

## Chapter 25

# The evolving landscape of policies, rules, and law in sport-related concussion

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### Abstract

Beginning in 2009 with the passage of the Zackery Lystedt law in the state of Washington, all 50 states have passed concussion laws that implement a mandatory framework of care for high school and youth athletes. The structure of these laws generally shares the three primary components of the Lystedt law: (1) preseason concussion education; (2) mandatory removal from play with suspected concussion; and (3) clearance from a healthcare professional prior to return to play. These same three policy components are also found at the collegiate and professional levels of sport, either through established policy or labor contracts. This chapter explores concussion-specific legal and policy developments that currently inform concussion management practices across multiple levels of the US athletic system.

### INTRODUCTION

Concern about the individual and public health consequences of sport-related concussion and repetitive head impact exposure has received increasing scrutiny. In response, clinical research has aimed to improve our knowledge of concussion and repetitive head impact biomechanics, pathophysiology, and clinical sequelae. As our biomedical understanding of concussion and repetitive head impact exposure has improved, attempts have been made to translate such knowledge into strategies to reduce the individual and public health burden of this injury. Many states, national sport governing bodies, and other stakeholders in the athletics environment have proposed policies to reduce the incidence of concussion and to mitigate repetitive head impact exposure, ensure timely diagnosis of concussion, guarantee appropriate medical management of concussion, or some combination of these aims. In this chapter, we survey the concussion policy landscape focusing on three key areas.

First, we examine the role of state-based legislative efforts to diagnose, manage, and prevent sport-related

concussion. Many states initially based their sports-related concussion legislation on Washington state's Zachary Lystedt law. However, nearly half of states have since amended their laws in some way (Lowrey, 2014). The commonalities and differences in state concussion legislation will be discussed, with a focus on primary prevention strategies, what ages/levels of athletes are covered under the law, and what kind of healthcare providers can clear athletes to return to play.

Second, we describe efforts of major governing bodies in sport to address concussion. Here we adopt a public health frame and describe primary and secondary prevention efforts, or policies aimed at preventing an initial concussion or reducing the health burden associated with an acute injury. Major trends across sports and leagues are presented, and illustrative examples are provided throughout.

Third, we identify current areas of improvement in the US concussion policy landscape. Here we evaluate the current knowledge of the effectiveness of existing policies based on rigorous policy evaluation

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studies. Specifically, we discuss gaps in knowledge, implementation, enforcement, and the need for additional policy effectiveness analyses to ensure that concussion policies are achieving their intended public health aims. Throughout the chapter, we maintain a focus on the clinician and his or her role in creating, sustaining, and improving US concussion policy.

## STATE CONCUSSION LAWS

In May 2009, the state of Washington passed the Zackery Lystedt law, the first state law attempting to establish a framework for management and return to play of youth and high school athletes with a sport-related concussion (Foreman, 2010). The law was a public response to the catastrophic brain injury sustained by Zackery Lystedt in 2006 during a middle school American football (henceforth “football”) game. A concussion suffered earlier in the game went undetected, and after returning to play, he suffered a second blow to the head that resulted in a catastrophic event that left him with permanent impairment and disability.

In the wake of the injury, Zackery, his family, and a coalition of individuals and organizations in the state of Washington, including the Seattle Seahawks of the National Football League (NFL), began lobbying for a bill that would provide minimum requirements for how an athlete with a sport-related concussion should be managed. After the Washington bill passed in 2009, the NFL pledged to support the passage of similar bills nationwide. With the passage of the Mississippi law in January 2014, all 50 states plus the District of Columbia have a concussion law for youth and/or high school athletes (National Football League, 2015).

The Lystedt law provided a regulatory template that essentially established three core elements from which all subsequent state concussion bills were crafted (Zackery Lystedt Law, 2009; Harvey, 2013; Kirschen et al., 2014). These three elements were then amplified and nationally disseminated when the NFL launched a national campaign to advocate for state concussion laws. The Lystedt law served as the foundation for the model legislation offered to states by the league. (National Football League, 2015) These elements are:

1. education about concussion for coaches, athletes, and parents
2. removal from play with suspected or diagnosed concussion, with no return on the same day
3. return to play only after clearance from a licensed healthcare provider.

Across the states, implementation and oversight strategies enacted by the legislation vary. In some states (e.g., Virginia), responsibility for the implementation and oversight of the provisions of the legislation is assigned

to the state department of education or its equivalent (Virginia Board of Education, n.d.). In other states (e.g., Washington), responsibility is shared, often between the department of education and the state athletic association, the latter of which may be tasked with policy development, data collection, enforcement, or all of the above (Washington Interscholastic Activities Association, n.d.). In the following sections, we explore the details of these three core components of concussion legislation. Importantly, these laws pertain to concussion in all sports, and not just those occurring in football.

## CONCUSSION EDUCATION

The first element of state concussion laws – education for coaches, athletes, and parents – was generally intended to increase concussion knowledge and help ensure that athletes and their parents were properly informed of the risk of sustaining a concussion, and its possible consequences, prior to deciding to participate in sport. States differ significantly in how they address this component of their laws. For example, 34 states require concussion training for coaches, while three states make education for coaches available, but do not require it (The Network for Public Health Law, 2016). By comparison, 44 states require education for parents while also requiring both parental acknowledgment of that information and signed parental informed consent for the participating child (The Network for Public Health Law, 2016). Five additional states provide concussion education for parents, but do not require acknowledgment of receipt or informed consent. Finally, 47 states require some form of concussion training or education of the athletes themselves, though there is variability in how this education is provided (The Network for Public Health Law, 2016).

