

Trends and Epidemiologic Factors Contributing to Soccer-Related Fractures That Presented to Emergency Departments in the United States

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Background: Understanding the risks and trends of soccer-related injuries may prove beneficial in creating preventative strategies against season-ending injuries.

Hypothesis: Soccer-related fractures will have decreased over the past 7 years.

Study Design: Descriptive epidemiology study.

Level of Evidence: Level 3.

Methods: The National Electronic Injury Surveillance System (NEISS) database was queried to identify soccer-related injuries from 2010 through 2016. The sum of the weighted values provided in the NEISS database was used to determine injury frequency and allowed us to estimate the incidence and annual trends of soccer-related fractures. The estimated annual number of hospital admissions resulting from each fracture location was calculated. Statistical analyses were performed, and a linear regression was used to analyze the annual injury trends, reported as the correlation coefficient.

Results: Over the 6-year period, there were an estimated 1,590,365 soccer-related injuries. The estimated annual frequency of soccer-related injuries slightly increased from 225,910 in 2010 to 226,150 in 2016 ($P = 0.477$). The most common injuries were sprains/strains (32.4%), followed by fractures (20.4%). Fractures at the wrist were the most common (18%), while upper leg fractures were the most common soccer-related fractures to be admitted to the hospital (51.6%). The annual trends of the most common soccer-related fractures demonstrated increases in shoulder ($r = 0.740$; $R^2 = 0.547$; $P = 0.057$) and wrist ($r = 0.308$; $R^2 = 0.095$; $P = 0.502$) fractures. There were no significant changes in the trends of soccer-related fractures of the lower arm ($r = 0.009$; $R^2 = 7.3 \times 10^{-5}$; $P = 0.986$), finger ($r = 0.679$; $R^2 = 0.460$; $P = 0.094$), lower leg ($r = 0.153$; $R^2 = 0.024$; $P = 0.743$), ankle ($r = 0.650$; $R^2 = 0.422$; $P = 0.114$), toe ($r = 0.417$; $R^2 = 0.174$; $P = 0.353$), or foot ($r = 0.485$; $R^2 = 0.235$; $P = 0.270$).

Conclusion: Despite the reported growing number of soccer players in the United States, the overall number of soccer-related injuries has remained relatively stable. Overall, 60% of reported fractures occurred in the upper extremity, with the wrist being the most common site, while lower extremity fractures were the most likely to lead to hospital admission.

Clinical Relevance: This study offers an overview of the most common types of fractures that affect soccer players and may prove beneficial in creating preventative strategies against season-ending injuries.

Keywords: soccer; fractures; trends; epidemiology

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With more than 24 million Americans playing, of which 4.2 million are registered with the United States Soccer Federation, soccer is the most popular youth sport in the United States.¹³ In fact, over the past 40 years, the number of players who are US Youth Soccer members has increased from approximately 103,000 in 1974 to 3,000,000 in 2014.²³ Therefore, as the number of soccer players continues to increase each year, so does the number of soccer-related injuries, such as neurological injuries, sprains, strains, blunt force trauma, and fractures.^{2,3,6,9,10,12,15,16,18,19,21}

Previous studies that have compared soccer-related injuries have revealed an upward trend in the number of both adult and pediatric injuries, as well as postinjury hospital admissions.^{9,15} Consequently, as some of these injuries may result in substantial limitations, a better understanding of their overall risk and trends may provide further epidemiologic data that may aid in the development and improvement of preventative strategies to potentially decrease the rates of injury. A similar phenomenon has been seen in other popular youth sports, such as (American) football, where continued research has substantially reduced the number of concussions and musculoskeletal injuries.⁴

As research in other sports has provided evidence for the effectiveness of preventative strategies, such as improved protective gear or rule modifications, in limiting the number of injuries, similar work needs to be performed in soccer. As the game continues to develop and grow, with many players joining each year, continued research identifying potential hazards for players needs to be performed. Only after first identifying what injuries are most common can strategies such as specific injury prevention stability and strength training be put into place. Despite the fact that participation in soccer and absolute number of injuries have increased over the past 10 years, we hypothesize a decrease in the number of fractures in the hopes that improved protective gear and rule changes over the past few years have helped limit the number of injuries of this type. Therefore, the purpose of this study was to track the trends and epidemiologic factors contributing to increased incidence of orthopaedic injuries in US soccer players of all ages with an emphasis on fractures. Specifically, we (1) compared the frequency and annual trends of soccer-related injuries; (2) identified the incidence, frequency, and annual trends of soccer-related fractures; and (3) identified the frequency of hospital admissions after soccer-related fractures.

