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Current Issues in Pediatric Sports Concussion

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This article reviews current issues in the following areas of pediatric sports-related concussion: incidence of concussion, potential long-term effects, return to play, and the emergence of legislation regarding concussion education and management programs. Incidence of concussion is presented in context of emergency room visits, as well as under-reporting of concussions. The literature on history of concussion is reviewed, for high school, collegiate, and professional athletes, with respect to potential long-term effects of cerebral concussion. Specific discussions of effects include: decreased cognition and increased symptom reporting following multiple concussions, and recent diagnoses of chronic traumatic encephalopathy in non-professional and youth athletes. Recent legislative and advocacy efforts are reviewed, including mandated programs in specific states.

Keywords: Concussion; Mild traumatic brain injury; Long-term effects.

INCIDENCE OF CONCUSSION

According to the Center for Disease Control (CDC), there are over 1.3 million annual hospital emergency room visits due to a suspected traumatic brain injury (TBI) (Faul, Xu, Wald, & Coronado, 2010). Children ages 0–4 are responsible for the most ER visits, at a rate of 1091 per 100,000, while children ages 5–14 visit at a rate of 458 per 100,000 (Rutland-Brown, Langlois, Thomas, & Xi, 2006). There are approximately 144,000 annual ER visits specifically for concussion in children ages 0–19 (Meehan & Mannix, 2010). Approximately 4/1000 children ages 8–13 years (e.g., pre-high school) and 6/1000 children ages 14–19 years (e.g., high school) had an ER visit for sports-related concussion between 2001 and 2005 (Bakhos, Lockhart, Myers, & Linakis, 2010). The overwhelming majority of these visits result in discharge, with only 13% being admitted for treatment (Bazarian, McClung, Cheng, Flesher, & Schneider, 2005). Concussion awareness appears to be on the increase; researchers have noted that even though high school-aged athletes (e.g., 14–19) showed declines in participation in organized sports, ER visits for concussions sustained in organized sports increased over 200% from 1997–2007 (Bakhos et al., 2010).

In the United States, there are an estimated 200 TBIs per 100,000 Americans, and approximately 80% of annual TBIs are classified as mild (Sorenson & Kraus, 1991). Stratification of annual incidence of concussions is quite difficult. Extrapolating from 2009 US Census data, and using long-standing estimates of

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200/100,000, annual incidence of TBI is approximately 600,000 per year, of which 491,000 are mild TBIs (see Figure 1). These numbers are far from the reported 1.5 million annually by the CDC (Thurman et al., 1999), which would require a rate of 500/100000. With respect to incidence across the ages represented by youth athletes, 200/100,000 is an average incidence across all ages from numerous studies, representing a range of 180/100,000 for children ages 0–4, up to 300/100,000 for children 15–19. Normalized mild TBI incidence, according to actual age-based data, increases as a function of increasing age (see Figure 2).

It has been estimated that there are 300,000 TBIs occurring from sports-related activities each year in the United States (Sosin, Sniezek, & Thurman, 1996). However, given the number of youth participating in multiple sports, as well as the findings that incidence of mild TBI is under-reported (Booher, Wisniewski, Smith, & Sigurdsson, 2003; McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004), these may represent an underestimation of the incidence of mild TBI. As an example, approximately 5.6% of high school football players sustain a concussion within a season (Guskiewicz, Weaver, Padua, & Garrett, 2000), and this estimation increases to 15% when accounting for unreported concussions (Williamson & Goodman, 2006). Again, verification of reported estimates is difficult. Extrapolating from age-based population data (US Census Bureau, 2009) and rates of ER visits for concussion by age group (Bakhos et al., 2010), there are over 260,000 concussions in high school and college-aged children each year (see Figure 3). Using population-weighted estimates of concussion incidence (Gessel, Fields, Collins, Dick, & Comstock, 2007), the combined incidence of concussions in these age groups is

