Concussion management in soccer

Review

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Abstract

Brain injuries in sports drew more and more public attentions in recent years. Brain injuries vary by name, type, and severity in the athletic setting. It should be noted, however, that these injuries are not isolated to only the athletic arena, as non-athletic mechanisms (e.g., motor vehicle accidents) are more common causes of traumatic brain injuries (TBI) among teenagers. Notwithstanding, as many as 1.6 to 3.8 million TBI result from sports and recreation each year in the United States alone. These injuries are extremely costly to the global health care system, and make TBI among the most expensive conditions to treat in children. This article serves to define common brain injuries in sport; describe their prevalence, what happens to the brain following injury, how to recognize and manage these injuries, and what you can expect as the athlete recovers. Some return-to-activity considerations for the brain-injured athlete will also be discussed.

1. Introduction

Soccer is the most popular sport in the world, with participation exceeding 265 million people. Although not considered a full contact sport like American football or ice hockey, collisions frequently occur in soccer between players. It is not uncommon for ball and object (goalposts) to collide with players. These collisions often lead to injuries including concussions. The general epidemiology of soccer-related concussions is unknown. In the American collegiate setting, men’s and women’s soccer trails only American football with regard to concussion injury rates, and concussions in soccer accounts for approximately 5% of total injuries in any given collegiate season. It is reported over 50,000 concussions occur annually in men’s and women’s high school soccer alone in the United States. Concussion in high school women’s soccer has been reported at a rate of 3.4 injuries per 10,000 athlete exposures, trailing only high school football, men’s ice hockey, and men’s and women’s lacrosse.

It has traditionally been thought concussions in soccer occur from player to player collisions involving the upper body of the involved players. This has led to the adoption of stricter enforcement policies amongst soccer governing bodies in regards to elbow, arm, and head to head contact. It should be noted, however, more recent research has suggested almost one third of soccer related concussions occur after a player deliberately strikes the ball with their head. This is alarming as heading is an important soccer skill and is employed up to 800 times in a single season at the professional level. Due to the prevalence of concussion and
collision nature of soccer, it is imperative for coaches at all age levels to understand the basic principles of proper concussion recognition and management.

2. Definition of concussion

The most common type of sports-related traumatic brain injury (TBI) is cerebral concussion. Although the term concussion is widely used, there is no universally agreed upon definition of concussion. Despite this, concussions are often defined as a brain injury, induced by biomechanical forces, which results in a complex pathophysiological process affecting the brain. Additionally, the resulting clinical, pathological, and biomechanical features of the injury are often used to define concussion. Concussions are the result of forces transmitted to the head, through direct contact with the head, face, chest or elsewhere on the body. In soccer, another player, the ground, the goal post or the soccer ball itself can create these concussive forces. Concussions often result in rapid, but short-lived, impairment of neurological function. These clinical symptoms are often the result of functional disturbances and not structural injury. Thus, traditional imaging modalities (e.g., magnetic resonance imaging (MRI) or computed tomodraphy (CT) scans) often result in negative findings when diagnosing a soccer player with concussion.8

Concussions are a form of diffuse brain injury, such that concussive injuries result in widespread disruption of neurologic functioning. A severe type of diffuse brain injury involves damage to the neuronal axons, which may lead to deficits in cognitive functioning such as difficulty remembering or concentrating. In its most severe form, diffuse axonal injury can result in the disruption of brainstem centers responsible for heart rate, breathing, and consciousness.9,10 However, even with this information in mind, it is important to understand that concussive injuries rarely result in sudden death. Additionally, the overwhelming numbers of concussions do not result in a loss of consciousness (LOC). More typically, concussive injuries catalyze a neurometabolic cascade in the brain. It is through this combination of axonal injury and neurometabolic dysfunction that gives rise to the common signs and symptoms associated with concussion.

