Management of Sport-Related Concussion in the Pediatric and Adolescent Population

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abstract

Concussions make up nearly 10% of all high school athletic injuries. Recent changes in concussion management guidelines and legislation aim to make concussion care more standardized and safe but simultaneously pose a challenge for the primary care and sports medicine physician. Pediatric and adolescent concussions may cause anxiety for the treating physician due to concerns over return-to-play decisions, academic issues, and the potential for second impact syndrome. Determining when to refer a patient to an emergency department acutely, to an outpatient concussion clinic, or to other subspecialists may be a difficult decision for the primary care physician. The aim of this article is to review current evidence regarding concussion treatment and return-to-school and return-to-play recommendations to provide the primary care and sports medicine physician with practical guidelines for managing concussions. [Orthopedics. 2016; 39(1):24-30.]

The high school sports associated with the greatest risk of concussion include football for males and basketball and soccer for females. Among high school football players, 1 in 5 players will suffer a concussion each academic year. Other high-risk sports include rugby, ice hockey, and lacrosse. For reasons currently not fully understood, within a given sport, females incur a higher rate of concussions than males.

The 2012 Zurich Consensus Statement defines a concussion as “...a complex pathophysiological process affecting the brain, induced by biomechanical factors” resulting from either direct force to the head or a blow to the body causing transmission of force to the head. Whereas loss of consciousness was once thought to be a predictor of severity of concussion, severity is currently determined by the nature of the head injury, burden on the athlete, and duration of the clinical postconcussive symptoms. In fact, the majority of concussions do not involve loss of consciousness or observable neurological signs. The cardinal features of concussion presentation include confusion and amnesia. Other postconcussive symptoms may include sleep disturbances, headache, loss of consciousness, disorientation, increased emotionality, irritability, slowed reaction time, difficulty with concentration or memory, fatigue, blurred or double vision, sleep disturbances, dizziness, poor balance, and sensitivity to light or noise. However, there is great variability between concussed individuals in terms of both their initial presentation and their postconcussive symptoms.

There has been a significant increase in attention from the medical community, as well as the general public, regarding concussions in sports. Classification and treatment of sport-related concussion have changed significantly over the past 10 to 15 years. In the 1980s and 1990s, categorical scales were commonly used.
to classify concussions using 12 or more different grading methods. In 2002, the Consensus Statement on Concussion in Sport did not support the use of any grading scales. Prior to 2002, it was not uncommon to allow an adolescent athlete to return to the same game or practice if his or her symptoms resolved within 15 minutes from the time of injury. State legislation mandating up-to-date management and education surrounding concussion did not exist prior to 2009. Research and development of initial management guidelines for youth sport-related concussion have received noteworthy attention. It is now highly recommended that health care providers do not allow an adolescent or pediatric athlete to return to play on the same day of injury. The majority of young athletes will have complete resolution of their symptoms within 7 to 10 days from the time of injury and should return to play only after they have completed a progressive physical and cognitive return-to-play protocol.

**Recognition and Management**

If a concussion is suspected, the athlete should immediately be removed from play for evaluation by a medical professional such as an athletic trainer or physician. Often players self-report injuries, but coaches play an integral role in recognizing on-field incidents or signs or symptoms that may indicate the need for a player to undergo concussion evaluation. A clinician should consider the diagnosis of concussion in a patient who demonstrates one or more of the following symptoms and signs: (1) mental status change (such as amnesia or confusion); (2) physical or somatic (such as blurry vision, headache, or fatigue); and (3) behavioral (such as irritability or personality changes). The initial examination by the primary care physician, neurologist, or sports medicine physician should include a detailed concussion history and comprehensive neurological examination focusing on core neurologic function, mental status, cognitive performance, gait, and balance. When a self-reported symptom checklist, postural control testing, and neurocognitive assessment are administered in totality during initial evaluation, sensitivity of concussion diagnosis ranges from 89% to 96%. A thorough concussion history should determine whether there was prolonged loss of consciousness, other associated signs (vomiting, seizures), prior history of concussion or other head injury, confounding factors (history of migraines or other headache disorders, learning disorders, psychiatric diagnosis [eg, depression or anxiety], sleep disturbances), and whether the patient has attempted to return to school/work or sports. Postconcussion-like symptoms are often prevalent in nonconcussed individuals, such as headache, fatigue, or lack of focus, and the physician must carefully discriminate acute from typical baseline symptoms during the evaluation. It is important to establish whether there has been improvement or deterioration in symptoms and clinical status since the time of injury; hence, it is appropriate to follow the patient with serial visits on a regular basis.