METHODS

Database

This study was deemed exempt by our institutional review board as it used nonidentifiable information obtained from a public source. The National Electronic Injury Surveillance System (NEISS) database was queried to identify soccer-related injuries that occurred between January 1, 2010, and December 31, 2016. Operated by the US Consumer Product Safety Commission (CPSC), the NEISS provides a nationwide probability sample of consumer product-related injuries based

on a sample of US emergency department (ED) visits.²² Information was collected on all injured patients who presented to the 100 hospitals that make up the stratified probability sample. All the hospitals are grouped into 5 strata, of which 4 are based on the hospital size/annual number of ED visits and 1 comprises children's hospitals. Annual sampling frames of all hospitals that have EDs in the United States, including the total number of ED visits, is performed by the CPSC. The information for each case collected from NEISS hospitals is assigned a sample weight that is determined by the inverse of the probability of selection for the hospitals in each stratum. Adjustments are made to these data to make sure that hospitals follow certain required specifications, and new sampling frames are used to ratio-adjust the sample's statistical weights for the present sample of NEISS hospitals to more accurately represent the total number of annual ED visits for the US population.¹⁷ Of note, the ratio adjustment is the ratio of the known total number of hospital ED visits in a population frame over the estimated total ED visits in the sample of hospitals.²⁰ The variables collected at each hospital include age, sex, race, date, diagnosis category, body part injured, injury location, disposition, and a narrative field for describing the injury.^{20,22}

Patient Selection

The NEISS database was used to identify patients between January 2010 and December 2016 who sustained soccer-related injuries. The weighted estimate of the frequency of injuries was determined by using the NEISS statistical weight calculations that were provided in the data, which yielded a total of 1,590,365 study participants to be included for analysis.

Variables Assessed

The primary variables assessed included the annual trends of soccer-related injuries; the incidence, frequency, and annual trends of soccer-related fractures; and the frequency of hospital admissions after soccer-related fractures. The sum of the weighted values provided in the NEISS database was used to determine the injury frequency and allowed us to estimate the incidence and annual trends of soccer-related fractures and the annual trends of the body parts affected by soccer-related fractures. The estimated annual number of hospital admissions resulting from each fracture location was calculated.

Study Population

There were 1,016,759 men and 573,606 women included, with a mean age of 17 years (range, 2-95 years). Race was identified as 48.7% white, 5.4% black, 15.9% other (predominantly Hispanic), 1.6% Asian, 0.14% American Indian, and 0.11% Native Hawaiian; 28.5% were missing the race category. Patients between the ages of 10 and 19 years of age experienced the highest frequency of soccer-related injuries (64.3%).

Data Analysis

Data were entered into an Excel spreadsheet (Microsoft Corporation), and data analyses were performed using SPSS

