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Community Awareness of Youth Sport Related Concussion: A Neuropsychological Perspective

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Abstract

There continues to be growing public awareness regarding concussions and the detrimental effects sustaining such an injury can have on one's life. Of increased importance is the understanding of how concussions impact children and adolescents, particularly as a result of sport engagements. Contact sports involving youth account for 41% of the concussions seen in emergency departments (Waltzman et al., 2020). Of note, hospital estimates tend to underrepresent the total number of sport-related concussions as they do not factor patients treated in a community setting (Bazarian et al., 2020). In consideration of this public health epidemic, there is a current projection of 1.6 to 3.8 million concussions per year in the United States (Hiasat & Nischal, 2020). This number is based on individuals and their families who sought out treatment and neglects to account for the injuries that are unreported for a variety of reasons (e.g., injuries that the individual, their parents, coaches, athletic director, or the community did not recognize as a sustained concussion at the time of or after the injury). While there have been efforts to better educate youth athletes, their parents, and the community, large gaps in knowledge and misconceptions prevail regarding the definition of a concussion and what to do in the case of a potential concussion. In attempts to address these deficits, this article strives to define and expand upon various components associated with concussions. Factors to be addressed in this current review consist of the signs and symptoms of concussion, methods of diagnosis, the process of returning to learn and play (following an evaluation), and the various factors that impact the recovery process.

Keywords

Neuropsychology, Concussion

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What is a concussion?

An international symposium on concussion in sport has identified criteria associated with the term concussion and the various features associated with this type of injury (McCrory et al., 2009). The decided upon criteria are as follows. First, concussions are the result of any direct and traumatic blow to the head, face, neck, or anywhere else on the body in which the impact jolts the brain. Second, these injuries result in the sudden onset of various neurological impairments, which may resolve spontaneously and are typically brief in nature. These can include headaches, feelings of nausea, visual changes, dizziness, and other physiological manifestations. Third, the signs and symptoms associated with concussions typically demonstrate the presence of functional impairments as opposed to structural injuries. These functional impairments are evaluated via neurocognitive testing, subjective symptom report, and neurobehavioral assessments (Dambinova et al., 2016). Fourth, loss of consciousness may occur; however, this is not a requirement for a concussion diagnosis. Fifth, concussions cannot yet be seen or discovered with neuroimaging, such as MRI or CT scans (McCrory et al., 2009). Positive findings or abnormalities on neuroimaging would indicate a more severe injury which is not consistent with a concussion. Additionally, the signs and symptoms typically resolve in the order in which they appeared, which may be prolonged in some situations and due to various factors. As demonstrated by these criteria, it is imperative that youth athletes, their parents, and members of the community understand that the identification of a concussion goes beyond pure external observations and/or self-reported symptoms.

Concussion Identification

Identifying concussions are oftentimes not as clear cut as one may hope. This injury can easily go undetected by both the observer and athlete if they are not aware of what signs and symptoms to look out for. To clarify the distinction between signs and symptoms of a concussion, it can be helpful to think of a sign as what a coach or parent can observe, and a symptom as what the athlete reports. Common signs of concussion may include loss of balance, forgetfulness of instruction, appearing dazed, and immediate changes in mood. Symptoms of concussion typically fall in the four categories of physical, cognitive, emotional, and/or sleep related. Of note, it is common for athletes to demonstrate signs and symptoms from multiple categories after sustaining a concussion. The physical

symptoms may consist of headache, dizziness, balance difficulties, and visual changes. Cognitive symptoms are characterized by confusion, disorientation, memory loss, mental fogginess, and difficulty concentrating. Emotional symptoms that are commonly reported include irritability and changes in mood. Lastly, sleep related symptoms often consist of drowsiness, sleeping less than usual, sleeping more than usual, and difficulty falling asleep (Ferry & DeCastro, 2023).

The acute phase of concussion occurs within the first 10 days post-injury (Dougan, Horswill, & Geffen, 2014). A common misconception to be addressed is that symptom onset must occur immediately following the injury. This highlights the importance of continual monitoring and assessment of an athlete's signs and symptoms after experiencing a possible concussion. Adolescents, especially female athletes, have been identified as the most susceptible to concussions when compared to children and adults (Baillargeon, Lassonde, et al., 2012; Kostyun & Hafeez, 2014), with lasting working memory deficits being observed following a concussion (McCrory et al., 2017). To begin treatment in response to these symptoms, first-line diagnostic assessments, such as the Glasgow Coma Scale, are often utilized (Dougan, Horswill, & Geffen, 2014).

