Original Article

The Finger, Wrist, and Shoulder are the Most Commonly Injured Areas in Youth Volleyball Players but the Incidence of Injuries Decreased Overall Between 2012 and 2022

Kyle K. Obana, M.D., Priya Singh, B.A., Nikan K. Namiri, M.D., William N. Levine, M.D., Bradford O. Parsons, M.D., David P. Trofa, M.D., and Robert L. Parisien, M.D.

Purpose: To analyze epidemiology, mechanisms, and diagnoses of upper extremity volleyball injuries in youth who present to United States emergency departments. **Methods:** Data from the National Electronic Injury Surveillance System were analyzed for upper extremity volleyball injuries in patients ≤18 years old from January 1, 2012, to December 31, 2022. Data were collected for body part, diagnosis, mechanism of injury, and disposition. Weighted national estimates were calculated using the hospitals' corresponding statistical sample weights. Linear regressions were used to analyze annual trends. χ^2 tests were used to analyze categorical variables. **Results:** A weighted national estimate of 131,624 upper extremity volleyball-related injuries occurred in the study period. Average age was 13.9 ± 2.3 years. Female patients constituted 77.6% of patients; 99.3% of patients did not require admission. The most common body parts injured were fingers (43.0%), wrists (22.8%), and shoulders (12.2%). The most common identifiable mechanisms of injury were impacts with the floor (19.4%), impacts with the ball (14.7%), and spikes/serves (5.7%). Most common diagnoses were strains/sprains (42.6%) and fractures (19.5%). Most common locations of fracture were fingers (57.4% of all fractures), wrists (16.6%), and lower arms (12.4%). There was a decrease of 544 overall injuries per year ($P = .03$, 95% confidence interval [CI] −1031 to −58). Female players experienced more contusions/abrasions (16.0% vs 9.9%, $P < .001$) and strains/sprains (46.1% vs 30.4%, $P < .001$) compared with male players. Female patients had decreases of 513 overall injuries ($P = .01$, 95% CI −881 to −144), 349 strains/sprains ($P = .002$, 95% CI −530 to −168), 102 contusions/abrasions ($P = .008$, 95% CI 170 to −34), and 92 fractures per year ($P = .03$, 95% CI −175 to −10). **Conclusions:** Youth volleyball players are at risk of upper extremity injury, particularly involving the fingers, wrist, and shoulder. Despite increasing national participation in youth volleyball, there is a decreasing incidence of upper extremity injuries. **Level of Evidence:** Level IV, prognostic case series.

Volleyball is an increasingly popular sport among both youth male and female athletes.[1] In the National Federation of State High School Associations High School Athletics Participation Survey, male participation in high school volleyball increased 4.6% from the 2018-2019 season to the 2021-2022 season.[1] Currently, it is the second most popular sport for high school female students, with only 2,500 fewer national participants than that of track and field.[1] With greater numbers of youth volleyball participants, there is pressure to participate in year-round play through school and club teams. Recent reports indicate that 56% of volleyball clubs, which contain multiple teams, were established in the last decade and more than one third of clubs were established in the last 6 years.[2]

With year-round specialization, athletes are subjected to greater cumulative hours of upper extremity stress, leading to subsequent injury. This is a combination of direct trauma from various forces such as the ball, floor, or other players, as well as the chronic use of the upper

From the Department of Orthopaedic Surgery, New York-Presbyterian, Columbia University Irving Medical Center, New York, New York, U.S.A. (K.K.O., W.N.L., D.P.T.); Icahn School of Medicine at Mount Sinai, New York, New York, U.S.A. (P.S.); and Department of Orthopaedic Surgery, Mount Sinai Hospital, New York, New York, U.S.A. (N.K.N., B.O.P., R.L.P.).

Received July 14, 2023; accepted December 4, 2023.

