Prevalence of Upper Extremity Volleyball Injuries Within Different Adult Age Groups

A Comprehensive Analysis of National Data From 2013-2022

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Background: The mean age of volleyball athletes has increased over the past decade, raising concerns about musculoskeletal injuries. There is no literature on how different mechanisms of injury (MOI) affect different adult age groups.

Purpose: To evaluate epidemiologic trends, diagnoses, and mechanisms of volleyball-related upper extremity injuries within different adult age groups.

Study Design: Descriptive epidemiology study.

Methods: Data from the National Electronic Injury Surveillance System for volleyball-related upper extremity injuries in patients aged between 19 and 79 years, between January 1, 2013, and December 31, 2022, were analyzed. Data included body parts, diagnosis, MOI, and disposition. Calculations used corresponding hospital sample weights for national estimates (NEs). Patients were divided into either 20-39, 40-59, or 60+ years age groups. Linear regressions were used to analyze annual trends, chi-square tests were used to analyze categorical variables, and the Holm *P* value adjustment method was utilized in post hoc analysis.

Results: A weighted NE of 41,164 volleyball-related upper extremity injuries occurred in the study period. The mean age was 35.8 $\pm$ 14 years, and male patients constituted 49.4% of all patients. The most injured body parts of all age groups were fingers (33.2%), shoulders (28.9%), and wrists (16%). The most common identifiable MOI were impacts with the floor (24%), impacts with the ball (18.7%), and spikes/serves (6.9%). The 20-39 age group experienced shoulder dislocations at the greatest rate of all age groups (NE = 3362 [37%]) and sustained injuries from spike/serve movements at the greatest rates (NE = 2214 [8.2%]; $P < .01$). Of the 3362 shoulder dislocations in the 20-39 age group, 1445 (43%) were during spikes/serves. The 60+ age group had the greatest rates of sprains/strains (NE = 1353 [41.1%]). Additionally, the 60+ age group suffered from injuries secondary to impacts on the floor (NE = 1242 [37.7%]) and impacts with the ball (NE = 769 [23.4%]) at the greatest rates ($P < .01$).

Conclusion: Our study demonstrated that adult populations are at risk for volleyball-related upper extremity injuries, specifically affecting the finger, wrist, and shoulder. MOI among age groups differed, as younger adults more often sustained injuries from dynamic movements, whereas older adults sustained injuries from trauma.

Keywords: adult; mechanisms of injury; National Electronic Injury Surveillance System; sports; upper extremity; volleyball

Volleyball is a popular sport among both male and female athletes.[15] For the first time in national history, a professional women's league called the Pro Volleyball Federation debuted[1] in 2024. The National Collegiate Athletic Association estimates approximately 38% of the US population participates in recreational or competitive volleyball[5] and that the mean age of women and men are 26 and 29.5 years old, respectively.[14] National surveys estimate that 61% of all volleyball participants are >30 years old and 30% are >40 years old.[26] The elevated age of participation in volleyball raises concerns for musculoskeletal (MSK) injuries, as advanced age has been shown to decrease adaptive potential and recovery time.[9] Previous literature has also demonstrated that advanced age has detrimental effects on the likelihood and severity of sustaining MSK injury.[7,18,22]

In general, there are 2 types of MSK injuries within volleyball: (1) acute trauma directly from external variables—

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such as the floor, ball, other players, and equipment—and (2) overuse injuries from continuous upper extremity use. Previous studies have evaluated volleyball-related injuries in pediatric, high school, and collegiate populations and found that direct trauma—most commonly involving the fingers, wrists, and shoulders—is the greatest contributing mechanism of injury (MOI) in all age groups.[11,19,20,22] On the other hand, it is well documented that repetitive unilateral overhead movements—such as spiking, serving, and blocking—lead to upper extremity strength asymmetry, decreased glenohumeral external rotation range of motion (ROM), and increased internal rotation (IR) strength, which may contribute to overload injuries or other maladaptive limitations.[3,6,8,11,22] As a result, repetitive unilateral overhead movements predispose individuals to degenerative disease and a higher risk of overload injuries like shoulder dislocation.[26]

Despite national surveys reporting this increase in athlete age, there is a lack of research on volleyball-related injuries in different adult age groups. Therefore, the goal of this study was to evaluate the epidemiologic trends, prevalence, and mechanisms of upper extremity injuries in adult populations aged $\geq$19 years. Given the effect of advanced age on deteriorating natural processes, we hypothesized that older age groups would have increases in both acute and chronic injuries of the upper extremities compared with younger age groups.

