Epidemiology of Upper Extremity Soccer Injuries Among High School– and College-Aged Players in the United States: An Analysis of the 1999-2016 NEISS Database

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Background: Although lower extremity injuries are more common than upper extremity injuries in high school– and college-aged soccer players, upper extremity injuries may be equally severe. The epidemiology of upper extremity injuries is poorly characterized in this population.

Hypothesis: Upper extremity injuries are an important contributor to soccer-related morbidity among high school– and college-aged players.

Study Design: Descriptive epidemiology study.

Level of Evidence: Level 3.

Methods: The National Electronic Injury Surveillance System (NEISS) is a nationally representative sample of 100 hospital emergency departments (EDs). Each record contains demographic and injury information. Records from 1999 to 2016 were analyzed, including patients between the ages of 14 and 23 years with a soccer-related injury sustained at school or during an athletic event.

Results: A total of 1,299,008 high school– or college-aged patients presented to the ED for a soccer-related injury from 1999 to 2016, of which 20.4% were in the upper extremity. Patients were predominantly male (58.0%) and high school–aged (81.4%). Males constituted a greater proportion of upper extremity injuries when compared with other injury locations (63.5% male for upper extremity). Upper extremity injuries were more likely to be fractures (43.7% vs 13.9%) and dislocations (7.1% vs 3.4%) and less likely to be strains/sprains (27.8% vs 56.6%). Males suffered more shoulder dislocations (81.8% males among patients with shoulder dislocation vs 57.8% among those with other injuries), finger dislocations (72.0% vs 58.0%), upper arm fractures (74.9% vs 57.6%), and forearm fractures (68.3% vs 57.3%).

Conclusion: Upper extremity injuries are frequent in high school– and college-aged soccer players presenting to the ED. Efforts to reduce soccer-related injuries should include strategies targeting the upper extremity, perhaps reducing the incidence of high-energy falls.

Clinical Relevance: Efforts to reduce soccer-related injuries should include strategies targeting upper extremity injuries, particularly among males and college-aged players.

Keywords: epidemiology; NEISS; soccer; upper extremity

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Youth soccer participation in the United States has been increasing across all ages for the past 20 years.[15,20] Lower extremity injuries are more common and better studied compared with upper extremity injuries in athletic populations. High school– and college-aged players, however, may frequently experience upper extremity injuries, including severe injuries such as dislocations and fractures.[3,8,21]

Data on the epidemiology, morbidity, and outcome of upper extremity injuries in soccer players are limited, potentially due to lack of academic interest. Upper extremity injuries, however, can have serious long-term consequences: Of soccer players 15 years or older with upper extremity fractures, 15% had not returned to play at 2 years, and 5% had persistent symptoms that impaired soccer ability.[23] Of these, clavicle and distal radius fractures were the most severe, while finger fractures had shorter recovery times.[23] Approximately half of high school soccer players who sustain a shoulder injury cannot return to sport for 3 or more weeks.[3] Other studies of male soccer players undergoing shoulder surgery report recovery times of 3 to 4 months before returning to full participation.[2,13] Among childhood soccer injuries treated in US emergency departments (EDs), 98.3% of patients were treated and released.[1,26] In pediatric soccer players presenting to a level 1 trauma center, 25% had injuries severe enough to require trauma activation and hospitalization, while another study found that 60.6% of patients who required admission had a fracture.[26,28] However, large-scale data describing the frequency and severity of upper extremity soccer injuries are limited.

Epidemiologic data are critical for those monitoring ongoing efforts to minimize injury via rule or equipment changes. The purpose of this study was to determine the epidemiology of upper extremity injuries in high school– and college-aged soccer players presenting to EDs in the United States. A secondary purpose was to comprehensively characterize upper extremity injury epidemiology with regard to annual trend, month, body part, sex, and age group.

