

Sport-related concussions in adolescent athletes: a critical public health problem for which prevention remains an elusive goal

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Abstract: Sport-related concussions in young athletes are common, generally under reported and often unrecognized. Preventive strategies include education, modification of sport rules, use of equipment such as headgears, face masks and mouth guards, and neck muscle training. Evidence is limited to support effectiveness of these preventive measures with the exception of rule modification in some sports. In the United States, laws have been enacted that require medical evaluation and clearance prior to return to play; however, evidence thus far does not show that laws have been effective in reducing the incidence of concussions in sport. More research is needed in all areas of preventive measures. Sports participation is a complex personal decision on the part of the adolescent and his or her family. They should be provided with all information on inherent risks so that they can make an informed decision.

Keywords: Concussion; protective equipment; neck muscle training; law; public policy

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Introduction

Sport participation by adolescent athletes is an important developmental milestone and should be encouraged for its well established benefits. However, it should be recognized that sport participation carries inherent risk of injury. Our efforts should therefore be directed to mitigate such risks of injury, rather than trying to completely eliminate such risks. Sport-related concussions in youth are common and can have significant long term adverse impact on an athlete's life. This paper reviews the concussion preventive strategies within the context of organized youth sports.

A number of preventive measures and strategies have been developed and tried with variable effectiveness. Primary prevention of concussion is an elusive concept because in most sports, every time an athlete is in practice or game there is an inherent risk for concussion. The only sure way of not having a sport-related concussion is not

to participate in sports with risk for concussion. Since not participating in sports is not such a viable option, our efforts are at best directed at secondary and tertiary prevention of concussion and its complications.

Evaluation of preventive strategies

Educational programs

A number of studies have described different educational programs that target different audiences (1-15). The main target audiences include athletes, coaches, school officials, and healthcare providers. On a broader scale school-based and community based educational models have been implemented. Different organizations, such as the United States Centers for Disease Control and Prevention have used mass media and social media to disseminate information about sport-related concussions to raise general

public awareness. Examples of concussion education program include Heads Up (CDC), Think First, Sport Legacy Institute Community Educators, Brain 101: The Concussion Playbook, and Barrow Brainbook (5).

The goal of individual or population based educational programs is behavior change. Some of the behaviors targeted for change include recognition of the significance of concussion signs and symptoms, reporting by athletes of concussion symptoms, adherence to rules of the sport, avoiding risk compensation behavior, consistent and correct use of protective equipment, and following medical recommendations during treatment and rehabilitation. Any concussion education strategy must include athletes, coaches, athletic trainers, parents, sport officiating individuals, and school representatives. A cohesive program should target long term change in attitude and culture change to ensure a positive sport participation experience by youth. Although, most educational programs are effective in raising the level of knowledge for short term, there is not sufficient evidence to indicate that educational programs are effective in behavior change or reducing the incidence of concussions in young athletes (2,5,12).

Modification and enforcement of rules of the sport

Modification and enforcement of rules of the sport have been evaluated for their effectiveness in reducing the incidence of concussions (1,2,15-16). Enforcement of rules requires active engagement and cooperation among athletes, coaches, school officials and parents. Rule enforcement should be viewed within the context of increased player safety. Historically, there is robust evidence of decreased incidence of head and neck injuries in American football following change and enforcement of head tackle rules (2). Similarly appropriate body checking techniques in ice hockey and heading techniques in soccer have been shown to reduce injuries including severity of concussions (2,15-16). Overall, the evidence supports that modification and enforcement of rules of the games is effective in reducing concussions in some sports.

Protective equipment

Helmets

Development and marketing of helmets is a huge industry. Use of helmet is required in certain sports, such as American football. In addition, protective headgears have been developed for other sports, such as rugby and soccer.

Concussion can result from direct impact of head with hard surface as well as from deceleration, acceleration and rotational forces, in which there is no direct impact to the head. Protective headgear has been shown to reduce the incidence and severity of some injuries from direct impact to the head, such as skull fractures (2,17,18). Helmets have been shown to mitigate the severity of head impact in some instances; however, there is lack of evidence to show that helmets or other protective headgears are effective in preventing concussions (2,19-23). In most sports, multiple impact helmets are used. This type of helmet typically compresses and returns to its original state following an impact. Although such helmets have been shown to reduce the peak deceleration and increase the duration of the deceleration for linear injuries, they do not reduce rotational acceleration (2). Newer technology in helmet design may improve the effectiveness of helmets to mitigate impacts of concussion (21).

Mouth guards

Numerous studies have evaluated the effectiveness of mouth guards for concussion prevention (24-29). Mouth guards are required in some sports. There are different types of mouth guards with variable effectiveness in preventing injuries to the face and teeth. Mouth guards are primarily designed to prevent dental and maxillofacial trauma. It is thought that mouth guards may reduce the severity of the concussion by absorbing some of the forces from an impact to the face. They primarily reduce the force being transferred to the base of the skull. Although, mouth guards do prevent and reduce dental and maxillofacial injuries, they have not been shown to reduce the incidence or severity of concussions (2).

