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Concussions in Youth Football

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Abstract

Head injuries, including concussions, have received a lot of attention over the last year. After week six of the 2010 National Football League (NFL) season, the NFL fined three players \$175,000 each for illegal contact that included direct blows to the head of an opponent. Approximately 38 million boys and girls participate in youth sports each year. Concussions are among the most prevalent injuries reported in this group and reported most frequently in youth football. This has resulted in many states enacting legislation about educating players, parents, and coaches on how to recognize head injuries, including guidelines about returning to play or practice after a suspected head injury. Fortunately, there are many excellent resources to help coaches and others in this regard. The Centers for Disease Control (CDC) has developed "Heads Up: Concussions in Youth Sports" which includes a tool kit for coaches and administrators to help recognize, prevent, and appropriately respond to suspected head injuries in the athletes they serve. Additionally, USA Football in collaboration with the NFL and the NFL Players Association, have produced a series of educational materials that address

proper techniques, appropriate conditioning, and adequate protective equipment for football players. This article provides an overview of the prevalence of head injuries in youth football and presents information on initiatives that could reduce their occurrence.

Keywords: Concussion; youth football; prevention; recognition; return to play

Introduction

At one time considered a silent epidemic (Goldstein, 1990), concussions in American football have been getting significant attention lately. This includes the cover story of November 1, 2010 Sports Illustrated magazine (King, 2010) and front page coverage in the September 29 issue of Education Week (Samuels, 2010). Approximately 1.2 million high school students participate in football each year. Of those, between 3.6 and 5.6 percent sustain concussions (Broglio, et al., 2009). Additionally, concussions account for about 9 percent of all athletic injuries in high school sports, with football players having the highest head injury rate (Halstead, & Walker, 2010). A concussion, derived from the Latin word *concussus*, which means “a shaking,” is defined as a “complex pathophysiological process infecting the brain induced by biomechanical (body movement) forces (McCrory, Meeuwisse, & Johnston, 2008). Although head injuries can occur in almost any sport or recreational activity, they are most prevalent in activities with a high probability of head impact such as football, boxing, or martial arts or in those activities where high velocity falls may occur as in basketball or soccer (Kelly, et al., 1991). A cerebral contusion (bruise) is the most common form of concussion (Hureibi & McLatchie, 2009). While these typically occur as a result of a direct blow to the head, the actual cause of the brain injury is the force created during acceleration-deceleration or rotational movements of the head (Halstead & Walker, 2010). These types of forces are generated when the head hits a solid force like another player or the ground. When this occurs the brain moves rapidly against the solid interior of the skull resulting in disruption in the brain cells causing a series of biochemical events that could ultimately lead to brain cell death.

Although there is ample evidence that a single traumatic brain injury can have catastrophic results, the severity seems to increase as a result of subsequent blows or “second-impact syndrome” (Wetjen, Pichelmann, & Atkinson, 2010). This occurs when the athlete encounters one or more additional blows to the head before the symptoms from the initial impact have been realized and evaluated. The additional head contact may result in swelling of the brain, which can lead to death or permanent disability. It is uncertain at this time whether the subsequent blows alone are responsible for cerebral swelling. It is, however, well documented that adolescent athletes are at much greater risk of this occurrence

than is the normal population. In fact, all reported cases of second-impact syndrome have been in athletes nineteen years of age or younger (McCrory, et al., 2008). Coaches, players, and parents should make every attempt to prevent concussions and be fully capable of recognizing the signs and symptoms when brain injury occurs.

Preventing a Concussion

There are three critical components in the prevention of head injuries. Those include proper techniques and governance (rules), adequate conditioning, and quality protective equipment that is correctly fitted and maintained. USA Football, which has locations in all 50 states, is endorsed by the National Football League (NFL) and the NFL Players Association. This organization has educated tens of thousands of youth football coaches since 2006 and provides a Certified Coaching Education Program (CCEP), which is a two-hour course that is delivered online. The USA Football website includes excellent sources of brief and informative training videos on each aspect of head injury prevention. The USA Football concussion awareness information can be found at <http://www.usafootball.com>.

Preventing concussions in football centers around avoiding contact with the top of the helmet. This technique is commonly referred to as spearing and is a violation of game rules at all levels of football. Education programs, like the ones developed by the Centers for Disease Control (CDC) discussed subsequently, use catch phrases like “Heads Up” to remind players and coaches about techniques that will decrease the chance of head injury. As mentioned, USA Football provides excellent training for coaches in techniques that will likely reduce head injuries.