The Sport Concussion Assessment Tool 3 (SCAT3) proves a useful instrument to guide clinicians in the evaluation of concussion. The SCAT3 includes a postconcussion symptom scale and 3 tests evaluating cognitive abilities. Currently, more research is needed to identify the implications of the final point score because these remain unclear due to lack of normative data. However, if used serially, the SCAT3 can help track overall improvement vs decline in symptoms, signs, cognitive and neurologic function, and balance. The Child SCAT3 is nearly identical to the SCAT3 but was developed for children aged 5 to 12 years and includes a more child-specific symptom scale and evaluation tools. The Child SCAT3 can be accessed at [http://bjsm.bmj.com.sls-eproxy.ucdenver.edu/content/47/5/263](http://bjsm.bmj.com.sls-eproxy.ucdenver.edu/content/47/5/263) and the SCAT3 can be accessed at [http://bjsm.bmj.com.sls-eproxy.ucdenver.edu/content/47/5/250](http://bjsm.bmj.com.sls-eproxy.ucdenver.edu/content/47/5/250). A Concussion Recognition Tool was also introduced in the latest guidelines on Concussion in Sport for coach and parent use on the sideline whenever a Certified Athletic Trainer or other health care professional is not present.

It is the responsibility of the primary care or sports medicine physician to coordinate care with specialists and also provide guidance and recommendations for athletic trainers and home care of the injured patient. During the first 24 to 48 hours after a concussion has been sustained, it is important for the parent or present medical staff to recognize any red-flag symptoms that indicate a worsening condition, including, but not limited to, increased severity of headaches, nausea and vomiting, numbness or tingling in an extremity/extremities, mental confusion, and slurred speech. If a red flag is identified or suspected, immediate medical attention is necessary. Any individual diagnosed with a concussion should not be left alone for the first 48 hours and should not be permitted to operate motorized vehicles. Concussed patients should avoid alcohol consumption, sleep aids, and narcotic pain medications in the first 48 hours after injury to better monitor and evaluate their postconcussive symptoms. Patients with concussion require both physical and cognitive rest, including limitations on their exposure to television, computers, internet, video games, cellular phone use, loud music, and/or movies. Exposure to such activities may need to be limited to decrease exacerbation of symptoms. Minimizing symptom provocation will help the athlete return to cognitive and social activities of daily living.

To date, the exact degree and duration of rest needed by a concussed patient has not been established with evidence-based research. Preliminary data suggest that an initial brief period of relative rest (the first 1 to 2 days postinjury) is prudent and may be of benefit, but prolonged bed rest or absence from school or social activities may be detrimental to healing. Resting until...
symptom free is no longer the consensus recommendation because prolonged rest may predispose an individual to fatigue, depression, and deconditioning. Rather, concussed patients should gradually return to school and social activities over the first few days to weeks after a concussion in a way that does not considerably aggravate symptoms. School-aged children and employed adults may need academic or workplace accommodations, but this can usually be discontinued after the first 1 to 2 weeks. For patients with prolonged postconcussion symptoms, establishing a daily light aerobic exercise plan may serve to reduce symptoms and speed the time to recovery. Athletes should participate only in noncontact aerobic activity up to, but not past, their symptom threshold. The most favorable time frame to initiate such light activity while symptomatic has yet to be established.

