Neurosurg Focus 33 (6):E11, 2012

Comparative analysis of state-level concussion legislation and review of current practices in concussion

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Object. Forty-two states and the District of Columbia have passed legislation based on the Lystedt law of Washington state, enacted in 2009 to protect young athletes who have sustained a concussion. The aim of this study was to note the several similarities and differences among the various laws.

Methods. Concussion legislation was compared for 50 states and the District of Columbia. Evaluation parameters of this study included stipulations of concussion education, criteria for removal from play, requirements for evaluation and return to play after concussion, and individuals required to assess young athletes. Other parameters that were not consistent across states were also noted.

Results. Forty-three states and the District of Columbia have passed concussion legislation, and an additional 4 states have pending legislation. All states with existing legislation support concussion education for coaches; however, only 48% require coaches to undergo formal education. Athletes must be educated on concussion in 86% of states and parents in 88.7%. Suspicion of concussion is a criterion for removal from play in 75% of states; signs and symptoms of concussion are criteria for removal from play in 16% of states. The individuals allowed to evaluate and clear an athlete for return to play differ greatly among states.

Conclusions. Injury prevention legislation holds historical precedent, and given the increasing attention to long-term sequelae of repeated head trauma and concussion, concussion legislation has been rapidly passed in 43 states and the District of Columbia. Although the exact stipulations of these laws vary among states, the overall theme is to increase recognition of concussion in young athletes and ensure that they are appropriately cleared for return to play after concussion.

(http://thejns.org/doi/abs/10.3171/2012.9.FOCUS12280)

Key Words • **concussion legislation** • **sports injury** • **concussion** • **injury prevention**

In October 2006, Zackery Lystedt, a 13-year-old fullback on his football team, was playing just another game. At the end of the first half he sustained a hit and was momentarily dazed. He was benched for a few plays but allowed to return to the game after halftime, playing the remainder of the third and fourth quarters with some notable changes to his usual behavior. After the game he collapsed and was taken to the emergency room, requiring multiple craniotomies to treat intracerebral hemorrhage and edema.[2] In May 2009, Washington state passed the Zackery Lystedt Law, requiring immediate removal from play of any young athlete suspected of having sustained a concussion. This law also stipulates clearance from a licensed health care provider trained to evaluate head injuries before an athlete can return to play.[24] Largely driven by professional athletic associations such as the National Football League, awareness of the very important issue of sports-related concussion has increased and served as an impetus for greater regulation among younger athletes.[21] Since the implementation of the Lystedt law, 42 additional states and the District of Columbia have passed similar legislation, and 4 states have pending legislation. There are subtle differences and many consistencies among the various states; however, certain stipulations critical to protecting young athletes remain constant.

Methods

Concussion legislation passed by each state was compared regarding the population to which legislation applies, criteria for removal from play, educational components, and stipulations for clearance to return to play. States in which legislation was pending were not counted in terms of the criteria comparing laws.

Legislation was accumulated from the legislatures of the various states and the Council of the District of Columbia, and the status of the laws was updated in June 2012.

Results

Among the 50 possible states and the District of Columbia, only 3 states currently have neither a law regarding concussion regulation nor a pending law. No bill was ever submitted in Montana; legislation was voted down in Maine; and in Mississippi, the legislation never made it past committee hearings. Four states—Michigan, Ohio, South Carolina, and West Virginia—have pending legislation. Legislation exists in the remaining 43 states and the District of Columbia. (For the sake of convenience we will henceforth refer to "44 states" and include the District of Columbia in referring to 44 states.)

Although details regarding the age at which the various bills apply are not specifically mentioned in most cases, athletes at the college level and those 19 years and older are universally not affected by these bills, leaving other governing bodies such as the National Collegiate Athletic Association to manage concussions at that level. The majority of the laws with which we are concerned are directed toward school-age youth and young athletes participating in organized sports.

Coach Education

As part of many states' legislation, coaches must be educated to some extent regarding concussion recognition as well as the sequelae, treatment, and criteria for return to play following concussion. The extent of education required by each legislature varies greatly (Fig. 1). Some states offer education in the form of an information sheet, whereas others require training that must be renewed in various time frames. Among the states with laws that have passed, 48% require coaches to undergo formal training either online or in a classroom. However, 20% of states offer some form of optional education or have no recommendations within their current laws. The remaining 32% require coaches to receive some form of education that consists of an information sheet or other unspecified means of conveying the information.