Adequate conditioning with head injury prevention in mind should emphasize overall body strengthening with particular emphasis on the muscles of the neck. Broglio, et.al. (2009) examined the forces generated during head impact in high school football players. This research revealed that the greatest forces were generated in games as opposed to practice and the most significant impacts occurred when contact was made with the top of the helmet. These authors made an additional observation that the forces experienced by the high school players were greater than those experienced by their college counterparts. This seems counterintuitive because logic would suggest that the bigger, stronger, and faster players at the college level would generate and experience higher level of impact forces. The authors postulated that the impact magnitude in the college players was attenuated by the larger muscle mass observed in this group. This characteristic may have allowed the college players to better control the head, reducing the movement, upon impact. It is also believed that the college players are better skilled in appropriate techniques and therefore experience less head trauma. These findings confirm the need for teaching proper “heads up” techniques in youth football players when blocking and tackling and also address

the need for adequate conditioning that includes a good strength training program with emphasis on the musculature of the neck.

Football helmets have improved greatly over the years. What once was a leather pad strapped to the head is now a modern protective device that distributes and weakens impact to the skull. In recent years, a “concussion helmet” has been introduced and has had positive anecdotal results (Foster, 2007). The X1 Xenith Helmet, designed by a former Harvard University quarterback, purports to significantly reduce the movement of the head by using shock absorption padding. Specifically, these helmets have eighteen thermoplastic nodes filled with air. This design works much like an airbag deployed during a car wreck, slowing the victim’s acceleration toward the dashboard of the car. While theoretically this design should reduce brain injury, there have been no formal studies to confirm this hypothesis. Although there is currently no protective headgear that will completely eliminate the chance of a concussion, modern helmets seem to reduce the occurrence of serious head injuries. Helmet use also provides a significant reduction in other minor head injuries such as lacerations to the head and face, surface contusions, and facial fractures (Marshall et al., 2002). The National Operating Committee on Standards for Athletic Equipment (NOCSAE) has established guidelines for all protective equipment in athletics. The NOCSAE standards can be reviewed at <http://www.nocsae.org/>. The National Federation of State High Schools Associations mandates the use of NOCSA certified helmets. It is important that coaches confirm NOCSAE certification of all protective equipment, especially headgear. There is also some evidence that mouthguards aid in protection against head injuries. It is believed that these devices may absorb some of the force generated with a blow to the head. The evidence is equivocal with respect to mouthguards preventing concussions but relatively strong for the prevention of damage to the teeth (Benson, Hamilton, Meeuwisse, McCrory, & Dvorak, 2009).

Developing good injury prevention programs requires that the injury be analyzed by both the injury phases and the contributing factors to the injury. The Haddon Matrix is an injury prevention tool that looks at factors related to personal attributes, vector or agent attributes, and environmental attributes before, during and after an injury (Robertson, 1998) and can be a useful tool for organizing the factors involved in sport-related concussions and identifying possible interventions (Bahr, Kannus, & van Mechelen, 2003). This matrix takes into consideration the three phases of head injury: pre-event, event, and post-event. It also considers factors of the athlete at risk of head injury, the vector (the other player who delivers the blow), and the physical and social environment. The matrix below (Table 1) represents an example of the Haddon Matrix applied to sports-related injuries. By utilizing this framework, those striving to prevent head injuries can evaluate the relative importance of different factors and design interventions (Echlin, Upshur, Peck, & Skopelja, 2005).

Table 1

Haddon Applied to Sports-Related Injuries

Phases	Factors			
	Athlete	Vector (other player and equipment)	Physical Environment	Social Environment (Community norms, policies, rules)
Pre-event	Velocity created Mass Age Genetics* Experience Knowledge of protective gear	Velocity of other player Mass of other player Experience of the other player	Maintenance of field	Social norms regarding protective gear Training on properly fitting and wearing protective gear School funds for protective gear
Event	Age Genetics* Proper use of protective gear Posture	Posture of the other player Helmet design, ability to absorb impact	Surface hardness	Enforcement of wearing protective gear appropriately
Post-event	Knowledge to report symptoms Age Genetics*		Proximity to medical care Proximity and availability of trained medical response team Rehabilitation programs in place	Coach and athletic trainer knowledge of symptoms EMT and doctor training Public support for appropriate care

Note: There is some evidence that genetics may also play a role in susceptibility to concussion. A gene that encodes a class of lipid transport proteins in brain cells has been found to be associated with severity of traumatic brain injury. However, this gene has yet to be shown to predispose individuals to a higher risk of concussion (Kristman et al., 2008; Terrel et al., 2008).

Haddon also identified ten countermeasures for determining approaches to injury prevention (Christoffel & Gallagher, 1999). These strategies can be applied to sport-related concussion countermeasures in adolescents as described below.

1. Prevent the creation of the hazard in the first place. Application: Prohibit all contact sports among adolescents; Eliminate “spearing” in high school football.
2. Reduce the amount of energy in the hazard. Application: Use regulations to restrict age groups that are allowed to participate in contact sports or modify the way the sport is played at each age group.

