A Review Paper

Concussions in American Football

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Abstract

Major advancements in sport-related concussion (SRC) management have been made across time to improve the safety of contact sports, including football. Nevertheless, these advances are often overlooked due to concerns regarding the potential long-term effects of SRC. Although further research is needed, it is critical that current efforts are focused on better understanding SRC in order to recognize and change ongoing factors leading to prolonged recoveries, increased risk for injury, and potentially long-term effects. To reduce risk for these outcomes, future focus must be placed on increased education efforts, immediate reporting of injury, prevention techniques, targeted treatment, and the development of multidisciplinary treatment teams nationwide. Finally, with the progress in understanding concussion, it is important to remain vigilant of additional advances that will help to further improve the safety of contact sports, including football.

Football is an important component of American culture, with approximately 3 million youth athletes, 1.1 million high school athletes, and 100,000 college athletes participating each year.[1] Participation in football provides athletes with physical, social, psychological, and academic benefits. Despite these benefits, widespread focus has been placed on the safety of football due to the risk for sport-related concussion (SRC) and potentially long-term effects; however, little recognition has been given to the advancements in concussion management across time and occurrence of concussions during most life activities. Although it is reasonable for concerns to be presented, it is important to better understand SRC and the current factors leading to prolonged recoveries, increased risk for injury, and potentially long-term effects.

What Is a Concussion?

Concussions occur after sustaining direct or indirect injury to the head or other parts of the body, as long as the injury force is transmitted to the head. Athletes often experience physical, cognitive, emotional, and sleep-related symptoms post-concussion secondary to an "energy crisis" within the brain.[2] The energy crisis occurs as the result of transient neurological dysfunction triggered by changes in the brain (eg, release of neurotransmitters, impaired axonal function).[2,3] Concussion is undetectable with traditional imaging; however, advanced imaging techniques (eg, diffuse tensor imaging) have shown progress in assessing axonal injury.[3] Symptom duration post-concussion is highly variable due to individual differences; a recent study showed recovery took 3 to 4 weeks for memory and symptoms.[4,5]

Previous Concussion Management

Identification techniques and return-to-play guidelines for concussion have significantly changed across time. In the past, concussion grading scales were utilized for diagnosis and return to play was possible within the same contest.[6,7] It has since been recognized that initial concussion severity makes it difficult to predict recovery.[3] For example, research revealed memory decline and increased symptoms 36 hours post-injury for athletes with a grade 1 concussion (ie, transient confusion, no loss of consciousness, concussion symptoms or mental status changes that resolve within 15 minutes of injury) compared to baseline.[7] Another study found duration of mental status changes

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to be related to slower symptom resolution and memory impairment 36 hours to 7 days post-injury.[6] Consequently, return to play within the same contest was likely too liberal. Guidelines today recommend immediate removal from play with suspected SRC. Nevertheless, the "play through pain" culture has led athletes to continue playing after SRC, contributing to prolonged recoveries and potentially long-term effects.

Current Concussion Management: Continued Concerns and Areas of Improvement

Despite increased awareness of concussions, recent estimates revealed high rates (ie, 27:1 ratio for general players) of underreporting in college football, particularly amongst offensive linemen.[8] Researchers have studied recovery implications for remaining in play, with one study revealing a 2.2 times greater risk for prolonged recovery in college athletes with delayed vs immediate removal.[9] Another similar study discovered an 8.8 times greater risk for prolonged recovery in adolescent and young adult athletes not removed vs removed from play.[10] Further analysis found remaining in play to be the greatest risk factor for prolonged recovery compared to other previously studied risk factors (eg, age, sex, posttraumatic migraine).[10] Additionally, significant differences in neurocognitive data were seen between the "removed" and "not removed" groups for verbal memory, visual memory, processing speed, and reaction time at 1 to 7 days and 8 to 30 days.[10] The recovery implications of remaining in play and the additional risk for second impact syndrome (SIS), or repeat concussion when recovering from another injury, emphasizes the need for further education efforts amongst athletes to encourage immediate reporting of injury.[11]

Sideline Assessment

Sideline assessment has become a vital component of concussion management to rule out concussion and/or significant injury other than concussion. Assessment should include observation, cognitive/balance testing, neurologic examination, and possible exertion testing to ensure a comprehensive evaluation of all areas of potential dysfunction.[12] Indications for emergency department evaluation include suspicion for cervical spine injury, intracranial hemorrhage, or skull fracture as well as prolonged loss of consciousness, high-risk mechanisms, posttraumatic seizure(s), and/or significant worsening of symptoms.[12]