Parent and Athlete Education

Another matter that varies greatly among the states with concussion legislation is the level at which student athletes and their parents are educated about concussions. Although no states require athletes to undergo any sort of formal training on concussion, many do offer some level of education (Fig. 2). While 88.7% of states offer parents either education or an information sheet on concussions, 81.8% of the states with legislation require the parents to read and sign the information sheet, taking parental involvement and awareness to a mandatory level. Note, however, that only 75% of states require the athletes—those directly affected by concussions—to read and sign the information sheet. Eighty-six percent of states offer either an information sheet or some form of education, although it is not specifically directed at the athlete; the remaining 14% do not require the athlete to be educated in any way regarding concussions.

Removal-From-Play Criteria

After sustaining a concussion, current guidelines support immediate removal of the athlete from play.[47] At minimum, the athlete should undergo evaluation by an appropriate health care provider. However, the criteria for removal from play vary greatly among states (Fig. 3). The most cautious recommendation indicates removal of an athlete when there is any suspicion of a concussion. Among states with legislation, 75% require removal of an athlete when concussion is suspected, which elevates the importance of education for coaches, since they are often among the first to interact with an athlete after an injury. Adopting a less conservative measure, 16% of states require removal only when signs or symptoms of concussion are exhibited by the athlete. Of the remaining states, 2% require removal only following loss of consciousness, 2% require simply the establishment of guidelines, and 5% have no removal component at all.

Health Care Practitioner Standards

The individuals or entities allowed to evaluate, treat, and eventually clear athletes who have sustained a concussion for return to play are directly specified in most

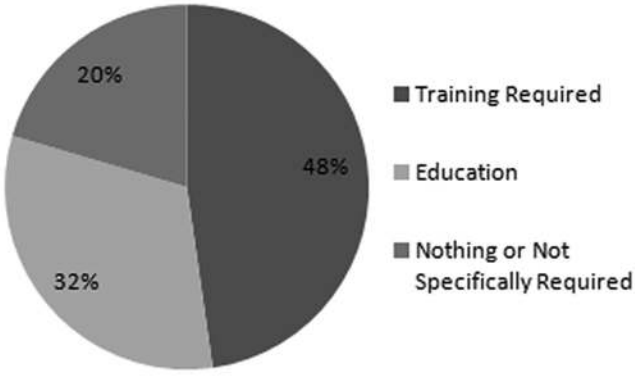

Fig. 1. Graph showing required coach education delineated by state concussion legislation. Percentages indicate states requiring each level of education among legislatures with laws.

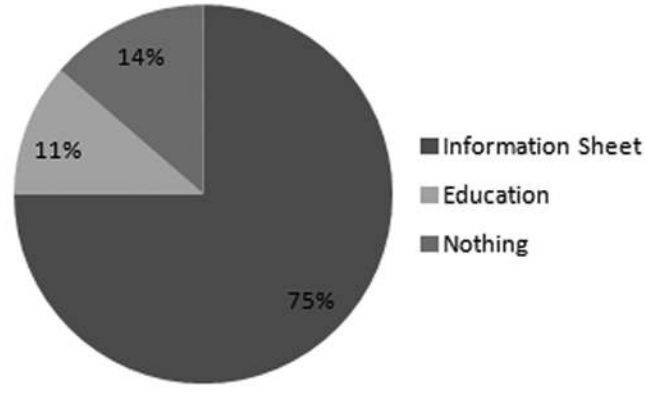

Fig. 2. Graph demonstrating required education for athletes as delineated by state concussion legislation. Percentages indicate states requiring each level of education among states with legislation.