It is unclear if these educational efforts were meant as a form of primary prevention, contributing to behavior changes that would reduce concussion or secondary brain injury. For example, greater understanding of the consequences of concussion might make athletes more likely to engage in safer on-field behavior, thereby preventing the occurrence of concussion. However, it is not clear that educational interventions alone can change behaviors in a way that would lead to prevention opportunities. Moreover, Lowrey (2014) argues that very few of the original laws contained any primary prevention strategies.

Regardless of the original intent, the education requirements of the laws do address critical knowledge gaps within the community. Studies suggest that, across sports and across multiple levels of competition, athletes have little knowledge about concussion, including its severity and common symptoms (Kaut et al., 2003; Sye et al., 2006; Cusimano, 2009; Cournoyer and Tripp, 2014). The same is true of coaches (Valovich

McLeod et al., 2007; Mrazik et al., 2011; Rivara et al., 2014) and parents (Sullivan et al., 2009; Bloodgood et al., 2013; Mannings et al., 2014). Research also demonstrates that athletes are hesitant to report concussions (Kerr et al., 2014, 2016; Rivara et al., 2014), which creates a critical barrier to timely recognition and diagnosis.

However, available research suggests mixed results from concussion education efforts across a variety of sports, target groups, and instructional methodologies (Provvidenza et al., 2013). Rivara and colleagues (2014) found that concussion education of high school football and girls' soccer coaches had little effect on coaches' awareness of concussions occurring to their athletes, regardless of the kind or frequency of the educational intervention. Valovich McLeod et al. (2007) found that, while educated youth sport coaches were better at identifying concussion symptoms than their noneducated peers, misperceptions remained. Covassin and colleagues (2011) found beneficial effects of the Centers for Disease Control and Prevention's Heads Up: Concussion in Youth Sports initiative among youth sport coaches. One rationale for the mixed effects is the wide variation in the content and delivery methodology of the concussion education provided under state mandate. (Baugh et al., 2014a).

For student education, the results are similarly mixed. Cusimano and colleagues (2014) found a significant learning effect in minor-league hockey players after video-based concussion education, but that effect decreased after 2 months (Register-Mihalik et al., 2013). Other research has found that concussion education increases the reporting behavior of athletes who suspect they may have a concussion (Bramley et al., 2012; Register-Mihalik et al., 2013) and decreases the proportion of athletes who participated in sport with active symptoms of a concussion (Register-Mihalik et al., 2013). Further research in adolescent hockey athletes indicates that there may be possible negative consequences if the content or viewing environment is not evidence-based (Kroshus et al., 2014).

Some states have extended the education requirements for medical professionals to include athletic healthcare providers who typically have responsibility for concussion diagnosis and management. These typically include athletic trainers and team physicians and are beyond the education required as part of their existing credentialing requirements. For example, the state of Texas requires biennial concussion education of athletics trainers, physicians, or other licensed healthcare professionals serving on school district-based concussion oversight teams (Texas Education Code Ann., Chap. 38). Similarly, New Jersey requires school physicians, athletic trainers, and others to complete a "interscholastic athletic head injury safety training program," to be created and maintained by the state's department of

education. Lastly, Massachusetts requires annual concussion training of athletic trainers, nurses, and physicians, and even includes athletic administrators and marching band directors.

## REMOVAL FROM PLAY

The second element – play prohibitions if a concussion is suspected – directly addresses the circumstances of Zackery Lystedt's original injury by attempting to eliminate the possibility of a concussed athlete sustaining additional blows to the head. As of March 2016, legislation in all 50 states and the District of Columbia prohibits an athlete with a concussion from returning to play on the same day (The Network for Public Health Law, 2016). In his 2012 analysis, Harvey (2013) found that only 42 of 50 states had, at that point, enacted laws that required removal of an athlete with a suspected or confirmed concussion to be removed from play (component #2 above). But between 2014 and 2016, over 20 states have passed at least one substantive amendment to their original concussion law (The Network for Public Health Law, 2016), including changes that enhance the primary prevention capabilities of the legislation (Lowrey, 2014).

To date, few studies have explored the effectiveness of these laws, especially their impact on cultural aspects of concussion, e.g. willingness of athletes to disclose suspected concussion. One reason for this gap in knowledge is the methodologic challenges of accessing relevant data prior to and following the passage of a law. LaRoche and colleagues (2016) found that concussion-reporting behavior was significantly higher among high school and collegiate athletes in Wisconsin following passage of a state concussion law. However, they also found that, among those who did not report a concussion, the most common reason was that they did not want to leave a game. Thus, the mandate may be having the opposite effect on reporting behavior than was intended. Another study evaluated differences in healthcare utilization rates between states that adopted concussion legislation early versus later (Gibson et al., 2015). Early-adopter states experienced an increase in concussion care than later-adoption states (Gibson et al., 2015), but the extent to which adoption of the legislation caused the differential increase is less clear.

## RETURN TO PLAY WITH CLEARANCE

The third element, clearance from a licensed healthcare provider, has been implemented with both inconsistency and some contention. The inconsistency arises from variation in the definition of "licensed healthcare provider" based on the unique state-level practice boundaries enacted through regulatory legislation for medical and health professions. The contention arises for the same

reasons, as consideration of regulatory boundaries ignited professional controversy over which professions are properly trained and legally able to provide such clearance to athletes with sport-related concussion.