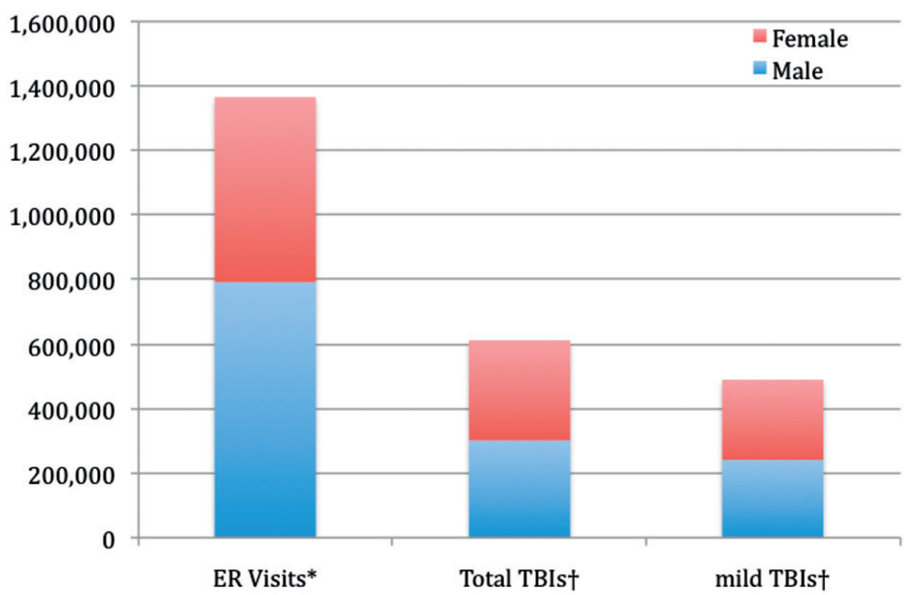

Figure 1 Incidence of emergency room, TBI, and mild TBI by gender. *Emergency room visits extrapolated from U.S. Census Bureau: 2009 Population Estimates and Projections and average annual rates from Faul et al. (2010). †Incidence data based on 2009 US Population Estimates and Projections data and 200/100,000 for TBI and 160/100,000 (80%) for mTBI (Sorenson & Kraus, 1991).

nearly 140,000, which is significantly higher than age-based estimates of mild TBI based in incidence per 100,000 (Kraus, 1993).

Female athletes typically sustain concussions at a higher rate than male athletes (Gessel et al., 2007). Explanations range from a smaller size and weaker neck strength for female athletes to a more aggressive male athlete who is playing a faster-paced sport (Barnes et al., 1998) and is more adept at protecting himself from

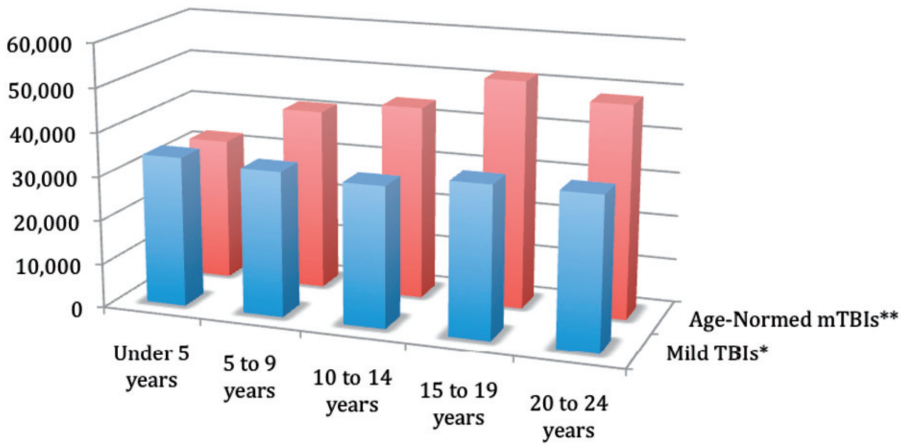

Figure 2 Incidence of mild TBI by age. *Mild TBI data extrapolated from US Census Bureau, Population Estimates Program, 2009 Data, and incidence of 160/100,000 (80% of TBIs; Sorenson & Kraus, 1991). **Age-normed mild TBI data extrapolated from US Census Bureau, Population Estimates Program, 2009 Data, and average rates per 100/000 by age group from Kraus (1993).