**Return-to-School Planning**

Although cognitive activity that requires concentration, such as schoolwork, is not dangerous for the concussed patient, school attendance, homework, and academic testing may exacerbate or prolong concussion symptoms. Medical providers will need to document in writing any academic accommodations prescribed and may benefit from maintaining open communication and coordinating treatment with the patient’s teachers and school administrators. The goal is to limit cognitive activity to a level that is tolerable for the student and that does not worsen or result in the reemergence of concussion symptoms. Tolerance for cognitive activity increases as the student recovers, but the rate of recovery may vary from one student to another.

Similar to the concussion return-to-play protocol, concussed students will need a gradual, progressive return-to-school plan. Flexibility and additional supports for learning are needed during recovery. Students may benefit from trying self-paced homework at home first, prior to attempting school-paced schoolwork. They may need quieter working environments, decreased workloads, frequent rest breaks, or more time to complete tasks or assignments. Tests may need to be postponed for the first 1 to 2 weeks. Instructions or new concepts may need to be repeated, and extra patience and support from teachers may be necessary. It is generally recommended that students recovering from a concussion sit in the front of the classroom where they can be closely monitored and assisted by the teacher. Specific academic accommodations should be guided by the patient’s symptoms. For example, a child with light sensitivity may need to reduce reading or computer usage and dim computer screens, whereas a patient with noise sensitivity may need to eat lunch in a quiet classroom or be excused from band or orchestra practice. Students with prolonged postconcussive symptoms that affect learning may be candidates for specialized educational plans through their schools. It is important to note that the Zurich 2012 consensus statement recommends that students do not attempt return-to-play activity until they have successfully completed their full return to school.

**When to Refer for Specialized Care**

Evaluating clinicians are often faced with difficult decisions during the assessment and treatment of concussion. The authors have developed a SAFE (Symptoms, Assessment, Follow-up, Execute return-to-play) clinical decision-making flowchart to assist providers, in conjunction with athletic trainers, in making these challenging determinations (Figure). The clinician must first determine whether there is a need for emergency department referral for an emergent computed tomography (CT) scan. Due to concern over ionizing radiation from CT scans, particularly in children, and limitations to the types of injuries that the scan can detect, many emergency departments are limiting their use of CT scans. Evidence-based indications for CT scan include suspicion of skull or neck fractures, intracranial hemorrhage, brain contusion, mass effect, and cerebral or cerebellar herniation related to head trauma. In the first 48 hours after a head injury, an emergent CT scan may also be indicated if any of the following are evident in the concussed patient: seizures, any focal neurological deficits, loss of consciousness greater than 5 seconds, severe headache (patient rating 9 to 10 out of 10), slurred speech, significant drowsiness, or active vomiting (1 or more times).

Referral to a concussion clinic or specialist should be considered when the postconcussive symptoms have lasted more than 10 days. In some circumstances, patients who have sustained multiple concussions within a short time frame, have identified comorbidities, or have more concerning symptoms of a moderate traumatic brain injury may be referred directly to a specialist, such as a neuropsychologist, rehabilitation physician, or neurologist, to discern any confounding pathologies. Magnetic resonance imaging (MRI) of the brain should also be considered in these cases to evaluate for any underlying malformations, intracranial cysts, or other structural anomalies that may be responsible for the delay in recovery of the athlete that may not be visualized on CT scan. Magnetic resonance imaging and CT have historically been part of clinical care if there is concern for intracranial injury. Furthermore, as described by Johnston et al., further research is needed to gain normative values for neuroimaging, and the practicing clinician must understand the options, limitations, and capabilities of each available system. Certain structural anomalies may also put the athlete at increased risk when returning to contact sports, such as symptomatic Chiari malformations or history of intracranial hematoma evacuation. In these situations, referral to a neurosurgeon for decisions on return to specific sports may be necessary.
Return-to-Play Guidelines and Recommendations