METHODS

Data Sources

As the National Electronic Injury Surveillance System (NEISS) is a publicly available and deidentified database, this study was not considered human subjects research under 45 CFR part 46 and was therefore exempt from institutional review board review. The NEISS database is maintained by the Consumer Product Safety Commission.[5] The NEISS is a probability sample of 100 hospital EDs stratified based on hospital size, including weights that can be used to produce national estimates. Each record includes patient demographics, injury type (eg, body location, suspected injury diagnosis), and activities/products associated with the injury. Many orthopaedic investigations have used the NEISS to analyze injury epidemiology.[1,16,19,26,27,29,31]

Patient Selection

Records from 1999 through 2016 were analyzed for soccer-related injuries (code, 1267) occurring either at school or during sports among patients aged 14 to 23 years.

Dependent and Independent Variables

The primary outcome was injury occurrence. Independent variables included patient age, sex, diagnosis, and body part/region as well as month and year of injury. Patient age group was categorized as high school (14-18 years) or college (19-23 years). Injury diagnoses categorized as "other" included burns, amputations, crush injuries, foreign body injuries, electric shock, and dental injuries.

Statistical Analysis

Descriptive statistics across patient and injury characteristics were generated. Distribution of age group and sex for specific upper extremity injuries was determined, with proportions compared using chi-square or Fisher exact tests, as appropriate. Trends were assessed using logistic regression, with time as the independent variable and upper extremity injury versus injury in another location as the dependent variable. This approach allowed us to analyze trends in the proportion of upper extremity injuries over time. Records with missing data were excluded on a listwise basis. All analyses were completed using SAS software (version 9.4; SAS Institute). All analyses used statistical procedures that accounted for the NEISS survey design (eg, surveyfreq, surveymeans, surveylogistic). Statistical significance was set at $P < 0.05$ a priori.

RESULTS

Demographics

In total, 1,299,008 high school and college patients (33,367 unweighted records) presented to the ED for a soccer-related injury from 1999 to 2016 (all future figures were calculated using weighted injury counts) (Table 1). Injuries followed a bimodal distribution, with peaks during the spring and fall, corresponding with soccer seasons. In particular, the September through October time period exhibited the largest numbers of both upper extremity and non–upper extremity injuries (33.9% of total injuries in September-October; n = 439,784).

Injury Type and Pattern of Distribution

Upper extremity injuries were more likely to be fractures ($P < 0.0001$) and dislocations ($P < 0.0001$) and less likely to be strains/sprains ($P < 0.0001$) (Tables 2 and 3).

Injuries by Patient Sex

Males were disproportionately represented among patients presenting with shoulder dislocations (81.8% male among shoulder dislocations vs 57.8% male among all other injuries in the sample; $P < 0.0001$), finger dislocations (72.0% vs 58.0%; $P = 0.0068$), upper arm fractures (74.9% vs 57.6%; $P < 0.0001$), and lower arm fractures (68.3% vs 57.3%; $P < 0.0001$).

Injuries by Patient Age

College-aged patients were similarly disproportionately represented among those presenting with shoulder dislocation (51.0% college-aged among shoulder dislocation patients vs

Table 1. Upper extremity injuries by sex and age group[a]

	All Injuries		Non–Upper Extremity	Upper Extremity	
Variable	n	%	%	%	*P*
Sex					<0.0001
Male	753,669	58.0	56.6	63.5	
Female	545,171	42.0	43.4	36.5	
Age group (y)					<0.0001
14-18	1,057,752	81.4	80.9	83.4	
19-23	241,256	18.6	19.1	16.6	

[a]Total patient numbers may differ slightly due to missing data for patient sex.

18.3% college-aged among all other injuries in the sample; $P < 0.0001$) and finger dislocation (36.1% vs 18.5%; $P < 0.0001$) but constituted a significantly lower proportion of patients with lower arm fracture (14.1% vs 18.9%; $P < 0.0001$).

DISCUSSION

Male patients were disproportionately represented among soccer players presenting to the ED for upper extremity injuries, as well as players with particularly severe upper extremity injuries (eg, dislocations and fractures). Patients with upper extremity injury were disproportionately high school–aged, though patients presenting specifically with dislocations of the upper and lower extremities were disproportionately college-aged.

