SPORTS-RELATED CONCUSSIONS OF HIGH SCHOOL ATHLETES

By

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To the people who made this paper and degree possible:

First, to my loving husband who has supplied me with endless forehead kisses as I poured over my books, articles, and laptop. Thank you for believing in me and helping me focus on the next step toward something you know is so important to me. To my parents, who were incessant cheerleaders, always reminding me to enjoy this journey of education and reminding me to appreciate all of the blessings in my life. Thank you for the balance you provide to my often-chaotic life. And, finally, to my committee members, who have given me the gift of time and effort. Thank you for your guidance in helping me satisfy my degree by writing a paper on a subject that has both professional and personal importance to me.
A concussion is a mild traumatic brain injury that often occurs to high school athletes who participate in contact sports. It involves injury to the brain tissue of an individual caused by impact. It is estimated that 62,000 high school athletes sustain these injuries every year in the United States and numbers are on the rise. The symptoms of a concussion in a high school athlete vary greatly and can be vague, making recognition difficult. In addition, there are a number of published guidelines for how and when a concussed high school athlete should return to play. This article provides the advanced practice nurse review of concussion diagnostics, a review of current guidelines, as well as implication for practice. Nurse practitioners are in a position to be advocates for their patients by coordinating with parents, coaches, neurologists, and patients to ensure high school athletes receive the most appropriate care.
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Sports-Related Concussions in High School Athletes

Over the last three decades, more than twenty concussion management guidelines have been published with the intent of providing guidance and direction for coaches, athletic trainers, and for medical providers to make complex diagnostic, management, and return to play decisions. These guidelines are especially important for the high school athlete because trainers, parents, providers, and the athletes themselves are usually less experienced in recognition and treatment of concussions, there is less information regarding the management of injured adolescents, and the negative sequelae of a concussion can be significant. Although the many existing guidelines have helped raise awareness and improved the care of injured athletes, multiple directives have also created considerable confusion and have sparked much discussion.

Scope and Significance

The American Academy of Pediatrics recommends that parents contact their child’s health care provider for advice for anything more than a light bump on the head. Depending on circumstances, this may be done over the phone, in the office, or in the ER. With an estimated 62,000 high school athletes sustaining concussions every year in the United States, many nurse practitioners and other providers will be asked to recommend the safest and best care. Conflicting recommendations will likely cause each provider to assess the high school athlete differently with different strategies for management of the injury as well as when the athlete may return to play without restrictions. This translates to a broad dichotomy in safety and playtime of each athlete who sustains a concussion, even within the same community.

According to the Center for Disease Control and Prevention, approximately 1.4 million incidents of traumatic brain injury are reported every year in the US. For those head injuries
that are severe, care is straightforward and goes through a hospital Emergency Department when possible. Yet, over one million of these head injuries are considered mild and roughly 300,000 are related to sports.\textsuperscript{2,5} The assessment and management of these injuries often occurs in an outpatient setting and can be complex to manage because of a lack of consensus regarding when a high school athlete may return to play without risk of increased brain injury.\textsuperscript{5} These patients require careful diagnosis, assessment, and very specific guidelines on when they can safely return to play.

Concussions among high school athletes can occur in any sport where physical contact and speed are factors. Hockey, lacrosse, soccer, and American football have the highest incidences of concussion, with American football leading with 63 percent of the total concussions.\textsuperscript{2} In football alone, it is estimated that 20 percent of all high school football players in the US sustain brain injuries each season.\textsuperscript{2,6} Many go unreported, as players are often reluctant to testify to symptoms that will pull them out of a game or practice.\textsuperscript{7} And, because symptoms are mostly subjective, a player can often sustain a concussion without a coach or parent even noticing.\textsuperscript{7}