Return-to-play guidelines pertain to any physically demanding activity pursued by the athlete postinjury, including organized team sports, recreational fitness, physical education classes, and recess periods in the school setting. Current evidence suggests that the concussed patient is at greatest risk for another concussion within the first 10 days after initial injury. In 2004, a concussion return to play protocol was published as part of the Prague Consensus Statement. This consensus statement has since been updated, most recently by the 4th International Conference on Concussion in Sport held in 2012. The return-to-play protocol is as follows: (1) no activity with symptom-limited physical and cognitive rest; (2) light aerobic exercise; (3) sport-specific exercise; (4) noncontact sport-specific training drills; (5) full-contact practice after medical clearance; and (6) return to competitive play.

Concussed patients must be symptom free, without the use of pain medications such as narcotics, ibuprofen, naproxen, or acetaminophen, prior to initiating the return-to-play protocol. Each of the steps requires a minimum of 24 hours to complete. The athlete may continue to the next level if asymptomatic at the current level, both during the activity and for 24 hours at rest after the activity. If uncomplicated, the return-to-play protocol requires approximately 1 week to complete. If any symptoms occur, the athlete must drop back to the previous step and only continue after he or she is symptom free for a 24-hour period at rest.

It is important to recognize that current return-to-play guidelines are based on a consensus statement, and thus the exact number of days before individuals can return to sport has yet to be established. In addition, there is early evidence that, after a brief period of complete rest, introducing light cardiovascular activity while still symptomatic may improve symptoms and speed recovery. There is a lack of evidence defining the number of concussions an individual can sustain before he or she must retire from contact sports. The primary care provider should consider referral to a concussion specialist if the patient has suffered from repeated concussions because these decisions are made on an individual basis.

Importance of Following Return-to-Play Guidelines

The updated 2012 Zurich guidelines strictly state that no player, at any level, should return to play on the same day as the concussive injury. Due to the possibility for delayed onset of symptoms, certain diagnostic characteristics or cognitive deficits may not present during the acute sideline evaluation. A one-size-fits-all strategy does not exist for concussion management, and pediatric concussions should be treated more conservatively than adult concussions.

Young athletes...
should never be allowed to return to a practice or game on the same day as a suspected concussion injury and should follow more cautious return to play.\textsuperscript{20,21} Current data demonstrate different physiological responses and longer recovery with head injuries in the youth population.\textsuperscript{20,22} Second impact syndrome, a rare, catastrophic event currently only reported in individuals younger than 24 years,\textsuperscript{23} may arise when a second concussion occurs while the athlete is still symptomatic and healing from a prior concussion. Rapid swelling around the brain may occur, causing seizure, coma, severe neurological damage, or death.\textsuperscript{2}

**Computerized Testing**

Several computerized neuropsychological batteries have appeared in the literature and in practice, including the Automated Neuropsychological Assessment Metrics (ASAM), HeadMinder Concussion Resolution Index, Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), and CogSport.\textsuperscript{24} Computerized testing has many functions in concussion management and diagnosis, including baseline assessment, monitoring postinjury cognitive deficits, and tracking symptom exacerbation. It has been shown that cognitive recovery may not coincide with symptom resolution; sometimes cognitive recovery precedes—but more often follows—symptom recovery.\textsuperscript{3} In some cases, neuropsychological testing can help providers discern whether a patient has truly returned to preinjury cognitive levels. Computerized assessment offers a number of advantages, including easy data storage, improved accuracy in measuring reaction time, and rapid integration of data into report format for professional interpretation.\textsuperscript{24} Although the administration of these tests may be uncomplicated and available for use by athletic trainers or physicians, the interpretation of the results should be managed by a licensed clinical neuropsychologist.\textsuperscript{4,25} Hence, computerized neuropsychological testing remains a controversial topic in concussion assessment and management by athletic trainers and sports medicine and primary care physicians.\textsuperscript{26}