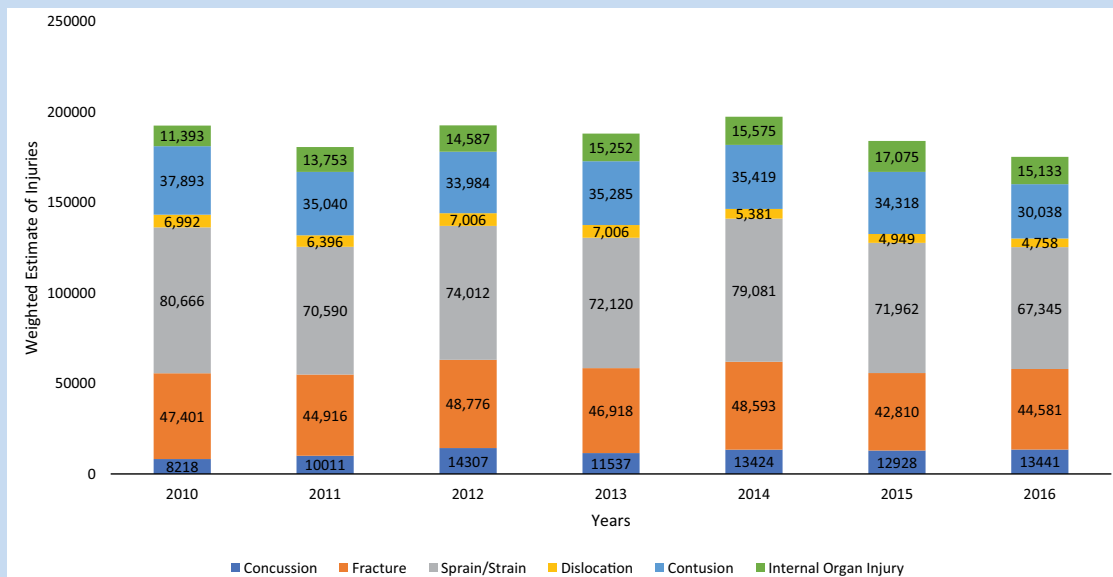


Figure 1. Soccer-related injury trends from 2010 to 2016 for the 6 most common injury types.

software (v 24; IBM Corp). A linear regression analysis was performed to analyze annual trends of soccer-related fractures and the soccer-related fractures by body part; this was reported as the correlation coefficient (r) and the coefficient of determination (R^2). A P value of less than 0.05 was the threshold for statistical significance.

RESULTS

Over the 6-year period, there were an estimated 1,590,365 soccer-related injuries. The estimated annual frequency of soccer-related injuries remained relatively stable, with a slight increase from 225,910 in 2010 to 226,150 injuries in 2016 ($P = 0.477$). The most common injuries were sprains/strains (32.4%), followed by fractures (20.4%), contusions (15.2%), internal organ injuries (6.5%), concussions (5.3%), and dislocations (2.7%) (Figure 1). The frequency of soccer-related fractures by body part and hospital admissions is provided in Table 1. In general, upper extremity injuries were more prevalent than lower extremity injuries.

Of the fracture sites, upper leg fractures comprised the highest percentage of hospital admission (51.6%) (Table 1). The annual trend of the most common soccer-related fractures demonstrated increases in both shoulder ($r = 0.740$; $R^2 = 0.547$; $P = 0.057$) and wrist ($r = 0.308$; $R^2 = 0.095$; $P = 0.502$) fractures; however, these did not prove to be significantly different. In addition, there were no significant changes in the trends of soccer-related fractures of the lower arm ($r = 0.009$; $R^2 = 7.3 \times 10^{-5}$; $P = 0.986$), finger ($r = 0.679$; $R^2 = 0.460$; $P = 0.094$), lower leg ($r = 0.153$; $R^2 = 0.024$; $P = 0.743$), ankle ($r = 0.650$; $R^2 = 0.422$; $P = 0.114$), toe ($r = 0.417$; $R^2 = 0.174$; $P = 0.353$), or foot ($r = 0.485$; $R^2 = 0.235$; $P = 0.270$). The annual percentage of patients with soccer-related fractures who

were admitted to the hospital increased from 3.1% in 2010 to 4.7% in 2016 ($r = 0.484$; $R^2 = 0.234$; $P = 0.271$).

DISCUSSION

Despite soccer's being one of the most popular sports in the world and the fastest growing sport in the United States,^{8,11,18} the present study did not find an increase in the overall soccer-related injuries in the United States between 2010 and 2016. However, the results do identify the most common injuries seen in soccer players, and fractures accounted for 20.4% of all injuries. Consequently, 60% of the reported fractures were in the upper extremity, with the wrist being the most common site of fracture in US soccer players; lower extremity fractures (32%) were the most likely to lead to hospital admission. Overall, only 3.1% to 4.7% of soccer-related injuries required hospital admission, with upper leg fractures being the most common reason for admission. Using these data, new preventative strategies, such as improved gear or rule changes, can be enacted to make the game safer for all players. Specifically, since wrist fractures contributed the most to the overall fracture prevalence, there needs to be increased focus on wrist protection.

