Comparison of Volleyball-Related Injuries at US Emergency Departments Between High School and Collegiate Athletes

A 10-Year NEISS Database Study

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Background: There is a paucity of current data regarding the sport-specific injury patterns and epidemiological trends associated with volleyball.

Purpose: To provide an updated, comparative assessment of the epidemiology of volleyball-related injuries among female high school– and college-aged athletes and to characterize the burden of these injuries on emergency departments (EDs) across the United States.

Study Design: Descriptive epidemiological study.

Methods: Data were obtained from the National Electronic Injury Surveillance System for volleyball-related injuries between 2012 and 2021 in high school–aged (14-18 years) and college-aged (19-23 years) patients. Incidence, injury characteristics, incident locales, and dispositions were analyzed with weighted population statistics based on National Federation of State High School Associations and National Collegiate Athletic Association data as well as incidence rates and incidence rate ratios (IRRs) and 95% CIs.

Results: In total, an estimated 214,302 female athletes aged 14 to 23 years were evaluated in EDs across the United States with volleyball-related injuries between 2012 and 2021. Female college-aged athletes were nearly 3 times more likely to be evaluated with these injuries than their high school–aged counterparts, with incidence rates of 12.8 per 100 at-risk individuals among college-aged athletes and 4.3 per 100 at-risk individuals in high school–aged athletes (IRR, 0.338; 95% CI, 0.333-0.342). The ankle, head, and knee were most frequently injured, often involving strains/sprains, contusions, fractures, and concussions. The IRRs of nearly all injuries were higher among collegiate athletes, especially among knee (IRR, 4.56; 95% CI, 4.40-4.72) and shoulder (IRR, 5.07; 95% CI, 4.81-5.35) injuries.

Conclusion: Among volleyball-related injuries evaluated in EDs between 2012 and 2021, the incidence rates of injuries in college-aged athletes far surpassed those of their high school–aged peers irrespective of injury type or bodily location. While sprains and strains were the most frequent injuries, head injuries accounted for the second most common diagnosis in both groups, suggesting that clinicians should maintain a high index of suspicion for concussion when evaluating players.

Keywords: NEISS; volleyball; epidemiology; NCAA; high school

Volleyball is one of the most popular sports among young female athletes in the United States.[7,17] A reported 452,808 high school–aged female athletes played volleyball nationwide during the 2018-2019 season, making volleyball the second most popular sport in this demographic.[13] Similarly, volleyball was the fifth most popular sport played by female college-aged athletes in 2018, with >1000 registered National Collegiate Athletic Association (NCAA) women's volleyball teams composed of >17,000 players.[12] Despite its popularity, few studies have been published regarding the sport-specific injury patterns and epidemiological trends associated with volleyball.[5,8,15,16]

While considered a noncontact sport, volleyball players are known to be at risk for traumatic injuries because of the physically demanding nature of the sport.[2,5,8,9,15] Existing studies have noted high incidences of ankle and knee injuries among players.[1,5,7,15,17] Additionally, the sport's propensity for high upper extremity load predisposes

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volleyball athletes to shoulder, hand, and wrist injuries.[1,5,7,15,17] Previously published data also suggest that while high school– and college-aged athletes experience similar injury patterns, collegiate athletes may be at greater risk for both acute and overuse injuries.[16] Despite these risk factors, existing literature has not examined the characteristics of volleyball-related injuries in high school– and college-aged athletes evaluated in emergency departments (EDs) across the United States.

The purpose of this study was to provide an updated, comparative assessment of the epidemiology of volleyball-related injuries among female high school– and college-aged athletes. Additionally, we aimed to characterize the burden of these injuries on EDs across the United States. We hypothesized that injury severity would increase with higher level of play, and therefore, college-aged athletes would be evaluated more frequently in EDs for volleyball-related injuries than their high school–aged counterparts.

