within the rigid confines of the skull (due to an enlarging blood clot) can cause serious neurological problems, and can even be life-threatening. Some hematomas are surgical emergencies. Hematomas that are small can sometimes go undetected initially, but may cause symptoms and require treatment several days or weeks later.

The warning signs of a serious brain injury are the following:

- Pain: Constant or recurring headache
- Motor dysfunction: Inability to control or coordinate motor functions or disturbance to balance
- Sensory: Changes in ability to hear, taste or see; dizziness; hypersensitivity to light or sound
- Cognitive: Shortened attention span; easily distracted; overstimulated by environment; difficulty staying focused on a task, following directions or understanding information; feeling of disorientation, confusion and other neuropsychological deficiencies.
- Speech: Difficulty finding the "right" word; difficulty expressing words or thoughts; **dysarthric** speech.

Seek immediate medical attention if any of these warning signs occur.

## Managing Concussions: The NFL's Protocol

Because each player and each concussion is unique, there is no set time-frame for recovery and return to participation under the **NFL's current guidelines**. The decision to return a player who has a concussion back to practice and games resides with the team physician designated to manage the concussion protocols and is confirmed by an Independent Neurological Consultant (INC), who is consulted specifically for the player's neurological health.

After a player is diagnosed with a concussion, the protocol calls for a minimum of daily monitoring. The player's past concussion exposure, medical history and family history are considered, creating a more complete picture of his health. The protocol progresses through a series of steps, moving to the next step only when all activities in the current step are tolerated without recurrence of symptoms. Communication between the player and the medical staff during the protocol is essential.

The first step is rest. During this time, in addition to avoiding physical exertion, the player is to avoid electronics, social media and even team meetings until he returns to his baseline level of signs and symptoms. The next step introduces light aerobic exercise, which takes place under the direct oversight of the team's medical staff. If aerobics are tolerated, the team physician will reintroduce strength training. The fourth step includes some non-contact football-specific activities, and the fifth step, which is clearance to resume full football activity, comes only after neurocognitive testing remains at baseline and there are no recurrence of signs of symptoms of a concussion.

When the team physician gives the player final clearance, the player has a final examination by the INC assigned to his team. As part of this examination, the INC will review all reports and tests documented through player's recovery. Once the INC confirms the conclusion of the team physician, the player is considered cleared and is eligible for full participation in the next game or practice.

This protocol allows for players to heal at their own individual rates, includes the expertise of both the team physicians and a neurological consultant and specifically includes an assessment of not only the most recent concussion but also takes into account the medical history of the player.

## NCAA Concussion Update

The National Collegiate Athletic Association (NCAA) **2011-2012 Sports Medicine Handbook** includes a section called "Concussion or Mild Traumatic Brain Injury (mTBI) in the Athlete," which notes, "In the years 2004 to 2009, the rate of concussion during games per 1,000 athlete exposures for football was 3.1; for men's lacrosse, 2.6; for men's ice hockey, 2.4; for women's ice hockey, 2.2; for women's soccer 2.2, for wrestling, 1.4; for men's soccer, 1.4; for women's lacrosse, 1.2; for field hockey, 1.2; for women's basketball, 1.2; and for

men's basketball, 0.6, accounting for between four and 16.2 percent of the injuries for these sports, as reported by the **NCAA Injury Surveillance Program** by the Datalys Center." The NCAA defines concussion or mild traumatic brain injury as "a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces."

The handbook also states, "NCAA member institutions must have a concussion management plan for their student-athletes on file with specific components as described in Bylaw 3.2.4.16 (see Guideline 2i)."

The NCAA plan

- Requires student-athletes receive information about the signs and symptoms of concussions. They also are required to sign a waiver that says they are responsible for reporting injuries to the medical staff.
- Mandates institutions to provide a process for removing a student-athlete that exhibits signs of a concussion. Student-athletes exhibiting signs of concussions must be evaluated by a medical staff member with experience in the evaluation and management of concussions before they can return to play.
- Prohibits a student-athlete with concussion symptoms from returning to play on the day of the activity.
- Requires student-athletes diagnosed with a concussion be cleared by a physician or a physician's designee before they are permitted to return.