The implementation of appropriate prevention strategies for soccer injuries has been limited by the shortage of quality injury surveillance data from both amateur and community sport settings as well as from professional and elite settings.⁷ The findings of the present study are in line with a previous analysis of soccer-related injuries, which also used the NEISS database along with data from the High School Reporting Information Online surveillance system. Kerr et al¹² used the NEISS database from 2004 to 2013 to describe the epidemiology of soccer injuries sustained by individuals aged 14 to 17 years and 18 to

Table 1. Frequency of soccer-related fractures by body part and hospital admission^a

| Body Location | Fractures | Hospital Admission |
|---------------|----------------|--------------------|
| Wrist | 58,326 (18) | 852 (1.46) |
| Lower arm | 51,776 (15.98) | 2023 (3.91) |
| Finger | 32,933 (10.16) | 115 (0.35) |
| Lower leg | 31,637 (9.76) | 5196 (16.42) |
| Ankle | 31,581 (9.75) | 1937 (6.13) |
| Shoulder | 28,452 (8.78) | 305 (1.07) |
| Toe | 17,355 (5.36) | 81 (0.47) |
| Foot | 16,801 (5.19) | 110 (0.65) |
| Hand | 9028 (2.79) | 15 (0.17) |
| Elbow | 8955 (2.76) | 1206 (13.47) |
| Knee | 4254 (1.31) | 268 (6.3) |
| Upper arm | 4103 (1.27) | 622 (15.16) |
| Upper trunk | 3782 (1.17) | 276 (7.3) |
| Lower trunk | 3635 (1.12) | 321 (8.83) |
| Upper leg | 2238 (0.69) | 1155 (51.61) |
| Head | 318 (0.1) | 160 (50.31) |
| Neck | 225 (0.07) | 16 (7.11) |

^aValues are shown as frequency (percentage).

22 years who presented to the ED and compared them with those sustained by individuals who presented to athletic trainers, as reported from the High School Reporting Information Online surveillance system and the National Collegiate Athletic Association (NCAA) Injury Surveillance Program database. They found that soccer-related fractures presenting to the ED were one of the most common diagnoses (22.2%), but this was in contrast to the fractures that were reported in the high school (7.5%) and NCAA (2.8%) injury databases.¹² Similarly, Esquivel et al⁹ also used the NEISS database from 2000 to 2012 to report on soccer injuries that occurred in individuals between the ages of 5 and 49 years and found that fractures accounted for 23% of injuries. While these studies both used data from the NEISS, the present study differs in the years of data collection. Additionally, the present study offers a population sample with a broader age range than previous studies, as patients between the ages of 2 and 95 years were included.

Previous studies^{1,9,12,15} analyzed the distribution of soccer-related injuries by type and location, then further categorized these injuries by frequency of occurrence within specific age groups. This approach was beneficial as it helped identify not

only the most common types of injuries but also in which age groups they are most commonly seen. This information is important particularly in the pediatric population, where injuries tend to be more complex and severe, thus prompting emergency room visits and requiring more extensive follow-up care.^{1,9} In a similar mind-set, it is crucial to stay up to date with the overall statistics and ongoing trends of sport-related injuries, particularly where there is exponential growth in popularity and participation. de Putter et al⁵ conducted a population-based study investigating the trends in incidence and causes of upper extremity fractures in children and adolescents. That study revealed that distal radial and carpal fractures comprised approximately 25% of all pediatric fractures, with increasing incidence rates seen due to rising rates of participation in contact sports such as soccer. Demonstrating similar findings, Lawson et al¹⁴ reported on a consecutive series of 2774 distal radial fractures in patients who presented to a trauma center and found that 50% of the sports-related wrist fractures were attributable to soccer. Moreover, they determined that 21% of soccer-related wrist fractures were due to the ball striking the hand, while 79% were due to falls.

Collectively, these findings provide insight into the trends and epidemiologic factors contributing to soccer-related injuries, which can be used to develop preventative strategies to reduce player injuries. This large-scale approach was the basis for the present study as it better yields true injury rates associated with overall play and may further guide the development of injury preventative strategies.

There are several limitations of the present study. The NEISS database includes data collected only from ED visits, without encompassing data from lower severity injuries that did not prompt an ED visit or from patients who were seen in walk-in clinics or by their primary care physicians. With these injuries unaccounted for, this likely underestimated the true rates of soccer-related injuries. Also, because of limitations of the data, there was a lack of consideration for confounding variables such as underlying pathology that may affect bone density and/or structure, which could potentially increase the likelihood of fracture.

CONCLUSION

Despite the reported growing number of soccer participants in the United States, the overall number of soccer-related injuries has remained relatively stable. Overall, the most common injuries were sprains/strains (32.4%) followed by fractures (20.4%). Consequently, 60% of the reported fractures corresponded to the upper extremity, with the wrist being the most common site, while lower extremity fractures (32%) were the most likely to lead to hospital admission. Only 3.1% to 4.7% of soccer-related injuries required hospital admission, with upper leg fractures being the most common.

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