Not only are concussions one of the most prevalent injuries sustained by high school athletes in the United States, the numbers of head injuries are on the rise. During the last 16 years of reporting from the NCAA, rates of concussion have increased by 7 percent annually on average.\textsuperscript{8} This may be due to the fact that more concussions are happening secondary to faster, bigger athletes, and a false sense of security from improved equipment, such as better helmets and pads.\textsuperscript{8} This increase in reported concussions could also be due to providers and coaches being more aware and better at recognizing and diagnosing head injuries. Still, it may be that there are just more concussions, specifically mild ones, that are counted as head injuries. Most
likely, the truth involves a combination of these factors. Regardless of the reason, providers will increasingly be faced with the treatment of these athletes.\textsuperscript{8,12}

Pathophysiology

What is a concussion? On a cellular level, a concussion is understood to consist of mild degrees of axonal damage and is the disruption of these brain cells that impairs nerve impulses. This damage causes swelling, degeneration, and even transection of important axons, or nerve cells in the brain.\textsuperscript{9} Excitatory neurotransmitters—acetylcholine, glutamate, and aspartate—are released and free radicals are generated by injured nerve cells in the brain.\textsuperscript{10} All of these contribute to secondary injury of brain tissue, which can include bleeding, increased swelling, and ischemia. When severe enough, these occurrences can be fatal.\textsuperscript{11}

The term concussion can be used interchangeably with the term mild traumatic brain injury (mTBI), which is defined as “a complex pathophysiologic process affecting the brain, induced by traumatic biochemical forces, secondary to direct or indirect forces to the head.”\textsuperscript{12} Traumatic brain injuries are rated in terms of severity, from mild—i.e. a “concussion”—to severe. A traumatic brain injury may be caused by a direct blow to the head or to the body of an individual and results in diffuse structural and/or physiological changes in brain function.\textsuperscript{13} Symptoms can include headache, confusion, amnesia, dizziness, irritability, loss of consciousness, or vomiting.\textsuperscript{14} However, symptoms can be vague, or mild, and present minutes to hours after injury, which can make detection quite difficult.\textsuperscript{15}

Diagnostic Evaluation

Previous thought was that a concussion occurred when an individual lost consciousness.\textsuperscript{13} However, today it is understood that a loss of consciousness is the exception rather than the rule. In fact, most mild traumatic brain injuries occur without the loss of consciousness. Now, it is
accepted that the “hallmark” of a mild traumatic brain injury is amnesia, usually occurring immediately after an impact. This amnesia almost always involves loss of memory for the moment of injury, and frequently includes loss of recall for the events immediately before and after the trauma. Early signs of a concussion also include headache, vertigo or imbalance, dizziness, lack of awareness of surroundings, nausea, and vomiting. Any combination of these symptoms may present immediately following a head trauma or evolve gradually over several minutes to hours. Later signs of a concussion include mood and cognitive disturbances, sensitivity to light and/or noise, and sleep disturbances.

Post-traumatic seizures are seizures that occur within 1 week of a head injury and are not associated with epilepsy. They occur in fewer than 5 percent of the people who sustain a mild-to-moderate traumatic brain injury and are more common in more severely injured individuals. Neurological deterioration of any kind (i.e. seizures, worsening headache, confusion, or lethargy) after a mild traumatic brain injury is highly suggestive of an evolving intracranial hematoma, which usually occurs secondary to a tear, however slight, in an intracranial artery or vein. These individuals must seek medical attention immediately to avoid catastrophic brain injury.

An uncomplicated mild traumatic brain injury is limited to a structural axonal injury. A mild traumatic brain injury may be complicated by a coexistent area of bruising on the brain that can be associated with ischemia and edema and the possible development of a hemorrhage.