Address correspondence to Dr. Kyle K. Obana, M.D., Department of Orthopaedic Surgery, New York-Presbyterian, Columbia University Medical Center, 622 West 168th St., PH 11-1130, New York, New York 10032, U.S.A. E-mail: kyleobana@gmail.com

2666-061X/23967

https://doi.org/10.1016/j.asmr.2023.100862

extremity with overhead motion.[3-5] Previous studies on volleyball injuries demonstrate that the finger is the most injured upper extremity body part secondary to acute impact from the ball or the floor.[3,5] Comparatively, the overhead swing motion subjects the shoulder to chronic stress. This leads to limb asymmetries, including increases in internal rotation shoulder strength and decreased internal rotation range of motion.[6-10] These mirror the same physical changes in baseball players that predispose to overuse injuries.[6,11]

Previous studies have used the National Electronic Surveillance System (NEISS) database to analyze sport-specific injury profiles and trends in the youth population. Despite the rising popularity of youth volleyball, few have investigated orthopaedic volleyball-related injuries.[3-5,12-16] One NEISS study published more than a decade ago analyzed youth volleyball-related injuries, but it did not provide a comprehensive analysis of the mechanisms of upper extremity injuries.[3] The purpose of this study was to analyze epidemiology, mechanisms, and diagnoses of upper extremity youth volleyball injuries presenting to US emergency departments (EDs). The authors hypothesized that there would be an increasing incidence of upper extremity youth volleyball injuries due to gaining popularity and participation in the sport.

Methods

Data Collection

The NEISS database from the Consumer Product Safety Commission for sports-related injuries was accessed. The NEISS database is a representative sample of all 5,000 United States EDs based on data from 100 hospitals with minimum of 6 beds and 24-hour services. ED visits for patients aged 18 years old and younger from January 1, 2012, to December 31, 2022 were included. Patients with injuries that were not volleyball-related and those that were not specified were excluded. The corresponding hospital for each data point is assigned a statistical sample weight based on the volume of that respective hospital, which is used to calculate a national estimate to represent national trends. Data were collected by querying all volleyball-related injuries (product code 1266: volleyball [activity, apparel, or equipment]) involving the shoulder (product code 30), elbow (product code 32), lower arm (product code 33), wrist (product code 34), upper arm (product code 80), hand (product code 82), and finger (product code 92).

Variables collected were date of presentation, age, sex, race, body part, injury diagnosis, disposition, and a narrative written by the health care provider. Each narrative was manually reviewed by the first 2 authors to confirm the injury occurred while playing volleyball and to identify the mechanism of injury. If there were disagreements regarding interpretations of narratives, these were discussed and brought to the attention of the senior author. Mechanisms of injury included impact with a player, impact with the ball, impact with the floor, impact with the net, impact with the pole, overuse, other, spike/serve, or not specified. Injury mechanisms were classified as "not specified" if the narrative specified the injury occurred while playing volleyball but did not specify how the injury occurred (eg, "injured during volleyball game").

The narratives were reviewed to identify injuries sustained during non—volleyball-related activities. Examples included injuries that took place beyond the volleyball court (eg, on the street or at home), volleyball-related injuries that did not occur while playing (eg, tripped and fell while walking to volleyball practice), and injuries that did not specify activity.

Statistical Analysis

Statistical analyses were performed using STATA/MP Software 13.0 (StataCorp LLC, College Station, TX). Linear regressions were performed to analyze injuries. χ^2 analyses were performed to analyze categorical variables. Statistical significance was set at $P < .05$. National estimates were calculated by multiplying raw data with the statistical weight of the corresponding hospital.

Results

Overall Results

There were 3,913 reported upper extremity volleyball-related injuries from the sampling of 100 EDs, with 137,486 estimated national upper extremity cases from extrapolation. After applying inclusion and exclusion criteria, 131,624 (95.7%) injuries were included for analyses (Fig 1). Average age was 13.9 ± 2.3 years. Female athletes constituted 77.6% of patients. Race consisted of 68,856 White patients (52.3%), 42,234 not specified race (32.1%), 10,206 Black patients (7.8%), 7,714 other race (5.9%), 2,036 Asian patients (1.5%), 303 American Indian/Alaskan Native (0.2%), and 275 Native Hawaiian or other Pacific Islander (0.2%). In total, 130,656 (99.3%) patients were treated and released or examined and released without treatment, 527 (0.4%) left without being examined, 371 (0.3%) were treated and admitted for hospitalization, and 70 (0.1%) were treated and transferred to another hospital.