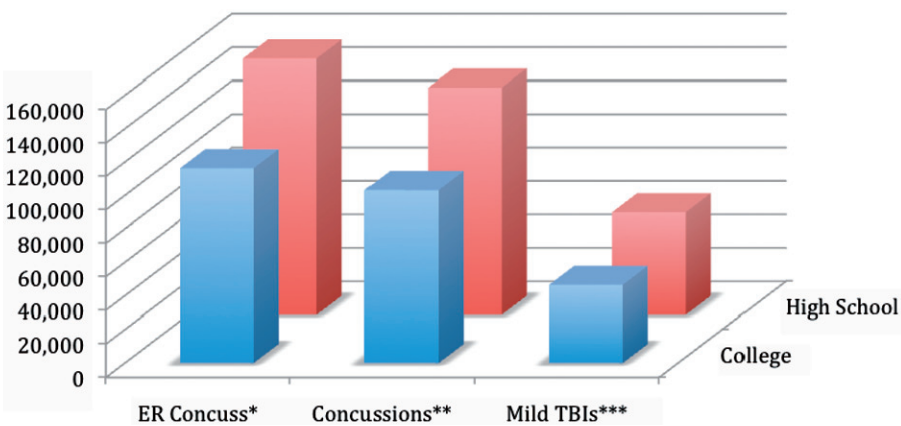

Figure 3 Emergency room visits for concussion, concussion rates, and population-based mild TBIs for high school and college-aged students. *Emergency room visits for concussion based on 2009 US Census Report data and age-group data for ER visits for concussion from Bakhos et al. (2010). **Concussion incidence data based on weighted national estimate of annual concussions in HS athletes, and extrapolated for college students (Gessel et al. 2007). ***Mild TBI incidence based on average TBI rate by age group from Kraus (1993).

injury (Boden, Kirkendall, & Garrett, 1998). At the high school level, comparing concussion incidence across similar sports reveals a slightly higher rate for girls vs boys in soccer (6.2% vs 5.7%), basketball (5.2% vs 4.2%), and softball/baseball (2.1% vs 1.2%) (Powell & Barber-Foss, 1999). At the collegiate level, female athletes are more likely to sustain concussions during games, and male athletes are more likely to sustain concussions during practices, with the highest incidence of concussion coming from women's soccer and men's lacrosse (Covassin, Swanik, & Sachs, 2003).

DEFINING CONCUSSION AND ITS EFFECTS

Concussion, or mild TBI, has been defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces (McCrory et al., 2009). It is important to note that concussion may result from a direct blow to the head, or through forces translated to the head from another part of the body (e.g., whiplash). A concussion is typically characterized as a transient, or temporary, condition with a brief period of impairment followed by spontaneous recovery. Sustaining a concussion may or may not involve a loss of consciousness (LOC) (McCrory et al., 2009). While LOC has been associated with post-concussion symptoms in children (Yeates et al., 2009), it has not been associated with severity of deficits or symptoms in adults with mild TBI (Lovell, Iverson, Collins, McKeag, & Maroon, 1999; Sterr, Herron, Hayward, & Montaldi, 2006). Clinical presentation of concussion can involve the presence of a number of symptoms, which are typically categorized as physical, cognitive, emotional, and/or sleep (see Table 1). Neuroimaging (e.g., CT, MRI) is typically normal following a concussion, making such neuroimaging techniques of little use in diagnosis. Rather, concussion is viewed as a metabolic injury, with a disruption in glucose metabolism and regional cerebral blood flow (Giza & Hovda, 2001). This metabolic "cascade" is characterized by a mismatch between energy supply and demand, and may extend up to 7–10 days post-injury. This recovery time frame is supported by behavioral data in which concussed collegiate athletes required 7–10 days for performance on neuropsychological testing to return to pre-season levels (Alves, Rimel, & Nelson, 1987).