3. Signs and symptoms of concussion

There are many signs and symptoms associated with concussive injuries. Signs of concussion are those deficits that can be observed by other individuals, specifically medical personnel. Concussive symptoms are deficits that we rely on the athlete to report to us. A non-exhaustive list of common concussion signs and symptoms are as follows: headache, nausea, dizziness, vision problems, difficulty concentrating, changes in sleep patterns/drowsiness, emotional changes (irritability, sadness), sensitivity to light/noise, LOC, amnesia (retrograde and/or anterograde), unstable walking/balance problems, general confusion/disorientation, difficulty remembering, vomiting, combative ness, and/or changes in behavior/ personality. While these signs and symptoms are some of the more common deficits post-concussion, it is important to understand that these signs and symptoms 1) are not specific to only concussion, 2) do not all have to be present in order for a concussion diagnosis to be made, and 3) should prompt immediate removal of an athlete from play until such time as they can be evaluated by a medical professional.

LOC and amnesia are often thought to be common indicators of concussive injuries, but in reality do not adequately represent the complexity of concussion. LOC occurs in less than 10% of all concussive injuries.11 Amnesia, along with confusion, is considered to be a hallmark of concussion and may appear directly after the trauma or have a delayed onset.12 While LOC and amnesia are relatively rare, these signs may be indicative of more serious brain injury.13 and athletes experiencing these signs should be further evaluated to rule out more severe and potentially catastrophic brain injuries. Headache, balance problems, and slow mental processing are the most frequently reported concussion symptoms.14,15 Approximately 85% of concussed athletes report a headache after injury, while 77% report symptoms of dizziness and balance problems.15

Concussive symptoms are an individualized phenomenon, meaning that the number and severity vary greatly between individuals and are influenced by many factors. While most athletes report symptoms at the time of injury, it can take several hours after injury for some athletes to feel the onset of symptoms.8,13,15 Therefore, athletes should be monitored carefully during the acute stages of injury in order to properly identify and manage delayed symptoms. While there have been no obvious differences in pre-injury symptom reporting between males and females,16 women typically report a higher frequency and overall symptom severity post-concussion.17 Lastly, many concussive symptoms are similar to those of attention deficits disorders, anxiety, or depression. Individuals with pre-existing mental health disorders should be monitored carefully because concussions may exacerbate those symptoms. All of these factors relating to concussive symptoms are important and may play a role into predicting recovery. While complex, referring the players you suspect of having sustained a concussion to the appropriately trained medical professionals in your jurisdiction will help you better care for your athletes.

4. Concussion recognition

The first step in caring for athletes suffering a concussion is recognizing the injury has occurred. Unless the athlete experienced LOC, recognizing a concussion may be a challenging task. It is likely that the athlete will appear dazed, dizzy, and disoriented following a concussion. In more obvious injuries, coaches and other personnel may recognize that the athlete is having difficulty standing on his or her own, or that they are unable to properly follow instructions (e.g., what play to run, or what position to be in). In cases where there are no obvious signs of concussion and the athlete does not immediately report or recognize symptoms, it is possible for concussions to go undiagnosed at the time of injury. To minimize this risk, it is imperative for coaches to be well educated about concussion signs and symptoms, in hopes of being able to recognize them
if the athlete is not forthcoming. Youth coaches who are more educated about concussions are better able to recognize the signs and symptoms, which decreases the risk of subsequent concussion or potential catastrophic injury for the athlete. Once any concussion signs or symptoms have been identified, the athlete should be removed from the field of play and undergo further evaluation to determine if a concussive injury has occurred.