Observation

On the sideline, it is important to identify any immediate signs of injury (ie, loss of consciousness, anterograde/retrograde amnesia, and disorientation/confusion). Since immediate signs are not always present, it is important to be aware of the most commonly reported symptoms, including headache, difficulty concentrating, fatigue, drowsiness, and dizziness.[13] If symptoms are not reported by the athlete, balance problems, lack of coordination, increased emotionality, and difficulty following instructions may be observed during play.[12]

On-Field Assessment

Cognitive and balance testing are essential in determining if an athlete has sustained a concussion. Immediate declines in memory, concentration abilities, and balance abilities are common. Given limitations in administering long testing batteries on the sideline, brief standardized tests such as the Standardized Assessment of Concussion (SAC), Balance Error Scoring System (BESS), and Sport Concussion Assessment Tool (SCAT) are commonly utilized. Identification of cognitive and/or balance abnormalities can help the athlete recognize deficits following injury.[12] Balance problems are experienced due to abnormalities in sensory organization and generally resolve during the acute recovery period.[14,15] Cognitive difficulties typically persist longer than balance problems, though duration varies widely.

Neurologic Evaluation

A neurologic evaluation including cranial nerve testing and evaluation of motor-sensory function (ie, assessment for the strength and sensation of upper and lower extremities) is important to identify focal deficits (ie, sensation changes, loss of fine motor control) indicative of serious intracranial pathology.[12] Additionally, clinicians have suggested inclusion of vestibular and oculomotor assessments due to frequent dysfunction post-concussion.[12,15,16] Examination of the vestibular/oculomotor systems through tools such as the Vestibular/Ocular

Motor Screening (VOMS) assessment (assesses both the vestibular and oculomotor systems) and King-Devick Test (primarily assesses saccadic eye movements) can elicit symptoms that may not present immediately. If assessment appears normal, exertion testing can be utilized to determine if symptoms are provoked through physical exercise that should include cardio, dynamic, and sport-specific activities to stress the vestibular system.[12]

Risk Factors for Injury and Prolonged Recovery

Medical professionals must consider the presence of risk factors when managing concussion in order to make appropriate treatment recommendations and return-to-play decisions. Research has demonstrated the role of female gender, learning disability, attention-deficit/hyperactivity disorder, psychiatric history, young age, motion sickness, sleep problems, somatization, concussion history, on-field dizziness, posttraumatic migraine, and fogginess in increased risk for injury and/or prolonged recovery.[17-25] Additionally, athletes with ongoing symptoms from a previous injury are at risk for sustaining another injury.

Acute Home Concussion Management

Although strict rest has been recommended post-concussion, recent research evaluating strict rest vs usual care for adolescents revealed greater symptom reports and longer recovery periods for the strict rest group.[26] Based on these findings and emphasis for regulation within the migraine literature (due to the common pathophysiology between migraine and concussion[27]), we recommend that athletes follow a regulated daily schedule post-concussion including: 1) regular sleep-wake schedule with avoidance of naps, 2) regular meals, 3) adequate fluid hydration, 4) light noncontact physical activity (ie, walking, with progressions recommended by a physician), and 5) stress management techniques. Use of these strategies immediately can help in preventing against increased symptoms and stress, and decreases the need for medication in select cases. Additionally, over-the-counter medications should be limited to 2 to 3 doses per week to avoid rebound headaches.[28]

In-Office Concussion Management

Athletes diagnosed with SRC will experience different symptoms based on the injury mechanism, risk factors, and management approach. Comprehensive evaluation should include assessment of risk factors, injury details, symptoms, neurocognitive functioning, vestibular/oculomotor dysfunction, tolerance of physical exertion, balance functioning, and cervical spine integrity (if necessary).[29,30] Due to individual differences and the heterogeneous symptom profiles, concussion management must move beyond a "one size fits all" approach to avoid nonspecific treatment strategies and consequently prolonged recoveries.[29] Clinicians and researchers at University of Pittsburgh Medical Center have identified 6 concussion clinical profiles (ie, vestibular, ocular, posttraumatic migraine, cervical, anxiety/mood, and cognitive/fatigue) that are generally identifiable 48 hours after injury.[29,30] Identification of the clinical profile(s) through a comprehensive evaluation guides the development of individualized treatment plans and targeted rehabilitation strategies.[29,30]

Vestibular. The vestibular system is responsible for stabilizing vision while the head moves and balance control.[15] Athletes can experience central and/or peripheral vestibular dysfunction to include benign paroxysmal positional vertigo (BPPV), visual motion sensitivity, vestibular ocular reflex impairment, and balance impairment.[30,31] Symptoms typically include dizziness, impaired balance, blurry vision, difficulty focusing, and environmental sensitivity.[15,29,30] Potential treatment options include vestibular rehabilitation, exertion therapy, and school/work accommodations.