Recovery

Epidemiological studies of collegiate football players have shown that athletes with uncomplicated concussions usually report complete resolution of symptoms within seven days, and neurocognitive functioning returning to baseline within five to seven days. A three-year NCAA prospective cohort study of 15 colleges published in 2003 revealed the resolution of
symptoms associated with concussions. Averaged results showed that self-reported symptoms resolve by day seven post-injury, balance resolves in three to five days, and neurocognitive functioning resolves in five to seven days. By day seven, 91 percent of the athletes who sustained concussions reported complete recovery and restored baseline neurological functioning.\textsuperscript{19}

Another three-year prospective cohort study published in 2006 focused on high school athletes. Of the 136 athletes who sustained concussions, 45 percent reported complete recovery in one week. 73 percent reported recovery within two weeks, 82 percent in three weeks, and 91 percent in four weeks. The final results showed 97 percent of the injured athletes reported full recovery by five weeks after the injury.\textsuperscript{45}

Associated Syndromes

\textit{Post-Concussion Syndrome}

Post-concussion syndrome is defined as the prolonged symptoms from a concussion that can include nausea, headaches, irritability, vision changes, and sleep disturbances among others, and can last from days to years. Yet, the severity of the symptoms does not always correlate with the severity of the injury.\textsuperscript{21,24,41} When mild cognitive, physical, or affective symptoms persist collectively or in combination for longer than seven to ten days they are typically referred to as post-concussion syndrome.\textsuperscript{20} These symptoms can persist for weeks, months, or even years. 80 percent of patients with a mild or moderate concussion will experience some symptoms of post-concussion syndrome.\textsuperscript{23} Acute post-concussive symptoms are greatest within the first ten days of the injury. After one month, symptoms are usually markedly improved, even subclinical. After three months, most patients have completely recovered from post-concussion
syndrome. Estimates state that 10 to 25 percent of mildly concussed patients will have symptoms that persist longer than one year.\textsuperscript{28}

Although the deficits seen and the duration of symptoms that occur are similar in both older and younger adolescents, younger adolescents experience more pronounced deficits in memory than older adolescents.\textsuperscript{23} Evidence shows that the cognitive deficits seen in children 14 to 18 years old with concussions persist longer than athletes 18 to 25 years of age.\textsuperscript{41} In addition, younger adolescents experience more pronounced deficits in verbal and visual memory than older teenagers.\textsuperscript{44} For these reasons it is imperative that the high school athlete who sustains a concussion is managed conservatively, which means early recognition, frequent follow-ups, and carefully supervised gradual return to play.\textsuperscript{23, 25, 41}

\textit{Cumulative Effects}

Studies have shown that while recovery of a single mild traumatic brain injury may occur quickly allowing an athlete to resume full-contact play, there is some risk for that athlete to be more prone to future concussions.\textsuperscript{46} Researchers have reported that high school and university athletes with three or more concussions show small but measurable cumulative effects.\textsuperscript{47} Moreover, when an athlete sustains at least three concussions there is likely to be worse on-field presentation, greater acute changes in memory, and prolonged recovery.\textsuperscript{19, 48}

\textit{Second Impact}

The biggest risk in returning a concussed athlete to play, no matter how mild, is the occurrence of a “second impact.”\textsuperscript{24, 41} Second impact is the term used to denote intense diffuse cerebral swelling that occurs after a second concussion while an athlete is still symptomatic from an earlier concussion.\textsuperscript{24, 25} This can occur within the same game or while the athlete is still recovering days or weeks after the initial concussion. Although very rare, this is generally a fatal
complication of a mild head injury.\textsuperscript{24,25,27} Between 1992 and 1997, there were at least seventeen deaths related to second impact in the United States, with periodic cases continuing to be reported.\textsuperscript{26} This serious risk factor led to the further development of many guidelines regarding management of athletes who have sustained concussions.\textsuperscript{30}

Review of “Return to Play” Guidelines

\textit{Cantu Guidelines}

One of the first “return to play” guidelines to be published were the Cantu Guidelines.\textsuperscript{29} A neurosurgeon, Dr. Robert Cantu, established these guidelines in 1986 secondary to his clinical experiences with athletes who sustained mild traumatic brain injuries. The Cantu Guidelines were developed for on-field management of a concussed athlete. Cantu proposed a grading scale between one and three to be used as a supplement with clinical judgment. Those with a grade one concussion were said to not have loss of consciousness and amnesia limited to less than 30 seconds. These athletes were returned to play the same day if they are asymptomatic at rest and with exertion. Grade three concussions were those when an athlete lost consciousness for over one minute or had amnesia lasting longer than 30 minutes. These athletes were allowed to return to play in one month if asymptomatic at rest and with exertion.\textsuperscript{29}