5. Concussion evaluation

5.1. Examination

Once the decision has been made to remove the athlete from play for a suspected concussion, it is important to conduct a thorough examination. This evaluation should include an examination of the injured athlete’s cranial nerve function, balance, and cognition. While important to assess all cranial nerves, the examiner should focus on cranial nerves II, III, and IV in order to eliminate the possibility of a more severe brain injury. Cranial nerve II (optic nerve; visual acuity) is assessed by having the athlete read or identify selected objects at near and far ranges. Cranial nerves III (oculomotor nerve) and IV (trochlear nerve), both of which control eye movement, can be evaluated by determining visual coordination and asking the athlete to track a moving object. It is also important to observe the athlete’s pupils to determine if they are equal in size and equally reactive to light. An abnormal test would result in either or both of the athlete’s pupils constricting when a light source is pointed directly into them. It is important to recognize that abnormal movement of the eyes, irregular changes in pupil size, or atypical reaction to light often indicate increased intracranial pressure, and require an immediate referral to an advanced medical care facility (e.g., emergency room).

It is essential to note the athlete’s condition early in the evaluation process. If they appear to worsen over time, both pulse and blood pressure should be taken. Recognizing an athlete in medical decline is imperative. Developing an unusually slow heart rate or an increased pulse pressure after removal from activity may be signs the athlete is suffering from increasing intracranial pressures. These are important considerations for detecting a more serious and potentially life-threatening injury. If any deficiencies are noted during the cranial nerve assessment or the athlete’s condition appears to be worsening rapidly, an emergency medical situation should be assumed and the athlete should immediately be transported to an emergency or neurosurgical department.

It is important to keep in mind throughout the evaluation that an athlete should never be returned to play on the same day as a suspected concussion. “Suspected” is a keyword, as the examiner should always err on the side of caution and assume a concussion if objective measures are unable to completely rule out the possibility a brain injury has been sustained. Once all potential for life threatening injuries has been ruled out, it is necessary to proceed with additional testing to identify potential deficits in balance and/or cognition, as it is possible either of these domains may be affected even in the absence of reported symptoms.

5.2. Objective measures of balance

Balance deficits have been shown to persist up to 72-h following concussion. Therefore, it is important to include some measure of balance in a thorough concussion evaluation. The Balance Error Scoring System (BESS) was developed to provide sports medicine professionals with a rapid and cost-effective method of objectively assessing balance in athletes on the sideline or athletic training room following a suspected concussion. The BESS consists of three different stances—double leg, single leg, and tandem—performed on two different surfaces—firm and foam—for a total of six conditions (Fig. 1). The BESS trials require the athlete to balance for 20 s with their eyes closed and hands on their iliac crests. During the single-leg balance tasks, the athlete should balance on their non-dominant leg (dominant leg defined as the leg in which the athlete would kick a soccer ball), with their contralateral leg in 20° hip flexion and 30° knee flexion. During each of the 20-s tests, athletes should be instructed to stand quietly and motionless in the stance position, keeping their hands on the iliac crests with their eyes closed. If the athlete loses their balance at any point during the test, they should make any necessary adjustments and return to the initial testing position as quickly as possible. Participants are scored by adding one error point for each error committed during each of the six balance tasks (with a maximum of 10 errors allotted for any single trial). Errors include lifting their hands off their iliac crest, opening their eyes, stepping, stumbling, or falling, moving their non-stance hip into more than 30° abduction, lifting their forefoot or heel, and remaining out of the test position for more than 5 s. It is beneficial to compare this post-injury assessment of balance to a baseline measure if it is available, although normative data have been published for healthy subjects.

5.3. Objective measures of cognition

Several cost-effective tools have been developed for use on the sideline to screen for potential cognitive deficits following a suspected concussion. The Standardized Assessment of Concussion (SAC) has been developed and validated in the literature as an effective means of assessing cognitive function quickly and easily on the sideline. The SAC requires approximately 6—7 min to administer and assesses four domains of cognition including orientation, immediate memory, concentration, and delayed recall. A composite total score of 30 possible points is summed to provide an overall index of cognitive impairment and injury severity. As practice effects are of concern with repeat testing, multiple equivalent forms of the SAC have been developed. The SAC is capable of identifying significant differences between concussed athletes and non-injured controls, and is also capable of distinguishing between pre-season baseline and post-injury scores.
More recently, the Sport Concussion Assessment Tool 3 (SCAT3) and Child-SCAT3 have been developed. These new tools incorporate the SAC and firm-surfaced BESS conditions along with several other sideline-based tests including a symptom checklist and coordination examination. Both the SCAT3 and Child-SCAT3 take approximately 12–14 min to complete. The Child-SCAT3 is nearly identical to the SCAT3 and was designed for administration to children under 13 years of age. Modifications include a different symptom evaluation and slight changes to the SAC and BESS. The authors of these tools recommend pre-season baseline testing be performed if possible.