Ocular. The oculomotor system is responsible for control of eye movements. Athletes can experience many different posttraumatic vision changes, including convergence problems, eye-tracking difficulties, refractive error, difficulty with pursuits/saccades, and accommodation insufficiency. Symptoms typically include light sensitivity, blurred vision, double vision, headaches, fatigue, and memory difficulties.[15,29,30] Potential treatment options include vision therapy, vestibular rehabilitation, and school/work accommodations.[32]

Posttraumatic Migraine. Headache, the most common post-concussion symptom, can persist and meet criteria for posttraumatic migraine (ie, unilateral headache with accompanying nausea and/or photophobia and phonophobia).[29,30,33] Implementation of a routine schedule, daily physical activity, exertion therapy, pharmacologic intervention, and school/work accommodations are potential treatment options.

Cervical. The cervical spine can be injured during whiplash-type injuries. Therefore, determining the location, onset, and typical exacerbations of pain can be helpful in identifying cervical involvement.[29,30] Symptoms typically include headaches, neck pain, numbness, and tingling. Evaluation and

therapy by a certified physical therapist and pharmacologic intervention (eg, muscle relaxants) are potential treatment options.[29,30]

Anxiety/Mood. Anxiety, or worry and fear about everyday situations, is common post-concussion and can sometimes be related to ongoing vestibular impairment. Symptoms typically include ruminative thoughts, avoidance of specific situations, hypervigilance, feelings of being overwhelmed, and difficulty falling asleep.[29,30] Potential treatment options include implementation of a routine schedule, exposure to provocative situations, psychotherapy, pharmacologic intervention, and school/work accommodations.[34]

Cognitive/Fatigue. A global concussion factor (including cognitive, fatigue, and migraine symptoms) has been identified within 1 to 7 days of injury. Although this factor of symptoms generally resolves during the acute recovery period, it persists in select cases.[13] Symptoms typically include fatigue, decreased energy levels, nonspecific headaches, potential sleep disruption, increased symptoms towards the end of the day, difficulty concentrating, and increased headache with cognitive activities.[29,30,35] Routine schedule, daily physical activity, exertion therapy, pharmacologic intervention (eg, amantadine), and school/work accommodations are potential treatment options.[30]

Conclusion

Advancements in SRC management warrant change in the conversations regarding concussion in football. Specifically, conversations should address the current understanding of concussion and improvements in the safety of football through stricter concussion guidelines, detailed sideline evaluations, recognition of risk factors, improved acute management, and identification of concussion profiles that help to direct individualized treatment plans and targeted rehabilitation strategies. The biggest concerns related to concussions in football include underreporting of injury, premature return to play, and receiving routine rather than individualized treatment. Therefore, to further improve the safety of football and management of concussion it is essential that future efforts focus on the following 6 areas:

Education: Improved understanding of concussion is imperative to reducing poor outcomes and widespread concerns.

Immediate reporting: Reporting of concussion must be expected and encouraged through consistent responses by coaches to reduce underreporting and fear of reporting in athletes.

Prevention techniques: Athletes must be taught proper form and playing techniques to reduce the risk for concussion. Proper form and technique should be incentivized.

Targeted treatment: Individualized treatment plans and targeted rehabilitation strategies must be developed based on the identified clinical profile(s) to avoid nonspecific treatment recommendations.

Multidisciplinary treatment teams: Given the heterogeneous symptoms profiles and need for care provided by different medical specialties, multidisciplinary teams are essential.

Remain current: With the progress in understanding concussion, providers must remain vigilant of future advances in concussion management to further improve the safety of football.

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Erratum

In the Editorial Board Biographies in the May/June issue (*Am J Orthop.* 2016;45(4):198), Associate Editor Jose B. Toro, MD, was incorrectly listed as director for orthopedic traumatology at Cohen Children's Medical Center Hospital. Dr. Toro does not hold that position.