

Concussion: Key Stakeholders and Multidisciplinary Participation in Making Sports Safe

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As unstructured play declines, organized sports leagues have become a highly popular form of physical activity in young people. As concussive injuries are garnering increased media attention and public awareness, there is a growing concern for athlete safety. Although athletic trainers and physicians play a large role in keeping athletes healthy and safe, this article investigates nontraditional, multidisciplinary teams that are involved in promoting athlete safety, including the role of equipment makers, coaches, referees, governing bodies of sport, lawmakers, and fans. As opposed to a focus on diagnosing or managing concussive injuries, this article seeks to promote injury prevention strategies.

KEY WORDS: Concussion, Injury prevention, Safety, Sports injuries

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Sport participation at any age carries an inherent risk of athletic injuries. As concussion awareness gains traction, parents of young children are rightfully questioning whether sports, especially collision sports such as football and ice hockey, are sufficiently safe to play. These concerns are legitimate and reflected in declining youth participation. Pop Warner football lost more than 20 000 participants from 2010 to 2012, whereas USA Football reported a 6.7% decline in children between 6 and 14 years of age.¹ Although withholding youth athletes from participation reduces their risk of concussion and musculoskeletal injury, it also denies children the physiological, psychological, and social benefit of sports. Therefore, the primary purpose of this paper is to highlight the benefits of sport participation, starting from a young age, and detail the steps multidisciplinary teams can take to reduce injury risk, specifically the risk of sports-related concussion.

According to the Centers for Disease Control and Prevention, 12.5 million (~17%) children and adolescents between 2 and 19 years of age are obese.² As obesity rates continue to increase,

children are becoming more at risk of physical consequences, such as short- and long-term orthopedic, cardiovascular, endocrine, pulmonary, and neurological problems and psychosocial issues, such as low self-esteem, poor body image, and economic immobility.³ One way to combat this epidemic is through promoting physical activity in children. Getting young people actively involved in recreation and sporting activities at an early age responds to the US Surgeon General's plea for "exercise as a means to reduce the risk of chronic diseases such as obesity and diabetes"⁴ as well as the Healthy People 2010 initiative.⁵ For youths, organized sporting activity goes beyond the physical benefits by offering children an outlet to grow mentally, emotionally, and socially.⁶ As society continues to advance wellness, the idea of gaining physical activity through unstructured play has greatly diminished and been replaced by competitive league sports.⁷

Currently, there are more than 41 million children playing organized sports.⁸ Although there has been an increase in the overall number of youth participants, some of the most dramatic changes are seen in contact and collision sports. In the early 1990s, Pop Warner football had 130 000 participants between 5 and 16 years of age.⁸ Today, the number of athletes enrolled in the program has more than tripled to 425 000.⁹ As contact and collision sports generally continue

ABBREVIATIONS: **NCAA**, National Collegiate Athletic Association; **NFL**, National Football League; **NHL**, National Hockey League

to increase in popularity, there is a concurrent movement toward increased concerns for the safety and welfare of young athletes. Although not the lone concern, the main focus has centered on the risk of concussion and its potential effects on young sports participants. This concern is especially prominent in sports such as football and ice hockey. In the United States and Canada, youth ice hockey players are not permitted to body check until the age of 11 years or older.¹⁰ Conversely, youth football has no nationwide tackling age restrictions. Combined with the increasing attention and awareness of concussion, there is debate among coaches, parents, and scholars about whether to institute age rules similar to hockey.

WHY START KIDS YOUNG?

Although the health and safety of our youth are of the utmost importance, there are several reasons to enroll young children in contact and noncontact sports. In academic settings, physical education programs are being replaced with academic curriculum offerings, thereby reducing the built-in component of exercise and recreation as part of conventional education.⁷ Additionally, technological advances, such as video gaming systems, computers, and television, have essentially eradicated unstructured play in teenagers. So although the overall number of participants in youth sports has increased, it is not surprising that there are decreases in the number of participants between the ages of 14 and 17.⁷ For various reasons, approximately 35% of youth participants of all ages drop out from sports each year.¹¹ In a study by Seefeldt et al,¹² it was found that 25.3% of 10-year-old children play sports, but only 3.3% of these same children are still involved in sports at age 18. In an effort to ensure safety, parents may wish to wait to enroll their children in athletic participation until later in life. However, given the fact that older children are less likely to participate, it is possible that children will lose their interest in sports altogether. Additionally, withholding participation can prevent years of physiological, psychological, and social development benefitted by sport. With children more likely to become sedentary as they age, it is important to establish the importance of physical activity and good habits early.