Table 1 Physical, cognitive, emotional, and sleep symptom clusters

Physical	Cognitive	Emotional	Sleep
• Headache	• Feeling mentally "foggy"	• Irritability	• Drowsiness
• Nausea	• Feeling slowed down	• Sadness	• Sleeping less than usual
• Vomiting	• Difficulty concentrating	• More emotional	• Sleeping more than usual
• Balance Problems	• Difficulty remembering	• Nervousness	• Trouble falling asleep
• Dizziness			
• Visual Problems			
• Fatigue			
• Sensitivity to light			
• Sensitivity to noise			

Symptom clusters from Pardini et al. (2004).

A second concussive injury, while the brain is still in this metabolic cascade/imbalance, can have catastrophic effects. In these rare cases of "second impact syndrome" there is an immediate, devastating brain response, which involves a loss of intracranial autoregulation, diffuse cerebral bleeding, cerebral edema, and brainstem failure (Fischer & Vaca, 2004). This phenomenon of second impact syndrome has been observed in athletes ages 16–23, typically without a loss of consciousness at the time of the second impact (Mori, Katayama, & Kawamata, 2006). In animal models the greatest vulnerability to a second MTBI was after 24 hours, and greatest at 3 days (Tavazzi et al., 2007; Vagnozzi et al., 2007), however these findings have yet to be applied to humans.

Researchers hypothesize that the human brain may be more vulnerable to concussion during critical pre-adolescent developmental periods (Giza & Hovda, 2001). However, the dangers of sports-related concussion appear to extend beyond the critical 7–10-day window of documented vulnerability, as well as pre-adolescent ages. High school athletes (ages 14–18) were found to have prolonged cognitive recovery following concussion (e.g., working memory, processing speed, reaction time), in comparison to college athletes (ages 18–25) (Field, Collins, Lovell, & Maroon, 2003). This raises the question of whether pediatric, high school, and collegiate athletes should be evaluated using different return-to-play (RTP) criteria. Consensus experts extended the RTP criteria developed for collegiate and professional athletes to youth athletes ages 5–18, with the caveat that children should not return to training or play until they were symptom free (McCrory et al., 2004). These guidelines were updated to include the need for a more conservative RTP approach, with extended rest and graded exertion until completely symptom free (McCrory et al., 2009). At present there are still no specific guidelines for managing concussions in youth athletes, and no differentiation between pediatric, adolescent, and high school athletes. While neuropsychological assessment is thought to contribute significant information and is an important component in RTP decisions (McCrory et al., 2009), the most widely used neuropsychological screening measures are not recommended for youth athletes younger than 10 years of age (ImPACT, Cogsport) or high school age (HeadMinder CRI). However, while these instruments may include normative date for youth, none of these programs has specific versions for children or youth athletes. Development of youth-specific measures, and establishment of psychometric properties by individuals other than the manufacturers, would be of considerable benefit to youth athletes as well as the clinicians serving them.

LONG-TERM EFFECTS OF CONCUSSION

Research has shown athletes have decreased performance on baseline neurocognitive testing on the basis of multiple previous concussions (Collins et al., 1999; Moser, Schatz, & Jordan, 2005). History of concussion has also been associated with prolonged recovery in a mixed high school and collegiate sample (Iverson, Gaetz, Lovell, & Collins, 2004). Professional athletes with a history of concussion were found to be three times more likely to experience depression (Guskiewicz et al., 2007), and five times more likely to experience mild cognitive impairment (Guskiewicz et al., 2005). Repetitive head trauma has been linked to progressive neuropathological deterioration, known as chronic traumatic encephalopathy (CTE). CTE has been identified in over 50 cases to date, and is associated with behavioral (e.g., memory disturbances, personality changes, Parkinsonism, and speech and gait abnormalities) as well as neuropathological changes (e.g., cortical atrophy and extensive tau-immunoreactive neurofibrillary tangles) (McKee et al., 2009). Once typically observed in professional athletes, CTE has recently been identified in a collegiate athlete with no professional sport exposure and no history of concussion (Schwarz, 2010c), as well as in an 18-year-old high school athlete (Hohler, 2009). Such findings, especially in athletes with no documented history of concussion, may challenge the belief that football players experience numerous "subclinical collisions" over the course of their athletic careers, from which recovery is relatively rapid (Pellman et al., 2004).