METHODS

Database and Query

Data for this cross-sectional, epidemiologic study of volleyball-related injuries evaluated in US EDs were obtained from the National Electronic Injury Surveillance System (NEISS) database using a query of all volleyball-related injuries occurring between 2012 and 2021 in patients aged 14 to 23 years. The NEISS database sources de-identified data from approximately 100 EDs that serve as a probability sample for EDs nationwide. Data were obtained by a hospital coordinator assigned to the facility and acquired from both clinical information and follow-up telephone communication as needed. Since patient data were de-identified and collected from the NEISS database, institutional review board approval was not necessary for this analysis.

Data Collection

Patients aged 14 to 18 years were considered high school–aged athletes, while patients aged 19 to 23 years were considered college-aged athletes. Data queries were performed exclusive to female patients. Data on incidence, injury patterns, and patient dispositions were collected and analyzed.

Statistical Analysis

Weighted population statistics and corresponding 95% CIs were calculated based on National Federation of State High School Associations (NFHS) and NCAA data.[12,13] Incidence rates were calculated per 100 at-risk persons, with the population at risk calculated from the number of injuries based on nationwide estimates in the NEISS database out of the total number of national athletes with recorded volleyball participation in the NFHS and NCAA leagues. Incidence rate ratios (IRRs) and 95% CIs were calculated to compare incidence rates between high school– and college-aged athletes, and 2-sided mid-*P* values were calculated for all IRRs and Poisson approximations treated as discrete variables to construct incidence rate confidence intervals to improve the power of statistical analysis. Unpaired *t* tests were used to calculate trends between years. Statistical significance was defined as $\alpha \leq .05$.

RESULTS

In total, a weighted estimate of 214,302 female athletes aged 14 to 23 years were evaluated in EDs between 2012 and 2021 across the United States with volleyball-related injuries. Female college-aged athletes were nearly 3 times more likely to be evaluated with an injury, with overall incidence rates of 12.8 per 100 at-risk persons among college-aged athletes and 4.3 per 100 at-risk individuals in high school–aged athletes (IRR, 0.338; 95% CI, 0.333-0.342) (Table 1). Between 2012 and 2021, the incidence rate of volleyball-related injuries among high school athletes remained relatively consistent, only varying by 2.6 points. The incidence rate of injuries among collegiate athletes in this time frame remained consistently higher and more variable than that of high school athletes. Additionally, both age groups saw a substantial drop in the injury incidence rate per 100 at-risk persons in 2020, which coincided with the onset of the COVID-19 pandemic (Figure 1).

Injury Patterns

The most frequently injured body parts evaluated in the ED among both groups included the ankle, knee, head, and finger, while the most commonly specified diagnoses included strains or sprains (Figure 2). Our estimated weighted data suggest that sprains and strains were the most common ankle (86%; n = 44,568), knee (47%; n = 12,032), finger (48%; n = 11,875), and neck (70%; n = 1785) injuries among

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Ethical approval was not sought for the present study.

TABLE 1
Comparative Characteristics of Injuries by Age Group[a]

	High School (14-18 y)		College (19-23 y)		
	National Estimate[b]	IR per 100 At-Risk Persons	National Estimate[b]	IR per 100 At-Risk Persons	IRR (High School vs College)
Overall incidence	192,413 (89.8)	4.3	21,889 (10.2)	12.8	0.338 ± 0.00713
Disposition					
Treated and discharged	190,494 (89.8)	0.0428	21,621 (10.2)	0.1264	0.338 ± 0.0072
Transferred or admitted	459 (67.7)	0.0103	219 (32.3)	0.128	0.082 ± 0.082
Held for observation	222 (100)	0.00005	NR	NR	NR
Left against medical advice	1084 (95.7)	0.00024	49 (4.3)	0.0003	0.857 ± 0.147

[a]Data are presented as n (%) or mean ± SD unless otherwise indicated. IR, incidence rate; IRR, incidence rate ratio; NR, not reported.
[b]Percentage of total volleyball injuries.