METHODS

Data Collection

Sports-related injuries were collected via the National Electronic Injury Surveillance System (NEISS) database from the Consumer Product Safety Commission. The NEISS database represents over 5000 emergency departments (EDs) from 100 hospitals that offer 24-hour services and at least 6 admitting beds. From the database, inquiries of volleyball-related injuries (product code 1266: volleyball [activity, apparel, or equipment])—involving the shoulder (product code 30), upper arm (product code 80), elbow (product code 32), lower arm (product code 33), wrist (product code 34), hand (product code 82), and finger (product code 92)—were built. Each data point was given a statistical sample weight based on the capacity of that respective hospital, which was used to calculate an accurate national estimate to represent national trends. ED visits for patients between the ages of 19 and 79 years old between January 1, 2013, and December 31, 2022, were included.

The data set provided variables—including date of presentation, age, sex, race, body part, and final diagnosis—and a narrative written by a health care provider. These narratives were reviewed by the first 2 authors (P.L., E.M.S) to identify the MOI and ensure that the injury occurred from a volleyball-related incident. The senior author (J.Y.) was consulted in case of disagreements on the interpretation of narratives. Patients were further subcategorized into 20-39, 40-59, and 60 + years age groups, as physiologic differences are observed every 20 years. MOI was categorized as impacts with the ball, impacts with the floor, overhead arm motions (spike, serve, block), impacts with a player, impacts with a pole, impacts with a net, overuse, or other. If narratives provided insufficient detail or the exact mechanism was unclear, they were classified as "not specified" (eg, "injured while playing volleyball at the park").

Exclusion Criteria

Narratives describing nonvolleyball-related injuries were excluded. Examples include injuries that did not occur while playing volleyball and secondary injuries associated with another primary mechanism (eg, initial injury during football, exacerbated with volleyball).

Statistical Analysis

Statistical analyses were performed using RStudio Software 2023.06.0 + 421 (Posit, PBC). National estimates (NEs) were calculated by multiplying the associated statistical weight of the reporting hospital by each queried raw data point. Trends in NE for overall injuries, injury diagnoses, and MOI were assessed using linear regressions. Similar analyses were conducted to evaluate trends in age groups, sex, and the year 2020 to account for the effects of the pandemic. Chi-square analyses were used to analyze categorical variables. The Holm P value adjustment method was used in the post hoc analysis. Statistical significance was set at $P < .05$.

RESULTS

General Results

From the NEISS sampling of 100 EDs between January 2013 and December 2022, there were a total of 904 (NE =

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TABLE 1
Most Injured Volleyball Upper Extremity Locations

Body Location	Raw Number of Injuries	National Estimate of Injuries	%
Finger	314	13,545	33.2
Shoulder	252	11,760	28.9
Wrist	153	6529	16
Hand	68	3295	8.1
Elbow	47	2462	6
Lower arm	47	2433	6
Upper arm	14	731	1.8
Total	895	40,754	100

TABLE 2
Most Common Diagnoses of Volleyball-Related Upper Extremity Injuries

Diagnosis	Raw Number of Injuries	National Estimate of Injuries	%
Strain/sprain	275	13,668	33.5
Fracture	189	8004	19.6
Dislocation	173	7795	19.1
Other/not stated	149	6300	15.5
Contusion/abrasion	82	3939	9.7
Laceration	17	591	1.5
Other (hematoma, avulsion, dermatitis)	10	457	1.2
Total	895	40,754	100

41,164) volleyball-related upper extremity injuries. After applying the inclusion and exclusion criteria, 895 (NE = 40,754 [99%]) injuries were included for analysis. The mean patient age was 35.8 ± 14 years. In total, 878 (NE = 39,979 [98.1%]) were treated and discharged, 11 (NE = 434 [1.2%]) left before being evaluated, 5 (NE = 274; <0.7%) were admitted, and 1 (NE = 67; <0.2%) was transferred to another facility.