The Glasgow Coma Scale (GCS)

The Glasgow Coma Scale (GCS) is a well-known quantitative scale used to measure one's level of consciousness and severity of brain injury (DeMatteo, 2010). Formulated in 1974, the GCS measures the domains of eye functioning, verbal functioning, and motor functioning, with scores ranging from 0 (most severe) to 15 (least severe). Scores between 13-15 are interpreted as "mild brain injury," 9-12 as "moderate brain injury," and any score less than or equal to 8 as "severe brain injury" (DeMatteo, 2010). The GCS is both an immediate assessment tool for the severity of brain injury and a prognostic tool for predicting recovery rates and success (Brown & Fleiszer, 2015). According to Ly et al. (2022), most individuals with a sports-related concussion will score between a 13 and 15 on the GCS, as concussions are often referred to in the literature as mild traumatic brain injuries (mTBI). While the reliability and validity of the GCS tends to fluctuate across injury severity, current literature suggests this assessment tool has excellent interrater reliability for mild brain injuries, such as concussion (Kebapci et al, 2020).

Some researchers suggest using the extended Glasgow Coma Scale (GCS-E) as a more sensitive assessment tool for mild traumatic brain injuries. The GCS-E is a modified version of the GCS with the addition of an amnesia scale that ranges from 0 to 7 (most severe to least severe) to assess an individual's memory following a concussion. While a GCS score of 15 may suggest the absence of a

concussion, the GCS-E may identify memory difficulties characterized by the inability to recall details prior to the injury, indicating a false negative concussion diagnosis (Grubenhoff et al., 2016). To ensure a comprehensive assessment of athletes' reported symptomatology and cognitive functioning, it is recommended that medical staff utilize the GCS-E over the GCS (Grubenhoff et al., 2016). Additionally, neuropsychological assessments are frequently used as an additive component to concussion evaluation to fill gaps in concussion diagnosis and detect subtle changes within concussed patients (Grubenhoff et al., 2016). Obtaining as much information as possible about an athlete's concussion symptomatology is essential for a successful recovery. Therefore, the combined use of the GCS-E and neuropsychological assessments is recommended to provide a more accurate and comprehensive evaluation of concussion severity and prognosis.

How common are concussions?

As previously noted, there is a current projection of up to 3.8 million sport-related concussions per year in the United States (Hiasat & Nischal, 2020). Pfister and colleagues (2016) conducted a comprehensive systematic review of concussion in youth athletes which identified rugby, ice hockey, and American football as the top three sports with the highest concussion rate. Following these top three in order of highest concussion rate for youth sports are lacrosse, soccer, wrestling, basketball, softball, baseball, and cheerleading.

Another factor to consider regarding the commonality of concussions is rate of injury and sex differences across development. The demographics of youth athletes and concussion rates shift from predominantly males to females throughout childhood to adolescents (Snedaker et al., 2022). Snedaker and colleagues further noted that males were more likely to present with a concussion at elementary and middle school ages, while females had a higher rate of concussion in high school (2020). One possible explanation for this shift is likely attributed to the increased muscular development particularly in boys during puberty (Nutt et al., 2022). The overall increased neck strength in boys compared to girls in the adolescent stages may be seen as a protective factor for concussion susceptibility. Another consideration regarding sex differences and concussion rate is that females are more likely to report higher levels of fatigue and psychological distress than males post-acute mTBI (Anderson & Jordan, 2021). This finding is consistent with the extant literature which suggests females are less likely to internalize their symptoms and more likely to seek help compared to their male counterparts. The identification of these findings is important to increase community awareness so that there is equitable representation for concussion management for all youth athletes.