Physiologically, in young children, earlier exposure to motor skill development furthers future expertise¹³ and promotes a neuroanatomy supportive for both skill expertise and injury prevention.¹⁴ Research has shown that pre-adolescence is the optimal time to develop and acquire new skills.¹⁵⁻¹⁷ Although there are several noncontact sports to which these principles apply, there is also evidence that beginning contact and collision sports at a younger age prevents future injury. A study by Emery et al¹⁰ found that Bantam hockey players (ages 13-14 years) who previously played in a Pee Wee league (ages 11-12 years) where body checking was allowed were less likely to be concussed than those players who played Pee Wee in a nonchecking league. Along with concussion, it was found that the hockey players with previous checking experience were less likely to obtain many types of musculoskeletal injuries.

Beyond the physiological measures, it is important to briefly discuss the social and psychological benefits of sports participation. For elementary and middle school (third through eighth grades) students, studies have found that youth sport participants display increased self-esteem,¹⁸ body satisfaction,¹⁸ moral judgment,¹⁹ and reasoning.¹⁹ A 4-week physical activity intervention directed by Ullrich-French et al²⁰ showed improvements in social and physical competence and physical and global self-worth. Additionally, sports and physical activity are also known to lessen depression, anger, and cynicism in those who actively engage in exercise.²¹ Although athletic injury poses a risk to its participants, it is important to not only consider the physiological benefits that children receive from sports, but also the psychological and social benefits that come with athletic participation.

THE CONCUSSION EQUATION

Over the past 4 to 5 years, many groups have convened to place more emphasis on the seriousness of sport-related concussion. The media have certainly had a voice in the discussion, although sometimes being accused of sensationalizing the problem. Although most of the earlier focus had been on developing valid concussion assessment tools and management protocols, the more recent emphasis has been on concussion prevention. Both sides of the concussion equation are important; however, only recently have the scientific community and sports organizing bodies attended to the prevention side. Although concussions will never be fully eradicated from sports, and the need to properly assess and manage the injury will be there, focusing more attention on prevention holds the potential for significantly reducing the number of sports-related concussions for athletes of all ages and thereby minimizing concerns about the later life consequences of playing sports.

Equipment and Concussions

Although preventing any type of injury in athletes is crucial, the ability to minimize head injuries, particularly concussion, is vitally important. In collision sports such as football and ice hockey, the 2 main pieces of equipment used to protect the head and face area are mouth guards and helmets. Although helmets are excellent for preventing catastrophic head injuries, such as skull fractures, and mouth guards reduce the risk of dental injuries, there is no evidence that a "concussion-proof" helmet or mouth guard exists in football or ice hockey.²²⁻²⁴ Although helmets may reduce the amount of impact applied to the brain and skull,^{23,24} there is no clinical evidence to directly link a reduction in forces to reduced concussion incidence.²² Therefore, it is important for all coaches, parents, and athletes to understand that there is currently no athletic equipment that fully prevents concussive injuries.

Recent technological advances have allowed for accelerometers to be placed in sports helmets to directly assess the force and magnitude of head collisions in real time. A review by Forbes et al²⁵ found that high school players sustaining concussive injuries are subject to an average impact of 93.9g of translational acceleration

and 6505.2 rad/s² of rotational acceleration. Additionally, the authors found that only 0.02% of all collisions resulted in a concussive injury. A review of the clinical usefulness of helmet accelerometers by Guskiewicz and Mihalik²⁶ found that concussion may occur at lower magnitudes than originally thought; linear acceleration and rotational acceleration are equally as likely to cause concussion, and athletes with a high number of head impacts over the course of a season may never have a diagnosed concussion. Both reviews indicate that biomechanical data from helmet accelerometers should not currently be used to predict injury because the concussive threshold remains elusive.^{25,26} Although the helmet accelerometer data are not yet useful for concussion diagnosis, the data may be clinically useful because of its utility as a behavior modification tool (ie, illustrating to athletes and coaches the location and character of head impacts during tackling, blocking, and other contact encounters to promote healthier techniques that reduce the frequency and magnitude of head-impact exposure). New types of technology, including the helmet accelerometers, hold great promise in the future for the safety of athletes of all ages.