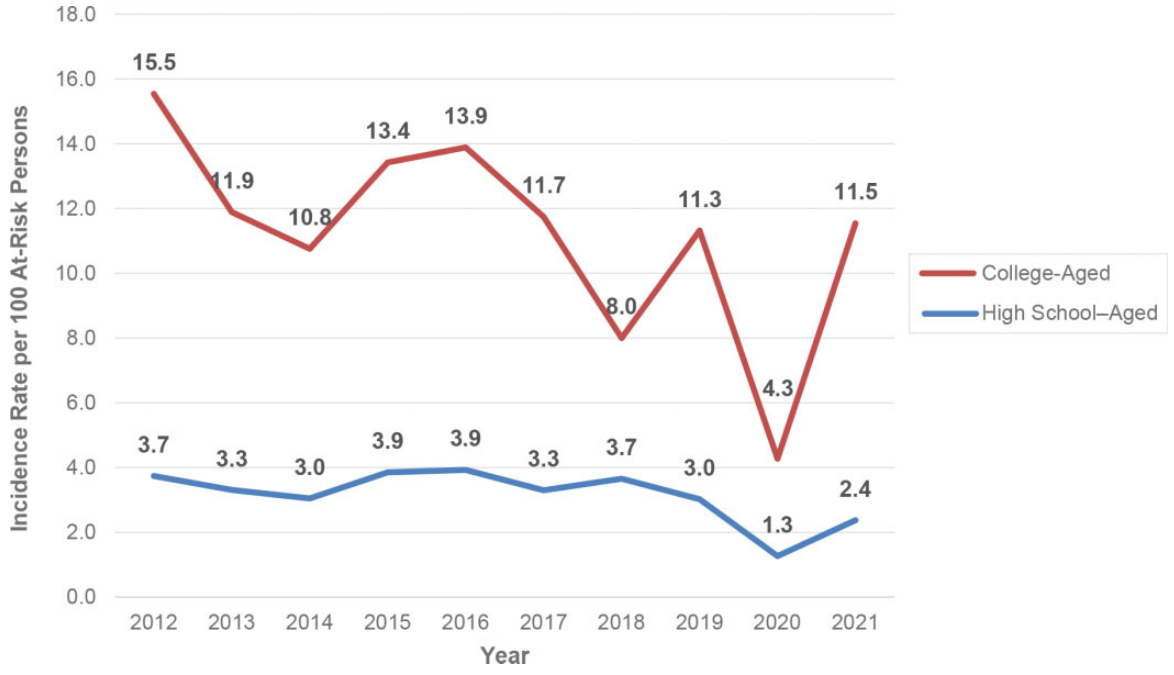

Figure 1. Incidence rates among high school and collegiate athletes by year.

the population of 14- to 23-year-old volleyball players evaluated in the ED between 2012 and 2021.

Although high school athletes represented roughly 90% of volleyball-related injuries evaluated in EDs, population-adjusted incidence rates demonstrated that nearly all injuries occurred at higher rates among college-aged athletes, with notably higher incidence of injuries to the head (IRR, 1.97; 95% CI, 1.88-2.06), shoulder (IRR, 5.07; 95% CI, 4.81-5.35), knee (IRR, 4.56; 95% CI, 4.40-4.72), ankle (IRR, 2.40; 95% CI, 2.32-2.47), and wrist (IRR, 2.97; 95% CI, 2.82-3.13) (Table 2). College-aged female volleyball athletes were >6 times more likely to be evaluated in the ED with upper arm injuries (IRR, 6.26; 95% CI, 4.69-8.35) than their high school counterparts. College-aged athletes also had higher population-adjusted rates of nearly all reported mechanisms of injuries, including concussions (IRR, 2.62; 95% CI, 2.47-2.78), dislocations (IRR, 6.29; 95% CI, 5.91-6.89), and lacerations (IRR, 4.0; 95% CI, 3.60-4.44).

Disposition

In total, of the estimated weighted population data, 99% of patients were treated in the ED and released (n = 212,115), succeeded by 0.5% of patients who left against medical advice (n = 1133) and 0.3% of patients who were admitted (n = 678). The odds of being admitted to the hospital were 12 times higher among college-aged athletes than among high school–aged athletes (IRR, 12.24; 95% CI, 10.43-14.37). The odds of patients being treated and released were also nearly 3 times higher among college-aged female volleyball athletes (IRR, 2.95; 95% CI, 2.91-3.00).

