Targeting Rule Implementation Decreases Concussions in High School Football

A National Concussion Surveillance Study

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Background: Concussions occur at higher rates in high school football as compared with all other high school sports. In 2014, the National Federation of State High School Associations implemented rules defining illegal contact against a defenseless player above the shoulders to reduce concussions in football players in the United States. To the best of our knowledge, rates of emergency department (ED)—diagnosed concussions of high school football players before and after the 2014 rule implementation have not been compared.

Hypothesis: It was hypothesized that (1) there would be lower rates of helmet-to-helmet and helmet-to-body-part concussions after rule implementation and (2) alternative mechanisms of concussion would not differ, as these would be less influenced by rule implementation.

Study Design: Cohort study; Level of evidence, 3.

Methods: Data from the National Electronic Injury Surveillance System (NEISS) were analyzed for high school football players 14 to 18 years old sustaining a concussion from January 1, 2009, to December 31, 2019. Data were collected on mechanism of injury, setting, and loss of consciousness. Raw data were used to calculate national estimates based on the assigned statistical sample weight of each hospital by the NEISS.

Results: A total of 4983 (national estimate = 154,221) high school football concussions were diagnosed in US EDs; 58.8% of concussions occurred during competition and 41.2% during practice. Between 2009 and 2013 the rate of concussions diagnosed in EDs rose 10.7% as compared with a 6.2% decrease between 2015 and 2019 ($P = .04$). Between 2009 and 2013, the rate of helmet-to-helmet concussions rose 17.6% as compared with a 5.6% decrease between 2015 and 2019 ($P = .03$). There were no significant changes between other mechanisms of concussion before and after the 2014 rule implementation.

Conclusion: We identified a decreased trend in overall and helmet-to-helmet high school football concussions diagnosed in the ED after implementation of the targeting rule. This study adds to the growing literature regarding the importance and efficacy of rule implementation in reducing sports-related concussions.

Keywords: concussion; youth; high school; football; targeting; rules; loss of consciousness

Concussions are traumatic brain injuries (TBIs) that result in transient neurological disturbances in function, and they occur at high rates in athletics.[14] Whereas the estimated incidence of sports-related concussion in the United States is as high as 3.8 million per year, rates of concussion are highest among high school football players compared with high school athletes participating in other sports.[10,16,23] This has been attributed to the increased incidence of body-to-body injuries in football compared with other contact sports such as ice hockey, wrestling, lacrosse, and soccer.[2,13] Youth athletes are particularly susceptible to concussions compared with adults because of incomplete myelination, decreased neck development, and greater head-to-body ratios.[5] Younger brains also require longer post-concussive recovery times before return to baseline is achieved. Furthermore, athletes who sustain a repeat concussion are 9 times more likely to experience loss of consciousness (LOC), anterograde amnesia, and retrograde amnesia compared with the primary concussive episode.[7]

Owing to the increased risk of poor long-term cognitive outcomes after concussion, monitoring of head injuries and implementing rules in football have gained rapid

The Orthopaedic Journal of Sports Medicine, 9(10), 23259671211031191
DOI: 10.1177/23259671211031191

momentum in recent years.[17] Rule implementation has been shown to be effective at reducing rates of injury across different sports. For example, the "spearing rule," implemented in 1971, significantly reduced overall high school football injuries.[20] In addition, moving the kickoff line from the 35-yard line to the 40-yard line, which is intended to increase kicks landing in the end zone, resulted in a significant reduction in concussions from 10.93 to 2.04 per 1000 plays.[30] Similarly, rules disallowing body checks in ice hockey resulted in a 38.2% decrease in body checking–associated injury among youth ice hockey players.[29]

In 2014, the National Federation of State High School Associations (NFHS) implemented various rules, including the "targeting rule," with the intent of drawing specific attention to the action of targeting and minimizing concussions in football players.[20,25] The targeting rule (rule 2-43) is defined as "an act of taking aim and initiating contact to an opponent above the shoulders with the helmet, forearm, hand, fist, elbow or shoulders." The rule was expanded to unnecessary contact against a "defenseless player" (rule 2-32-16) defined as "a player who, because of his physical position and focus of concentration, is especially vulnerable to injury."[6] To the best of our knowledge, rates of emergency department (ED)—diagnosed concussions of high school football players before and after the 2014 NFHS rule implementation have not been compared directly.