All 50 states include physicians (i.e., medical or osteopathic physicians) among the licensed healthcare providers capable of diagnosing concussion and eventually clearing athletes for return to play following resolution of the concussion. In seven states (Alabama, Delaware, Kansas, Kentucky, New York, Rhode Island, and Texas), physicians are the only licensed healthcare providers who can clear an athlete for participation following a concussion ([The Network for Public Health Law, 2016](#)). For example, Alabama authorizes only licensed physicians to provide return-to-play clearance, and that clearance must be provided in writing (Ala. Code 1975 §22-11E-2). As another example, Delaware allows concussion evaluations to be done by “qualified healthcare professionals,” defined as physicians (MD or DO), school nurses, nurse practitioners, physician assistants, or athletic trainers with collaboration and/or supervision from a physician (Del. C. 14 §303). However, only a qualified physician (MD or DO) can provide the written clearance necessary to return to sport.

A more common arrangement across existing laws is for a larger group of licensed healthcare providers to be expressly identified as capable of providing clearance to an athlete following a concussion. The five most common professionals are physicians (i.e., MD or DO), physician assistants, nurse practitioners, athletic trainers, and neuropsychologists ([The Network for Public Health Law, 2016](#)). For example, Arizona defines a licensed healthcare provider as a licensed physician, athletic trainer, nurse practitioner, or physician assistant (A.R.S. 15 §341.A.24(b)). Other jurisdictions, such as Arkansas and Indiana (AS §§ 14.30.142, 143; IC 20-34-7-1 through 6), refer to only a class of “licensed healthcare professionals.” In some states, such as Arkansas, it is presumed that the regulatory boards will interpret application to their respective professions, or that some other named entity (e.g., state board of education) will be responsible for identifying specific professions in policy.

A final component is whether the state requires the clearing licensed healthcare provider to have any specific training, education, and/or experience in sport-related concussion. In his 2013 analysis, before completion of laws in all 50 states, Harvey found that 26 of 45 jurisdictions had concussion-specific training requirements for the clearing health professional. Data from a 2016 summary ([The Network for Public Health Law, 2016](#)) suggest that 34 states currently require specific training for the health professional authorized to provide clearance for athletes. As previously mentioned, several states

require annual training of the health professionals responsible for evaluation and/or return-to-play clearance.

Many features of state concussion legislation have been adopted at other levels of sport. The following section describes concussion policy across other sport leagues and national governing bodies, including how the main provisions of the Lystedt laws are reflected in aspects of concussion policy novel to other competitive settings.

## **CONCUSSION POLICY IN THE ATHLETIC ARENA**

As societal awareness and concern about sport-related concussion have evolved, so too have the concussion-related policies and procedures of many professional and amateur sports leagues and sport governing bodies. In fact, the pace of change in concussion policy and procedure has been so rapid that it is difficult to comprehensively document them. Therefore, we present general themes in concussion policy across leagues, with illustrative examples of each.

The remainder of this review is presented in three sections. The first, education, explores the concussion education requirements across several levels of competitive sport, including collegiate and professional levels. The second adopts a public health frame, and explores policies and procedures reasonably considered forms of primary prevention, with the main goal of concussion prevention. The third section explores secondary prevention strategies, which focus on identification of a concussion once it has occurred, and related policies to mitigate the occurrence of secondary injury.

### **EDUCATION**

Concussion-related education is a cornerstone of concussion policies across leagues and levels. The presumed premise for the pervasiveness of concussion education across levels is the desire for athletes to make informed decisions about the risks and benefits of sports participation. An additional goal is likely to promote knowledge of the injury to improve the rate of reporting, while satisfying any legal obligation to adequately warn participants of the inherent dangers of sport participation. The extent to which these goals have been or can be achieved through a brief education is unclear. Nevertheless, nearly all concussion policies include some type of education component.

For example, in 2010, the National Collegiate Athletic Association (NCAA) adopted emergency legislation requiring all member schools (i.e., 1100 colleges and universities) to have a concussion management plan ([NCAA Constitution, 2010](#)). The structure of the legislative requirement directly reflects the three central



components of state concussion legislation reviewed above. A main tenet of the legislation was that all student-athletes, regardless of sport, receive annual education about the signs and symptoms of concussion. Student-athletes must acknowledge receipt of that information, as well as their obligation to report a concussion to a medical provider.

In 2015, additional legislation (National Collegiate Athletic Association, 2015a, b) required all schools in Division I to submit their written concussion safety protocols to a concussion safety protocol review committee, which would confirm the policy's adherence to interassociation "best practices" on concussion diagnosis and management (National Collegiate Athletic Association, 2017a, b). These "best practices" specify the educational requirements of a school's concussion policy, including the individuals requiring education, and establish the need for a signed acknowledgment of the education. Approved protocols from the 65 schools from the five conferences with autonomy are then made publicly available (National Collegiate Athletic Association, 2018). There is some early indication this process is having a positive impact on the quality of concussion management protocols (Pachman and Lamba, 2017), although there is room for improvement in return to learn (Buckley et al., 2017).

There is some variability in education policy at other levels of competition. At the high school level, the National Federation of State High Schools (NFHS) has no formal recommendations for concussion education, though the absence of such guidance is mitigated by: (1) the presence of state concussion law requirements which cover secondary school athletics in all states; and (2) the presence of state athletic association concussion policies. The NFHS does offer two popular concussion education videos, which are used by state athletic associations across the country. (National Federation of State High School Associations, n.d.).

Educational requirements do exist at the professional level, but differences exist across sports. For example, Major League Baseball's (MLB's) collective bargaining agreement (Major League Baseball, 2012) requires the commissioner's office to arrange orientation sessions for club medical personnel about concussion protocols, and more general education for club personnel throughout the year. It is unclear if the players are considered club personnel for purposes of education efforts.