While lower extremity injuries predominate among youth soccer players, upper extremity injuries contribute significantly to overall soccer-related morbidity.[1,16,18,28] It is possible that upper extremity injuries in soccer tend to be of higher severity than lower extremity injuries given the greater kinetic energy associated with falls. The analysis of soccer data in the National Collegiate Athletic Association (NCAA) Injury Surveillance Program supports this hypothesis: Fractures were more likely to occur during a game than practice and more likely to affect the upper extremity, usually due to falling on an outstretched hand (hand, wrist, and finger injury) or landing on the shoulder (clavicle fracture).[24]

Higher rates of upper extremity injuries have been reported in male athletes, though the results are mixed.[4,6,7,9,10,12,14,22,25] Darrow et al[7] found higher rates of shoulder and hand/finger injuries in male high school soccer players presenting to athletic trainers. Males also accounted for the vast majority of elbow dislocations among high school athletes.[9] The investigation by Hibberd et al[14] of NCAA data also indicated higher rates of acromioclavicular joint sprain among male versus female soccer players. Yard et al,[30] however, observed no difference in the proportion of upper extremity injuries among male versus female high school soccer players. With regard to our findings, it is possible that male and high school–aged soccer players experience a greater number of falls during sport, predisposing to a greater number of upper extremity injuries. Even if this hypothesis is correct, however, the cause of such falls remains unknown.

Dislocations and fractures were arguably the most severe upper extremity injuries prominent in our sample and disproportionately affected male players. Previous studies of soccer-related injury epidemiology have produced mixed results on sex-based differences in injury severity, though these studies have primarily examined lower extremity injuries.[7,8,11,23,24,30] It is possible that particularly high–kinetic energy injuries occur more frequently among male youth soccer players, accounting for this relative disparity. Alternatively, it is possible that male youth soccer players disproportionately present to the ED for upper extremity injuries of higher severity.

Patients presenting with upper extremity dislocations were more likely to be college- than high school–aged. Krauetler et al[17] similarly found that college athletes had a higher rate of shoulder dislocation injuries than high school athletes, with surgery being performed to correct 28% and 29.6% of shoulder dislocations in high school and college athletes, respectively. It is possible that college-aged athletes experience more dislocation injuries simply because of higher cumulative likelihood of past dislocation (ie, more years of exposure) and subsequent predisposition to future dislocations. If true, this hypothesis suggests that early intervention to reduce the rate of dislocation injuries at the high school or even pre–high school level may ultimately benefit players of all ages.

This investigation has several limitations. The NEISS collects generalized data regarding injuries and therefore lacks many variables that would be of interest in orthopaedic care (eg, specific mechanism of injury, fracture pattern, history of dislocation). Furthermore, the NEISS lacks information on long-term outcomes, including need for surgery, functional

Table 2. Injuries by body region and diagnosis (1999-2016)[a]

Injury	Upper Extremity	Lower Extremity	Head and Neck	Trunk	Total
Concussion					
No. of discharges	0	0	78,216	0	78,216
Percentage of total	0.0	0.0	6.0	0.0	6.0
Column percentage	0.0	0.0	25.5	0.0	—
Row percentage	0.0	0.0	100.0	0.0	—
Contusion, abrasion, laceration					
No. of discharges	43,789	118,355	110,643	36,928	309,715
Percentage of total	3.4	9.1	8.5	2.8	23.9
Column percentage	16.5	18.8	36.0	38.3	—
Row percentage	14.1	38.2	35.7	11.9	—
Dislocation					
No. of discharges	18,891	21,300	143	247	40,581
Percentage of total	1.5	1.6	0.0	0.0	3.1
Column percentage	7.1	3.4	0.0	0.3	—
Row percentage	46.6	52.5	0.4	0.6	—
Fracture					
No. of discharges	115,904	87,429	23,874	6336	233,543
Percentage of total	8.9	6.7	1.8	0.5	18.0
Column percentage	43.7	13.9	7.8	6.6	—
Row percentage	49.6	37.4	10.2	2.7	—
Internal injury					
No. of discharges	0	0	65,765	1820	67,585
Percentage of total	0.0	0.0	5.1	0.1	5.2
Column percentage	0.0	0.0	21.4	1.9	—
Row percentage	0.0	0.0	97.3	2.7	—
Strain, sprain					
No. of discharges	73,765	356,110	13,184	24,442	467,501
Percentage of total	5.7	27.5	1.0	1.9	36.0
Column percentage	27.8	56.6	4.3	25.4	—
Row percentage	15.8	76.2	2.8	5.2	—
Other[b]					
No. of discharges	12,646	45,505	15,329	26,589	100,069
Percentage of total	1.0	3.5	1.2	2.0	7.7
Column percentage	4.8	7.2	5.0	27.6	—
Row percentage	12.6	45.5	15.3	26.6	—
Total					
Number	264,995	628,699	307,155	96,362	1,297,211
Percentage	20.4	48.5	23.7	7.4	100.0