The signs of a concussion, according to the **NCAA**, are as follows:

- Amnesia
- Confusion
- Headache
- Loss of consciousness
- Balance problems
- Double or fuzzy vision
- Sensitivity to light or noise
- Nausea
- Feeling sluggish
- Concentration or memory problems
- Slowed reaction time
- Feeling unusually irritable

The NCAA handbook includes much more information on concussions starting on page 55. The NCAA also recommends viewing the **National Athletic Trainers' Association's Heads Up video**, which takes a closer look at the types of head injuries incurred and how they happen.

## Treatment

The standard treatment for concussion is rest. For headaches, acetaminophen (Tylenol) can be taken. Postconcussive headaches often are resistant to stronger narcotic-based medications.

## Post-concussive Syndrome

People who suffer a head injury may suffer from side effects that persist for weeks or months. This is known as **post-concussive syndrome**. Symptoms include memory and concentration problems, mood swings, personality changes, headache, fatigue, dizziness, insomnia and excessive drowsiness. Patients with post-concussive syndrome should avoid activities that put them at risk for a repeated concussion. Athletes should not return to play while experiencing these symptoms. Athletes who suffer repeated concussions should consider ending participation in the sport.

## Second-impact Syndrome

Second-impact syndrome results from acute, often fatal brain swelling that occurs when a second concussion is sustained before complete recovery from a previous concussion. This is thought to cause vascular congestion and increased intracranial pressure, which can occur very rapidly and may be difficult or impossible to control. The risk of second-impact syndrome is higher in sports such as boxing, football, ice or roller hockey, soccer, baseball, basketball and snow skiing.

The CDC reports an average of 1.5 deaths per year from sports concussions. In most cases, a concussion, usually undiagnosed, had occurred prior to the final one.

## Head Injury Prevention Tips

Buy and use helmets or protective head gear approved by the **American Society for Testing and Materials (ASTM)** for specific sports 100 percent of the time. The ASTM has vigorous standards for testing helmets for many sports; helmets approved by the ASTM bear a sticker stating this. Helmets and head gear come in many sizes and styles for many sports, and must properly fit to provide maximum protection against head injuries. In addition to other safety apparel or gear, helmets or head gear should be worn at all times for:

- Baseball and softball (when batting)
- Cycling
- Football
- Hockey
- Horseback riding
- Powered recreational vehicles
- Skateboards/scooters
- Skiing
- Wrestling

Head gear is recommended by many sports safety experts for:

- Martial arts
- Pole vaulting
- Soccer

### Sports Tips

- Supervise younger children at all times, and do not let them use sporting equipment or play sports unsuitable for their age.
- Do not dive in water less than nine feet deep or in above-ground pools.
- Follow all rules at water parks and swimming pools.
- Wear appropriate clothing for the sport.
- Do not wear any clothing that can interfere with vision.
- Do not participate in sports when ill or very tired.
- Obey all traffic signals, and be aware of drivers when cycling or skateboarding.
- Avoid uneven or unpaved surfaces when cycling or skateboarding.
- Perform regular safety checks of sports fields, playgrounds and equipment.
- Discard and replace sporting equipment or protective gear that is damaged.

### General Tips

- Wear a seat belt every time, whether driving or riding in a motor vehicle.
- Never drive while under the influence of drugs or alcohol, or ride as a passenger with anybody else who is under the influence.
- Keep unloaded firearms in a locked cabinet or safe, and store ammunition in a separate, secure location.
- Remove hazards in the home that may contribute to falls. Secure rugs and loose electrical cords, put away toys, use safety gates and install window guards. Install grab bars and handrails if frail or elderly.

## Additional Notes

Sports-related neurosurgical injuries were the focus of the **November 2011** issue of the *Journal of Neurosurgery*. It included the results of a study of 451 patients about the **mechanisms and consequences of head injuries** that references an anonymous survey that found that more than 46 percent of university soccer players experienced a concussion in just one fall season, and almost two-thirds of the same group experienced a concussion over the 12-month period while playing soccer. Another article described a new **smartphone app** designed for on the field concussion testing.

## Help Fund Current and Future Research

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