The National Electronic Injury Surveillance System (NEISS), a national public database maintained by the US Consumer Product Safety Commission (CPSC), collects information from 100 hospital EDs that have a minimum of 6 beds and 24-hour services, which are selected as a representative probability sample of 5000 US hospital EDs. Trained coders review and enter the data into the NEISS database. Each data entry is assigned 1 or more CPSC product codes that identify products or activities associated with the injury. National estimates (NEs) based on the individually assigned statistical sample weight of each hospital are provided to generate reliable epidemiological data.

Prior studies have utilized the NEISS to characterize injury types, mechanisms, and trends in various sports, including concussions in youth football players.[8,12,28,29] Jacobson et al[12] utilized the NEISS to identify increasing rates of both overall concussions and head-to-head concussions presenting to the ED between 2002 and 2012 among football players aged 5 to 13 years old.

The purpose of this study was to not only build upon the prior work of Jacobson, but also to identify whether the 2014 NFHS rule implementation (eg, the targeting rule) affected rates of high school football concussion presenting to the ED by comparing trends from pre-implementation (2009-2013) with those of post-implementation (2015-2019). It was hypothesized that there would be a lower rate of helmet-to-helmet and helmet-to-body-part concussions after implementation of the targeting rule. It was also hypothesized that rates of concussions caused by alternative mechanisms (eg, helmet-to-ground and other) would not differ, as these mechanisms of injury are less influenced by the 2014 rule implementation.

METHODS

Data Collection

We queried the NEISS for all football-related injuries (product code 1211) from January 1, 2009, to December 31, 2019, for patients 14 to 18 years of age who suffered a concussion (product code 52). The data queried contained information regarding the athlete's age, sex, body part involved, injury date, and injury diagnosis.

Each NEISS injury data set is associated with a narrative, which varies in content and length, that provides detail on the injury. These narratives were reviewed to determine the mechanism of injury, setting of injury (practice versus competition), and whether there was LOC. Mechanism of injury, as identified through the narrative, included helmet-to-helmet, helmet-to-ground, helmet-to-body-part, other, or not specified. Setting of injury was either practice, competition, or not specified. The narrative for each injury was also reviewed to determine whether the mechanism of injury was related to organized high school tackle football while wearing equipment.

Exclusion Criteria

Narratives were reviewed to exclude injuries sustained outside of organized high school tackle football or sustained while not wearing equipment. Cases that occurred at locations other than a football field (eg, home, street, or gym); mentioned playing with a family member; mentioned pickup games, gym class, physical education class, or playing for fun; or specified lack of equipment, such as playing without helmets or shoulder pads, were excluded. Cases that occurred during organized high school tackle football

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Final revision submitted March 3, 2021; accepted March 22, 2021.
One or more of the authors has declared the following potential conflict of interest or source of funding: B.M.S. has received grant support from Arthrex and education payments from Arthrex and Smith & Nephew. T.S.B. has received education payments from Arthrex and honoraria from Fidia Pharma. C.S.A. has received consulting fees, nonconsulting fees, and royalties from Arthrex. R.L.P. has received grant support from Arthrex and hospitality payments from Smith & Nephew. D.P.T. has received grant support from Arthrex and education payments from Arthrex and Smith & Nephew. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.
Ethical approval was not sought for the present study.

TABLE 1
Study Characteristics and Demographic Data

Patient Characteristics	Study Patients	Weighted National Estimate
Concussions, n	4983	154,221
Male patients, n (%)	4916 (98.7)	152,298 (98.8)
Female patients, n (%)	67 (1.3)	1923 (1.2)
Loss of consciousness, n (%)	482 (9.7)	14,148 (9.2)
Mean age at diagnosis, n (range) y	15.4 (14-18)	15.5 (14-18)

while wearing equipment but not associated with playing the game (eg, getting hit on the sideline by an errant ball), were also excluded.

Statistical Analysis

Statistical analyses were performed using STATA/MP Software 13.0 (StataCorp) and SPSS Version 26.0 (IBM SPSS Statistics for Windows). Analyses performed included rate of change calculations and unpaired Student *t* tests. Statistical significance was set at $P < .05$. In addition, to control for rule-change bias, the year 2014 was removed from analysis when comparing trends pre- and post-implementation of the rule. NEs were calculated by multiplying the raw, queried data with the assigned statistical weight of the respective hospital.