The NFL collective bargaining agreement requires an "Accountability and Care Committee" to:

*develop a standardized preseason and postseason physical examination and educational protocol to inform players of the primary risks associated with playing professional football and the role of the*

*player and the team medical staff in preventing and treating illness and injury in professional athletes (National Football League, 2011, p. 176).*

The NFL gameday concussion protocol (National Football League, 2016) is more specific about preseason education to staff and players about the signs and symptoms of concussion, as well as the importance of player disclosure of suspected concussion. The National Basketball Association (NBA) also requires education of players, coaches, and medical staff (National Basketball Association, 2016). At the time of this writing, information about the educational requirements for Major League Soccer is not publicly available.

Perhaps unsurprisingly given the dearth of information detailing the requirements of concussion education, subsequent research found significant variation in the information and delivery methodology of the education provided to athletes in the early years following implementation (Kroshus et al., 2014). Additional research suggested that education was one of the main areas of NCAA member schools' concussion policies that required improvement (Baugh et al., 2014b). A more recent study, however, found high compliance with athlete preseason concussion education (Buckley et al., 2017). Despite variation in concussion education, research inquiring as to athletes' preferences for content and delivery of concussion education found consistent themes: desired involvement of coaches and physicians and inclusion of more information relating to the possible consequences of continued play while experiencing a concussion (Kroshus and Baugh, 2016).

## PRIMARY PREVENTION

In the context of public health, the concept of primary prevention reflects a reduction in exposure to the possibility of an injury or illness. Primary prevention strategies for sports concussion reduce the frequency, duration, or magnitude of impacts that could lead to a concussive injury. Compared to secondary and tertiary prevention efforts (which aim for acute diagnosis and management and reduction in burden of injury or illness, respectively), primary prevention is the gold standard in prevention efforts. However, for many injuries and illnesses, a combination of primary, secondary, and tertiary prevention efforts is required to address the public health concern. Examples of primary prevention efforts in the sports concussion context, and the extent to which they have been proven successful, are described below.

### Contact limitations

Some sports and leagues have made rules limiting the amount of permissible contact, especially in contact/

collision sports like football, where repetitive head impact exposure is more common. For example, in the most recent collective bargaining agreement, the NFL and the NFL Players Association took steps to decrease the amount of contact that could occur in practices. Contact is fully prohibited during minicamps. During the regular season, the number of padded practices is limited to 14 per competitive season, 11 of which must be held during the first 11 weeks of the season, and the rest held over the remaining 6 weeks of the season ([National Football League, 2011](#)).

At the collegiate level of football, the NCAA has taken several steps to reduce the amount of head impact exposure. It recently released updated recommendations on year-round football practice contact ([National Collegiate Athletic Association, 2017c](#)) reducing full-contact practices to one per week during the regular season, and eliminating traditional full-contact two-a-day practices during the preseason. Teams may hold one full-contact session per day in the preseason. A second practice session may be held but is limited to walk-through or film study. Football student-athletes must be given off one full day per week in the preseason to allow physical rest and recovery. Some NCAA athletic conferences have also moved separately to limit the amount of contact allowed during practice. A study of one such policy found that fewer full-contact practices significantly reduced the rate of concussions and all injuries in general ([Steiner et al., 2016](#)).

Another approach to contact reduction has been eliminating or penalizing activities within a sport that have an especially high risk of concussion, sometimes in an age-adjusted manner. For example, in November 2015, and in response to an active concussion-related lawsuit, US Soccer eliminated heading for athletes under the age of 10, and limited the act for athletes between 11 and 13 years of age (U.S. [Soccer, 2015](#)). Similarly, checking was eliminated for peewee hockey players; when evaluated, this rule change resulted in fewer injuries overall and fewer concussions specifically ([Black et al., 2016](#)). In other cases, the rule changes are made within a sport across age ranges. For example, the targeting foul in football, which severely penalizes a player who deliberately aims for the head of a defenseless player while tackling, has been adopted across multiple levels of play ([Redding, 2016](#)).

### Protective equipment

Protective equipment, such as helmets and mouthguards, is frequently cited as a way to improve the safety of contact and collision sports and reduce the risk of concussion; however, to date such claims are largely unfounded. Although there is evidence that helmets

and mouthguards may aid in protecting against other injuries (e.g., eye, face, or mouth injuries), the evidence is mixed about the ability of a helmet to protect against concussion ([Delaney et al., 2008](#); [Daneshvar et al., 2011](#); [McGuine et al., 2014](#); [Rowson et al., 2014](#)) Conventional wisdom is that no equipment can prevent concussion.

The evolution of helmet design in the sport of football, from leather helmet to contemporary model, reflects a primary goal of reducing cerebral hemorrhage and skull fracture ([Daneshvar et al., 2011](#)). The NCAA did not mandate the use of football helmets until 1939, and the NFL followed suit in 1940 ([Levy et al., 2004b](#)). Those mandates are enforced through sport playing rules, which currently require that helmets be manufactured and maintained according to performance standards established by the National Operating Committee on Standards for Athletic Equipment (NOCSAE) ([National Operating Committee on Standards for Athletic Equipment, 2015a, b](#)). These standards have reduced the occurrence of catastrophic brain injury by 74% ([Levy et al., 2004a, b](#)). Current efforts to improve helmet standards have focused on augmenting the existing accounting of linear forces with a translational rotation component, which is thought to be a more important biomechanical predictor of sport-related concussion ([National Operating Committee on Standards for Athletic Equipment, 2016](#)).