\textit{Colorado Guidelines}

Another set of guidelines called the Colorado Guidelines were published by The Colorado Medical Society after the death of a high school football player from second impact in 1991.\textsuperscript{30} These guidelines also used a grading system and allowed for athletes with grade one concussions to return to play if the athlete’s symptoms cleared within 20 minutes of the injury. Athletes who had a loss of consciousness for any period of time qualified as grade three concussions in the Colorado Guidelines. These athletes are then recommended for immediate
transfer to an Emergency Department for evaluation. Then, they may return to play if
asymptomatic for a period of two weeks once a medical professional clears them.\textsuperscript{30}

\textit{American Academy of Neurology Guidelines}

In 1997, the American Academy of Neurology amended the Colorado Guidelines.\textsuperscript{31} These guidelines used the same grading scale and allowed for an athlete with a grade one
concussion to return to play after only 15 minutes if all symptoms cleared. For an athlete who
sustains a grade three concussion, the recommendation is that the individual be transported to the
hospital, where he or she should be observed overnight. Then, this athlete may return to play
when asymptomatic for one to two weeks.

\textit{American Academy of Orthopaedic Society for Sport Medicine Guidelines}

In the late 1990’s the American Orthopaedic Society for Sports Medicine (AOSSM) also
released a position statement of recommendations regarding appropriate “return to play”
guidelines.\textsuperscript{32} These recommendations moved away from the use of a numeric grading system
for determination of whether an athlete should return to play or not. Instead, the focus of
management was more individualized, rather than applying a universal standard or protocol. In
addition, these recommendations encouraged the use of neuropsychological testing as a
measurement of readiness to play.\textsuperscript{32}

\textit{Vienna Guidelines}

The latest, and perhaps the most used guideline was developed in November 2001. The
Federation Internationale de Football Association in conjunction with the International Olympic
Committee and the International Ice Hockey Federation organized a group of physicians,
neuropsychologists and sports administrators in Vienna, Austria.\textsuperscript{33} The deliberations of this
meeting lead to the publication of a document outlining recommendations for both the diagnosis
and management of concussions in sports. This guideline, called the Vienna Guideline, emphasizes neuropsychological testing as the “cornerstone” of post-injury assessment. This guideline does not allow same day return to play and introduces a systematic approach with increasing levels of activity prior to an athlete resuming full participation.

In November 2004, the 2nd International Symposium on Concussion in Sports was organized by the same group. This meeting occurred in Prague, Czech Republic and resulted in an updated and revised version of the Vienna Guidelines. In 2008, the 3rd International Symposium of Concussion in Sports was held in Zurich. Again, the Vienna Guidelines were amended and updated. The subsequent evolution of the original Vienna Guidelines was toward a more conservative approach to concussion recognition and management. This guideline did not use grading, but instead encouraged the use of neuropsychological testing to assess mild traumatic brain injury, meaning that more subtle changes to an athlete’s performance can be recognized. It also gradually reintroduces an athlete back into the sport, carefully reassessing for signs of post-concussion syndrome. Once an athlete remains asymptomatic while participating at one level, he or she may then advance to the next, and so on. This systematic approach allows time for symptom recognition and careful supervision of the athlete while engaging in activities that have the potential to exacerbate the brain injury.