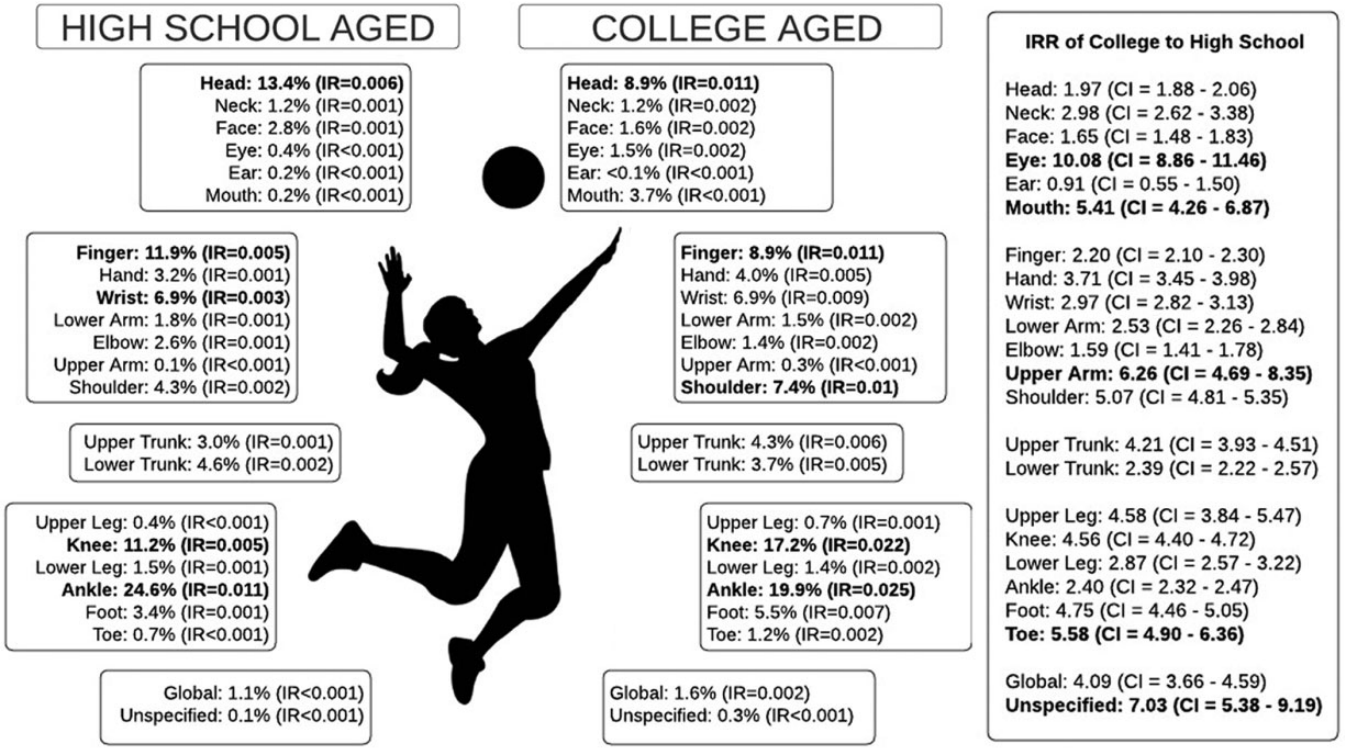

Figure 2. Incidence rates among female volleyball athletes evaluated in the emergency department. Bolded text indicates the top 5 injury sites by region. IR, incidence rate; IRR, incidence rate ratio.