[Bianco et al. \(2013\)](#) studied 59 years of Olympic-level boxing matches to determine the effect of rules changes on match verdicts with relevance to athlete health. Of interest here is the 1984 mandate for the use of a head guard. They found that head guards significantly reduced both the number of verdicts in which the referee stopped the contest because of an injury (e.g., cut to face) that left the boxer unable to defend himself or where the boxer was getting injured. The number of knockout verdicts also decreased. However, there was a significant increase in verdicts where the referee stopped the contest due to head blows, where the blow left the boxer unable to defend himself or where the boxer was getting hurt. These results led [Bianco et al. \(2013\)](#) to hypothesize that, while head gear decreased the occurrence of facial injury, it may have led boxers to take blows they would have previously avoided. Reductions in knockouts were likely the result of rules changes allowing the referee to stop the bout before a knockout. Head gear mandates were removed after 2013, but no empiric evidence about the impact of this change is yet available.

Any conversation about the effectiveness (or lack thereof) of protective equipment to prevent injury is incomplete unless accompanied by information about the importance of sport playing rules and coaching

technique. While the use of football helmets markedly reduced the occurrence of catastrophic head injury, it did not, for example, change the rate of catastrophic neck injury arising from the improper use of the head during the act of tackling. The rate of catastrophic neck injuries decreased only when use of the head in tackling was prohibited, coupled with changes in how coaches taught tackling technique (e.g., heads-up tackling) (Levy et al., 2004b). It is likely that any future efforts to reduce occurrence of concussion will result from the triad of protective equipment improvements, effective sport playing rule modifications, and safer playing technique.

## SECONDARY PREVENTION

Secondary prevention efforts around concussion aim to reduce the burden of the injury through early detection and procedures to reduce rates of reinjury. Examples of such efforts are provided below.

### In-competition monitoring

As a secondary prevention strategy, monitoring athletes for possible concussion during a competition can take several forms. Standard visual observation by sideline-based personnel, including sports medicine providers, coaches, teammates, and even parents, is the cornerstone of injury identification. However, sideline evaluation of concussion remains challenging because of the speed of action, the disorder of a typical sideline, delayed symptom onset, and the unwillingness of athletes to disclose their symptoms (McCroory et al., 2017). While sideline assessment of concussion is addressed in Chapter 8, this section focuses on two trends increasingly common to contact and collision sports meant to complement sideline efforts: booth observation of the playing field, and the use of wearable impact sensors.

In 2011, the NFL was the first American sport governing body to formalize policy for the use of an independent booth observer to observe the playing field for concussion events that may go undetected by sideline medical personnel. This policy is formalized in the league's gameday concussion protocols (National Football League, 2016) and requires the observer (a.k.a. "spotter") to be an athletic trainer. The spotter relies on video replay from ongoing network broadcasts to review game action. If the spotter suspects an injury, he or she can communicate directly to the team physicians or head athletic trainer of either team. In 2015, spotter authority was expanded to allow the spotter to call a medical timeout (National Football League, n.d.). To date, there is no published research establishing the effectiveness of the NFL's spotter program.

Beginning with the 2015 football season, several NCAA conferences began to replicate the booth spotter program. The specific policies governing the operations of the spotter are dictated by the individual conferences. For example, some conferences require a neutral booth observer, while others allow the observer to have a team affiliation. Additional variation exists in the replay capabilities made available to the observer. In response to these conference-level programs, the NCAA passed an experimental rule for the 2015 season that allowed the spotter to call a medical timeout. That experimental rule was made permanent ahead of the 2016 football season (Redding, 2016).

The second trend is the use of wearable impact sensors (head accelerometers) to register head impacts exceeding a certain threshold of gravitational units (g). While these sensors cannot measure impact to the brain *in vivo*, they assume that skull movement is a reasonable proxy for brain tissue stress. Presently, head accelerometers are an unreliable indicator of concussion and not currently recommended as a clinical diagnostic tool (McCroory et al., 2017; O'Connor et al., 2017).

### Removal from, and return to, competition

As with most state concussion laws, a standard policy component of most national governing bodies is that a player with a suspected concussion is immediately removed from play until a medical provider can evaluate the athlete. Return to competition on the same day is only allowed if the provider determines a concussion is not present. In the NFL, this requirement is complemented by the "Madden Rule" (after the Hall of Fame coach and broadcaster John Madden), which requires the player to immediately be taken off field to the locker room, where he can be fully evaluated in a quiet environment. If a concussion is diagnosed, the player may not return to the field (National Football League, 2016). Similarly, MLB requires immediate removal from play and full concussion evaluation for any player with signs or symptoms of concussion during an on-field evaluation by the athletic trainer. (Major League Baseball, 2012) Similar requirements exist in the NBA (National Basketball Association, 2016), and are also found in the NCAA concussion safety protocol checklist (National Collegiate Athletic Association, 2017a).

Similar uniformity can be found in return-to-play policies across organizations. With only minor variations, once the athlete is symptom-free and has returned to baseline levels, and with the approval of a physician, he or she may begin a graduated, exertional return-to-play protocol. Such protocols typically consist of five to seven steps, with each step occurring no sooner than

24 hours after the previous step (McCrorry et al., 2017). The steps involved in a typical graduated protocol include (McCrorry et al., 2017):

1. symptom-limited activity (activities that do not produce symptoms)
2. light aerobic exercise (e.g., stationary bike)
3. sport-specific exercise (e.g., running)
4. noncontact training (e.g., shooting drills)
5. full-contact practice
6. return to sport

If a step causes the recurrence of symptoms, the athlete falls back one step and waits 24 hours until retesting. Once the protocol has been completed, and with the approval of a physician, return to play may occur. One notable exception is the NFL, which requires return-to-play evaluation to be conducted by both the team physician and an unaffiliated neurologic consultant (National Football League, 2016).