3. Prevent the release of the hazard that already exists. Application: Allow traditional contact sports to only be played as non-contact sports (e.g., touch football).
4. Modify the rate or spatial distribution of release of the hazard. Application: Modify sport to eliminate high-risk, forceful contact between players. Separate, in time or space, the hazard and that which is to be protected. Application: Only allow certain types of contact (e.g., no spearing), avoiding contact that is likely to deliver a blow to the head or result in sudden movement of the neck.
5. Separate the hazard from that which is to be protected by a material barrier. Application: Provide protective equipment; Enforce use of advanced helmet technology and continue to develop effective protective gear.
6. Modify basic relevant qualities of the hazard. Application: Only allow adolescents of similar sizes to play contact sports together.
7. Make what is to be protected more resistant to damage from hazard. Application: Ensure players are consistently and properly wearing protective equipment; Incorporate neck muscle strengthening exercises into team workouts; Teach players the safest posture and position to take at time of impact.
8. Begin to counter the damage already done by the environmental hazard. Application: Concussion management; Make certain that players with concussion symptoms do not return to play immediately; Ensure that players, coaches, and athletic trainers recognize the symptoms of concussion in order for the injured player to receive immediate medical attention, rather than return to the game.
9. Stabilize, repair, and rehabilitate the object of the damage. Application: Develop rehabilitation plans at an early stage of injury treatment; Enroll the injured player in rehabilitation care to address physical and cognitive deficits from the injury.

Despite the risk of concussion, it is unlikely that schools, young athletes, and their parents would be willing to eliminate contact sports or even adjust them through age restrictions or adjustments to the rules as is suggested in countermeasure one. Due to the nature of sports like football, it would also be difficult to control the types of contact that occur because the velocities and masses of players cannot be controlled. Therefore, strategies six, eight, nine, and ten are likely to be the most appropriate and feasible

Recognizing a Concussion

As mentioned previously, it is critical to recognize the signs or indicators of a concussion due to the potential adverse consequences that can occur as a result of subsequent blows to the head. Second Impact Syndrome was first described in by Schneider (1973) and involved two young athletes who suffered concussions and a short time later died from relatively minor head contact. Although there is little information on the exact incidence and prevalence of Second Impact Syndrome, we do know that adolescent athletes involved in sports with a high risk of head impact are at the greatest risk (McCrory et al., 2008). When a concussion occurs, the regulatory aspects of the brain which control vital functions such as blood pressure, are disrupted or rendered completely dysfunctional. This can last for several hours or several days. It is during this period that a second impact, even if

the forces are relatively small, can cause catastrophic or even fatal elevations in cerebral blood pressure and swelling (Wetjen et al., 2010). When brain swelling goes unrelieved, brain cell death can occur.

Signs and symptoms of a concussion typically are classified in four different areas. Those are, physical, cognitive, emotional, and sleep. Table 2 presents the signs of a head injury in each area (Halstead, & Walker, 2010).

Table 2
Signs and Symptoms of a Concussion

Physical	Cognitive	Emotional	Sleep Patterns
Balance Problems	Difficulty in concentrating or remembering	Depression	Increase in sleeping
Headache		Irritability	Decrease in sleeping
Unusual Fatigue	Feeling sluggish	Anxiety	Drowsiness while awake
Appearance of being dazed	Short term memory loss	Emotional	
Nausea or vomiting	Confusion		
Sensitivity to light or noise	Slow speech		

It is essential that coaches, players, and parents recognize the signs of head injury so appropriate steps can be taken to reduce the chance of exacerbating the situation. Fortunately, there are readily available programs that stress education in recognizing concussions. The "Heads Up: Concussion in Youth Sports" program was developed in 2004. This program seeks to educate coaches, players, and parents to recognize concussion (Centers for Disease Control and Prevention (CDC), 2010). The "Heads Up" initiative provides important information on preventing, recognizing, and responding to a concussion. This program aims to equip coaches, parents, and young athletes with the "Heads Up" tool kit, which contains a fact sheet about concussions for athletes, coaches, and parents as well as other promotional materials like clipboards, magnets and posters that can provide constant reminders for coaches, athletes, and parents about head injuries. The Heads-Up program also has a quiz for coaches for a self-assessment on head injury knowledge. The Heads-Up materials can be downloaded or requested as a free tool kit from the CDC website at <http://www.cdc.gov/pubs/ncipc.aspx>. The CDC also promotes a free online training course on concussions for coaches of high school sports provided by the National Federation of State High School Associations (NFHS). The course can be accessed at <http://www.nfhslearn.com/index.aspx>