Concussion Evaluation Tools

Decisions regarding an athlete’s return to play are often made against the backdrop of a loud stadium with pressure from coaches, fans, parents, and other players. Because of this, the use of tests that help to objectively measure an athlete’s cognitive impairment can be very useful. A systematic assessment of the injury and its manifestations is essential to proper management and reduced morbidity. The more popular concussion assessments that are being used in high
Sports-Related Concussions

Schools and colleges throughout the United States include ImPACT, SAC, and ACE. These are all types of neuropsychological tests.36,39,40,12

Neuropsychological testing, or neuropsychological evaluation, is a testing method that measures athletes’ cognitive, behavioral, motor, language, memory, and executive functioning.36 This information can be used for recognition of a concussion, severity of the injury, and possibly as an assessment regarding when the athlete is able to return to play.36,37,38 These tests vary in length and form and are most accurate when compared to the individual’s pre-concussion baseline. Most take several minutes to administer and can be done with paper and pencil or, more commonly, with a computerized program. There are a variety of neuropsychological tests available.

**ImPACT**

ImPACT, which is the Immediate Postconcussion and Cognitive Test, is a popular, computerized battery that consists of seven individual test modules that measure multiple neurocognitive abilities.39 This test was developed in the early 1990’s and can be administered by a coach, athletic trainer, or provider with minimal training. These modules tests word discrimination, design memory, visual attention span, reaction time, symbol matching, color matching, and letter and word memory. There is also a 21-item symptom self-report included in the ImPACT program, where the athlete ranks the severity of symptoms. This test is designed to take only 20 minutes to administer and is protected against practice-skewed results, so an athlete can take the test multiple times without affecting the results. It is now available in many forms and can be completed on a laptop computer, increasing the opportunity for immediate and convenient evaluation. The results of this evaluation reveal slight changes in performance that otherwise might be undetectable to a coach or parent or clinician. This test does not, however,
replace clinical judgment or explicitly recommend when an athlete should return to play. Instead, these evaluations, like many other neuropsychological tests, measure the affects of a concussion and can often depict a resolution of postconcussion sequelae.39

The ImPACT program is thoroughly researched, with numerous articles citing the use and how the ImPACT tests are helping coaches and trainers to make better return-to-play decisions for athletes. There is an online resources as well as computer programs, pamphlets, downloads, books, and mailings.39 The research on this topic is well funded and accessible to providers, coaches, trainers, and parents alike. However, the computer program can be quite expensive and this can make using the ImPACT program in public high schools less probable.

SAC

The Standardized Assessment of Concussion, commonly called the SAC test, is another instrument designed to assess acute neurocognitive impairment on the sideline.40 This test can be done in as little as five minutes and measures orientation, immediate memory, neurological screening, concentration, delayed recall, and exertional maneuvers. Even individuals lacking expertise in neurocognitive or neuropsychological testing can conduct this test. Like the ImPACT test, the SAC test is most accurate when compared to an individuals pre-concussion baseline score. This short, step-by-step evaluation is available on small cards that can be carried by coaches, trainers, and even parents. Concussed athletes have significantly lower scores than those without concussions when scored using the SAC. This evaluation should not be used to judge whether an athlete is ready to return to play.40

The SAC was created in response to the American Academy of Neurology guidelines.40 There are free downloads and pamphlets as well as the grading forms available online. Low financial cost makes this assessment a viable option for public high schools. Additional official
forms and pocket cards can be ordered from multiple online sites for a fee, as well, making this type of testing very accessible. There are few studies, however, to compare the use of this assessment with some of the other available neuropsychological tests available.

ACE

Another similar tool, the Acute Concussion Evaluation (ACE) form, was developed for providers to use with an evidence-based protocol to conduct an initial evaluation and diagnosis of adults, adolescents, and children with suspected concussions. The ACE explores the characteristics of the injury, the types and severity of symptoms, and the risk factors that can lead to a prolonged period of recovery. It also includes asking parents and observers about health and family history as well as an accurate account of the injury. This assessment tool is made in pocket-sized pamphlets for coaches and trainers to be able to use on the sideline as part of a national campaign to raise awareness and improve the recognition and management of athletes, called “Heads Up.”

Because this assessment is federally endorsed, there is sufficient quality information and research behind this tool. In addition, any party may order a packet of information, including pocket cards and a manual regarding how the test should be best used, also complete with the research used in creating the assessment. This tool and this packet can be ordered or downloaded from the internet without cost from the Centers for Disease Control and Prevention website, which allows this tool to be very accessible.