Additionally, another inexpensive clinical tool has recently been established to investigate reaction time following a potential concussion. This clinical measure of reaction time (RT\text{clin}) has been shown to be positively correlated with more expensive computer based measures of reaction time and sensitive to reaction time deficits following concussion. The RT\text{clin} instrument consists of a thin, rigid cylinder attached to a weighted disk (e.g., an ice hockey puck). The instrument is then released and allowed to free fall towards the ground while the athlete is instructed to catch it as quickly as possible. The distance the instrument was allowed to fall is measured, recorded, and converted via mathematical formula into a clinical measure of reaction time. The test takes approximately 3 min to complete and the RT\text{clin} instrument can be manufactured via readily available commercial materials by anyone interested in including RT\text{clin} in a concussion management program.

Prior to return to full activity, it is necessary to repeat the above battery of tests as thoroughly as possible. While all assessments discussed above are intended to screen athletes suspected of concussion on the sideline immediately following injury, several tools are available which may provide a more in-depth assessment of any lingering deficits even in the absence of reported symptoms. A number of computerized neurocognitive testing platforms have been used to evaluate athletes following concussion. The Automated Neuropsychological Assessment Metrics (ANAM), CNS Vital Signs, CogniSport (marketed in North America as Axon Sport), HeadMinder Concussion Resolution Index, and the Immediate Postconcussion Assessment and Cognitive Test (ImPACT) are all currently available and have demonstrated tolerable reliability and validity. Although more expensive and timely to administer, the advantages of computerized testing include the ability to assess additional neuropsychological domains (such as processing speed and visual memory), the ability to administer baseline testing to large groups of athletes in a short period of time, and the multiple forms used within the testing paradigm to reduce the practice effects. It should also be noted there are many traditional (paper and pencil based) neuropsychological tests available. While these tests collectively take longer to administer, they may be administered without the need for computers or Internet, but do require highly trained personnel. Computerized test manufacturers often advocate the collection of baseline testing; however, recent scientific evidence and consensus recommendations.
have questioned the need for this time consuming and costly process.\textsuperscript{8,38,39} Each organization should carefully consider the need for large scale baseline testing based on available resources.

6. Concussion management

The majority of athletic concussions typically resolve in 5–7 days for collegiate athletes,\textsuperscript{15,40} but on average take longer for high school athletes.\textsuperscript{41} It is important to note these averages represent aggregate data based primarily on college American football players, and may not represent the full recovery spectrum one might see with athletes of differing ages and sports. Regardless, it is important to evaluate the athlete regularly throughout the course of recovery with graded symptom checklists and objective measures of postural stability and cognition. One in 10 concussions take longer to resolve, and clinicians must recognize that in some cases, it may take weeks or months—or sometimes longer—for symptoms to resolve and for athletes to begin feeling better. It is critical that coaches ensure athletes are fully recovered to protect them from adverse and potentially catastrophic outcomes like second impact syndrome.

Symptoms that can be commonly prolonged for concussed athletes include headaches, dizziness, and mood disturbances. Headaches are not all created equally, and represent a complex range of conditions that each requires individualized attention and care. They can range from being so severe that the athlete has a difficult time getting out of bed, to mild tightness and pressure around the head. Bright lights and loud noises may make headaches worse, so coaches should shield players from noisy game environments or night games with bright lights if the athletes have these symptoms. Headaches related to concussion may be migraine-like in nature, a tension-type headache, or secondary to cervical spine-related pain or visual disturbances. If a clinician is able to characterize the specific headache type, he or she can initiate the appropriate pharmacological treatment or lifestyle modifications to best enhance recovery. Physical therapy and vision therapy may be indicated in some more severe cases.