Return to neurocognitive baseline after concussive injury is often prolonged in adolescents compared with adults\textsuperscript{27} and further complicated by the brain maturation that occurs in adolescents in the time between baseline and injury. This continues to develop cognitive function can affect the use of these assessment tools and make it difficult to define “normal” test results in this age group.\textsuperscript{28} Multiple studies recommend updating an athlete’s baseline assessment annually to help account for normal cognitive gains, but this suggested procedure is also confounded by the practice effect: significant improvement is often seen between the first and second administrations of the same test.\textsuperscript{3,29-32} This can potentially inflate baseline values or mimic neurocognitive recovery. Test environment and learning disorders can also affect an athlete’s baseline scores.\textsuperscript{30}

A good history and clinical examination should not be replaced by computerized baseline and serial neuropsychological testing. Likewise, results of neuropsychological testing should never be used as the only tool for return-to-play decision making.\textsuperscript{3} Each case should be considered on an individual basis. The 2012 Zurich guidelines note the lack of definitive evidence to uniformly recommend baseline neuropsychological testing but acknowledge the possible advantage of using computerized neuropsychological assessment.\textsuperscript{3} At this time, baseline testing is not seen as a mandatory aspect of concussion prevention or management.\textsuperscript{3} Neuropsychological testing may be helpful in situations of severe concussion, prolonged postconcussive symptoms, multiple concussions, or questions of athlete truthfulness.

**Concussion Legislation**

In recognition of the potential long-term deleterious effects of concussions on the development of the adolescent, concussion legislation has become an important issue. The first concussion law to become effective was Washington State’s Zackery Lystedt Law in 2009. Most concussion sports laws include 3 action steps: (1) concussion education for coaches, parents, and athletes; (2) remove athletes from play after a suspected concussive injury; and (3) obtain medical permission to return to play.\textsuperscript{33} These actions are based on recommendations presented in the International Concussion Consensus Statement.\textsuperscript{4}

Since 2009, all 50 states and the District of Columbia have passed similar laws to address the treatment of and return-to-play protocols for traumatic brain injuries.\textsuperscript{34} These laws are varied and include multiple components, such as instructions for removal from play, collection of concussion and general medical histories, and specification of required training for involved personnel. There is also a wide spectrum of training requirements and regulatory agencies designated by various state concussion laws.\textsuperscript{33} Although legislation has been passed, it is reportedly difficult to monitor the effect that these laws have at the state level due to the additional resources needed for implementation, monitoring, and evaluation of the statewide program.\textsuperscript{33} While the legislative action is an important step, further barriers include difficulty for patients to access appropriate health care and ensuring medical health professionals are educated in the best practices in concussion management.\textsuperscript{35} Providers who work with concussed athletes, including medical practitioners, athletic trainers, coaches, neuropsychologists, and school teachers and administrators, should become familiar with the specific legislative requirements of their state.\textsuperscript{34}

**Conclusion**

Although sport-related concussion remains a challenging diagnosis to manage for athletic trainers and primary care and sports medicine providers in the outpatient setting...
setting, current research, state legislation, and consensus guidelines may assist practitioners in providing more consistent and safer care for their injured patients. Primary care physicians or sports medicine providers should be systematic in their approach to concussion management. The SAFE protocol (Figure) is provided as an outline for such treatment. Referral to an emergency department should be considered when any signs of more severe head injury are present. Emergent treatment should also be considered if the patient has worsening symptoms in the first 5 days. Referral to a concussion specialist should be considered if post-concussion symptoms are present for more than 10 days. Every athlete, regardless of age, must be removed from play if a concussion is suspected, and they must fully recover clinically and cognitively before consideration for return to play. The return-to-play protocol should be implemented with strict attention paid to any setbacks or reoccurrence of symptoms. Concussion patients may require special accommodations at school or work, and a symptom-guided approach is recommended. Neuropsychological examination and computerized testing should be interpreted by a neuropsychologist with training in both the administration and evaluation of the test.

REFERENCES