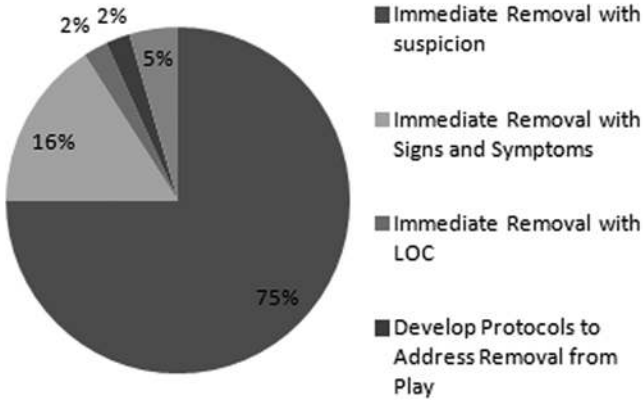

Fig. 3. Graph displaying the percentage of states with legislation utilizing various criteria for removal from play. LOC = loss of consciousness.

renditions of legislation (Fig. 4). Thirteen states allow any health care provider trained in the recognition and management of concussions to make such assessments, whereas 4 states permit any health care provider regardless of training to evaluate and do not further define "health care provider." Four states do not specify in any way who is allowed to evaluate concussions. Of the remaining, all 23 states allow physicians to evaluate concussions. Fourteen states allow physician assistants or nurse practitioners to make such assessments. Fourteen allow athletic trainers to assess concussions, but these states do not coincide completely with those allowing nurse practitioners and physician assistants. Nine states allow psychologists with appropriate training in concussion management to evaluate and clear athletes. Three states allow physical therapists to manage concussions, and 1 state allows chiropractors to do so.

Baseline Testing

There is evidence that baseline cognitive testing is beneficial in the evaluation of traumatic brain injury such as concussions.[54] However, not many states recognize such testing through legislation. Only 3 states mention baseline testing in their legislation, with 1 state requiring this testing and 2 only recommending it.

Incentives and Disincentives

Another component included directly in several laws is intended to incentivize compliance or penalize those who violate the law. Only 4 of the 44 legislatures include a punishment for noncompliance with the laws. Three states (Connecticut, Pennsylvania, and Tennessee) have suspension or revocation of coaches' licenses in the event of noncompliance. The fourth state, Massachusetts, includes a line in the law stating that noncompliant schools are subject to penalties. It is important to note that violation of these laws is targeted at punishing coaches, whereas only 1 state in the country holds schools most directly responsible.

Incentivizing compliance is a common component among the legislations. The incentive included in all cases is liability protection. The laws give either protection from or immunity to lawsuits in the event of an athlete's death or injury as a result of return to play if the laws were correctly followed. This is included in the legislation from 16 of the 44 states.

The inclusion of a punishment or incentive in legislation is important to increase compliance. With no repercussions or protection afforded by the legal system, the legislation for many states offers no reason for the laws to be upheld as they are currently written.

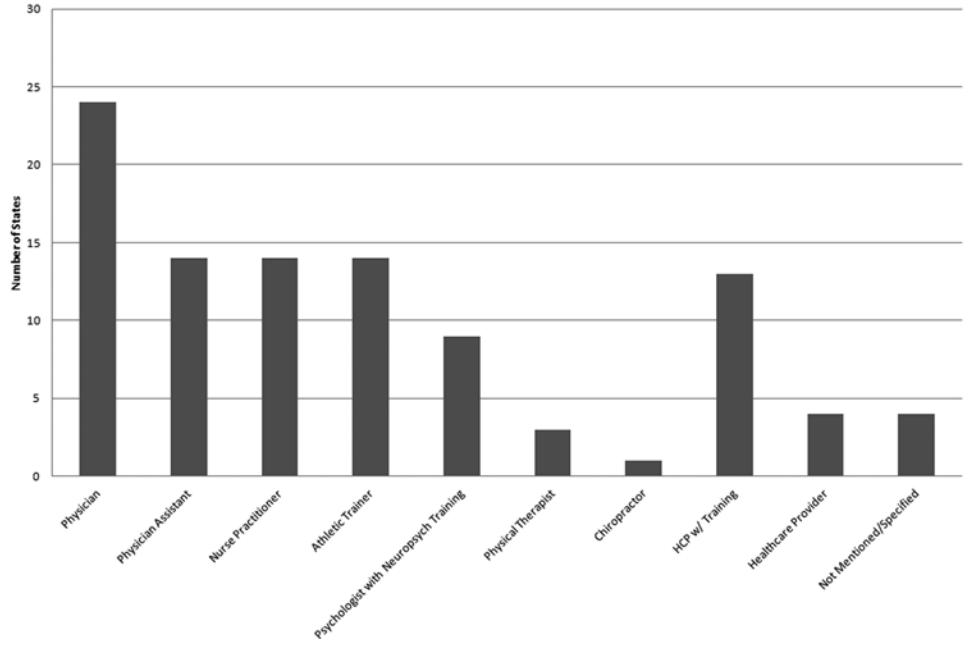

Fig. 4. Bar graph showing which health care providers are allowed to clear an athlete for return to play according to state-based legislation. HCP = health care provider; Neuropsych = neuropsychological.