## SUMMARY AND CONCLUSIONS

There are several levels at which concussion and repetitive head impact exposure policy has been implemented in the United States. State-based concussion legislation, sports league policies, and sport-specific rule making can serve as complementary practices to reduce the public health burden of concussion and repetitive head impact exposure. As the understanding of concussion and repetitive head impact exposure and the corresponding health implications continues to evolve, the approach to address these issues will need to similarly evolve. Continuing to move toward an evidence-based, age-, gender-, and sport-specific approach to mitigation of concussion and repetitive head impact exposure through policy is imperative. Following are recommendations toward improved policy.

Rule making should be accompanied by robust policy effectiveness analysis. Despite there being many policy interventions across leagues and levels aimed at preventing concussion and repetitive head impact exposure or reducing the associated health burden, there have been fewer evaluations of the effectiveness of these policies. In order for states and sports leagues to fulfill their moral duty to ensure the effectiveness of health-related policies (Lowrey et al., 2016), such investigations are needed.

Policy effectiveness analyses are important for several reasons. First, rule changes may have negative unintended health consequences. Second, it is possible that the rule change does not affect rates of injury or other health benefits. In this case, providing the appearance of protection can be misleading. Finally, if the health concern was sufficient to warrant a rule change, but the rule change does not promote the intended health gain, an

alternative rule may be warranted. In short, policy effectiveness studies are the only way to ensure that concussion policies are achieving the goal of reducing concussive injury.

As an example of the benefit of policy evaluation, one study evaluated the effects of the “targeting rule”—a football rule change aimed at reducing head-to-head impacts by penalizing purposeful hits of this nature (Westermann et al., 2016). This investigation of NCAA football athletes found the unintended consequence of increased lower-extremity injuries in the years following the rule’s implementation (Westermann et al., 2016). This finding highlights the importance of evaluating concussion-related policies to ensure that they are achieving their intended health improvement, and not unintentionally having deleterious effects.

Sports leagues and governing bodies should move toward gathering comprehensive injury and exposure data. One major barrier to conducting robust policy effectiveness analyses is a lack of sufficient data. Sports leagues and governing bodies can take a leadership role in promoting the collection of such data. It is only with such data that evidence-based policy recommendations can be made toward age-, sport-, and gender-specific policies to reduce the health impacts of concussion. As such, we recommend that, to the extent possible, future concussion and repetitive head impact exposure policy efforts include mechanisms to gather the injury and exposure information required to evaluate the extent to which the policy is achieving the intended health improvement.

Diffusion of successful policies exists across sports and levels. As specific policies are found successful in reducing rates or health burdens of concussion and repetitive head impact exposure in sport, they should be appropriately adjusted, implemented, and tested across levels of sport. For example, while there are mandated reductions in contact, and some associated literature demonstrating effectiveness, within football at the professional and collegiate levels, there are no such rules governing high school and youth football athletes. Implementing and testing the effectiveness of reductions in contact practice at younger levels are important from a public health equity standpoint, especially since there are many more youth and high school athletes than collegiate and professional athletes. Adopting this concept broadly will help ensure that sport safety can be achieved across sports and levels of play.

Clinicians should take a leadership role in concussion and repetitive head impact exposure policy making, as they play several critical roles in such policy. First and foremost, they are critical in evaluation, diagnosis, and management of athletes who have sustained concussion or repetitive head impact exposure. They are an important safety and secondary prevention mechanism



in restricting return to play only to those athletes who have sufficiently recovered from their injury. Clinicians also serve as recognized authorities and can communicate with other stakeholders in the athletics environment regarding effective (and less effective) strategies for reducing the incidence and burden of concussion and repetitive head impact exposure. Particularly in the case of youth athletics, where coach certification standards are mixed, clinicians can be an important authority on the importance of concussion and repetitive head impact exposure prevention and policy adherence. Finally, clinicians can serve an important role in research towards evidence-based policy.