History of concussion has also been linked to increased symptom endorsement in high school athletes: otherwise healthy, not recently concussed students with a history of two or more concussions reported significantly more concussion-related symptoms at the time of baseline testing (Schatz, Moser, Covassin, & Karpf, 2011). These results suggest that repetitive mild head trauma in youth may result in more frequent endorsement of symptoms associated with CTE. Given that over 60% of high school athletes have been identified as having sustained at least one previous concussion (Moser et al., 2005), and individuals with a history of concussion are at 3–6 times greater risk of sustaining another concussion (Guskiewicz et al., 2003; Kelly & Rosenberg, 1997), there appears to be a growing population of youth athletes who may experience as-yet-undiagnosed cognitive impairment later in life.

IDENTIFYING AND TREATING CONCUSSION SYMPTOMS

The risk of possible long-term impairment following concussion increases the need for careful identification of any concussion symptoms in the athlete. Thus any athlete who exhibits signs of concussion (e.g., fatigue, headache, disorientation, nausea, vomiting, feeling in a fog) should not be allowed to return to play (Cantu, 2003). Given the availability of numerous paper-based and computer-based concussion tests and testing programs (e.g., SAC, ImPACT, Headminders' CRI, CogSport, ANAM), there is considerable opportunity for diagnosis and management of sports-related concussions. Reliance on symptoms for diagnosis and return-to-play decisions is problematic, as symptoms may be under-reported following concussion since athletes are often motivated to return to competition (Echemendia & Cantu, 2003). In addition, much of an athlete's history is based on self-report, which has been shown to be unreliable (Hall, Hall, & Chapman, 2005). High school football players have been found to under-report symptoms (McCrea et al., 2004), with the most common reasons being: (1) not thinking the injury was serious enough to warrant medical attention, (2) motivation to not be withheld from competition, and (3) lack of awareness of a probable concussion. Even when athletes report being symptom free, they have been found to exhibit neurocognitive deficits, of which they are either unaware or which they fail to report (Van Kampen, Lovell, Pardini, Collins, & Fu, 2006). As a result, there is widespread belief that athletes should not be returned to play based solely on their self-report of symptoms—e.g., "when in doubt, sit them out'' (Aubry et al., 2002). Concussion-related symptoms are not consistently identified by youth coaches (Valovich McLeod, Schwartz, & Bay, 2007). While parents are able to identify concussion-related symptoms (Coghlin, Myles, & Howitt, 2009), they also identified numerous incorrect ''distractor'' symptoms, and may have difficulty identifying these symptoms in their adolescent children. Athletes across a wide range of age levels were unable to consistently identify concussion symptoms, diagnostic criteria, treatment approaches, or return-to-play guidelines (Cusimano, 2009). With respect to management, athletic trainers have been equally unaware of recent treatment guidelines (Covassin, Elbin, & Stiller-Ostrowski, 2009), and lack agreement in use of neurocognitive assessments (Covassin, Elbin, Stiller-Ostrowski, & Kontos, 2009). Consensus experts on sports-related concussion have recognized that pediatric concussive injuries may require differential treatment, due to the vulnerability of the developing brain, with a specific need for extended ''cognitive rest'' and limited exertion in youth as compared to adults (McCrory et al., 2004). More recently there has been a specific emphasis on the need for children to limit mental exertion following a concussion in academic and other cognitively demanding activities, including text messaging, video games, and computer usage (McCrory et al., 2009).