DISCUSSION

In our analysis and weighted estimate calculations of 2012-2021 NEISS data, female college-aged volleyball athletes were found to be nearly 3 times more likely to be evaluated in the ED with volleyball-related injuries than their high school–aged counterparts. Injuries among athletes evaluated in the ED most commonly involved the ankle (24%), followed by the head (13%), knee (12%), finger (12%), and wrist (7%). Approximately 99% of the analyzed patients, regardless of their age, were treated in the ED and released. However, our weighted data estimates suggest that college-aged volleyball athletes were 12 times more likely to be admitted than high school–aged volleyball athletes.

The findings of this study are in alignment with the existing literature on volleyball-related injuries. In their analysis of data sourced from the NCAA Injury Surveillance System (ISS) and High School Reporting Injuries Online, Reeser et al[16] reported significantly higher incidences of both acute and overuse injuries among female collegiate athletes when compared with high school–aged players. Similarly, Twomey-Kozak et al[18] described higher incidences of shoulder dislocations evaluated in EDs in the United States among collegiate athletes as compared with their high school counterparts, regardless of the type of sport. These findings mirror the trends evident in the present analysis, which demonstrate an overall 3 times higher likelihood of volleyball injuries requiring ED treatment among college-aged versus high school–aged athletes. Furthermore, college-aged patients were more likely to be admitted or transferred, rather than discharged to home, after evaluation in the ED. Of note, in a recent study, Wiersma et al[20] found that school-aged athletes who were evaluated in EDs after ankle injury had more severe injuries than those who were managed acutely in the athletic training setting. In accordance with existing research, our findings support the principle that collegiate athletes not only experience a higher incidence of volleyball-related injuries, but also may be more likely to sustain severe injuries when compared with high school athletes. The clinical relevance of these findings indicates that a greater suspicion for severe injuries may be warranted when evaluating collegiate athletes.

While not considered to be a contact sport, volleyball has a high incidence of concussions associated with it, which is a major point of concern for both athletes and clinicians.[4,10,16] Additional safety measures, such as requiring padding on exposed metal poles, have been implemented by the sport's governing body with the aim of reducing head injuries; however, concussion rates have remained high.[4,10,15] Reeser et al[16] reported concussions as the third most frequent injury diagnosis among high schoolers and the fourth most frequent among collegiate athletes. An analysis of NEISS concussion data for female high school athletes by Pirruccio et al[14] found volleyball to be the fifth most common sporting cause of concussions evaluated in the ED. Similarly, Chandran et al[4] found concussions to

TABLE 2
Injury Characteristics and Population-Adjusted Incidence Rates by Age Group

	High School (14-18 y)			College (19-23 y)		
	n	%	Incidence per 100	n	%	Incidence per 100
Body part						
Ankle	47,377	91.6	0.011	4359	8.4	0.025
Head	25,757	92.7	0.006	1945	7.3	0.011
Knee	21,570	85.1	0.005	3776	14.9	0.022
Finger	22,976	92.2	0.005	1941	7.8	0.011
Wrist	13,297	89.8	0.003	1517	10.2	0.009
Shoulder	8424	83.7	0.002	1641	16.3	0.010
Lower trunk	8903	91.6	0.002	817	8.4	0.005
Foot	6561	84.6	0.001	1196	15.4	0.007
Upper trunk	5903	86.1	0.001	955	13.9	0.006
Hand	6109	87.5	0.001	870	12.5	0.005
Face	5433	94.1	0.001	343	5.9	0.002
Elbow	5039	94.3	0.001	307	5.7	0.002
Lower arm	3368	91.1	0.001	328	8.9	0.002
Lower leg	2920	90.1	0.001	322	9.9	0.002
Global	2199	86.4	<0.001	346	13.6	0.002
Neck	2299	89.7	0.001	263	10.3	0.002
Toe	1276	82.4	<0.001	273	17.6	0.002
Eyeball	834	72.1	<0.001	323	27.9	0.002
Upper leg	823	85.0	<0.001	145	15.0	0.001
Ear	461	96.6	<0.001	16	3.4	<0.001
Mouth	392	82.9	<0.001	81	17.1	<0.001
Unspecified	251	78.7	<0.001	68	21.3	<0.001
Upper arm	237	80.6	<0.001	57	19.4	<0.001
Diagnosis						
Strain or sprain	88,708	89.6	0.020	10,284	10.4	0.060
Other/not stated	34,270	89.9	0.008	3833	10.1	0.022
Contusions, abrasions	21,029	90.7	0.005	2169	9.3	0.013
Fracture	14,749	89.6	0.003	1718	10.4	0.010
Concussions	11,867	90.8	0.003	1196	9.2	0.007
Internal organ injury	11,794	94.2	0.003	723	5.8	0.004
Dislocation	5207	80.5	0.001	1258	19.5	0.007
Laceration	2630	86.7	0.001	404	13.3	0.002
Avulsion	546	86.0	<0.001	89	14.0	0.001
Hematoma	418	100	<0.001	0	0.00	0
Foreign body	285	100	<0.001	0	0.00	0
Puncture	268	100	<0.001	0	0.00	0
Dermatitis, conjunctivitis	238	100	<0.001	0	0.00	0
Hemorrhage	125	100	<0.001	0	0.00	0
Nerve damage	115	74.7	<0.001	39	25.3	<0.001