In all age groups, there were 314 (NE = 13,545 [33.2%]) total finger injuries, making it the most affected body part. The second most injured body part was the shoulder with 252 (NE = 11,760 [28.9%]) total injuries. The wrist was the third most involved body part with 153 (NE = 6529 [16%]) total injuries. Table 1 represents the distribution of upper extremity injury locations within all patients.

Of the most common MOI, there were 403 (NE = 18,463 [45.3%]) total injuries that were not specified, 216 (NE = 9796 [24%]) injuries from impacts with the floor, and 174 (NE = 7615 [18.7%]) injuries from impacts with the ball. Of the most common diagnoses, there were 275 (NE = 13,668 [33.5%]) sprains/strains, 189 (NE = 8004 [19.6%]) fractures, and 173 (NE = 7795 [19.1%]) dislocations. Table 2 represents the distribution of final diagnoses within all patients.

Most Common Diagnoses of Top 3 Body Parts Injured

Of all finger injuries, there were 99 (NE = 4755 [35.1%]) sprains/strains, 84 (NE = 3290 [24.3%]) fractures, and 71 (NE = 3261 [24.1%]) dislocations. Of all shoulder injuries, there were 96 (NE = 4365 [37.1%]) dislocations, 80 (NE = 4056 [34.5%]) sprains/strains, 61 (NE = 2615 [22.2%]) other/not stated, and 12 (NE = 546 [4.6%]) contusions/abrasions. Of all wrist injuries, there were 71 (NE = 3457 [52.9%]) sprains/strains, 45 (NE = 1603 [24.6%]) fractures, and 16 (NE = 739 [11.3%]) contusions/abrasions.

Most Common MOI of Top 3 Body Parts Injured

Regarding finger injuries, there were 135 (NE = 6078 [44.9%]) injuries due to a nonspecified mechanism, 140 (NE = 5938 [43.8%]) due to impacts with the ball, 17 (NE = 652 [4.8%]) due to impacts with the floor, 9 (NE = 436 [3.2%]) from an overhead spike/serve movement, and 9 (NE = 306 [2.3%]) from impacts with another player. Regarding shoulder injuries, 134 (NE = 5945 [50.6%]) were due to a nonspecified mechanism, 61 (NE = 3047 [25.9%]) were due to impact with the floor, 38 (NE = 1989 [16.9%]) were from an overhead spike/serve movement, 7 (NE = 321 [2.7%]) were from impacts with the ball, and 5 (NE = 283 [2.4%]) were from impacts with another player. Regarding wrist injuries, there were 78 (NE = 3133 [48%]) injuries from impacts with the floor, 58 (NE = 2607 [39.9%]) were from a nonspecified mechanism, 8 (NE = 433 [6.6%]) were from impacts with the ball, and 2 (NE = 159 [2.4%]) were from impacts with another player.

Age Group Analyses

There were 594 (NE = 26,973 [66.2%]) injuries from the 20-39 age group, 234 (NE = 10,489 [25.7%]) from the 40-59 age group, and 67 (NE = 3291 [8.1%]) from the 60 + age group. In reference to MOI (Table 3), the proportion of injuries secondary to overhead spike/serve movements was highest in the 20-39 age group, with 49 (NE = 2214 [8.2%]) injuries secondary to overhead spike/serve movements. However, the 60 + age group had the highest proportion of injuries secondary to impacts on the floor with 25 (NE = 1242 [37.7%]) injuries and the highest proportion of injuries secondary to impacts with the ball with 16 (NE = 769 [23.4%]) injuries. Injury mechanism profiles between age groups were significantly different ($P < .01$).

Regarding diagnoses (Table 4), the 20-39 age group had the greatest rates of dislocations comprising 123 (NE = 5591 [21%]) injuries, whereas the 60 + age group had the greatest rate of sprains/strains with 28 (NE = 1353 [41.1%]) injuries. Diagnosis profiles between age groups were significantly different ($P < .01$).