Discussion

Background on Concussion

A concussion is defined as a complex physiological process affecting the brain, induced by traumatic biomechanical forces.[47] These forces can be caused by several mechanisms, often a direct blow to the head or neck. Concussion manifests as temporary impairment of neurocognitive function without structural abnormality of the brain, reveals no radiographic findings, and may or may not involve loss of consciousness with the initial insult. In part, the pathophysiology of concussion in a pediatric population may result from alterations in cerebral blood flow, with a reduction in cerebral blood flow occurring after concussion and a slow increase seen during the postconcussion recovery period.[43] Symptoms include headache, dizziness, difficulty with concentration, confusion, nausea, and light sensitivity.[11,41] The majority of these symptoms resolve after 3–7 days.[25,38,51] There is some difference in presentation between the sexes: males have been more likely to present with amnesia, confusion, and disorientation, whereas females are more likely to experience drowsiness and noise sensitivity.[25] Time to recovery is similar between males and females. Dizziness, in particular, has been associated with a protracted recovery time, meaning that recovery takes longer than 3 weeks.[38]

Epidemiological Factors

Concussions are estimated to have an incidence of approximately 1.7–2.5 cases per 10,000 athlete exposures among high school athletes, with athlete exposure defined as a single athlete's participation in 1 practice or competition.[11,39,41,59] Authors of a population-based study documented an incidence of approximately 1% for females and 1.9% for males.[68] Another study revealed that approximately 40% of emergency department visits for concussion involve children 8–13 years of age, and the remaining visits involve children 14–19 years of age.[5] Among all of these visits, 25% were related to organized team sports, and the rest were related to individual sports and leisure activities.

Although concussion was previously believed to be more common in males than females, increasing awareness along with further studies has shown that this injury is not primarily isolated to males. Football remains the most common sport associated with concussions, with an incidence of 3.3–6.0 cases per 10,000 athlete exposures.[11,39,41,59] Soccer tends to be the sport associated with not only the highest concussion rate in girls, but also the second highest concussion rate in most studies, with a rate of 1.4–4.1 cases per 10,000 athlete exposures.[11,33,39,41,59] Overall, however, boys' sports represented 75% of all concussions, and these head injuries were more frequently caused by player contact rather than surface or ball contact, which was more common with girls' sports.[11,39,51] Several studies have demonstrated between a 5- and 9-fold increase in concussion risk during games in multiple sports as compared with practice.[16–18] An 11-year prospective study showed a 4.2-fold increase in the concussion rate over the study period; however, the investigators noted that a greater awareness of concussion, as well as the increased presence of athletic trainers, may have contributed to this trend.[39] This finding would suggest that the incidence of sports-related concussion is higher than previously thought, making concussion legislation even more relevant.

These statistics become even more concerning when one considers that between 11.5% and 13.2% of concussions are recurrent.[11,41] In fact, a history of head injury is an independent risk factor for concussion, with a relative risk between 2.04 and 2.28 in athletes who have sustained a previous concussion.[22,59] Recurrent concussions, as compared with initial ones, have been linked to a prolonged time to symptom resolution as well as a greater incidence of loss of consciousness at the time of injury.[11] Several theories explain this increased risk of repeat concussion: Athletes with more playing time are prone to concussion as well as subsequent head injury, and athletes with recurrent concussions may have more aggressive styles of play.[46] Additionally, many concussions may go unreported. In a survey of over 1500 varsity football players, 29.9% of players reported a previous concussion and 15.3% had sustained a concussion during the season; however, only 47.3% reported the concussion at the time of injury. Reasons cited for not reporting included the following: they believed the injury was not serious, they did not want to be withheld from competition, or they did not have an awareness of the likelihood of a concussion.[44] This underreporting was further validated by a prospective study of physician-observed concussions in ice hockey, which demonstrated a concussion rate of 21.5 cases per 1000 athlete exposures, a 7-fold increase in the previously reported rates in youth hockey.[20] This underreporting raises concern that these athletes are placed at higher risk for repeat concussion. The crux of concussion legislation is to raise awareness of the severity of concussion and place stringent regulations on removal from play when concussion is suspected. Doing so allows formal evaluation of the athlete and may reduce the incidence of missed concussions by placing responsibility at several levels—athletes, coaches, parents, and trainers.