RESULTS

Between January 1, 2009, and December 31, 2019, there were 5563 (NE = 173,068) ED-diagnosed concussions related to football. After sorting through the narratives using inclusion criteria, 4983 (NE = 154,221) were included for analysis; 4916 (NE = 152,298; 98.8%) of the patients were male, and 67 (NE = 1923; 1.2%) were female (Table 1). The mean age at diagnosis was 15.4 years (NE = 15.5 years; range, 14-18 years).

During the study period (2009-2019), the annual incidence of concussions peaked in 2013 (Figure 1). Of the 1776 narratives that specified setting, 1040 (NE = 31,396; 58.8%) of concussions occurred during competition compared with 736 (NE = 22,003; 41.2%) during practice; 274 athletes (NE = 7033; 4.6%) continued to play after their concussive episode before definitive diagnosis of concussion in the ED.

Review of the narrative provided data for mechanism of injury: 2507 not specified (NE = 84,519; 54.8%), 1769 helmet to helmet (NE = 48,621; 31.5%), 478 helmet to ground (NE = 14,885; 9.7%), 143 helmet to body part (NE = 3746; 2.4%), and 86 other mechanism (NE = 2,450; 1.6%) (Table 2).

The particular body parts involved in helmet-to-body concussive episodes included the knee (58; NE = 1307; 34.9%), shoulder (32; NE = 873; 23.3%), foot (25; NE = 651; 17.4%), elbow (11; NE = 470; 12.5%), leg (7; NE = 275; 7.3%), chest (6; NE = 148; 4.0%), abdomen (3; NE = 17; 0.5%), and ankle (1; NE = 5; 0.1%).

LOC was reported in 482 of all concussions (NE = 14,148; 9.2%). Of the cases that specified setting, 137 (NE = 3110; 62.9%) of LOC occurred in competition and 68 (NE = 1833; 37.1%) occurred in practice. Distribution of LOC by mechanism was as follows: not specified (215; NE = 6846; 48.4%), helmet to helmet (174; NE = 4480; 31.7%), helmet to ground (62; NE = 1967; 13.9%), helmet to body part (23; NE = 556; 3.9%), and other mechanism (8; NE = 299; 2.1%) (Table 2).

There was a significant difference between the rate of concussions diagnosed before and after implementation of the targeting rule (Figure 2).

Between 2009 and 2013, the rate of concussions diagnosed in US EDs rose 10.7% as compared with a 6.2% decrease between 2015 and 2019 ($P = .04$) (Figure 2). Between 2009 and 2013, the rate of helmet-to-helmet concussions rose 17.6% as compared with a 5.6% decrease between 2015 and 2019 ($P = .03$) (Figure 3).

The rate of change of concussions with concomitant LOC changed from a decreasing rate of 6.1% between 2009 and 2013 to a decreasing rate of 8.2% between 2015 and 2019, although this difference was not significant ($P = .40$).

DISCUSSION

This study is the first to our knowledge to identify a significant decrease in overall and helmet-to-helmet concussions diagnosed in the ED after implementation of the 2014 rule change limiting helmet-to-helmet contact in football. The realization of increasing concussive episodes through 2013 is similar to that of Jacobson et al,[12] who identified an increase in overall and head-to-head concussions from 2002 to 2012 among youth football players. In addition, rates of helmet-to-ground, helmet-to-body-part, other, and not specified mechanisms were not different between the periods 2009-2013 and 2015-2019. Although we cannot demonstrate exact causality, we hypothesize that rule implementation in 2014 led to a specific decrease in helmet-to-helmet and overall concussions.

Helmet-to-helmet concussions constituted 31.5% of overall NE concussions and 31.7% of NE LOC events in our study (Table 2). Jacobson et al[12] identified a similar head-to-head concussion rate of 25% in youth football players. The slightly lower rate of helmet-to-helmet concussion by Jacobson et al compared with that found in this study may be attributed to the decreased musculoskeletal maturity of their cohort and resultant decreased forces generated during play. In addition, higher rates of LOC associated with helmet-to-helmet concussions compared with other mechanisms may be attributed to direct impact to the top of the helmet yielding the greatest linear acceleration and magnitude of impact, increasing the risk of concussion and LOC.[4]

