

Concussions in Soccer

An Epidemiological Analysis in the Pediatric Population

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Background: As the popularity of youth soccer has increased in the United States, more attention has been focused on the effect of concussion injuries, with recent debate on whether heading should be disallowed. There is little evidence examining the epidemiology of these injuries.

Purpose/Hypothesis: The purpose of this study was to examine the prevalence and incidence of youth soccer-related concussions. We hypothesized that concussion rates will correlate with increased participation in youth soccer.

Study Design: Descriptive epidemiology study.

Methods: The National Electronic Injury Surveillance System was used to collect data on concussion injuries that occurred during soccer in pediatric patients from 2008 through 2016. Soccer-related concussion injuries were identified using specific codes and were analyzed for variation in disposition. The types of contact were categorized into player-to-player, head-to-ball, player-to-post, and player-to-ground contacts. Contact types related to hospitalization were subanalyzed.

Results: A weighted total of 3285 concussion injuries were identified during the study period, with an average of 386 concussions each year. The average age was 13.5 years, and there were no differences seen in incidence between the sexes. The overall incidence of concussion injuries increased ($r = 0.789$), while hospitalizations decreased ($r = -0.574$). The most common cause of concussion was found to be player-to-player contact, followed by head-to-ground contact and then head-to-ball contact. Subanalysis showed that 13% of hospitalizations were due to head-to-ball contact, compared with 39% and 44% due to player-to-player contact and head-to-ground contact, respectively. The relative risk of hospitalization from a concussion due to head-to-ball contact was 7.06 compared with 22.60 due to head-to-ground contact.

Conclusion: The incidence of concussion in youth soccer has been increasing over the past decade as predicted, given the growing participation rates in both male and female soccer players. The most common cause of concussion was player-to-player contact, and the majority of concussions resulting in hospitalization occurred because of head-to-ground contact.

Keywords: soccer; concussions; youth; contact types

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Concussions and brain injuries have recently received a great deal of publicity in the National Football League and media. With the recent growth in youth sports participation, media attention has focused on concussions in the youth sports population, given the long-term impact and implications. The US Centers for Disease Control and Prevention (CDC) has reported a head-and-neck injury rate of 16.4% among athletes participating in recreational sports, with 64.9% of these injuries occurring in a youth population (range, 5-24 years).¹⁵ One US sport with a growing youth population is soccer, with a reported 808,000 high school soccer players reported in 2015.² Previous studies^{3,11} have identified football as having the highest number of concussions, followed by basketball and soccer. Increasing participation in soccer among the youth population supports increased awareness and tracking of these types of injuries.

Several researchers^{3,13,14} have examined the differences between concussions in children/adolescents and adults, with the consensus that concussions are more dangerous in younger populations because they have underdeveloped nervous systems. Concussions in youth populations may be less likely to be reported, given the lack of oversight and medical professional coverage; however, these concussions often have longer lasting symptoms, and the young athletes may have cognitive deficits that remain well after they have returned to play.^{5,6} In fact, this problem is so pervasive that the CDC has initiated a public health awareness campaign called Heads Up in Youth Sports to combat the problem. Data collected as part of this initiative found that in a survey study of nearly 800 high school athletes, approximately 69% reported that they continued to play even after experiencing concussion symptoms, and 40% reported that their coaches were never aware that they were experiencing concussion symptoms.³ It also found that young athletes may not report concussion symptoms for many of the same reasons given by their older counterparts, one of them including fear of losing their position on the team or roster spot.³

Concussions occur from direct head impact, which causes a complex pathophysiological process in the brain.^{5,10,11} Comstock et al⁵ reported that although most soccer injuries occur because of player-to-player contact in 4- to 7-year-olds, concussions were most commonly due to direct player-to-ball contact. The authors also reported that heading the ball accounted for 30% of concussions in male players and 25% in female players.⁵ Concussion rates were higher during competition activities when compared with practices, given the intensity of the activity.¹¹ Recent efforts to address concerns surrounding concussions in soccer have focused on making the game safer through rule changes. One proposed change is to prohibit children younger than 14 years from heading the ball. This rule change is based off a number of studies^{5,11,12,16} that have looked at concussion injuries, mainly in high school soccer. In general, about 30%-37% of concussions occur as a result of heading the ball, and this percentage is typically higher in boys.⁵ From these data, a rule banning heading could potentially eliminate one-third of concussions currently seen, but a better understanding of incidence and the importance of soccer-related concussions at the youth level is critical. The purpose of this study was to evaluate injury patterns and risk of concussions in the youth soccer population.