Young athletes have a higher risk of sustaining a concussion and are more vulnerable to its sequelae, probably due to a combination of factors: failure to recognize the signs of concussion, immaturity of the adolescent nervous system, decreased myelination, a greater head-to-body ratio, thinner cranial bones, and the amount of subjectivity associated with reporting symptoms.[64] Even when comparing high school and college athletes who have sustained a concussion, the former demonstrate prolonged recovery times and a 7-day postconcussion neurocognitive performance that matches the 3-day postconcussion performance of their collegiate counterparts.[23] The continuing emergence of research on the second-impact syndrome and chronic traumatic encephalopathy further supports the notion that we should be more vigilant in protecting young athletes at risk. A retrospective review of sudden death caused by subdural hematoma in athletes 14–18 years of age demonstrated a 12% incidence of prior concussion with persistent symptoms.[65] Second-impact syndrome, a consequence of repeat head injury, is

thought to result from rapid and malignant cerebral edema. Note, however, that the syndrome has been described predominantly through case reports and is still poorly understood.[37,45] What is better understood is the risk associated with repeated head injury, both concussive and subconcussive, leading to chronic traumatic encephalopathy, a neurodegenerative disease. A study of high school football players revealed an average of 652 subconcussive head impacts annually (range 5–2235 impacts).[10] This repetitive brain trauma, even in the absence of clinical concussion, has been associated with cognitive decline over time and chronic traumatic encephalopathy.[62]

Current Awareness and Practices

Concussion management depends highly on the knowledge base of all individuals involved, including athletes, coaches, athletic trainers, parents, and health care providers. This educational and awareness-building component is found throughout concussion legislation and is intended to improve the comprehensive knowledge about and care of athletes after concussion. All individuals involved will benefit from a more standardized approach to managing sports-related concussion, as any of the previously mentioned persons may be intricately involved in managing an athlete after concussion. According to the Zurich consensus,[47] an athlete with a suspected concussion should be immediately removed from play. The athlete should then proceed through a graduated return-to-play protocol. This strategy has widely been accepted as the appropriate management of an athlete postconcussion. The graduated protocol consists of a stepwise increase in activity level as long as the patient remains symptom free, with each step taking a minimum of 24 hours. There are 6 stages in this protocol, and thus the return-to-play progression should take approximately 1 week.[47] These recommendations are summarized in Table 1.

Neurocognitive testing is increasingly used to augment concussion evaluation and return-to-play decisions. Sideline testing allows quick assessment of a player's cognitive function and includes the Maddock questions of orientation, the National Football League Sideline Concussion Assessment Tool, and the Sport Concussion Assessment Tool (SCAT2).[54] Developing a strict sideline evaluation protocol allows rapid identification and triage of concussive injuries and allows closer observation of these athletes in the event that more serious symptoms develop. As neurocognitive testing becomes more prevalent it is being used not only after injury, but also before to obtain a baseline value and then sequentially to assess for neurocognitive decline. Thus, it becomes important to distinguish factors that can affect baseline values. Athletes with self-reported concussion histories tend to score lower on the SCAT2 than those with no concussion history, males tend to have lower baseline scores than females, and baseline scores tend to be higher among upperclassmen.[66] Other assessments of high school athletes have demonstrated lower-than-average values on concentration and balance testing, bringing into question the validity of the raw scores of subsets without a baseline comparison that would allow evaluation for a decline in score.[35] Over the span of a season, however, athlete scores on neurocognitive testing have been shown to remain stable despite repetitive contact in athletes who do not sustain a concussion, suggesting that baseline values obtained at the beginning of the season should otherwise remain constant and thus supporting the idea of obtaining baseline values prior to injury.[52] Neurocognitive testing also results in longer removal from play, suggesting that it allows more conservative management than physical examination and subjective assessment of symptoms alone.[50,51]