The prevalence of unreported concussions is another important concern for health care professionals, as estimates of concussion rates are likely lower than the actual incidence (Langlois, Rutland-Brown, & Wald, 2006). As previously noted, research suggests that female athletes are more likely to report concussions than males. However, both genders may still under report their symptoms due to a belief that their concussions are not severe enough to warrant a report (Miyashita, Diakogeorgiou, & VanderVegt, 2016). Gessel and colleagues (2007) compared the rates of concussion among high school and collegiate athletes and found that the incidence of concussion was higher in collegiate athletes than high school athletes. Interestingly, high school athletes reported concussions at lower rates than collegiate athletes, although concussions made up a larger percentage of total injuries reported in high school than at the collegiate level. High school athletes cited a lack of concussion awareness, underestimation of the severity of the injury, and reluctance to withdraw from competition as reasons for not reporting their symptoms (Gessel, Fields, et al., 2007). Overall, it is important to closely monitor concussions in school-aged athletes, as they may not voluntarily report symptoms which increase their risk for subsequent injuries.

Underreporting concussion symptoms remains a public health concern as athletes who do not report their injury are at risk for exacerbated symptomology and permanent neurological damage. Register-Mihalik et al. (2013) found that increasing knowledge and fostering positive attitudes towards concussion reporting were associated with higher and more accurate rates of symptom reporting in high school athletes. However, Kroshus and colleagues (2015) suggested that interventions should also focus on creating a supportive environment that promotes concussion reporting, as athletes who feel pressure from teammates, coaches, parents, and fans are less likely to report concussion symptoms in the future. This was further evidenced by more than half of the NCAA athletes who reportedly continued to play with concussion symptoms and were less likely to report future symptoms due to increased pressure from all four sources (Kroshus et al., 2015). Collectively, these results suggest that a multifaceted approach that includes better education, promoting positive attitudes, and creating a supportive reporting environment may be the most effective way to reduce the incidence of concussion under-reporting in sports.

Role of Neuropsychology in Diagnosis and Treatment

The National Collegiate Athletic Association (NCAA) recognizes the important role of neuropsychological testing in baseline assessments and in determining the impact of concussions (National Collegiate Athletic Association, 2022). While there is some discrepancy as to who should administer these assessments, it is widely agreed that the interpretation of the measures is best suited for a

neuropsychologist (Echemendia, R.J., Herring, S., & Bailes, J, 2009). Neuropsychologists bring a unique perspective to concussion diagnosis and management, providing insight into the cognitive, behavioral, and socio-emotional aspects of each case (Echemendia, R.J & Cantu R.C, 2003; Echemendia, R.J., Herring, S., & Bailes, J, 2009). They tailor their findings to each unique case by understanding neurocognitive assessment performance in congruence with the symptoms of diagnosis and recovery.

Neuropsychologists are trained to conduct assessments in a therapeutic and respectful manner, empathizing with athletes experiencing the stressors of a sport-related concussion (Echemendia, R.J., Herring, S., & Bailes, J, 2009). Moreover, neuropsychologists are trained to educate patients about their symptoms, diagnosis, and the short-term and long-term effects of a concussion. In the context of youth sports, neuropsychologists serve as an advocate for athletes both on and off the field and are committed to accurate diagnosis and management of concussions in order to maximize the athlete's overall health and well-being.

Neuropsychological approach

Neuropsychological testing is a crucial component of a multidisciplinary approach to sports-related concussions, as cognitive recovery and symptom resolution do not always coincide (McCrory et al., 2013). Neuropsychological testing identifies areas of strength and weakness, provides recommendations for treatment, and aids in care management throughout the recovery process. When evaluating the recovery process, it is important to understand how the athlete was functioning prior to the injury. This estimate is best known as one's premorbid functioning level. Measures used may include the Wechsler Intelligence Scale for Children – Fifth Edition (WISC-V), Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV), Wide Range Achievement Test, Fifth Edition (WRAT-5) word reading, Test of Premorbid Functioning (TOPF), and Wechsler Test of Adult Reading (WTAR) (McCrory et al., 2013; Belanger & Vanderploeg, 2005).