The concept of cognitive rest is a relatively new one in concussion management (Buzzini & Guskiewicz, 2006; McCrory et al., 2004), and appears to be targeted at pediatric, adolescent, high school, and collegiate athletes. The American Academy of Pediatrics recommends temporarily removing a concussed athlete from school, shortening their school day, reducing their academic workloads, and extending time allotted for completing assignments or tests (Halstead & Walter, 2010). While mandatory periods of cognitive rest may decrease anxiety and increase compliance on the part of the concussed athlete (Logan, 2009), compliance with instructions may be difficult to enforce (Valovich McLeod & Gioia, 2010). In fact, the lack of guidelines regarding implementing and standardizing cognitive rest as a treatment have resulted in a wide range of interpretations, with one college athlete being placed in a ''dark room'' following a concussion (Evans & Thamel, 2009). Unfortunately, while a period of cognitive rest may appear logical when treating a concussed youth athlete, there are no empirical data to support its efficacy. In fact, removing youth athletes from school with a diagnosis of concussion may place them at an increased risk for social and behavioral problem (e.g., ''illness behavior'') (Breslau, 1985).

LEGISLATION AND POLICY CHANGE

Commensurate with the increase in media coverage of sports concussion, there has been a growth of legislation, policy, and advocacy related to sports concussion. Given its place in the ''limelight,'' the National Football League (NFL) has experienced considerable scrutiny and criticism for its neglect or oversight in the management of sports-related concussion, resulting in Congressional hearings in early 2010 exposing the reality of chronic traumatic encephalopathy in career pro-football players. This exposure, supported by the NFL Players' Association, has resulted in a flurry of action on the part of the NFL, with the recent creation of a poster, hung in all locker rooms, that details the risk of concussion in football (Schwarz, 2010b).

With recent discoveries of the enduring effects of sports concussion in youth, striking lawsuits in cases of second impact syndrome, and position statements from professional groups, legislators are responding to the call for governmental regulations and support for local and national communities. Thus within the past few years there has been a flurry of state and federal legislation aimed at educating, funding, and establishing management guidelines.

For example, in May 2009 the state of Washington enacted the Zackery Lystedt Law (House Bill 1824 and Senate Bill 5763), which requires that any student who has suffered a concussion cannot be returned to play until cleared by a health care professional (BIA of Washington, 2010). In October 2006 Zackery, age 13, sustained a head injury during a football game in what appeared to be a routine tackle. He subsequently experienced bleeding in the brain, but was returned to play by coaches too soon after the initial concussion without being properly evaluated. The passage of this law was considered a major breakthrough as it requires informed consent from parents and athletes regarding acknowledgement of concussion risks, removal from play of any athlete suspected of having a concussion, and written clearance from a medical professional prior to return to play.

Since the passage of the Zackery Lystedt Law, nine other states passed similar laws (CT, MA, NM, OK, OR, RI, TX, VA, WA), with likely more by the time of the publication of the present article. As many other states follow suit, New Jersey has introduced Senate bill (No. 2103) which not only proposes safety training, removal from play of a concussed athlete, and written permission in order to return, but has also added protection to the school from liability if the school is in compliance with insurance coverage and school district policy for concussion management.

Regardless of whether new laws mandate concussion education or concussion management programs, schools and health care systems are not readily prepared for implementation. Issues such as lack of funding resources, lack of education and training, and fear of liability are barriers to the implementation of these laws even after passage (Schwarz, 2010a). Hospital emergency departments continue to be unaware of concussion guidelines, thus offering uninformed discharge instructions, while many schools cannot afford athletic trainers or concussion testing programs, despite parents' urgings. For example, it has been documented that approximately 50% of school nurses in the District of Columbia may not be able to properly assess concussion (Wagner, 2010). While athletic trainers are routinely employed by professional teams and NCAA Division I, II, and III athletic programs, only 42% of high schools in America have access to an athletic trainer (NATA, 2010).

United States Congressman Bill Pascrell, Jr. of New Jersey has attempted to address the problem of lack of education, resources, and funding for schools. In October 2008 Ryne Dougherty, a high school football player from Montclair, New Jersey, sustained a catastrophic head injury when he was returned to play before recovering from a concussion. His death was the impetus for Congressman Pascrell, along with Congressman Todd Platts of Pennsylvania (both of whom are co-chairs of the Congressional Task Force on Brain Injury), to introduce federal legislation that would assist states by providing $5 million in its first year of implementation.