[a]Row and column sums may differ slightly from indicated totals due to rounding.
[b]Injury diagnoses categorized as "other" included burns, amputations, crush injuries, foreign body injuries, electric shock, and dental injuries.

Table 3. Upper extremity injuries by body part and diagnosis (1999-2016)

Injury	Shoulder	Upper Arm	Elbow	Lower Arm	Hand or Wrist	Finger	Total
Contusion, abrasion, laceration							
No. of discharges	8676	446	6855	5436	17,090	5286	43,789
Percentage of total	3.3	0.2	2.6	2.1	6.4	2.0	16.5
Column percentage	14.2	20.2	38.4	18.0	16.4	10.6	—
Row percentage	19.8	1.0	15.7	12.4	39.0	12.1	—
Dislocation							
No. of discharges	11,123	16	2150	6	182	5414	18,891
Percentage of total	4.2	0.0	0.8	0.0	0.1	2.0	7.1
Column percentage	18.2	0.7	12.0	0.0	0.2	10.9	—
Row percentage	58.9	0.1	11.4	0.0	1.0	28.7	—
Fracture							
No. of discharges	23,960	1115	3649	21,876	43,303	22,001	115,904
Percentage of total	9.0	0.4	1.4	8.3	16.3	8.3	43.7
Column percentage	39.2	50.3	20.4	72.5	41.6	44.3	—
Row percentage	20.7	1.0	3.1	18.9	37.4	19.0	—
Strain, sprain							
No. of discharges	14,669	257	4237	1648	37,981	14,972	73,765
Percentage of total	5.5	0.1	1.6	0.6	14.3	5.6	27.8
Column percentage	24.0	11.6	23.7	5.5	36.5	30.1	—
Row percentage	19.9	0.3	5.7	2.2	51.5	20.3	—
Other[b]							
No. of discharges	2682	380	963	1193	5428	1999	12,646
Percentage of total	1.0	0.1	0.4	0.5	2.0	0.8	4.8
Column percentage	4.4	17.2	5.4	4.0	5.2	4.0	—
Row percentage	21.2	3.0	7.6	9.4	42.9	15.8	—
Total							
Number	61,110	2215	17,854	30,159	103,984	49,672	264,995
Percentage	23.1	0.8	6.7	11.4	39.2	18.7	100.0

[a]Row and column sums may differ slightly from indicated totals due to rounding.
[b]Injury diagnoses categorized as "other" included burns, amputations, crush injuries, foreign body injuries, electric shock, and dental injuries.

outcomes, and return to play. As with all retrospective data set analyses, these results are influenced by coding bias and unknown confounding variables. Because this sample consisted of only patients presenting to the ED, this probably represents inclusion bias as these patients likely have more severe injuries compared with the total population of injured soccer players.[16] This limits the generalizability of these results to total soccer-related injuries, although is useful for looking at this subset of more severe injuries.

CONCLUSION

Soccer players presenting to the ED with upper extremity injuries were disproportionately male and high school–aged. Patients with upper extremity dislocations and fractures were disproportionately male, and those with dislocations were also disproportionately college-aged.

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