Neuropsychological Testing

The ImPACT test, the SAC test, and the ACE test are all accurate indicators of neuropsychological function decline. They all test the main areas of concussion symptomology and provide objective information regarding deficits secondary to a mild traumatic brain injury.
Sports-Related Concussions

With concussion recognition and management discussions a hot topic in recent past, many organizations involved in sports or in the recognition and management of individuals who have sustained concussions are becoming more involved in the discussion regarding sports-related concussions. In addition, the use of such assessments is becoming more universal.

Implications for Nurse Practitioners

Before the injury

At the beginning of a sports season, prior to play, providers should recommend to coaches and trainers that all athletes should be administered some form of neuropsychological test, such as ImPACT, SAC, and ACE, to establish a baseline for each individual athlete. These results should be kept with the team during all practices and games so that, should an athlete be injured, a repeat test can be completed and compared immediately and conveniently.

Initial recognition, diagnosis, and management

When there is a suspected head injury, regardless of how slight, the player must be removed from the game or practice immediately. The acute evaluation of an individual includes a neurological assessment, along with an evaluation of the “ABC’s”: airway, breathing, and circulation. Fast identification of immediate neurological emergencies is crucial and athletes presenting with these symptoms should seek immediate medical attention. Once it is ascertained that the athlete is alert, breathing, and free of the above indications, and there are no other emergent injuries to treat, the athlete should be administered a neuropsychological battery. A decline from an individual’s baseline score of the neuropsychological test, any form of amnesia, or any symptoms associated with a concussion is grounds to have the player sit out the rest of the day. No athlete who has sustained a concussion or is suspected to have sustained a concussion should continue to play.
If the athlete has any concerning neurological abnormalities, concussion symptoms are severe, or the athlete has been on anticoagulation therapy (such as aspirin), a medical provider should urgently evaluate the athlete. Addressing immediate neurological emergencies is important because there is great risk for severe injury due to a secondary brain injury or chronic brain injury if the concussion goes unrecognized, especially for those athletes with specific increased risk factors. Data indicates that computed tomography (CT) examinations of the head are the test of choice for Emergency Departments because they are fast and available at most hospitals. Head CTs are also effective at identifying recent, severe injuries as well as skull fractures and other serious brain anomalies or injuries. Most major neurosurgical and clinically significant abnormalities are visible on CT, however, most head CTs are normal for an individual with a mild traumatic brain injury.

Magnetic resonance imaging (MRI) offers a more sensitive examination of brain tissue that can show minor abnormalities. A functional MRI is a relatively new procedure that uses magnetic resonance imaging to measure tiny metabolic changes that take place in active areas of the brain. This newer examination may have a place in concussion evaluation because it can produce helpful and objective data, however it is lengthy and very expensive. Most individuals with a mild traumatic brain injury have a normal MRI as well.

Any child who has a minor head injury requires observation, whether at home, in the office, or in the Emergency Department. If an athlete is seen in an Emergency Department and the results of a head CT are negative after a concussion, the patient may be sent home with a responsible caretaker if symptoms resolve within a few hours. An individual who will stay with the patient for at least 24 hours should be given explicit and understandable instructions for monitoring, when to seek medical attention, and when to follow up with a provider.
There are differing beliefs regarding the need to wake a patient from sleep to assess neurological functioning. The conservative approach involves waking the patient every two hours and asking him or her simple questions to ascertain orientation. Less conservative recommendations include letting the patient sleep through the night, but for adolescent athletes this is less appropriate. Sample orientation questions include asking the patient his or her name, date of birth, phone number, address, or inquiring about the date, the year, the events of the day, or the names of family members and pets. If the athlete can answer at least three questions correctly, he or she may be allowed to go back to sleep. If the athlete is awake, these questions should also be asked every two hours. If the athlete is unable answer any of these questions correctly, immediate medical attention is required.