The bill, H.R. 1347 Concussion Treatment and Care Tools Act of 2009 (ConTACT) has called for the development of concussion management guidelines, standards for return to play, and a conference of experts to establish guidelines. Grants would be provided to states for adopting the guidelines and implementing neuropsychological testing for athletes. In September 2010 the ConTACT bill was passed unanimously by a full committee of the House Energy and Commerce Committee. Soon thereafter it was passed by the United States House of Representatives. However, with recent elections and serious economic woes in the current U.S. economy, the bill was unable to clear the Senate. The House Education and Labor Committee also attempted to introduce a separate concussion bill, albeit much later than the ConTACT bill, entitled Protecting Student Athletes from Concussions Act (H.R 6172). H.R. 6172 places the burden on states and their school districts to create and implement their own concussion management programs, an item which could be challenged by states' rights proponents. In contrast to the ConTACT bill, H.R. 6172 does not mention neuropsychological testing in its wording, and does not advocate for establishing centralized guidelines that could be voluntarily adopted by schools, making implementation more difficult. Nevertheless, it appears that Congress may not be ready to commit to federally mandated regulations or funding of sports concussion programs and will instead rely on the Center for Disease Control to address sports concussion issues. As many await the passage of legislation, whether federal or state, a large number of schools and school districts are becoming proactive, taking it upon themselves to establish their own policies and procedures regarding concussion management. With position statements and guidelines from the National Athletic Trainers Association (Guskiewicz et al., 2004), National Academy of Neuropsychology (Moser et al., 2007), and the Concussion in Sports Group (McCrory et al., 2009), youth sports programs and health care practitioners can no longer ignore the necessity for improved, updated policies for concussion education, identification, treatment, and management. In addition, the recent legal case of a New Jersey athlete, Preston Plevretes—a college freshman who suffered second impact syndrome while playing football for LaSalle University—highlighted the legal vulnerability of schools, with a settlement of $7.5 million. Such a string of events has led the New Jersey State Interscholastic Athletic Association to introduce the Concussion Identification, Management, and Return to Play Policy Statement in April 2010. This statement recommends that member high schools develop forms to educate and inform student-athletes, school personnel, and parents/guardians, with annual training for all, and yearly distribution of educational sheets. The statement also details the return to play process, now placing pressure on New Jersey schools to integrate such recommendations into school policy. New Jersey is just one of many states across the country working quickly to create and adopt concussion policies.

It is important to note that development and implementation of concussion management legislation raises important issues regarding the role of the neuropsychologist. The administration of neuropsychological test measures by non-neuropsychologist sports medicine personnel has already been supported in statements by consensus experts, who commented that computer-based neurocognitive tests can be *administered* by a team physician, or be web-based, thus bypassing the need for formal assessment by a neuropsychologist (Aubry et al., 2002; McCrory et al., 2004). However, recommendations from the most recent consensus meeting of the Concussion in Sports Group (McCrory et al., 2009) have clearly stated that neuropsychologists, by virtue of their background and training, are identified as being ‘‘in the best position’’ to *interpret* neuropsychological tests. This viewpoint on the use of personnel to administer neurocognitive testing, and interpretation of results being restricted to neuropsychologists is supported by consensus experts on sports concussion in the field of neuropsychology (Moser et al., 2007). This is further supported by Echemendia, Herring, and Bailes (2009) who view baseline testing as a ‘‘technical procedure’’ which can be conducted by technicians (supervised or guided by neuropsychologists), whereas post-injury neuropsychological assessment should be conducted by an individual with ‘‘advanced neuropsychological expertise’’ and is thus best conducted by a clinical neuropsychologist.