Male Versus Female Patients

Our study included a total of 460 (NE = 20,128 [49.4%]) male patients and 435 (NE = 20,626 [50.6%]) female patients. Female patients experienced a total of 172 (NE = 8153 [59.7%]) of all sprains/strains, 90 (NE = 4257 [53.2%]) of all fractures, and 56 (NE = 2658 [67.5%]) of

TABLE 3
Distribution of Mechanisms of Injury[a]

Age Group, y	Not specified	Impact With Floor	Impact With Ball	Spike/Serve/ Arm Movement	Impact With Another Player	Other (Scratch, Insect)	Impact With Pole	Impact With Net	Overuse	Total
20-39	12,301 (45.6)	6080 (22.5)	4665 (17.3)	2214 (8.2)	1055 (3.9)	249 (0.9)	196 (0.7)	155 (0.6)	58 (0.2)	26,973 (10)
40-59	5128 (48.9)	2474 (23.6)	2181 (20.8)	435 (4.1)	192 (1.8)	16 (0.1)	0	49 (0.5)	15 (0.1)	10,489 (10)
60 +	1033 (31.4)	1242 (37.7)	769 (23.4)	175 (5.3)	0	0	66 (2)	0	17 (0.5)	3291 (100)
Total	18,463	9796	7615	2823	1247	265	252	204	89	40,754

[a]Data presented as a national estimate or national estimate (%).

TABLE 4
National Estimates of Final Diagnosis[a]

Age Group, y	Strain/ Sprain	Fracture	Dislocation	Other/ Not Stated	Contusion/ Abrasion	Laceration	Other Diagnosis (Hematoma, Avulsion, Dermatitis)	Total
20-39	8985 (33.3)	5205 (19.3)	5591 (20.7)	3810 (14.1)	2660 (9.9)	436 (1.6)	288 (1)	26,973
40-59	3331 (31.8)	2171 (20.7)	1792 (17.1)	2038 (19.4)	943 (9)	136 (1.3)	78 (0.7)	10,489
60 +	1353 (41.1)	629 (19.1)	412 (12.5)	453 (13.7)	336 (10.2)	19 (0.6)	91 (2.8)	3291
Total	13,668	8004	7795	6300	3939	591	457	40,754

[a]Data presented as national estimate or national estimate (%).

all contusions/abrasions. Female patients also saw a significant decrease in contusions/abrasions over the 10-year window (coefficient, −270 [95% CI, −355 to −206]; $P <$ .01). Notably, rates of dislocation were higher in men (31.3%) than in women (7.3%), whereas rates of strains/sprains were higher in women (39.5%) than men (27.4%). Diagnosis profiles between men and women were significantly different ($P < .01$).

DISCUSSION

The major findings from our study demonstrated that the most injured body locations were consistent throughout all adult age groups, as well as previous pediatric,[11] high school,[22] and collegiate studies.[2] However, final diagnoses and MOI did differ. The 20-39 age group experienced shoulder dislocations (37%) at a significantly greater rate than all other age groups.[11] Of the nationally estimated 3362 shoulder dislocations in the 20-39 age group, 1445 (43%) were secondary to overhead arm movements like spiking, serving, and blocking.

These findings are consistent with previous literature, showing that younger athletes are prone to joint dislocations secondary to dynamic movements[11,25]—a classic example being a baseball pitcher. The open chain kinetics of overhead movements require athletes to generate power and stabilization from their lower extremities, which propagate through their trunk and into their upper extremities.[4] Because the lower extremities are designed to bear a greater mechanical load, these overhead movements inevitably place significant work on the rotator cuff and stabilizing muscles.[17] Repetition of these overhead movements creates scapular dyskinesis, in turn causing maladaptive limitations, rotator cuff tendon degeneration, and increased risk of dislocation.[11,25] Stretching programs of the posterior shoulder capsule are a potential solution to this, as addressing IR deficits of the glenohumeral joint prevents internal impingement and tendon degeneration.[4,8,11,15] Other studies have proposed strength training regimens to improve IR ROM and rotator cuff muscle strength ratios.[13,24] However, the literature is general and does not optimize training based on age demographics. Future research is recommended to evaluate effective, long-term treatments of overuse injuries in this age group.