*Returning to Play*

Rehabilitating the injured athlete can be achieved through the following graduated algorithm, which has been adapted from the best guidelines for concussion recognition, assessment, and management. Previous guidelines, though many are well researched and supported by specialists all over the world, only contain part of the concussion treatment plan, leaving coaches, trainers, players, parents, and providers to search for comprehensive information. The purpose of the chart (seen on page 17) is to assimilate the conservative approaches researched in this article into a tool that presents all the pertinent and supported information regarding the management of concussions in the high school athlete. This tool has been adapted from the latest version of the Vienna guidelines for returning an athlete to regular game play. Also included is the most researched information on concussion recognition through the current concussion assessment tools, the best recommendations for early detection of concussions, and the medical risks of returning to play before healing of the brain is complete as
directed by multiple medical associations and specialists. The information is specific to the high school athlete because children and adults can present with concussions differently than adolescents and, therefore, should be treated with evidence-based practice specific to that age group.

Each step of this tool must be taken seriously and the athlete must not move onto the next step until he or she is completely symptom free for at least 24 hours. Returning an athlete to contact sports before complete recovery may increase the risk of adverse outcomes and long-term effects. Providers, coaches, and trainers should be aware that symptoms may worsen or re-emerge with exertion, indicating incomplete recovery, which may also be protracted with over-exertion. Yet, moderate levels of exertion have been shown to improve concussive symptoms and neurocognitive performance. Having an injured athlete progress through increasing intensity, non-contact activity may improve prognosis. But, the athlete must remain asymptomatic for any benefits from such activity to be gained. Full recovery of cognitive functioning is best exhibited by neuropsychological test performance. An algorithm recommended for nurse practitioner use is as follows: 12, 13, 14, 17, 18, 23, 25, 35, 41, 43, 46
### Sports-Related Concussions

#### If the following occurs:
- Seizure
- Worsening headache
- Vision changes
- Battle sign
- Possible skull fracture
- Possible neck injury
- Numbness or weakness in any body part
- Loss of consciousness >30 seconds
- Extreme confusion
- Extreme lack of coordination
- Vomiting 2+ times

#### If the following occurs:
- Amnesia/memory problems
- Confusion
- Problems with coordination
- Headache
- Nausea/vomiting x1
- Balance problems
- Fatigue
- Labile mood
- Neuropsychological test score decrease from baseline (SAC, ImPACT, ACE)
- High suspicion for concussion

## Return to Play Protocol
(Each Step = 24 Hours)

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<td>REST Complete Rest for 24 hours</td>
<td>LIGHT COGNITIVE STIMULATION Homework, reading, no exercise</td>
<td>LIGHT AEROBIC EXERCISE No contact, nonresistance training, low-moderate intensity</td>
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<td>SPORT SPECIFIC EXERCISE No contact, resistance training, moderate-high intensity</td>
<td>TRAINING AND DRILLS No contact, high intensity</td>
<td>FULL PRACTICE PARTICIPATION Contact, high intensity</td>
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<th>Step 7</th>
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<td>Normal Game Play</td>
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Each concussion must be treated independently as each athlete has individual brain chemistry, biophysics, and tolerance. When a medical professional has cleared the athlete, he or she can begin the return to play protocol. Only one step is to be done during a 24-hour period. Some athletes may progress through this schedule each day. Others may find that they plateau on a particular stage for a few days before progressing. This is acceptable and simply means the brain is trying to tell the body that it is not yet healed, and therefore at a higher risk for worsening brain injury or prolonged recovery.

Under no circumstance should an athlete return to play while symptomatic at rest or with exertion.