According to McCrory et al. (2013), brief formal neuropsychological assessment may be necessary for some athletes, particularly those who are asymptomatic. Neuropsychological assessment batteries for sports-related concussions incorporate measures assessing domains of attention and working memory, processing speed, executive functioning, and memory, particularly learning and retrieval. These domains can also be measured via computerized assessments such as the Sports Concussion Assessment Tool (SCAT-3), Headminder Concussion Resolution Index, CNS Vital Signs, Axon Sports Computerized Cognitive Assessment Tool (CCAT), the Immediate Post-concussion Assessment and Cognitive Testing (ImPACT), and most recently

SportGait. Computerized assessments are widely used to diagnose and manage concussions, although clinicians also use paper and pencil neuropsychological measures to capture cognitive domains that computerized tests do not capture (McCrory et al., 2013). Some examples of paper and pencil neuropsychological tests that are commonly used in the management of sport-related concussion include the Digit Span and Symbol Search subtests of the Wechsler Intelligence Scales, Trails A and B, D-KEFS, and the RBANS. In addition to cognitive testing, the Balance Error Scoring System (BESS) and vestibular/ocular-motor screening (VOMS) are important for assessing balance and additional vestibular and ocular motor impairments (Dziemianowiez et al., 2012; Collins et al., 2014).

How long will my child have concussion symptoms?

The recovery time for concussions is often unique to each athlete and should be treated as an individualized process (Williams et al., 2015). On average, high school athletes require 15 days to reduce their symptoms, while collegiate athletes require six days. These findings are contrary to other literature that suggests a 7–10-day recovery period is necessary (Belanger & Vanderploeg, 2005). The overall discrepancy in recovery time emphasizes the need for more consideration when working with younger athletes. The Consensus Statement on Concussion in Sport (McCrory et al., 2017) suggests that children and adolescent athletes may experience longer recovery times compared to older athletes, with symptoms potentially persisting for over a month. This is because children's brains are still developing and strengthening connections within, a process known as myelination, which may prolong certain concussion symptoms such as memory loss (Perrine, 2017). Additionally, lingering effects of concussions in the brain may persist for up to one month (Mayers, 2008). The field of neuropsychology can provide diagnostic testing and create tailored treatment plans to address these effects. Along with differences in brain and physical development and symptom reporting, individual differences may also play a role in concussion recovery rates.

Demographic factors

The recovery time for sport-related concussion is influenced by a range of factors such as sex, age, years of education, and other personal factors (Belanger & Vanderploeg, 2005; Dougan et al., 2014). In the acute phase following concussion, females, high school level athletes, and individuals with less education tend to experience more severe symptoms compared to males, college-level athletes, and individuals with higher education (Dougan et al., 2014). The biological processes of recovery in children and adolescents may be responsible for the longer recovery periods in this population (Williams et al., 2015). Given

these individual differences, a personalized approach to concussion management is essential to ensure proper recovery and prevent future injuries (McCrory et al., 2017). Moreover, returning younger athletes to play too soon may lead to increased risks of future injuries, longer symptom recovery times, and risk of post-concussion syndrome (PCS).

Post-concussion syndrome (PCS)

Post-concussion syndrome (PCS) is a possible outcome following mild traumatic brain injury. PCS is defined as a collection of symptoms lasting beyond the expected recovery period after the initial head injury (Mayo Clinic, 2017). The severity of the injury itself does not affect the risk of PCS (Mayo Clinic, 2017). PCS is particularly prevalent in children, with up to 33% experiencing persistent symptoms following a concussion (Chadwick, Sharma, et al., 2022). Risk factors for developing PCS include increased age, sex, and specific types of traumas (i.e., motor vehicle accidents, falls, and sports injuries) (Mayo Clinic, 2017). Symptoms of PCS typically appear within the first seven to ten days and can persist for three months to one year. These symptoms may include headaches, dizziness, fatigue, irritability, anxiety, insomnia, loss of concentration, memory loss, and sensitivity to noise and light (Eisenberg et al., 2014). The presence of PCS is likely to guide the considerations and recommendations throughout the recovery process, with notable emphasis on the athlete returning to school and sport.

Return to Learn

The return-to-learn approach is individualized and case specific depending on the recovery progress of the individual. Athletes are to be removed from academic settings immediately on the day of the reported and subsequently evaluated concussion (NCAA, 2020). Prior to the athlete progressing back to sport, they are encouraged to fully progress back into academics. This process can be complicated by the symptoms of concussion with notable disruptions in attention, concentration, memory, and overall fatigue. Depending on concussion severity, a common return to learn trajectory consists of no school for one to two days post-injury, followed by half-day attendance, and progressing to full school day attendance as tolerated by the athlete. The academic progression plan is an individualized process created by the athlete, family, and treatment team. A mentor from the institution is to be identified to help the athlete navigate the return-to-learn process and adjust courseload as needed. In complex cases, a multidisciplinary approach is utilized with the possible consultation of numerous

experts in different areas of health professions to determine when an athlete can return to academic settings without the provocation of symptoms.