Of all age groups, the 60 + age group had the highest rates of injury secondary to falls (37.7%). The 60 + age group also comprised 13.7% of all shoulder dislocations and 25.2% of all wrist fractures. Of the nationally estimated 129 wrist fractures in this age group, 100% were secondary to impact with the floor. It is important to note that the sample size was small and lacked statistical power. Nevertheless, there is extensive literature supporting the inverse relationship between advanced age and bone density.[19] Furthermore, advanced age negatively influences coordination, balance, and fine motor skills.[27] These changes observed in older adult patients may have contributed to the large proportion of wrist fractures secondary to impact with the floor, often referred to as falling on an outstretched hand (FOOSH). Upper extremities are designed for open-chain kinetics, and the closed-chain nature of FOOSH causes large amounts of force to propagate through the extremity, resulting in soft tissue tears as well as fractures or dislocations of bony structures.[6,23]

This likely explains the high prevalence of wrist fractures and shoulder dislocations in this age group. Current recommendations for mitigating FOOSH include physical therapy and dietary supplements to increase strength and bone density[12]; however, future research may explore alternative solutions such as designing protective equipment for this age group.

Finally, when evaluating MOI, there was a positive trend between advanced age and injury secondary to impact with the ball ($P < .05$), responsible for 14.2% of injuries in previous pediatric studies[11]—17.3% of injuries in the 20-39 age group, 20.8% of injuries in the 40-59 age group, and 23.4% of injuries in the 60 + age group. Furthermore, approximately 24% of finger injuries in adult age groups were finger dislocations, and of the 3261 finger dislocations, 1513 were secondary to impacts with the ball (46.4%). These trends may suggest a relationship between advanced age and decreased structural durability, causing an increased risk of finger dislocations. Previous literature has shown that advanced age leads to accelerated ligament degeneration due to loss of collagenous connective tissue,[7] as well as decreased synthesis of proteins, amino acids,[10] and supportive factors like vitamin D.[19] Furthermore, older populations are more prone to shortening and decreased density of these ligaments, leading to irritation to the joint like bursitis and tendinitis.[19] Current recommendations include physical therapy and dietary supplements[12]; however, the progressive increase in age groups warrants future research to evaluate the proficiency of these guidelines throughout different age demographics.

Overall, recommendations to prevent volleyball-related sports injuries include maintaining physical fitness, hydrating, warming up with dynamic stretching, and using protective equipment such as wrist and finger tape.[21,25] Although all age groups need to practice these recommendations to decrease rates of MSK injuries, the results of this study encourage more age-specific preventive measures to be explored to decrease the prevalence of volleyball-related upper extremity injuries.

Limitations

This study is not without limitations. First, the NEISS database relies on the triage summary that ED providers input during the initial encounter. A large proportion of volleyball-related upper extremity injuries (45%) did not characterize patient histories to a sufficient extent, leaving them as "not specified." This may have created bias during the interpretation of results. However, this matches the proportions of "not specified" injuries in many other NEISS studies.[16] We chose not to exclude these data points for a more accurate representation of trends and injury profiles. Given that "not specified" was the only mechanism to see a statistically significant decrease over the 10 years ($P = .03$), MOI distributions may change if described in further detail. Moreover, it is important to recognize that the NEISS database has a relatively small sample size of 100 hospitals across the United States; thus, the true incidence of volleyball injuries cannot be confirmed and may not accurately represent all national volleyball-related upper extremity injuries. Last, all encounters were with EDs and thus were predisposed to higher acuity patients. This may skew national distributions away from injury types, causing patients to seek care from athletic trainers, urgent care facilities, or primary care physicians. Nonetheless, NEs from the NEISS are considered reliable and representative of statistical samples.

CONCLUSION

Our study demonstrated that adult populations are at risk for volleyball-related upper extremity injuries, specifically affecting the finger, wrist, and shoulder. MOI among age groups differed, as younger adults more often sustained injuries from dynamic movements, whereas older adults from trauma. This study encourages the exploration of more age-specific measures in decreasing the incidence and significance of volleyball-related upper extremity injuries.

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