METHODS

National Electronic Injury Surveillance System

The National Electronic Injury Surveillance System (NEISS), which is overseen by the Consumer Product Safety Commission (CPSC), was used to collect data. The CPSC is responsible for sampling all active emergency departments in the United States. The NEISS data are a probability sample of 100 hospitals within the United States. Patient information is recorded in the database for every visit to an emergency department involving a consumer product, such as sports equipment. Data are continuously reviewed and

updated via telephone calls with patients within 1 week of reporting their injury. From this sample, national rates of injuries can be estimated. The sampling procedure and statistical basis for calculating national estimates using NEISS data are validated approaches and are described on the CPSC website (www.cpsc.gov/Research-Statistics/NEISS-Injury-Data). In addition, derivation of sampling weights used by the NEISS is well established and used by researchers and government agencies.⁴ After being weighted, the NEISS data provide estimates for the total number of injuries related to each consumer product that is included. Variables that are recorded include treatment date, sex, race, diagnostic category, injured body part, patient disposition, and location of injury.

Utilization of NEISS

Concussion injuries occurring during soccer in pediatric patients (2-18 years old) from 2008 through 2016 were collected. Soccer-related concussion injuries were identified using specific codes (soccer product code 1267 and head body part location code 75, with a diagnosis of concussion). All available characteristic variables were recorded for each case. Narratives were reviewed for each injury, and information related to the injury was recorded. This included information regarding the mechanism of injury, level of activity, concurrently sustained injuries, and discharge disposition.

Exclusion Criteria

Those narratives that listed a cause of injury that was not related to playing soccer or describing bystanders or coaches were excluded from our analysis.

Data Analysis

Using annual participation numbers, weighted totals were extrapolated based on the data provided from NEISS. Weighted totals and annual incidence rates of concussion injuries were calculated using the US Youth Soccer registry, which reports the annual number of youth registered to play soccer in the United States.² Cause of concussion was categorized into 4 groups: player to player, head to ball, player to post, and player to ground. The overall incidence of hospitalization due to a concussion was recorded. Concussion rates were compared based on cause and severity, as defined by injuries resulting in hospitalization. A correlation coefficient was used to assess the relationship between the total number of concussions, total hospital admissions, and mechanisms of injury over the study period. Incidence of concussions was compared between sex, cause of concussion, and pre- and post-2014 initiation of new hospitalization guidelines for pediatric concussions.

A subanalysis of patients hospitalized because of concussion injury was conducted to identify the most common types of contact related to hospitalization. The Spearman correlation coefficient was used to assess the rates of concussion injury and hospitalization compared with participation over the study period. Odds ratio analyses were used

to calculate the relative risks of concussion injuries based on contact type. All statistical analyses were performed utilizing the SPSS software (Version 24.0; IBM).

RESULTS

A weighted total of 3285 soccer-related concussion injuries were identified from the NEISS database during the 8-year study period. The total national estimates were calculated to be 135,901 concussions occurring annually in youth over the study period, making the soccer-related concussion rate 2.51% per year. The average age of the cohort was 13.5 years, with 45% (1469) of concussions occurring in female players and 49% (1617) reported in male players. The incidence of concussion injuries increased significantly over the study time period ($r = 0.789$), with a weighted average of 386 reported concussion injuries related to youth soccer each year. An average of 202 concussions occurred in male players each year and an average of 184 concussions in female players each year, with no significant differences seen in the overall prevalence or incidence between different ages or sexes (Table 1, Figures 1 and 2).

TABLE 1
Annual Weighted Concussion Incidence By Sex

Year	Total	Males	Females
2016	456	246	210
2015	420	220	200
2014	460	249	211
2013	369	193	176
2012	484	250	234
2011	353	183	170
2010	279	140	139
2009	265	136	129

The majority of patients were discharged from the emergency department after a concussion injury. A total of 151 (4.59%) patients sustaining concussion injuries were hospitalized over the study period, with an average number of concussion injuries of 18.9 per year (Table 2). The number of hospitalizations due to concussion injuries decreased over the study period ($r = -0.574$) (Table 2).