Much of the current literature on sport-related concussion stresses the importance of concussion management, rather than focusing on preventing the injury from occurring. Several states have passed sports concussion legislation involving education and management to mitigate the effects of concussions on young athletes. These states include Connecticut, Massachusetts, New Mexico Texas, Oklahoma, Oregon, Virginia, and Washington (Barton, 2010; Brain Injury Association of Colorado, 2010; Kohn, 2010). In May of 2009, Washington enacted House Bill 1824, which is considered to be the most comprehensive return to play following a suspected head injury legislation in the country. This law was named the Lystedt Law for Zackery Lystedt, a standout middle school athlete who suffered a concussion with approximately three minutes to go in the first half of a football game. The concussion went unrecognized and Zackery returned in the second half play on both offense and defense. During the second half, he received a blow to the head that resulted in a brain hemorrhage. This ultimately led to the removal of both sides of his skull and left him in and out of a coma for the next three months. Zackery survived his head injuries but is permanently disabled. Zackery's case has received national attention and was highlighted on CBS Evening News and presented at the 2010 Annual Meeting of the American College of Sports Medicine. The key components of the Lystedt Law are:

1. Athletes who may have suffered a concussion must be removed from play immediately. "When in doubt, sit them out."
2. Washington school districts will work with the state athletic association to educate athletes, coaches, and parents about concussions by establishing policies and developing information.
3. All student athletes and their parents/guardians will sign an information sheet that provides the risks and signs symptoms of head injuries prior to starting practice.
4. Athletes who have been removed from play must obtain written medical clearance from a licensed health-care provider trained in the evaluation and management of concussion before returning to play.

Washington youth sports associations wanting to use publicly owned playfields must comply with the Lystedt law. For more information on the Lystedt law see: http://www.tbiwashington.org/tbi_wa/bill1824.shtml. Table 3 summarizes a sample of state legislation with key provisions that have been passed to date.

Table 3
Concussion Management Legislation

State	Education Requirements			Return-to-Play requirements		
	Target Groups	Verification/Compliance	Content	Condition under which requirements apply	Removal from Play	Return to play conditions
Texas Will's Law (2007)	Coaches, Trainers, physicians who assist in sporting activities	Annual safety drill is required. The law provides that schools shall be subject to a range of penalties, ranging from reprimand to disqualification and can affect individuals, such as a coach or a school	Recognizing the symptoms of catastrophic sports injuries, including concussion	Loss of consciousness	Removal from play decision made by designated personnel	No same day return to play if loss of consciousness and no participation in athletics until athlete receives written authorization from a physician
Washington Zachery Lystedt Law (2009)	Coaches, Athletes, Parents	Parents and athletes must sign a yearly consent form	Recognizing the risks and symptoms of concussion, and the risk of continued play.	Suspicion of concussion	Immediate removal if concussion suspected	Athletes removed must be evaluated by a health care provider <i>and</i> receive written clearance to return to play
Oregon Max's Law (2009)	Coaches	School coaches must receive annual on-line training before the beginning of the season in learning to recognize the signs and symptoms of concussion and how to seek proper medical treatment of players suspected of having suffered a concussion	Recognizing the signs and symptoms of concussion and how to seek proper medical treatment	Symptoms of concussion	Immediate removal from game or training when there are symptoms of concussion	No same day return to play if a player: 1) exhibits concussion signs or symptoms following an observed or suspected blow to the head or body or 2) has been diagnosed with a concussion
Oklahoma's sports concussion safety statute (2010)	Coaches, Athletes, Parents	Requires youth athletes and a parent and/or guardian sign and return a concussion and head injury information sheet on a yearly basis before the athlete's first practice or being allowed to compete	Recognizing the risks and symptoms of concussion. Recognizing the risk of continuing to ply after head injury	Youth athletes suspected of having sustained a concussion in a practice or game must be immediately removed from competition.	Immediate removal if concussion suspected	No return to play until after they have been evaluated by an appropriate health care provider <i>and</i> received written clearance to return to play from that health care provider

Conclusion

It is critical that players, parents, and coaches are fully aware of the risks associated with any sport or recreational activity. This importance is heightened when there is a chance of head injury. Although the odds of sustaining a severe head injury in football are very low, all efforts should be made to reduce their occurrence. One traumatic brain injury is too many. Administrators and coaches can ensure that the athletes are provided appropriate equipment, especially headgear. Football helmets should be certified by the NOCSAE and properly fitted on each player. Youth football players should engage in overall strength and conditioning training with emphasis on the support muscles of the neck. Parents, players, and coaches should be fully aware of the signs and symptoms of a concussion. Coaches should be strongly encouraged to take advantage of the educational information available such as the Heads-Up program by CDC and the on-line training information available through USA Football.

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