Return to Play

Generally, the progression to return-to-play begins with symptom-limited activities, such as light aerobic workouts with no resistance. Activity then increases to more intense and specific exercises unique to the sport until a threshold is reached in medical clearance by the team physician, resulting in a return-to-play (Mayers, L., 2008; McCrory P., Meeuwisse W., Dvorak J., et al, 2017; NCAA, 2020). Each step is estimated to take approximately one day assuming there is no identifiable symptoms. It should be noted that return-to-play should not occur prior to unrestricted return-to-learn (NCAA, 2020). Of note, the return-to-play process is multidisciplinary and can involve an entire team of health professionals, including the athletic training staff, medical doctors, counselors, and neuropsychologists (Echemendia, R.J., 2003; NCAA). The consensus within the field is that this recovery and return-to-play process is unique to the individual and therefore, guidelines should be adapted based on the symptom presentation of the individual being assessed (McCrory P., Meeuwisse W., Dvorak J., et al, 2017; NCAA; Williams R.M, Puetz, T.W, Giza, G.C & Broglio, S.P, 2015).

The Need for Continued Education

McCrea and colleagues (2004) found that nearly 50% of high school football players who had suffered a concussion failed to report the injury, suggesting that youth athletes continue to under-report concussions. This may be due to not wanting to be pulled from play or not wanting to let their team down (McCrea et al. 2004; Register-Mihalik et al., 2013). Additionally, the application of an athlete's knowledge on sports-related concussion is not always followed, as a study by Sye et al. (2010) revealed that nearly 72% of athletes believed an individual with a suspected concussion should be able to play an important game in the season. A study by Bloodgood et al. (2013) reported that younger youth were more receptive to concussion information (13-15 years) than older youth (16-18 years). In a 2014 survey of high school football players, most players did not have adequate knowledge regarding concussion symptoms and consequences (Cournoyer & Tripp, 2014). Of the 75% of players that had received concussion education, only 54% of players reported learning from their parents. Moreover, parental subgroups which included parents who used the internet one to two times per week and had children aged 18-25 years old were among those with limited knowledge of sports-related concussions. Contrarily, parents who used the

internet multiple times a day and had children ages 10-13 years old were found to be more receptive to information regarding sports-related concussions. Swift and Wilson (2001) indicated that parental perceptions and understanding of concussions reflect a lack of understanding and awareness of the signs and symptoms, including the time frame of concussion recovery and the visibility of signs and symptoms of concussion. Therefore, parents may be susceptible to assuming the coaches and athletic trainers are well educated and follow the procedures to ensure their child's safety (Macdonald & Hauber, 2016). Overall, the limited knowledge of youth sport-related concussions may skew the perceived responsibility for care across members in the community. This further emphasizes the need for continued education regarding the misconceptions that surround concussions among the youth population.

Conclusion

Identifying and managing a concussion is a complex process that requires sufficient support, knowledge, and engagement from all members in the community. In both a community and clinical context, it is important to be aware of the common signs and symptoms associated with concussions (McCrea et al., 2013). Once a concussion has been identified, it is recommended the athlete follow-up with a multidisciplinary sports medicine team for further assessment and treatment. One member of this team is likely to be a Clinical Neuropsychologist who will utilize neurocognitive testing to assess the athlete's overall cognitive functioning following their concussion. Furthermore, the integrated efforts of the multidisciplinary team will help guide and determine when the athlete is ready to return to learn and play (McCrory et al., 2017).

All in all, youth sport-related concussions continue to remain a public health concern that needs to be addressed. Additionally, more effort should be put into safety, identification of signs and symptoms, and continued education to reduce the incidence rates of concussions (Kroshus et al., 2018). It is imperative for the medical and general community to take a proactive stance on a reactive injury that often results in various cognitive, emotional, and behavioral disturbances for athletes. A call to action from teams, schools, and states will provide a strong foundation for the community to maximize the safety of our youth athletes. This can be done by continuing to collect data surrounding concussion reports, immediate medical responses, and longitudinal outcomes to better understand concussion patterns and prevention.

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