be one of the most commonly reported injuries in the NCAA ISS database on collegiate female volleyball players. Our analysis of NEISS data found injuries to the head to be the second most common chief complaint by volleyball players who were evaluated in the ED, with concussions accounting for over half of all reported head injuries. Notably, the odds of college-aged volleyball athletes sustaining a concussion were >2 times higher than those of the high school–aged female volleyball athletes in our study. Given the lengthy recovery time after a concussion, coupled with the potential for serious long-term sequelae, these findings call attention to the importance of developing and implementing additional preventative measures aimed at reducing the incidence of concussion among young female volleyball players.[3,6,11,19] Furthermore, these results emphasize that clinicians should maintain a high index of suspicion for concussion when evaluating injured players in the acute setting.

Limitations

This study is not without limitations. As with any database, the scope of this study is limited to variables obtained by data collectors and does not include patients who were evaluated in urgent care, primary care, or sports medicine clinics. Analyzing only ED visits may also have biased our results toward injuries that athletic trainers and team physicians may feel less comfortable treating, such as head

injuries, and explain the relatively lower incidence of shoulder injuries than one might have expected. Similarly, NEISS data do not specify an athlete's position, which may contribute to their risk of injury, as well as their experience level or athletic league. The availability of team physicians and athletic trainers may vary with level of play. It is possible that collegiate athletes may have access to more resources, allowing them to forgo evaluation at EDs for minor injuries. Our age range determination for high school and collegiate athletes is based on national average ages as well as NFHS- and NCAA-reported populations, introducing the potential to exclude patients outside of traditional educational years from injury cohorts as well as unregistered athletes from the overall sample size. Last, calculations of incidence rates were dependent on census data and population estimates, introducing an extrapolation of NFHS and NCAA athlete populations as the overall source of athletes for the study nationwide. While individuals injured in recreational volleyball or sport unaffiliated with the NFHS or NCAA were included as part of the NEISS database, the population to determine the denominator of the overall incidence rate was limited to the NFHS- and NCAA-affiliated players. However, comparing ratios of these 2 major organizations to calculate appropriate incidence rates allows a more targeted understanding regarding the ratios of high school– and college-aged participants rather than assessing the entire population without volleyball affiliation nationwide.

CONCLUSION

Among volleyball-related injuries evaluated in EDs between 2012 and 2021, the incidence rates of injuries in female college-aged athletes far surpassed those of their high school–aged peers irrespective of injury type or bodily location. While sprains and strains were the most frequently evaluated injuries, head injuries accounted for an alarmingly high proportion of evaluated injuries in both groups, suggesting that clinicians should maintain a high index of suspicion for concussion when evaluating players. Ultimately, understanding current epidemiologic trends among volleyball-related injuries in high school– and college-aged populations is important for recognizing common injury patterns and for ensuring the appropriate allocation of resources and implementation of effective policy regarding injury prevention.

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