Face protection devices

Face protection devices have been used or are required in some sports. The best known of these are the face shields, visors and cages in ice hockey. These are primarily designed to protect against injuries to the eyes, face and teeth (17). It is thought that face protective devices may decrease the head acceleration after an impact and thereby reduce the force transmitted to the brain (2,17). This may reduce the severity of concussion; however, there is no evidence that face protective devices are effective in reducing the likelihood or severity of concussions (2).

Neck muscle training

Neck muscle strength training has been proposed as a

mechanism to reduce the severity of impact to the brain from direct impact to the head (30-33). It is thought that when the athlete can anticipate a collision, he or she can activate neck muscles and tense contracted neck muscle will fix and stabilize the head and neck (33). A fixed and stable head will likely reduce the impact to the brain in case of a collision. Studies have not shown that neck muscle strengthening can prevent concussions. Part of the problem lies in the fact that the athlete has only a few seconds to anticipate and act in real time during the game or practice.

Playing surfaces

The nature of different playing surfaces has been a subject of study as a factor for its contribution to sport related concussions (34,35). It has been shown that a concussion sustained while playing on an artificial turf is more likely to be associated with loss of consciousness. However, there are multiple associated factors that make it difficult to derive any conclusions as to association between the type of playing surface and risk of concussion. Most synthetic surfaces tend to become harder over time. The consistency of the playing surface depends on the specific material used, type of construction, level of play and the frequency of use. A playing surface with less padding may be more desirable for speed during a play; however, such a surface is also less likely to absorb impact of head injury. Sports such as cheerleading and gymnastics require shock absorbing playing surfaces.

Law and public policy

In the United States, the first state law related to concussions was passed in 2009 in Washington State. Since then all states have passed some form of law concerning sport-related concussions. Although the state laws vary, most follow a generally common theme. They all require education and training of athletes, coaches, and parents about risks of concussions; they require that player who has sustained a concussion be removed from further participation in sport; and the player must get a clearance from a licensed healthcare professional prior to return to sport (36-42). The laws in different states vary in terms of the type and level of education and the qualifications of healthcare professionals who can clear an athlete to return to sports participation. In the United States, it is considered a standard of care for all athletes to have a pre-participation evaluation on a periodic basis (every 1-2 years); however,

there is no public policy guiding or governing such a practice.

Discussion

Paucity of effective preventive measures

A number of educational models have been tried at both individual as well as population level. Most show short term effectiveness in increased knowledge and none to very small effect on reducing the incidence of concussions.

Modifying rules of sport and enforcing the rules have been shown to be effective in preventing and reducing the severity of concussions in contact collision sports, such as American football and ice hockey. Evidence supporting similar effects in other sports is limited at best.

Development and marketing of equipment to prevent concussions in sports is a multi-billion dollar industry. There is much deception and false and predatory marketing of such devices, in spite of the fact that no research supports the claims that helmets, mouth guards, or face protection devices prevent concussions. At best, there may be slight reduction in severity of concussion in some cases. Unfortunately, at this time there is no device that protects against sport related concussion. On the other hand, such devices should be recommended for preventing injuries that they actually do prevent, such as helmets to reduce skull fractures, mouth guards to reduce dental injuries, and face masks to reduce facial trauma.

Neck muscle training has been investigated for its role in preventing concussions. The evidence to support its effectiveness is equivocal and as such this may not be considered a viable measure to prevent concussions.

In the United States, all 50 states now have some form of law that addresses sport-related concussions. Thus far there is no evidence to show that following enactment of such laws the incidence of concussions has been reduced.

The youth sport culture

Although, the focus in this review is the role of education and change in culture as it relates to prevention of concussions in youth sport, it is important to recognize that societal attitudes and sport culture has implications for all children and adolescents who participate in various sports (3,43-50). In contemporary American society, participation in sports by children and adolescents is considered a rite of passage. Over the past 5 decades the context in which children

and adolescents participate in sports has changed. In the past, sports were youth organized community-based local activities; however, sports have since shifted from being youth organized activities to adult-organized activities for the youth; and from being fun oriented, spontaneous activity to highly organized competitions (3,44). Evidence suggests that sport participation is inherently neither a “good” nor “bad” experience for children (46). An important factor determining whether children and adolescents will have a positive or negative experience from participation in sports is influenced by how it is viewed by parents and other adults involved (3,47). Most children and adolescents love sports, and have a positive experience from sport participation; some children who engage in a more intensive participation are more likely to experience an increased level of stress from participation in sports (46). The overall outcome from sport participation is the result of interplay among multiple mediating factors: the athlete, family, peers, coach, and societal attitudes and expectations (44-50).