Concussions often lead to persistent dizziness, which is another common concussion symptom. Athletes will feel dizzy because of a disturbance in their vestibular system, which affects their balance. Athletes will often describe feeling “foggy” or unsteady when standing, walking, or changing positions (e.g., from seated to standing). Dizziness is often successfully treated with vestibular rehabilitation and rarely requires pharmacological interventions. Trained physical therapists typically implement vestibular rehabilitation, consisting of gaze and gait stabilization exercises.

If a patient/athlete is experiencing cognitive or mood issues, he or she can experience anxiety, have difficulty paying attention, or become depressed. Sometimes it is necessary to start medical treatment or psychotherapy.\textsuperscript{42,43} Coaches and athletic trainers should keep players engaged with team activities, though they should not take part in formal practice and game play while still recovering. It is important to make the athlete feel like he or she is still “part of the team” to reduce the emotional impact of not getting to be physically involved in the sport. Adequate sleep is also important for cognitive recovery and improved mood. Coaches should be aware that maintaining proper sleep hygiene is one way of regulating sleep. For example, concussed athletes should not be woken up for early morning team meetings at the expense of restful sleep. A number of things can be done during the day to promote sleep hygiene including, but not limited to, waking up at the same time every morning, promoting some sun exposure, exercise as prescribed without worsening symptoms, limiting television and social media use, and limiting daytime naps. At night, patients should go to bed at the same time everyday, take a warm shower before going to bed, do not go to bed too hungry or too full, avoid television or social media use prior to sleep, sleep in a dark and cool room, and avoid electronic devices and television should the athlete wake during the night.

An important consideration in an overwhelming number of concussions is the recognition that a return-to-academics often precedes (and is more important) than a return-to-sport. Thus, coaches need to be aware of a concussed athlete’s return to the classroom, as their cognitive rehabilitation can impact symptom resolution and their return to athletics. Although initially cognitive rest is recommended, managing cognitive exertion is often directed by symptom improvement. The basic tenets of cognitive management are 1) a “slow and steady” return, 2) sub-symptom level of activity, and 3) a team approach. The slow and steady “return to learn approach” involves completing schoolwork at home before reintroducing the athlete into a classroom environment.\textsuperscript{44} Athletes should gradually increase their homework to 3 or 4 h daily before returning to the classroom. At school, teachers and professors—and school nurses and counselors when present—should be aware of the student’s situation, and to allow for accommodations as necessary. This might include accommodating rest periods during the day, extra time for assignments, extended testing time, excused absences from certain classes and reduced non-essential schoolwork.\textsuperscript{45} Physical education courses should be abandoned until an athlete is clear to return to full physical activity. Initially, cognitive rest typically means a student should avoid activities that cause symptoms. Students should be excused from classes and avoid other forms of cognitive exertion. This means they should avoid activities like reading, watching television, or using electronics until their symptoms improve. As students return to a normal workload, they should try to work in quiet and comfortably lit spaces to keep symptoms at bay.

In the best situations, the entire academic team around a concussed athlete works together to provide an environment conducive to athlete recovery from symptoms in the athlete’s own time. This academic team includes teachers, guidance counselors, school nurses, coaches, athletic trainers, and team/personal physicians and necessitates a cohesive communication network so that all are capable of communicating with others. It is paramount that physicians frequently assess an
athlete’s progress and make adjustments to the athlete’s management plan accordingly.