A review of narratives related to each concussion injury found that head-to-player contact accounted for 33% of concussions, followed by head-to-ball contact, which accounted for 24%; 22% were due to multiple types of contact, followed by head-to-ground and head-to-goalpost contact, which accounted for 18.2% and 2.6%, respectively. The incidence of concussion related to ball-to-head contact increased over the study period ($r = 0.886$), while player-to-player contact decreased ($r = -0.661$) (Figure 2). Of the total 3285 injuries, 151 resulted in hospitalizations, at an average of 5.45% per year. Of these hospitalizations, 13% were due to head-to-ball contact, 39% were due to player-to-player contact, and 44% due to head-to-ground contact. Odds ratio calculations for hospitalization from a concussion found that there was a 7.06 increased relative risk from a concussion due to head-to-ball contact, a 22.6 times increased risk from a concussion due to head-to-ground contact, and a 19.2 times increased risk from a concussion due to player-to-player contact. Hospitalization due to player-to-player contact had a 19.78 increased risk and 1.41 increased risk when compared with hospitalization due to head-to-goalpost contact.

DISCUSSION

While previous studies have examined soccer-related concussion injuries, we aimed to provide a comprehensive epidemiological analysis of pediatric soccer-related concussions at the national level. By using the NEISS database, we were able to provide a national overview of incidence rates as well as causes of treated concussions. Our

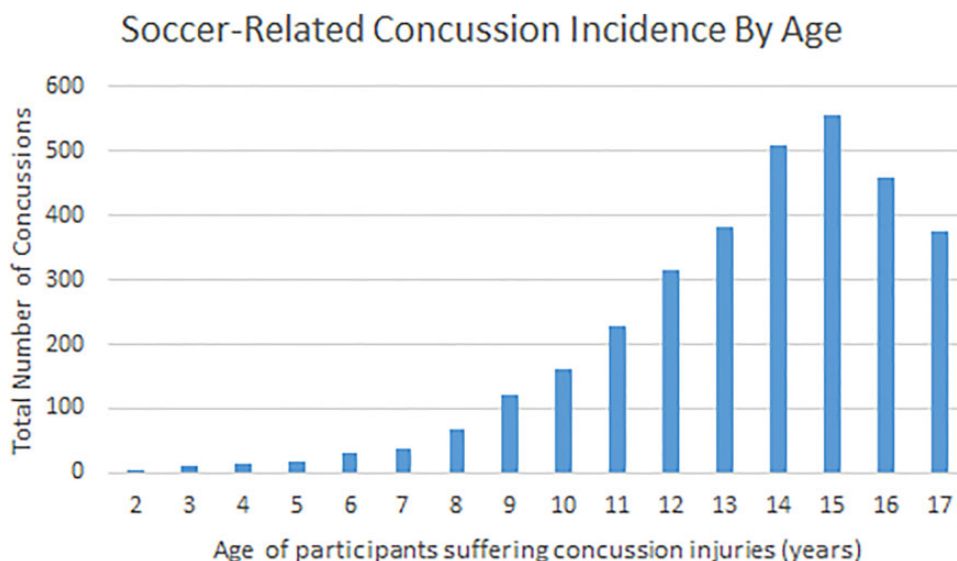


Figure 1. Soccer-related reported concussion incidence by age.

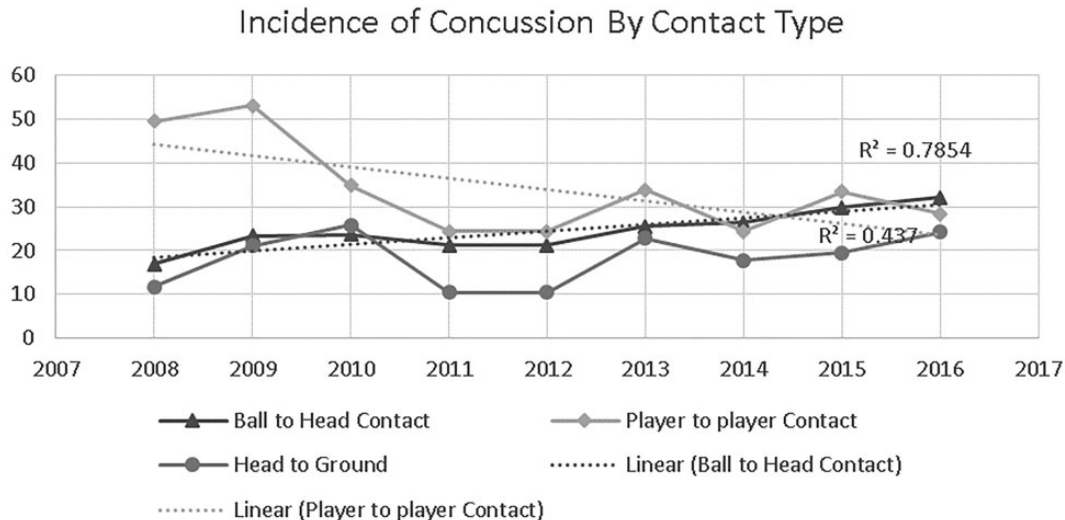


Figure 2. Reported incidence of concussion injuries categorized by contact type.