## REFERENCES

- Baugh CM, Kroshus E, Bourlas AP et al. (2014a). Requiring athletes to acknowledge receipt of concussion-related information and responsibility to report symptoms: a study of the prevalence, variation, and possible improvements. *J Law Med Ethics Fall*: 297–313.
- Baugh CM, Kroshus E, Daneshvar DH et al. (2014b). Concussion management in United States College Sports: compliance with National Collegiate Athletic Association concussion policy and areas for improvement. *Am J Sports Med* 43: 47–56.
- Bianco M, Loosemore M, Daniele G et al. (2013). Amateur boxing in the last 59 years. Impact of rules changes on the type of verdicts recorded and implications on boxers' health. *Br J Sports Med* 47: 452–457.
- Black AM, Macpherson AK, Hagel BE et al. (2016). Policy change eliminating body checking in non-elite ice hockey leads to a threefold reduction in injury and concussion risk in 11- and 12-year-old players. *Br J Sports Med* 50: 55–61.
- Bloodgood B, Inokuchi D, Shawver W et al. (2013). Exploration of awareness, knowledge, and perceptions of traumatic brain injury among American youth athletes and their parents. *J Adolesc Health* 53: 34–39.
- Bramley H, Patrick K, Lehman E et al. (2012). High school soccer players with concussion education are more likely to notify their coach of a suspected concussion. *Clin Pediatr (Phila)* 51: 332–336.
- Buckley TA, Baugh CM, Meehan 3rd WP et al. (2017). Concussion management plan compliance: a study of NCAA power 5 conference schools. *Orthop J Sports Med* 5: 2325967117702606.
- Cournoyer J, Tripp BL (2014). Concussion knowledge in high school football players. *J Athl Train* 49: 654–658.
- Covassin T, Elbin RJ, Sarmiento K (2011). Educating coaches about concussion in sports: evaluation of the CDC's "Heads Up: Concussion in Youth Sports" initiative. *J Sch Health* 85: 233–238.
- Cusimano MD (2009). Canadian minor hockey participants' knowledge about concussion. *Can J Neurol Sci* 36: 315–320.
- Cusimano MD, Chipman M, Donnelly P et al. (2014). Effectiveness of an educational video on concussion knowledge in minor league hockey players: a cluster randomised controlled trial. *Br J Sports Med* 48: 141–146.
- Daneshvar DH, Daneshvar DH, Baugh CM et al. (2011). Helmets and mouth guards: the role of personal equipment in preventing sport-related concussions. *Clin Sports Med* 30: 145–163.
- Delaney JS, Al-Kashmiri A, Drummond R et al. (2008). The effect of protective headgear on head injuries and concussions in adolescent football (soccer) players. *Br J Sports Med* 42: 110–115; discussion 115.
- Foreman M (2010). Sidelined for safety: New laws keep student athletes with concussions benched, State Legislatures, National Conference of State Legislators.
- Gibson TB, Herring SA, Kutcher JS et al. (2015). Analyzing the effect of state legislation on health care utilization for children with concussion. *JAMA Pediatr* 169: 163–168.
- Harvey HH (2013). Reducing traumatic brain injuries in youth sports: youth sports traumatic brain injury state laws, January 2009–December 2012. *Am J Public Health*: e1–e6.
- Kaut KP, DePompei R, Kerr J et al. (2003). Reports of head injury and symptom knowledge among college athletes: Implications for assessment and educational intervention. *Clin J Sport Med* 13: 213–221.
- Kerr ZY, Register-Mihalik JK, Marshall SW et al. (2014). Disclosure and non-disclosure of concussion and concussion symptoms in athletes: review and application of the socio-ecological framework. *Brain Inj* 28: 1009–1021.
- Kerr ZY, Register-Mihalik JK, Kroshus E et al. (2016). Motivations associated with nondisclosure of self-reported concussions in former collegiate athletes. *Am J Sports Med* 44: 220–225.
- Kirschen MP, Tsou A, Bird Nelson S et al. (2014). Legal and ethical implications in the evaluation and management of sports-related concussion. *Neurology* 83: 352–358.
- Kroshus E, Baugh CM (2016). Concussion education in U.S. collegiate sport: what is happening and what do athletes want? *Health Educ Behav* 43: 182–190.
- Kroshus E, Daneshvar DH, Baugh CM et al. (2014). NCAA concussion education in ice hockey: an ineffective mandate. *Br J Sports Med* 48: 135–140.
- LaRoche AAN, Lindsay D, Connelly PK et al. (2016). Sport-related concussion reporting and state legislative effects. *Clin J Sport Med*: 26.
- Levy ML, Ozgur BM, Berry C et al. (2004a). Analysis and evolution of head injury in football. *Neurosurgery* 55: 649–655.
- Levy ML, Ozgur BM, Berry C et al. (2004b). Birth and evolution of the football helmet. *Neurosurgery* 55: 656–661; discussion 661–652.
- Lowrey KM (2014). Revising the game plan: primary prevention, early detection, and the future of concussion laws, The Network for Public Health Law. Available online at [https://www.networkforphl.org/the\\_network\\_blog/2014/07/21/474/revising\\_the\\_game\\_plan\\_primary\\_prevention\\_early\\_detection\\_and\\_the\\_future\\_of\\_concussion\\_laws](https://www.networkforphl.org/the_network_blog/2014/07/21/474/revising_the_game_plan_primary_prevention_early_detection_and_the_future_of_concussion_laws). Accessed 30 March 2017.
- Lowrey KM, Morain SR, Baugh CM (2016). Do ethics demand evaluation of public health laws? Shifting scientific sands and the case of youth sports-related traumatic brain injury laws. *J Health Care Law Policy* 19: 99–117.