Coaches and Athlete Safety

Coaches are a crucial piece in the player safety puzzle due to their responsibilities to teach and enforce proper technique. This is especially important in collision sports, where tackling and body checking are taught from an early age. Skill development is optimized through an interaction of the player, the environment, and the specific skill/technique at hand.²⁷ Therefore, proper coaching is incredibly important to learning correct technique. Heads Up Football, sponsored by USA Football, is an online program aimed at educating coaches about proper tackling fundamentals and reducing the amount of head contact.²⁸ By educating and certifying coaches, player safety can be increased and head injuries can be reduced by correct tackling and body-checking technique.

The idea of Heads Up tackling and removing or limiting the amount of head impact during contact is strongly supported by data. In 1968, 36 fatalities and 30 permanent paralysis injuries were reported in football.²⁹ Rule changes made in 1976, which eliminated the head and neck from the primary point of contact, have greatly reduced the number of football-related deaths each year. However, the majority of football-related head and neck deaths that still occur; all but 7 deaths since 1990 have resulted from brain injury.²⁹ The authors of the 2011 Annual Survey of Catastrophic Football Injuries comment that “coaches who are teaching helmet or face to the numbers tackling and blocking are not only breaking the football rules, but are placing their players at risk for permanent paralysis or death.” Therefore, the significance of coaches teaching proper technique relating to head and neck contact cannot be overstated.

In addition to teaching the fundamentals of sports, coaches are responsible for creating an environment where good sportsmanship is emphasized and dangerous play is discouraged. To reduce

the amount of penalties and aggressive behavior, the Canadian province of Quebec instituted a “Fair-Play” code of conduct that sought to integrate a high level of sportsmanship into the game without changing the structure of hockey.³⁰ For the Pee Wee (11-12 years old) age group, the teams using the “Fair-Play” system had fewer penalties per game, 5 times fewer major penalties, no fighting penalties, and half the number of game suspensions. For the Bantam (13-14 years) age group, the “Fair-Play” teams had 30% less major penalties and 25% less game suspensions compared with teams not using the “Fair-Play” system. This study supports the idea that coaches who emphasize sportsmanship and good behavior can reduce the amount of illegal conduct in a sport, specifically those types of infractions that are likely to cause injury. Due to its success, the “Fair-Play” code has been extended to other Canadian provinces.

Governing Bodies of Sport

National sports-governing bodies, such as the National Football League (NFL), National Hockey League (NHL), and the National Collegiate Athletic Association (NCAA), are responsible for creating and enforcing rules that protect the safety of their athletes. Officials and referees are primarily responsible for policing and enforcing player safety rules in collision sports, whereas the league itself may step in for calls missed in real time and additional punishment. When dealing with concussive injuries, rules dealing with helmet-to-helmet collisions or contact above the shoulders have become especially important.

The National Athletic Trainer Association’s position statement on helmet-to-helmet contact in football specifically highlights the roles and importance of referees and organizations in maintaining player safety. Pertaining to officials, the statement reads that existing rules should be enforced to limit the amount of head-down contact and that “stricter officiating would bring more awareness to coaches and players about the effects of head-down contact.”³¹ The National Athletic Trainer Association also hits on the importance of education, stating that annual learning programs for all referees should emphasize the purpose behind head-down rules and highlight that the “purpose of helmet-contact penalties is to protect the athlete.”³¹ Last, the statement emphasizes the role of governing bodies of sports, reminding the organizations that it is their job to make sure the officials are thoroughly educated about the rules and that those rules are being fully enforced.³¹