TABLE 1: Six stages of a graduated return-to-play protocol

Stage	Activity
1	no activity
2	light aerobic exercise, goal <70% of max predicted heart rate
3	exercise drills specific to sport, noncontact
4	training drills specific to sport, more complex than Stage 3, noncontact
5	full contact training practice
6	return to play

Since the diagnosis of concussion is highly subjective, it is imperative that athletes understand its signs and symptoms as well as the critical nature of symptom reporting and accurate performance on neurocognitive testing. A survey of amateur rugby players demonstrated that 38.5% of respondents had not been informed of the signs and symptoms of concussion, and several of these individuals also thought that immediate return to play would be appropriate.[7] A separate survey of high school rugby players indicated that they understood only 50% of the concussion guidelines and 60% of the requirements for removal from play and that there was only a 22% rate of compliance with obtaining medical clearance before returning to play.[63] On the other hand, rising awareness of the consequences of concussion has been accompanied by an increase in athletes' knowledge of concussion and the risks of early return to play, as demonstrated by a 2-year study of junior hockey players showing better compliance with immediate removal from play as well as a longer delay in returning to play.[30] Educational programs have been effective in raising awareness of concussion among athletes as well as communicating that knowledge and removal from play must be combined with modification of play practices to avoid riskier behaviors during sports events, an equally important aspect of concussion prevention.[19,36]

The many state-based laws requiring an educational component on concussion may help in expanding awareness. A recent study of a concussion education curriculum delivered by medical students and health care professionals demonstrated a passing rate increase from 34% on a pretest to 80% on a posttest among students 9–18 years of age.[4] To our knowledge, the only study demonstrating the impact of concussion legislation on the familiarity with head injury was performed at the University of Washington by Shenouda et al.[61] These authors evaluated knowledge of the guidelines contained in the Lystedt law and recorded that 96% of respondents (parents, coaches, and other persons involved in athletics) understood that concussions were a form of traumatic brain injury and that 90% would delay

an athlete's return to play when neurological symptoms were present. Fewer individuals understood return-to-play guidelines, including written clearance (73%), or that a parent could not clear the athlete for return to play (88%). This finding suggests that further educational efforts, such as those included in the subsequent iterations of concussion legislation, may need to be improved to convey the importance of diagnosis and evaluation of concussion as well as return-to-play recommendations.

Coaches carry equal responsibility in understanding and identifying concussion, as well as immediately removing from play those athletes suspected of having sustained a concussion. However, documented knowledge among coaches suggests that further education is needed to prepare them for this role in concussion management. Although coaches admit that they have an important role, the majority of them in 1 study admitted having limited knowledge and cited magazines and newspapers as their primary source of information.[53] Other studies have revealed increasing knowledge among coaching staff who do not have athletic trainers available at practices, and these coaches cite conferences and coaching associations as their primary source of information, with upward of 70%–95% of coaches appropriately consulting a health care provider for return-to-play decisions.[31] The education of coaches on symptoms has proved beneficial in terms of their ability to identify a possible concussion as well as understand its management, suggesting that educational programs geared toward coaching staff is a necessary component of care.[29,58,67]

Sidelines management of concussion continues to be an important factor and may be facilitated by coaching staff, team physicians, or often an athletic trainer. Appropriate sidelines management has been shown to improve outcome and decrease costs associated with sports-related concussion.[27] Data from the 2009–2010 school year from 192 high schools across 20 sports showed that 94.4% of concussions were assessed by athletic trainers and another 58.8% by a primary care physician. The return-to-play decision was made by a physician in 50.1% of cases and by an athletic trainer in 46.2% of cases, with computerized neuropsychological testing in 41.2% of all cases. Athletes with longer-duration symptoms were more likely to obtain physician clearance before returning to play.[49] Athletic trainers on the field are therefore an important component of concussion management in the acute phase. However, even current practice patterns among athletic trainers lack standardization and adherence to current guidelines. An assessment of athletic training students and program directors demonstrated a variation in practice patterns for concussion assessment, management, and return-to-play guidelines, often with athletic trainers using a multidimensional approach rather than following any existing guidelines on concussion management.[15]