As discussed earlier, it can take varied amounts of time to recover from a concussion. With stable post concussive symptoms, athletes can return to a graded exercise program to improve exercise tolerance and even improve symptoms. As discussed earlier, it can take varied amounts of time to recover from a concussion. With stable post concussive symptoms, athletes can return to a graded exercise program to improve exercise tolerance and even improve symptoms.46 Athletes can also begin to exercise with team members, but coaches should monitor their heart rate throughout practices. Being able to physically return to their sport will likely make athletes happy and boost their overall sense of well-being. Athletes who complete a graded exercise program, followed by the Zurich return to play protocol have a high likelihood of returning to play successfully.47

7. Return-to-activity progression

There are many keys to a successful recovery, but the first and most important is that no athlete should return to participation while still symptomatic. Athletes should undergo a stepwise return-to-activity process once they are symptom-free, and other objective measures (e.g., balance and cognitive testing) have returned to within normal limits (Table 1). Each step of the return-to-activity progression should typically take 24 h, allowing coaches and the sports medicine team time to determine whether an athlete’s symptoms were exacerbated during a particular stage. Assuming no adverse events, the return-to-activity process should take approximately 5–7 days from the time an athlete is deemed symptom-free.

An athlete’s readiness to return-to-activity may be affected by a number of factors. These include the athlete’s previous history of concussion, the nature of the sport (contact vs. non-contact), and whether there are signs the athlete’s condition is deteriorating. In the event of a more serious and potentially catastrophic brain injury (i.e., epidural or subdural hematoma), proper management should be supervised by a neurosurgeon, and full clearance to begin a graduated return-to-activity protocol should be authorized by the attending neurosurgeon. These cases are often more complicated than concussions, and decisions as to whether to disqualify athletes from further competition or return them to play safely should be carried out on an individual basis, and only following input from several members of the athlete’s medical team. It is important for coaches and parents to work with their athletes’ medical professional throughout this return-to-activity process.

8. Conclusion

The keys to a successful concussion management program are: 1) objective evaluation, 2) coaches’ role in preventing concussion, and 3) importance of medical team. Objective testing methods have evolved over the last 2 decades to offer clinicians a more meaningful way of diagnosing athletes with neurological deficits and preventing catastrophic outcomes. Coaches must recognize the recovery and return-to-activity considerations involve many factors, and that it may be dangerous to rely solely on symptom self-reports. The presence of trained emergency care providers (e.g., physicians, athletic trainers, emergency medical services, etc.) is essential to facilitate injury recognition of all soccer injuries including concussion. Coaches must recognize the contributions they can make to promote a safe playing environment, and to enrich an athlete’s injury recovery through sound and conservative approaches to managing potential injuries in sessions they supervise. The recommendations provided herein should not replace the independent evaluation of a physician. All athletes suspected of suffering from a concussion should be removed from participation and referred to the appropriate medical professional in their respective jurisdiction.

Table 1

<table>
<thead>
<tr>
<th>Rehabilitation stage</th>
<th>Functional exercises at stage</th>
<th>Rehabilitation objective</th>
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<tbody>
<tr>
<td>1. No activity</td>
<td>Symptom limited physical and cognitive rest</td>
<td>Recovery</td>
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<tr>
<td>2. Light aerobic exercise</td>
<td>Walking, swimming, or stationary cycling keeping intensity &lt;70% maximum permitted heart rate; no resistance training</td>
<td>Increase heart rate</td>
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<tr>
<td>3. Sport-specific exercise</td>
<td>Skating drills in ice hockey, running drills in soccer; no head impact activities</td>
<td>Add movement</td>
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<tr>
<td>4. Non-contact training drills</td>
<td>Progression to more complex training drills (e.g., passing drills in football and ice hockey), may start progressive resistance training</td>
<td>Exercise, coordination, and cognitive load</td>
</tr>
<tr>
<td>5. Full contact practice</td>
<td>Following medical clearance, participate in normal training activities</td>
<td>Restore confidence and assess functional skills by coaching staff</td>
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<tr>
<td>6. Return to play</td>
<td>Normal game play</td>
<td>Full return to activity</td>
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References

Concussion management in soccer


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