The NFL, NHL, and other professional sporting organizations have adopted several policies and rule changes relevant to reducing head impact exposure and the risk of concussion in athletes over the past 5 years. Additionally, the NCAA implemented a policy in April 2010 requiring all member institutions to have on file a concussion management plan.³² This plan stated that a student-athlete who exhibits signs, symptoms, or behaviors consistent with a concussion shall be removed from practice or competition and evaluated by an athletics health care provider with experience in the evaluation and management of concussion. Student

athletes with a diagnosis of a concussion will not return to activity for the remainder of that day. Medical clearance will be determined by the team physician or their designee according to the concussion management plan. The policy also emphasized that medical personnel should have the unchallengeable authority to determine management and return-to-play of any ill or injured student athlete. Institutions should ensure that coaches have acknowledged that they understand the concussion management plan and their role within the plan and that they received education about concussions and have no supervisory role (including hiring or firing authority) over the medical personnel.³²

A new point of emphasis within the NFL, NHL, and NCAA is eradicating contact on defenseless players and hits from behind. These rules are important because they allow players to prepare for contact before impact. In a study by Mihalik et al,³³ illegal collisions, such as elbowing or intentional contact to the head, made up 17% of all collisions in youth ice hockey. These illegal collisions resulted in higher linear and rotational acceleration compared with legal collisions. Similarly, another Mihalik et al³⁴ study found that unanticipated collisions resulted in higher linear and rotational acceleration compared with collisions that were anticipated. This is in agreement with a study looking at male high school lacrosse players, in whom concussions most commonly occurred when the player was unaware of the pending contact and could not brace for impact.³⁵

In addition to enforcing current rules, it is the responsibility of the governing bodies of sports to continually update existing or add new rules. A study by Ocwieja et al³⁶ found that, on average, special team players with a closing distance of greater than 10 yards are subjected to higher linear acceleration than any other play type. Additionally, a study by Yard and Comstock³⁷ showed that there was a disproportionately high amount of concussive injuries on kickoffs. With this information in mind, the NFL made rule changes to kickoffs before the 2011 season that moved the kickoff line from the 30- to the 35-yard line and reduced the maximum running start for the kickoff team from 10 yards to 5 yards. The intention was to reduce the number of returned kickoffs. This rule change reduced the number of concussions sustained on the kickoff from 26.3 (2008-2010 average) to 15 in 2011, but interestingly it did not result in fewer touchdowns being scored on the kickoff (R. Ellenbogen, unpublished data presented at NFL Combine, February 2013). The NCAA instituted a similar kickoff rule change in 2012. Similarly, the NCAA observed a reduction in the incidence of concussions during kickoffs. These types of rule changes are beneficial to the health and welfare of all involved athletes, but maintain the high level of excitement and competition in sporting games.

Concussion Legislation

Although collegiate and professional organizations have committees and personnel dedicated to player safety for all of its constituents, the same cannot be said for most high school and youth sports bodies. To protect these athletes, state legislators have

begun passing laws in the name of athlete welfare. According to USA Football, all states except one (Mississippi) have concussion legislation currently in place.³⁸ Washington was the first state to have a legal concussion policy; the Lystedt law is named in honor of then 13-year-old Zackey Lystedt, who sustained permanent brain damage after returning to play in a junior high football game after a concussive injury.³⁹ Although concussion legislation varies, there are 3 primary components in nearly all state concussion laws: (1) educating coaches, players, and parents on the common signs and symptoms of concussive injuries; (2) removing any athlete suspected of sustaining a concussive injury from play and not allowing him or her to return to play on the same day; and (3) not allowing an athlete to return from a concussive injury without proper medical clearance.³⁹

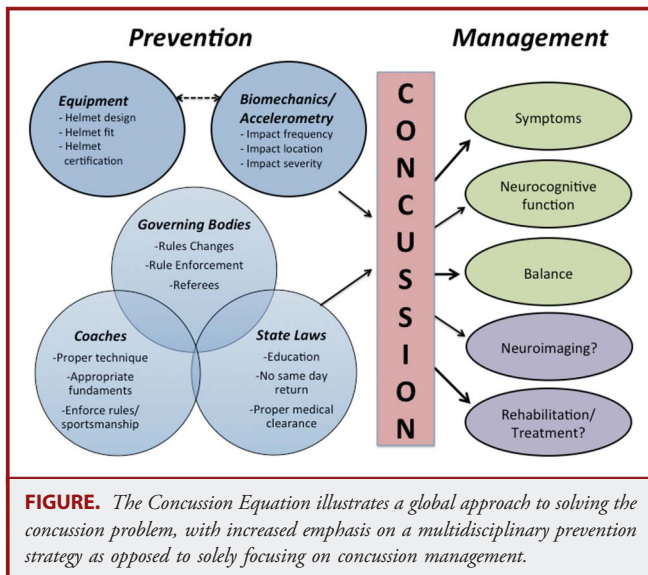
Although state concussion laws represent a good starting place for athlete safety, they are not without their own limitations. In general, state concussion laws are sometimes difficult to enforce and therefore do not outline penalties for individuals and institutions failing to comply. Additionally, many states have not established minimum requirements regarding medical personnel needed for game and practice settings or the minimum concussion training and education requirement for clinicians making return-to-play decisions.³⁹