The most common body parts injured were 56,569 fingers (43.0%), 29,996 wrists (22.8%), and 16,111 shoulders (12.2%) (Table 1). The most common mechanisms of injury were 70,095 not specified (53.3%), 25,573 impacts with the floor (19.4%), 19,289 impacts with the ball (14.7%), and 7,457 spikes/serves (5.7%) (Table 2). Most common diagnoses were 56,014 strains/sprains (42.6%), 25,724 fractures (19.5%), and 21,326 other (16.2%) (Table 3). Most common locations of fracture were 14,776 fingers

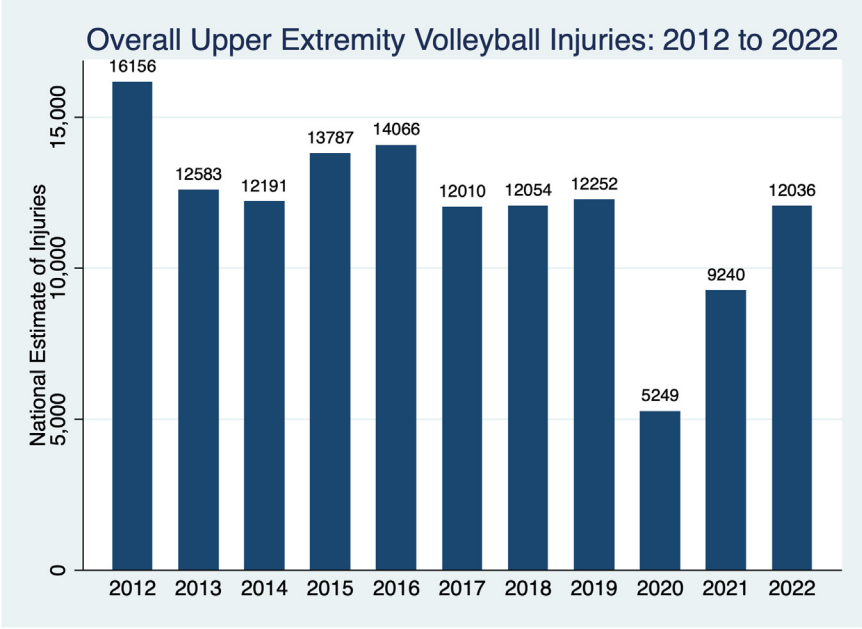

Fig 1. Annual youth volleyball upper extremity injuries from 2012 to 2022.

(57.4%), 4,262 wrists (16.6%), and 3,188 lower arms (12.4%) (Table 4). The most common mechanisms of fracture were 12,322 not specified (47.9%), 6,649 impacts with the floor (25.9%), and 3,826 impacts with the ball (14.9%) (Table 5).

Most Common Diagnoses of the Top 3 Body Parts Injured

The most common finger injuries were 24,680 strains/sprains (43.6%), 14,776 fractures (26.1%), and 7,173 other (12.7%). The most common wrist injuries were 17,262 strains/sprains (57.5%), 5,769 other (19.2%), and 4,262 fractures (14.2%). The most common shoulder injuries were 7,989 strains/sprains (49.6%), 3,592 dislocations (22.3%), and 3,295 other (20.5%).

Most Common Mechanisms of the Top 3 Body Parts Injured

The most common mechanisms of finger injuries were 36,529 not specified (64.6%), 13,621 impacts with the ball (24.1%), and 1,974 impacts with the floor (3.5%). The most common mechanisms of wrist injuries were 13,024 not specified (43.4%), 10,100 impacts with the floor (33.7%), and 3,021 impacts with the ball (10.1%). The most common identifiable mechanisms of shoulder injuries were 8,372 not specified (52.0%), 3,112 impacts with the floor (19.3%), and 2,388 spikes/serves (14.8%).

Overall

Over the study period, there was an annual decrease in overall injuries (−544, $P = .03$, 95% confidence interval [CI] −1031 to −58). After the 2020 season was removed to account for the impact of the coronavirus disease 2019 (COVID-19) pandemic, there was still an annual decrease in overall injuries (−377, $P = .02$, 95% CI −687 to −66). There were also annual decreases in strains/sprains (−395, $P = .002$, 95% CI −609 to −181) and contusions/abrasions (−122, $P = .005$, 95% CI −197 to −48); however, there were no changes in fractures ($P = .11$) or dislocations ($P = .35$). There were annual decreases of wrist injuries per year (−137, $P = .03$, 95% CI −254 to −21) and lower arm injuries per year (−49, $P = .04$, 95% CI −94 to −3), but not finger ($P = .07$), elbow ($P = .14$), hand ($P = .13$), shoulder ($P = .16$), or upper arm injuries ($P = .71$). There was an annual decrease in not specified mechanism of injury (−619, $P < .001$, 95% CI −870 to −368) but not impact with a player ($P = .14$), impact with the ball ($P = .31$), impact with the floor ($P = .18$), impact with the net ($P = .45$), impact with the pole ($P = .35$), overuse ($P = .51$), other ($P = .89$), or spike/serve ($P = .11$).