A multipronged approach to concussion awareness and education must not exclude physicians, especially since most legislation mandates clearance by a physician or other health care provider and since current knowledge does not represent an appropriate level of understanding among physicians who may be evaluating young athletes after concussion. A survey of practitioners who care for children indicated that less than 50% knew the appropriate return-to-play guidelines.[6] Nonclinical factors may also play a role in the management of patients with sports-related concussion, including medicolegal matters and concerns of the parents, players, and coaches, as noted in a study demonstrating only 23% use of a nationally recognized guideline regarding return to play.[28] Another study revealed that appropriate discharge instructions regarding return to play after hospital admission for a sports-related concussion were given only 30% of the time.[26] Certain situations warrant special consideration in concussion management, such as individuals with multiple concussions, younger athletes, and persons with prolonged symptoms after concussion.[57] Athletes with prolonged symptoms tend to have a higher referral pattern to physicians for evaluation,[51] so it is not unreasonable to infer that these more complex cases are more frequently seen by physicians, further reinforcing the importance of physician education, especially in more complex presentations.

Providers should be made aware that proper concussion management protects young athletes and their developing brains and that there are legal consequences to inappropriate management. Past lawsuits have involved negligent supervision of practices, with implications of error reaching as high as the school district, failure to exercise reasonable care regarding return to play, and improper treatment and diagnosis by a physician.[32] Each individual responsible for the supervision, assessment, and clearance of a young athlete who has sustained a concussion may be considered legally responsible for his or her outcome if an appropriate standard of care is not followed.

One method of disseminating concussion education is through online modalities, but these resources must be appropriately regulated to ensure readability of the documents at a grade-appropriate level for comprehension as well as accuracy of the information. An evaluation of online resources for concussion education revealed an 11th grade reading level, which may be too high for younger athletes to comprehend. Additionally, approximately 40% of websites containing information on concussion have incorrect information, such as misrepresentation of the need to seek physician consultation after concussion.[3] The media plays an important role in concussion management as well, as the portrayal of how concussions are handled may impact public awareness of appropriate management as well as an athlete's perception of the serious nature of this injury. Media audiences exposed to postconcussion return to play while watching athletic events may accept it as appropriate management.[48] The public's exposure to concussion management in professional athletics holds particular importance in youth concussion as the standards for return to play vary with age and experience and the risk incurred by younger athletes after concussion is higher. Therefore, the appropriate management of a younger athlete suspected of having sustained a concussion does not necessarily coincide with the management of the older athletes in widely televised competitions.

Compliance With Return to Play

An impetus behind concussion legislation is to increase compliance with return-to-play guidelines by re-

quiring clearance by a professional trained in concussion management before allowing an athlete to resume participation in sports. A previous study of hockey players with an average age of 20 years demonstrated a 33% noncompliance rate after the player had been advised never to return to play and a 25% noncompliance rate after being advised to wait for complete resolution of symptoms.[1] Over a 3-year period, 15%–40.5% of high school athletes across 100 high schools and 9 sports returned to play prematurely, with males more likely than females to resume play before the recommended guidelines.[69]

Precedent for Legislative Intervention

Historical precedent exists for injury prevention legislation, and past efforts demonstrate both improvements in patient outcome and decreased costs of health care associated with preventable injuries. The most widely known injury prevention legislation consists of seat belt laws, both primary (an individual can be pulled over simply for not wearing a seat belt) and secondary (a fine for not wearing a seat belt can be enforced only if the driver has been pulled over for another reason), existing in every state except New Hampshire. These laws have been associated with an overall 4.5% increased use of seat belts from 2002 to 2008, with a 9% higher rate of seat belt use among states with primary as opposed to secondary laws.[12] It has been estimated that a 10% increase in seat belt use may result in over $15 million in cost savings in a single year.[14] A booster seat law in Wisconsin led to an increase from 24% to 43% in the use of booster seats, with some differences among various racial populations.[9] Similarly, graduated driver licensing systems have been shown to reduce motor vehicle collision rates in teenagers. One such law in Connecticut demonstrated a 40% reduction in motor vehicle collision rates for 16-year-olds, 30% for 17-year-olds, 16% for 18-year-olds, and 7% for 19-year-olds.[56] Similar injury prevention laws exist for many other situations such as distracted driving, all terrain vehicle use, and impaired driving.[40,42]