This study also identified a higher rate of competition-associated concussions and LOC compared with practice, which is consistent with data from prior studies.[11,24] Rates of concussion in competition (58.8%) versus practice

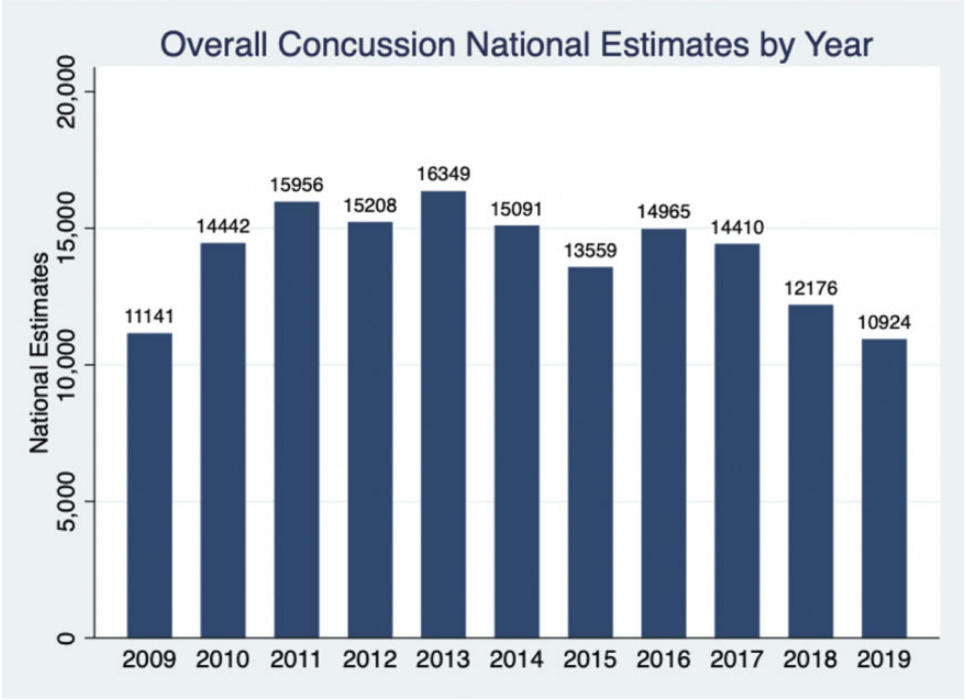

Figure 1. National estimates of concussion totals by year.

TABLE 2
Mechanism of Injury for Concussion and Loss of Consciousness[a]

	Concussion		Loss of Consciousness	
Mechanism	Study Participants	National Estimate	Study Participants	National Estimate
Not specified	2507 (50.3)	84,519 (54.8)	215 (44.6)	6846 (48.4)
Helmet to helmet	1769 (35.5)	48,621 (31.5)	174 (36.1)	4480 (31.7)
Helmet to ground	478 (9.6)	14,885 (9.7)	62 (12.9)	1967 (13.9)
Helmet to body part	143 (2.9)	3746 (2.4)	23 (4.8)	556 (3.9)
Other	86 (1.7)	2450 (1.6)	8 (1.6)	299 (2.1)
Total	4983	154,221	482	14,148 (9.2)

[a]Data are reported as n (%).

(41.2%) identified in the current investigation mirror those found by Bartley et al[2] for football players in the act of tackling in competition (59.9%) versus practice (40.1%) and being tackled in competition (63.2%) versus practice (36.8%). The higher rate of concussions sustained in competition may be attributed to the increased contact and aggressive play during competition.[2]

Interestingly, rates of helmet-to-body injuries were not significantly different between the pre- and post-implementation intervals in this study. We hypothesize this may be attributable to the low incidence of helmet-to-body related concussions of only 2.5% in the current study. Increased power may reveal a statistical difference with regard to this particular metric.

Previous studies have identified the effect of various rule implementations in decreasing rates of concussion in football. Wiebe et al[30] analyzed concussion rates as related to the implementation of novel kickoff rules and found that simply moving the kickoff line from the 35- to the 40-yard line reduced concussions dramatically from 10.93 to 2.04 per 1000 plays. This finding is likely because of the increased chance of the ball being kicked into the end zone, thus ending play and decreasing collision exposure to all athletes on the field. In addition, Pfaller et al[21] found a decrease in practice-associated high school football concussions after rule implementation limiting contact during practice by the Wisconsin Interscholastic Athletic Association.