Table 1. Distribution of Upper Extremity Body Parts Injured Among Youth Volleyball Players From 2012 to 2022

Body Part	Raw Data	National Estimate of Injuries	%
Finger	1,631	56,569	43.0
Wrist	803	29,996	22.8
Shoulder	456	16,111	12.2
Hand	314	10,943	8.3
Elbow	220	8,803	6.7
Lower arm	295	8,269	6.3
Upper arm	33	933	0.7
Total	3,752	131,624	100.0

Table 2. Distribution of Upper Extremity Mechanisms of Injury Among Youth Volleyball Players from 2012 to 2022

Mechanism of Injury	Raw Data	National Estimate of Injuries	%
Not specified	1,878	70,095	53.3
Impact with the floor	741	25,573	19.4
Impact with the ball	615	19,289	14.7
Spike/serve	232	7,457	5.7
Impact with a player	166	5,316	4.0
Other	63	2,095	1.6
Overuse	29	886	0.7
Impact with the net	14	474	0.4
Impact with the pole	14	439	0.3
Total	3,752	131,624	100.0

Male Versus Female Injuries

Compared with female players, a greater proportion of male players experienced dislocations (11.5% vs 3.6%, $P < .001$) and fractures (33.0% vs 15.7%, $P < .001$). Comparatively, a greater proportion of female players experienced contusions/abrasions (16.0% vs 9.9%, $P < .001$) and strains/sprains (46.1% vs 30.4%, $P < .001$).

Female players experienced an annual decrease of overall injuries per year (−513, $P = .01$, 95% CI −881 to −144), strains/sprains per year (−349, $P = .002$, 95% CI −530 to −168), contusions/abrasions per year (−102, $P = .008$, 95% CI −170 to −34), and fractures per year (−92, $P = .03$, 95% CI −175 to −10) but not dislocations ($P = .63$). Male players did not demonstrate changes in overall injuries per year ($P = .72$), contusions/abrasions per year ($P = .17$), fractures per year ($P = .53$), strains/sprains per year ($P = .15$), or dislocations per year ($P = .10$).

Discussion

The finger and wrist constituted the greatest proportions of upper extremity injuries in the current study is consistent with previous reports on both youth and adult volleyball injuries.[3-5] In addition, the proportion of finger and wrist injuries in this study (43.0% and 22.8%, respectively) is consistent with previous reports.[17-20] Expectedly, the most common identifiable mechanism of injury for the finger was impact with the ball, resulting in a high incidence of strains/sprains (43.6%) and fractures (23.1%). This occurs when the finger is either jammed or forced into hyperextension by the ball, causing ligamentous and/or bony injury. Although previous studies have reported falling to the ground as the most common mechanism of youth volleyball injuries, these studies did not isolate upper extremity injuries.[3] Athletes may reduce risk of finger injury by taping circumferentially from the distal to the proximal phalanx, including over the distal and proximal interphalangeal joints. This should increase the force required to hyperextend the joints, although the effectiveness of this method has not been studied. The most common identifiable mechanism of injury for the wrist was impact with the floor (33.7%), resulting in strains/sprains (57.5%) and fractures (14.2%). Similarly, wrist taping may reduce risk of subsequent wrist injury during falls as wrist guards may be too restrictive and interfere with play when contacting the ball along the volar surface of the wrist.

With earlier youth volleyball specialization and year-round involvement through school and club teams, there is greater risk of traumatic and atraumatic upper

Table 3. Diagnoses of Upper Extremity Injuries Among Youth Volleyball Players From 2012 to 2022

Diagnosis	Raw Data	National Estimate of Injuries	%
Strain/sprain	1,439	56,014	42.6
Fracture	851	25,724	19.5
Other	658	21,326	16.2
Contusion/abrasion	554	19,269	14.6
Dislocation	194	7,094	5.4
Laceration	23	895	0.7
Avulsion	14	512	0.4
Hematoma	6	318	0.2
Crushing	5	186	0.1
Nerve damage	5	131	0.1
Puncture	1	84	0.1
Foreign body	2	71	0.1
Total	3,752	131,624	100.0