SPECIFIC SPORT-RELATED ISSUES

Policy change can also relate to sport-specific levels of contact or use of protective equipment. Lacrosse is a unique sport for cross-gender comparisons, as male lacrosse players are required to wear helmets yet female lacrosse players are not. Concussions in collegiate women’s lacrosse players accounted for 9.8% of all injuries, as compared to 8.6% of men’s (Dick, Lincoln et al., 2007; Dick, Romani, Agel, Case, & Marshall, 2007). While mandatory use of a helmet for male lacrosse players does not appear to significantly decrease risk of concussion, it may explain why female lacrosse players sustained twice as many facial injuries necessitating ER visits (Yard & Comstock, 2006) as compared to males. While high school aged male lacrosse players are most likely to sustain concussive events from player-to-player contact, females tend to sustain concussive injuries from head-to-stick or -ball contact (Hinton, Lincoln, Almquist, Douoguih, & Sharma, 2005). Mandatory use of helmets in female lacrosse players would seem an obvious solution to decreasing such injuries in female athletes, and has been recommended for nearly a decade (Diamond & Gale, 2001). However, more than half of collegiate and post-collegiate female lacrosse surveyed indicated that introducing protective eyewear would result in greater incidence of illegal contact (Waicus & Smith, 2002). Given that males are thought to be susceptible to concussions due to their aggressive nature (Barnes et al., 1998), mandating the use of protective equipment (e.g., eye shields or helmets) in female athletes raises fears that such equipment might increase the risk of injury due to increased aggressive play (Dick, Lincoln et al., 2007).

With respect to ice hockey there are different regulations regarding the age at which body checking is allowed: in the United States body checking is introduced at ages 11–12 years, but there are leagues which do not permit not permitting body checking across all leagues and age groups, (e.g., up to ages 15–16 years) (2007–09 Official Rules of Ice Hockey, 2007). Recent research reveled that youth (e.g., 11–12-year-old) ice hockey players were at three times greater risk of concussion, severe injury (e.g., loss of more than 7 days of playing time), and severe concussion (e.g., loss of more than 10 days of playing time) when playing in a league in which body checking is permitted compared with playing in a league in which body checking is not permitted (Emery et al., 2010). At the collegiate level, in the absence of ‘‘allowable’’ body checking, concussions were identified as the most common injury for female hockey players, and contact with the boards or another opponent was the most common cause of injury (Schick & Meeuwisse, 2003). In male collegiate hockey players, use of a half-face shield and no mouth guard was associated with increased risk of concussion and increased loss of playing time, compared to players using a full-face shield and a mouth guard (Benson, Mohtadi, Rose, & Meeuwisse, 1999). These data on lacrosse and ice hockey point to the utility of protective equipment in preventing concussion and protecting from head and face injuries. While all football players are required to wear helmets, high school football players have been shown to experience, on average, 15 ''hits'' to the head each season involving greater than 15 g of force, with approximately 27% occurring during practice sessions (Broglio et al., 2009). However, despite suggestions to decrease contact drills in football practices, especially for younger athletes (Schwarz, 2010a), there have been no policy changes at any level. Analogously, cheerleaders have been found to be at greatest risk of concussion while performing ''stunts'' such as pyramids, lifts, catches, and tosses (Shields, Fernandez, & Smith, 2009), with a greater frequency of concussions sustained during practices and two-level pyramids (Schulz et al., 2004). In spite of these findings there are no rules governing the frequency by which cheerleaders are allowed to engage in these activities.

SUMMARY

Clearly the concern about sports concussion and its risk, whether at the professional, college, or youth levels, continues to escalate with an unending routine print, TV, and radio presence. Families and communities have joined forces with athletes and legislators to address this public health issue in growing intensity. The evolution of youth sports has resulted in participation in sports at earlier ages than ever and year-round participation in multiple sports. With this evolution comes an increase in athletic exposures and subsequent increase in concussive events. The demand for concussion care and support will also escalate, perhaps more quickly than our current medical, athletic, and school programs will be able to handle. Health care professionals, including neuropsychologists, who are uniquely qualified to provide support in this specialized area of expertise, will need to step up to the plate to help meet this critical demand and public need.

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