TABLE 2
Annual Hospitalizations Due to Soccer-Related Concussion Injuries

Year	Hospitalized	% Hospitalized
2016	7	1.528
2015	5	1.190
2014	9	1.957
2013	21	5.691
2012	25	5.165
2011	32	9.065
2010	29	10.394
2009	23	8.67

results demonstrated an overall low annual soccer-related concussion injury rate of 1.7%, which increased significantly over the 8-year study period. Consistent with the recent literature on high school athletes, our results demonstrated that the most common mechanisms of injury leading to a concussion in soccer were head-to-ground and player-to-player contact, and not necessarily head-to-ball contact.^{1,10} In addition, we found that the relative risk of hospitalization is much higher in cases associated with head-to-ground and player-to-player contact when compared with head-to-ball contact, suggesting that other mechanisms of reducing injury may be more effective than simply eliminating heading. According to the official Fédération Internationale de Football Association website, the number of youths registered with the US Soccer Federation (USA) totaled 3.9 million in 2014, with an increase of up to 89% from 1990.^{8,9} Given the numbers of youth playing soccer in the United States, an increased awareness of serious soccer-related injuries is warranted.

The primary mechanism of injury involved in pediatric concussions associated with soccer is players receiving a blow of some kind from another player or hitting the ground. Yard et al¹⁶ showed that when an injury on the soccer field

resulted from illegal activity, concussions were more likely. Thus, while certain types of contact are permitted, instances of contact that are prohibited by the rules, such as purposefully throwing an elbow or shoulder—behaviors that are more likely to result in a concussion, should be called a foul by the referee. Additionally, O’Kane et al¹² recorded that a foul was called only 15% of the time when a play resulted in concussion. So while heading does lead to concussions, it has more to do with the events surrounding the header rather than just head-to-ball contact. For example, headers that are contested, resulting in heavy contact between players, are clearly more likely to result in a concussion than an uncontested header with only head-to-ball contact. If referees are instructed to more strictly enforce the rules, it may deter players from engaging in contact with other players, resulting in a decrease in concussions and other injuries.

Another mechanism for concussions was head-to-ground contact, suggesting that the playing surface may be a major factor in injury risk. As turf and playing surfaces have evolved, research has focused on how this change in surface has led to different types of injuries that are occurring in adults, but no differences in severity.^{6,7} Fuller et al⁷ demonstrated a significant difference in head-and-neck injury rates among male soccer players when comparing artificial turf and grass, with artificial turf having significantly higher injury rates. Based on our results in the youth population, results in the youth population concussions related to head-to-ground contact carried the highest risk of hospitalization, suggesting they are the most severe and that surface type should be a consideration. Again, further investigation is warranted to better elucidate the effects of playing surface on concussion rates in the youth population specifically.

While we have brought some new insights into the debate on whether to remove heading from pediatric soccer, this study is not without limitations. The NEISS database is limited in that it only records emergency department

visits and may exclude less severe concussions that did not present to a hospital setting, thereby underreporting the actual concussion injury rate in this youth population. In addition, the NEISS data do not include any follow-up information, which limits our assessment of the severity and outcomes of the recorded concussions. Additionally, our data are limited with regard to mechanism of injury information because it was based on the recorded types of contact. Future studies detailing the mechanism or cause of concussions and including sideline reporting of concussion in the youth population should be performed to mitigate these limitations and obtain more accurate rates of injury risk and severity in soccer.

CONCLUSION

Overall, the incidence of concussions in youth soccer is increasing over the past decade as predicted, given the growing participation rates in both males and females. Our results found that the most common cause of soccer-related concussions is player-to-player contact. In addition, the highest risk of hospitalization was found with head-to-ground contact. Based on these findings, there is limited evidence to support a blanket ban on heading the ball in youth soccer at this time. Future studies should further examine the biomechanics of heading the ball in order to assess the risk for serious concussion injuries before a rule change.

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