However, not all rule changes have been successful in reducing concussions. Stemper et al[26] analyzed 5 Division I Football Bowl Subdivision (FBS) programs and found that the elimination of 2-a-day preseason practices did not decrease rates of concussion. This was attributed to subsequent increases in hourly impact exposure and contact

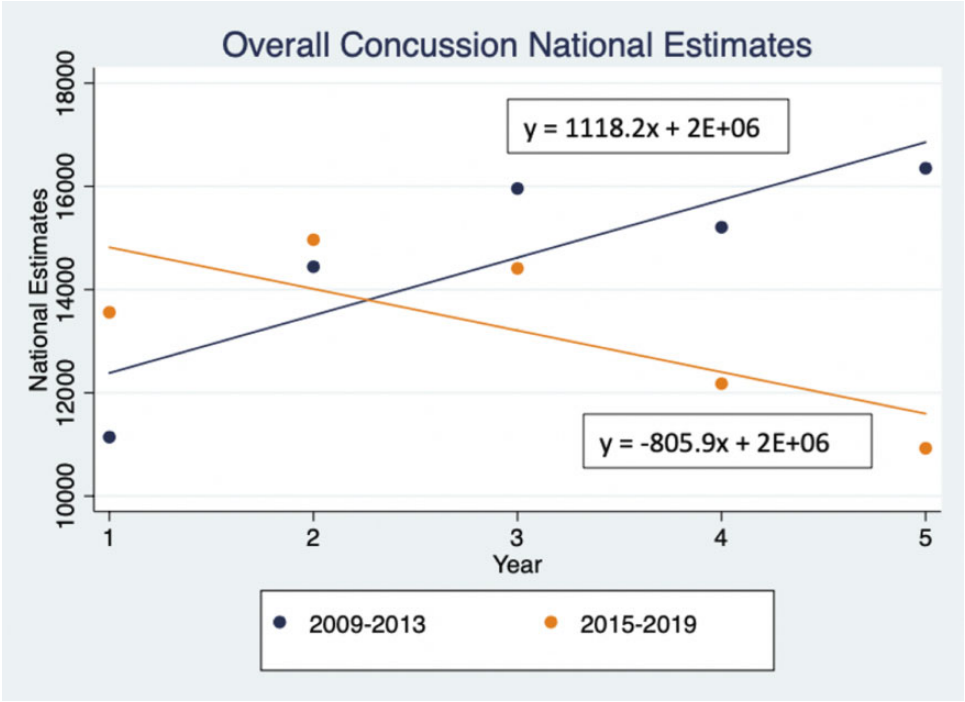

Figure 2. Overall concussions by year (2009-2013 vs 2015-2019).