Society's Role: Changing Sporting Culture

We live in a society that glorifies sport, and there is enormous benefit from participation in sport. However, society should embrace the responsibility of ensuring that we find a balance between encouraging increased participation in sport and maximizing the safety of young sports participants. This is a responsibility of many, including equipment manufacturers, coaches, athletic trainers, physicians, game officials, sport governing bodies, legislators, researchers, and, ultimately, the athletes themselves. Fans too must be respectful of the physical sacrifices that athletes make. This includes accepting rule changes that may alter the game, but protects the athlete and improves safety. In essence, during this pivotal time in the evolution of sports, one aims at striking a nearly perfect balance between adjustments that promote player safety while preserving the integrity and character of the great games we cherish. If these groups work toward a common goal, a change in sport culture can occur. Concussions are, first and foremost, a brain injury linked to long-term risks of physical and psychological issues, such as depression⁴⁰ and mild cognitive impairment.⁴¹ The mindset and culture of sport as they relate to concussion and head trauma must change and can be accomplished without an outright elimination of contact sports.

Athletes and Parents

Although the focus of this paper is on the nontraditional, multidisciplinary personnel that can help in the concussion prevention initiative, there is responsibility on the athlete and the parents of minor athletes to take reasonable steps to reduce the risk of concussion. Athletes must live within the rules of the game,



listen to their coaches, follow proper technique, and have appropriate equipment that fits correctly. Although this may be difficult in critical game situations, especially with minor athletes who are still developing neurologically, safety at all points throughout athletic participation must come first.

With increased concussion education and awareness, athletes and parents should be aware of the signs and symptoms of a concussion. However, research indicates that the message of current concussion awareness policies aimed at educating minor athletes and their parents is not comprehended fully. Several studies have found that the effect of concussion education programs depends on the age of the child, with younger athletes having lower concussion knowledge scores⁴² (J.K. Register-Mihalik, unpublished data, February 2014). A study by Cusimano et al⁴³ found that one-fourth of adults and children could not name more than 1 symptom of concussion and one-fourth of their participating youths were unsure whether an athlete experiencing concussion symptoms should continue in athletic participation despite their symptoms. Although concussion education is an important part of prevention, research suggests that minor athletes and their parents may still not be able to accurately assess the signs and symptoms of concussion and make informed decisions about when to be removed from play. Although concussion education is far from perfect, it is an important first step to reduce the likelihood of experiencing multiple concussions within a short time frame. Because concussions will never be fully preventable, recognizing and providing appropriate care for concussive injuries is crucial. If an athlete recognizes the signs and symptoms of a concussive injury, he or she, with support from the parents, must be willing to sit out games while the brain recovers. Although there are personnel and organizations designed to protect athlete safety, the athlete and his or her parents must also identify safety as top priority.

CONCLUSION

Although competitive sport provides many physical, social, and psychological benefits, participating in athletic activities comes with an inherent risk of injury. When dealing with concussions and other head- and neck-related injuries, it is particularly important to emphasize the health of the athlete and promote a multidisciplinary approach for prevention and management that engages all stakeholders. Although concussions may not be entirely preventable in contact and collision sports, we cannot simply accept that they are inherent. Turning our attention more toward prevention rather than management is a reasonable next step in reducing the risk of concussion and catastrophic injury. The prevention (left) side of the concussion equation (Figure) provides a foundation for how this might be accomplished. Herein we call to action athletes, coaches, officials, governing bodies, and fans to work together to protect athlete safety while still maintaining highly competitive and entertaining sporting events.

Disclosure

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