On-going care

An athlete should follow-up with a provider within one week of the initial injury so the provider can evaluate for persisting symptoms or if there is any deterioration regarding the health, emotions, neurologic function, or safety of an individual who has sustained a concussion. If the athlete wants to return to play and is not suffering from any emergent symptoms, he or she must agree to carefully monitor symptoms and honestly report them to minimize the risk of serious brain injury. Emphasizing the importance of honesty in self-reporting symptoms of concussions with the adolescent athlete is critical. Athletes at all levels have been known to minimize or withhold symptoms of concussions to prevent being removed from a game or demoted from a specific role or position in the sport. Insuring the athletes’ understanding of the seriousness of the injury and providing emotional support for the injured athlete is crucial.

Symptom treatment and referrals
To treat the symptoms of post-concussive syndrome a patient may be prescribed NSAIDS for headache and neck pain. Narcotics should be avoided because they may cause respiratory depression, mask signs of worsening neurological symptoms, and have also been linked to increased risk for depression and anxiety in patients with mild traumatic brain injuries. For significant post-concussive depression and sleep disorders tricyclic antidepressants may be used, though the risk of such medications should be weighed carefully with the benefits. Massage and chiropractic care may also help to alleviate tension headaches and neck pain associated with post-concussion syndrome.\textsuperscript{12,50,51} If symptom reduction is not evident within five days of the injury, a referral should be made to a specialist who cares for patients with mild traumatic brain injury. If the presentation of symptoms is complex or the severity of symptoms is of concern, a referral may be appropriate sooner.\textsuperscript{12}

Referring an injured athlete for psychiatric treatment to treat depression and anxiety secondary to the concussion may be appropriate for persistent symptoms. A referral to neurology is recommended for persistent headaches, seizures, vertigo, or problems with cognition. To rule out other causes for post-concussive syndrome-like symptoms, a provider may elect to check electrolytes, a CBC with differential, urinalysis and toxicology screen.\textsuperscript{50,51}

Implications for Research

Comparative studies that review the efficacy and use of different concussion screening tools as well as the safety of return to play guidelines are imperative. The present guidelines have been effective to raise awareness, increase reporting of concussion, and have improved the safety of high school athletics, however objective comparisons between each of them has not been done. It is important to quickly identify an athlete who has sustained a concussion and to determine the best method to carefully protect that athlete from further brain damage while
minimizing the time in which he or she is unable to participate in the sport. Everyday there is more publicity spotlighting the increase in reported concussions and the dichotomy in concussion management. The need for large sample comparative studies is becoming very important in the growing environment of alarming concern for high school athletes who are sustaining concussions every year.

There is also research needed for analyzing the need for waking an adolescent every two hours after sustaining a mild traumatic brain injury. This study should be a retrospective study with a sample size over 1,000 to compare the benefits of waking adolescent patients every two hours for neurological assessment with the benefits of sleep for the injured adolescent. A study like this would yield pertinent information regarding the management of concussed high school athletes within the first twenty-four hours.

Studies focused on the long-term sequelae of those athletes who sustain mild traumatic brain injuries in high school and college would also be very valuable and could perhaps change the way concussions are viewed. In the recent past there has been more attention drawn to the possibility that there may be more damage done to brain tissue than initially believed occurs with a mild traumatic brain injury. Studies that relate anxiety, depression, sleep disorders, anger problems, memory problems, or migraines with old head injuries and, perhaps, even prognosis and treatment, could be very valuable to providers who are assessing individuals who may have sustained a concussion at some point in his or her adolescence.

Conclusion

The most important considerations in management of mild traumatic brain injury in the high school athlete are the identification of immediate neurological emergencies and urgent referral for evaluation and treatment. Next, it is important to identify high-risk individuals of
second impact syndrome so that this fatal phenomenon may be prevented. Thirdly, the provider should recognize and manage neurologic sequelae and post-concussive symptoms. Finally, the overall objective for conservative management of the concussed high school athlete is to help prevent cumulative and chronic brain injury, while working with parents, coaches, trainers, and the athlete to return to play. Use of the assimilated algorithm by nurse practitioners is a necessary step toward raising concussion awareness and achieving more immediate and accurate care for injured athletes, while providing a safe process for returning a concussed high school athlete to normal play.
Sports-Related Concussions

References


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