- Major League Baseball (2012). 2012–2016 Basic agreement. Available online at [http://mlbplayers.mlb.com/pa/pdf/cba\\_english.pdf?SPSID=1113059&SPID=181320&DB\\_OEM\\_ID=34000](http://mlbplayers.mlb.com/pa/pdf/cba_english.pdf?SPSID=1113059&SPID=181320&DB_OEM_ID=34000). Accessed 28 May 2017.
- Mannings C, Kalynych C, Joseph MM et al. (2014). Knowledge assessment of sports-related concussion among parents of children aged 5 years to 15 years enrolled in recreational tackle football. *J Trauma Acute Care Surg* 77: S18–S22.
- McCrary P, Meeuwisse W, Dvorak J et al. (2017). Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016. *Br J Sports Med* 51: 838–847.
- McGuine TA, Hetzel S, McCrea M et al. (2014). Protective equipment and player characteristics associated with the incidence of sport-related concussion in high school football players: a multifactorial prospective study. *Am J Sports Med* 42: 2470–2478.
- Mrazik M, Bawani F, Krol AL (2011). Sport-related concussions: knowledge translation among minor hockey coaches. *Clin J Sport Med* 21: 315–319.
- National Basketball Association (2016). National Basketball Association concussion policy summary - 2016-17 season, National Basketball Association, New York, NY.
- National Collegiate Athletic Association (2010). Concussion management plan. NCAA Constitution. National Collegiate Athletic Association, Indianapolis, IN.
- National Collegiate Athletic Association (2015a). Concussion safety protocol [A], NCAA Constitution 3.2.4.18.1. National Collegiate Athletic Association, Indianapolis, IN.
- National Collegiate Athletic Association (2015b). Information to Concussion Safety Protocol Committee [A], NCAA Constitution 3.2.4.18.11. National Collegiate Athletic Association, Indianapolis, IN.
- National Collegiate Athletic Association (2017a). Concussion safety protocol checklist, National Collegiate Athletic Association, Indianapolis, IN.
- National Collegiate Athletic Association (2017b). Interassociation consensus: diagnosis and management of sport-related concussion best practices, National Collegiate Athletic Association, Indianapolis, IN.
- National Collegiate Athletic Association (2017c). Interassociation consensus: year-round football practice contact for college student-athletes recommendations, National Collegiate Athletic Association, Indianapolis, IN.
- National Collegiate Athletic Association (2018). Concussion safety protocol management. Available online at <http://www.ncaa.org/sport-science-institute/concussion-safety-protocol-management>. Accessed 27 May 2017.
- National Federation of State High School Associations (n.d.) Courses. Available online at: <https://nfhslearn.com/courses?searchText=Concussion> (accessed May 28, 2017).
- National Football League (n.d.) ATC Spotters. Available online at: <http://operations.nfl.com/the-game/gameday-behind-the-scenes/atc-spotters/> (accessed May 29, 2017).
- National Football League (2011). Collective bargaining agreement. Available online at <https://nflpaweb.blob.core.windows.net/media/Default/PDFs/2011%20CBA%20Updated%20with%20Side%20Letters%20thru%201-5-15.pdf>. Accessed 26 May 2017.
- National Football League (2015). Find out more about Zackery Lystedt Law. Available online at <http://www.nfl.com/news/story/0ap2000000339066/article/find-out-more-about-zackery-lystedt-law>. Accessed 30 March 2017.
- National Football League (2016). NFL Head, Neck, and Spine Committee's protocols regarding diagnosis and management of concussion. In: National Football League, Available: online at <https://www.playsmartplaysafe.com/focus-on-safety/protecting-players/nfl-return-to-participation-protocol/>. Accessed 27 March 2017.
- National Operating Committee on Standards for Athletic Equipment (2015a). Standard performance specification for newly manufactured football helmets, NOCSAE, Kansas City, KS.
- National Operating Committee on Standards for Athletic Equipment (2015b). Standard performance specification for recertified football helmets, NOCSAE, Kansas City, KS.
- National Operating Committee on Standards for Athletic Equipment (2016). NOCSAE finalizes first-ever football helmet standard to address concussion risks from rotational forces and first chest protector standard for commotio cordis. Available online at <http://nocsae.org/wp-content/uploads/2017/02/NOCSAE-2017-January-Meeting-Release.pdf>.
- O'Connor KL, Rowson S, Duma SM et al. (2017). Head-impact-measurement devices: a systematic review. *J Athl Train* 52: 206–227.
- Pachman S, Lamba A (2017). Legal aspects of concussion: the ever-evolving standard of care. *J Athl Train* 52: 186–194.
- Provvidenza C, Engebretsen L, Tator C et al. (2013). From consensus to action: knowledge transfer, education and influencing policy on sports concussion. *Br J Sports Med* 47: 332–338.
- Redding R (2016). 2016 and 2017 NCAA football rules and interpretations, National Collegiate Athletic Association, Indianapolis, IN.
- Register-Mihalik JK, Guskiewicz KM, Valovich McLeod TC et al. (2013). Knowledge, attitude, and concussion-reporting behaviors among high school athletes: a preliminary study. *J Athl Train*: 130712125721004.
- Rivara FP, Schiff MA, Chrisman SP et al. (2014). The effect of coach education on reporting of concussions among high school athletes after passage of a concussion law. *Am J Sports Med* 42: 1197–1203.
- Rowson S, Duma SM, Greenwald RM et al. (2014). Can helmet design reduce the risk of concussion in football? *J Neurosurg* 120: 919–922.
- Steiner ME, Berkstresser BD, Richardson L et al. (2016). Full-contact practice and injuries in college football. *Sports Health* 8: 217–223.
- Sullivan SJ, Bourne L, Choie S et al. (2009). Understanding of sport concussion by the parents of young rugby players: a pilot study. *Clin J Sport Med* 19: 228–230.
- Sye G, Sullivan SJ, McCrary P (2006). High school rugby players' understanding of concussion and return to play guidelines. *Br J Sports Med* 40: 1003–1005.
- The Network for Public Health Law (2016). Youth sport concussion laws: Table, Available online at <https://www.networkforphl.org/The Network for Public Health Law>.

- Soccer US (2015). Frequently asked questions. Available online at <http://www.ussoccer.com/about/recognize-to-recover/concussion-guidelines/player-safety-campaign-faqs>. Accessed 28 May 2017.
- Valovich McLeod TC, Schwartz C, Bay RC (2007). Sport-related concussion misunderstandings among youth coaches. *Clin J Sport Med* 17: 140–142.
- Virginia Board of Education (n.d.) Guidelines for policies on concussions in students. Available online at: <http://www.doe.virginia.gov/boe/guidance/health/2016-guidelines-for-policies-on-concussions-in-students.pdf>.
- Washington Interscholastic Activities Association (n.d.) Concussion management guidelines. Available online at: <http://www.wiaa.com/subcontent.aspx?SecID=623> (accessed May 27, 2017).
- Westermann RW, Kerr ZY, Wehr P et al. (2016). Increasing lower extremity injury rates across the 2009-2010 to 2014-2015 seasons of National Collegiate Athletic Association Football: an unintended consequence of the "targeting" rule used to prevent concussions? *Am J Sports Med* 44: 3230–3236.
- Law Zackery Lystedt (2009). RCWA: 28A.600.190.