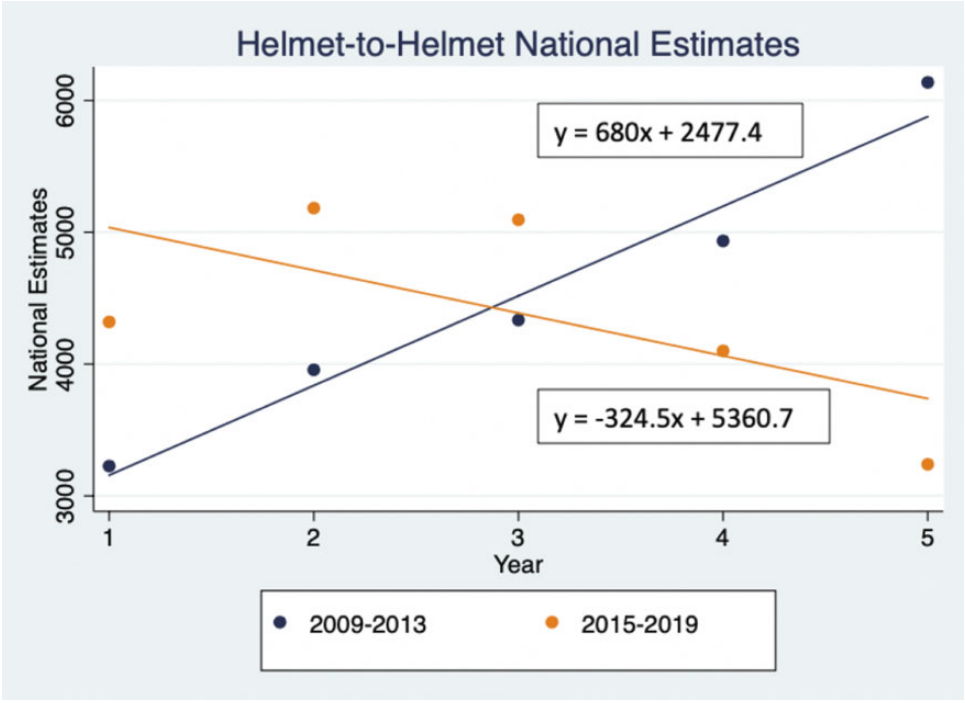

Figure 3. Helmet-to-helmet concussions by year (2009-2013 vs 2015-2019).

days.[26] In a separate study, Stemper et al[27] analyzed 5 Division I FBS programs and found that a 10% decrease in the number of preseason practices did not significantly decrease the number of preseason concussions, with 1 team demonstrating a 35% increase. In addition, these players experienced 40% more head impacts during the preseason as compared with the regular season. The authors suggest that specific rules targeting contact practice duration, head impact exposure, or limiting time during high-risk drills may be more effective in lowering the occurrence of concussions.

Reducing the risk of concussion is particularly important when athletes are either unable to identify or unwilling to report the symptoms of a concussion. In this study, 274 (NE = 7033; 4.6%) athletes continued playing after receiving 1 or more probable concussive-inducing impacts prior to the definitive diagnosis in the ED. This excluded players who continued to play with symptoms but never presented to the ED. Previous research has identified rates of unreported concussion ranging from 30.5% to 51.5%.[1,18,19] McCrea et al[18] found that the decision to not report concussions was often multifactorial, with 66.4% of all players disregarding the symptoms as not severe enough to warrant medical attention, 41.0% not wanting to be withheld from competition, and 36.1% being unaware they might have a concussion. Additional research has identified 25% of athletes do not report symptoms because of pressure from teammates, coaches, parents, and fans.[15] The decision to continue playing before presenting for concussion evaluation may also be attributed to the perception that frequent, low-magnitude impacts are routine. Subsequently, multiple smaller hits may have a cumulative effect on development of post-impact symptoms. Baugh et al[3] found that offensive linemen continued to play despite receiving multiple lower-magnitude head impacts, with subsequent development of increased post-impact symptoms compared with other positions.

Limitations of this study are attributed to the biases of using a national database. Classification of concussion mechanism was limited to the information provided in the narrative. Owing to the scarcity of information, we were unable to identify whether concussions occurred during specific team's offensive, or defensive plays. In addition, "not specified" mechanisms derived from the narrative constituted a large portion of the overall national estimates in this study (54.8%). We felt, however, it was important to include these data to provide a more accurate representation of the overall trends in concussion. The targeting rule was implemented rather recently (2014), limiting the sample size and therefore the power of the study. Future studies with a greater subset of data would be valuable. This study is also limited only to athletes presenting to the ED and does not encompass concussions that may be diagnosed by athletic trainers, primary care physicians, specialists, or urgent care clinics and, thus, not included in the NEISS data. Athletic trainers and team physicians may be more comfortable identifying and treating concussions than in the past and, thus, more cases may be treated in the training room or physician's office, reducing the number admitted to the ED. However, presentation to the ED may reflect an increased case severity as compared with that generally seen during athletic competition or practice. In addition, the recently reported decline in youth football participation over the past decade may have decreased potential exposure and, thus, decreased the number of concussions in this study.[22] Finally, we were unable to calculate the true incidence of national injuries because of the nature of the NEISS to stratify data across 100 hospitals. Despite this, the national estimates are a representative sample of national diagnoses based on the raw data that allow us to reliably analyze trends in high school football concussions.

CONCLUSION

This study is the first to our knowledge to identify a decreased trend in overall and helmet-to-helmet—related high school football concussions diagnosed in the ED after implementation of the targeting rule. This study adds to the growing literature regarding the importance and efficacy of rule implementation in reducing sports-related concussions.[9,29,30] Further study is warranted to provide a more comprehensive understanding of the impact of national protocols and policies on the rates of football-related concussion in young athletes.

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