The idea of punitive measures, such as fines, for not complying with safety legislation would suggest that increasing penalties for programs that do not comply with the concussion legislation stipulations may increase the efficacy of this legislation. Since only 4 states currently include punitive measures for noncompliance, the addition of such stipulations may increase adherence to the legislation. As an example, a comparison of states with primary versus secondary seat belt laws would suggest that primary laws are more efficacious. Both primary and secondary seat belt laws are associated with a relative increase in seat belt use compared with the level in the absence of legislation. Primary laws are associated with a seat belt use prevalence difference of 20–72 per 100 drivers compared with no law, whereas secondary laws are associated with a prevalence difference of 20–50 per 100 drivers compared with no law. Seat belt laws with primary enforcement measures demonstrated slightly lower relative risks of death (0.69–0.97) than those with secondary enforcement measures (0.62–1.03).[55] This finding would suggest some benefit to the ability to exercise punishment measures for noncompliance alone. Similar outcomes have been demonstrated for bicycle helmet legislation. After the implementation of a bicycle helmet law in California, the levying of fines targeted at parents or individuals who did not comply with helmet legislation increased helmet use from 13.2% to 31.7% over a 4-year period.[34]

Disputing the possible argument that education alone is sufficient to prevent injury is the trend seen with bicycle helmet use. A pediatric trauma center in Buffalo, New York, which was active in injury prevention education, did not realize a significant rise in helmet use until a bicycle helmet law was enforced, with helmet use increasing from 2% to 26% after legislation and less severe injuries sustained in children wearing helmets and no deaths in the helmeted population.[60] A study in Florida demonstrated that the combination of legislation and educational programs yields the best results for injury prevention. After bicycle helmet legislation was enacted, helmet use rose from 5.6% to 20.8%, with the largest increase (26.9%) occurring in those age groups targeted for additional educational programs on helmet use.[8] It is this precedent set by prior injury prevention legislation and the success of combined legislation and education that form the basis of concussion legislation and its potential success in reducing the long-term consequences of concussion in youths.

The Lystedt law, only introduced in 2009, is the first iteration of concussion legislation, and thus few studies exist to demonstrate the efficacy of such legislation in affecting the incidence of concussion. Studies are currently underway, such as that by The Cloudburst Group, which has been contracted by the Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, to evaluate the findings, promising practices, and unintended consequences of this legislation.[13] Additionally, since concussion awareness is largely still developing and the true incidence of concussion is not known, it will be difficult to assess the impact of these laws in the short term. It is possible that attempts to measure the success of these legislative efforts may actually demonstrate an increase in sports-related concussion as a result of increased awareness and higher rates of diagnosis, as has been demonstrated in past studies of concussion epidemiology. If this happens it will be important to consider the effect of the educational campaign on awareness and diagnosis rather than to conclude that the laws have been ineffective. Drawing a parallel with the success of other legislative measures, we hope that concussion legislation will have a long-term benefit for the health of our young athletes.

Conclusions

Forty-four states have passed concussion legislation requiring various components of education and training for athletes, coaches, and other stakeholders. Slight differences exist among these legislative efforts; however, the legislations' main goals, which resonate throughout the varying renditions, are to improve recognition of concussion and standardize a process for clearing concussed student athletes for return to play. Legislation has historically proven effective in injury prevention, and those invested in youth athletes hope that concussion legislation will be similarly successful. Further investigation into

these efforts are necessary, with consideration given to the likelihood that increasing concussion awareness and stringent requirements for removal from play may bring us closer to understanding the true incidence of concussion, which is probably higher than currently thought. This must be remembered when considering revision of these legislative efforts. Moreover, the addition of incentives or punitive measures may increase compliance with concussion legislation.

Disclosure

The authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Tomei. Acquisition of data: Doe. Analysis and interpretation of data: Tomei, Doe. Drafting the article: Tomei, Doe. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Tomei. Study supervision: Tomei.

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Manuscript submitted August 11, 2012.
Accepted September 27, 2012.
Please include this information when citing this paper: DOI: 10.3171/2012.9.FOCUS12280.

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