Peer influence

Peer approval of athletic performance and abilities is highly valued by athletes and their families. Adolescents also begin to compare their own abilities with that of peers. During adolescence, peers are a source of information for appraisal of personal abilities and self-worth as well as an important socializing influence (48). Athletic ability, an important marker for social status, is highly valued by high school students; they would rather succeed in athletics than in academics (3). Participation in team sports is believed to greatly increase the teenager’s popularity and peer acceptance. Sport participation becomes the sole motivation for some students to stay in school (48).

Parental influence

Some parents may have unresolved needs of their own (such as unfulfilled athletic wishes from childhood), and identify their self-esteem with athletic success of their children (3,46,47,50). This creates undue pressure on children to perform and excel in sports. Some parents consider sport participation by their child as an investment for future rewards such as athletic scholarship, or financial success (3). In other instances a child’s success in athletics may become a symbol of social status for parents (3). In few instances, parental over involvement can lead to aggressive behaviors at the game or practice, yelling at children or other parents, fighting with coaches, with negative influence on social and psychological development of the child athlete (3,46,47,50).

Parent may become angry at the child who loses, makes mistakes, or wants to drop out of one or more sports (3). Children may be pushed to continue to participate despite injury, parents may shop doctors for favorable opinion (3). For children and adolescents, who want to pursue competitive sports, parents have to invest considerable energy, time, and financial resources, often stressing the family system (3,47). The balance between appropriate positive encouragement and over involvement can be difficult to achieve by all family members.

Influence of coach

The coach is involved in player selection, recruitment, determining the role of the athlete on the team, training, game plan preparation, and foster team cohesion (3). The child’s behaviors, self-perceptions, and self-esteem are greatly influenced by a coach’s interpersonal behaviors, values, goals and priorities that are set (3). Some coaches may have their own unmet needs and may be living them through their athletes. On the other hand, the adolescent may also have unmet dependency needs and become dependent on the coach as an adult figure (surrogate parent) in a so called dependency relationship (3,48). Coaches can have a great positive influence on the moral and social development of a child and adolescent; coaches can act as counselors or advisors and help adolescents in trouble as well as teach those prosocial values, teamwork, and cooperation (3).

Societal and media influence

Media portrayal of professional athletics can be highly influential in shaping young athlete’s perceptions of sports, with potential for fame and success (3). Many professional athletes are heroes and role models for children and adolescents. The importance of winning reinforces the message that winning at all costs is success in life; however, only a small number of youth ever attain the fame of elite and professional athletes (3,44). It is important to recognize that success in professional sports does not necessarily translate into success in life (3). On the other hand, many successful athletes can also serve as positive role models by contributing to youth programs back into their schools and communities. Some athletes show self-determination and value of hard work by succeeding in spite of physical handicap or socioeconomic barriers (3,49).

In spite of significant progress to include all children and adolescents in sport based on their abilities, organized sport is an exclusionary process, selecting a few elite

athletes, while excluding most (3). Professionals who work with children and adolescents play an important role in counseling those who feel left-out and discouraged, and their families that not being in organized sport activities is not the “end of the world” (3). A whole range of activities other than organized sport participation should be recognized as important and valued. All children, adolescents and their families should be encouraged and supported to get them involved in such activities (3).

Conclusions

More resource and efforts should be redirected from simple knowledge-based education about concussion to developing programs that address the inherent culture of American youth sport that is conducive to concussion and other sport related injuries. There is a need for a cultural paradigm shift from winning in sport at all costs to sports for fun and sport being adult organized and adult governed activity to a more youth directed and youth organized spontaneous activity.

There should be more cohesive efforts in modifying rules of the sport and more research across sports to assess their effectiveness in this area and more robust enforcement of rules of the sport. There should be a more rigorous oversight of the industry that claims their devices prevent concussions. Such claims should be based on evidence supported by robust research. With the use of any injury protective device in sport, the concept of risk compensation has been studied by several investigators. This is based on the theory that everyone has an acceptable level of risk. If the level of risk is reduced from the individual's acceptable risk, there is a tendency for the individual to take a higher risk and reach an equilibrium. This principle is also applicable to any other risk reduction strategy.

Prevention and management of sport related concussions should be within the purview of healthcare professionals and scientists and not legislatures. Law and public policy debate should focus more on the culture of youth sport in America in general rather than targeting (and hoping to prevent) narrowly on laws to prevent concussions.

Decision to participate in sport is a very personal and complex process for the young athlete and his or her family to consider. They should be provided with all the information and resources available for them to make an informed decision. Without addressing the broader issues of sport culture, and role of sport in the lives of children and adolescents, we are not likely to succeed in preventing sport related concussions or other injuries in youth. The

important role of youth sport culture in shaping sport related behavior, and its positive and negative influence should be recognized.

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Footnote

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