Table 4. Location of Upper Extremity Fractures Among Youth Volleyball Players From 2012 to 2022

Fracture Location	Raw Data	National Estimate of Injuries	%
Finger	486	14,776	57.4
Wrist	122	4,262	16.6
Lower arm	125	3,188	12.4
Hand	63	1,766	6.9
Elbow	30	833	3.2
Shoulder	16	466	1.8
Upper arm	9	433	1.7
Total	851	25,724	100.0

Table 5. Mechanisms of Upper Extremity Fractures Among Youth Volleyball Players From 2012 to 2022

Fracture Mechanism	Raw Data	National Estimate of Injuries	%
Not specified	373	12,322	47.9
Impact with the floor	226	6,649	25.9
Impact with the ball	148	3,826	14.9
Collision with a player	56	1,397	5.4
Spike/serve	26	1,125	4.4
Other	12	185	0.7
Impact with the net	6	119	0.5
Impact with the pole	3	73	0.3
Overuse	1	16	0.1
Total	851	25,712	100.0

extremity injury.[2] Despite these risk factors, this study found decreasing incidence of in overall injuries, strains/sprains, contusions, lower arm injuries, and wrist injuries during the study period. This may be attributed to the decline in athletic participation due to the COVID-19 pandemic, as seen in the large decrease in injuries during 2020, with a subsequent increase in 2021. However, with removal of the 2020 season to account for the impact of the pandemic on volleyball participation, there was still a significant annual decrease in injuries during the study period. Additionally, high school volleyball participation increased from the 2019 season to the 2021 season, suggesting there was not a tremendous impact from the COVID-19 pandemic on participation.[21] Another explanation is the greater use and access to urgent cares to offset the ED burden. Volleyball injuries in this study did not require admission (99.3%), which is consistent with previous studies.[3,5] Thus, urgent cares are equipped to manage these minor injuries (eg, abrasions, strains/sprains), likely obviating many potential ED visits. Sex-specific differences in injury profiles may also be a driving factor, as female athletes constituted almost 80% of the study population. Unlike male athletes, female athletes demonstrated decreasing incidence of overall injuries, contusions/abrasions, strains/sprains, and fractures. The declining incidence may reflect the use of protective equipment, particularly arm guards and long-sleeve jerseys, among female athletes to reduce the impact from the ball on the upper extremity while digging, setting, or blocking.[22] This is supported by the greater proportion of female players experiencing contusions/abrasions in the current study, which may be a driving factor for utilization of protective equipment. Impact with ball injuries did not decrease, although this finding may be confounded by high proportion of unspecified mechanism of injury from the narratives (53.3%).

The current study elucidates injury profiles of upper extremity fractures in youth volleyball players, which have been reported in limited detail in the literature.[3-5,23,24] Overall, 19.5% of patients in this study were diagnosed with an upper extremity fracture. The finger and wrist were the 2 most fractured regions, constituting 57.4% and 16.6% of overall upper extremity fractures, respectively. Similarly, Pollard et al.[3] found that finger fractures/dislocations constituted 64% of all upper extremity youth volleyball fractures/dislocations, although they did not provide the relative proportions of each. The most common identifiable mechanisms of fracture were impact with the floor and impact with the ball (25.9% and 14.9%, respectively). Despite the inherent risk of trauma secondary to falling onto the court, there were very low proportions of elbow, shoulder, and upper arm fractures (3.2%, 1.8%, and 1.7%, respectively). The greater risk of finger and wrist fractures may reflect the tendency to impact the floor when diving diagonally to dig the ball, which reduces the translated force from the wrist to the shoulder. In a recent study on high school volleyball players, digging the ball was the third most common activity contributing to injury in practice and second most common in games.[4] This contrasts a completely vertical fall, in which there is a greater translated force from the wrist to the elbow and shoulder, which occurs less commonly in volleyball.

Although the finger and wrist are the most common acute upper extremity volleyball injuries, youth volleyball players are highly susceptible to chronic shoulder injuries due to early sports specialization, year-long participation, and minimal spike/serve regulations.[4,17,25] Spiking/serving was the third most common mechanism of shoulder injuries in this study and contributed to the large proportion of shoulder strains/sprains. Cross-body spikes, straight-ahead spikes, and jump serves generate a tremendous amount of shoulder internal rotation torque and elbow varus torque.[26] Studies report that although the kinetic demand is lower than baseball or tennis due to slower internal rotation angular velocities, greater shoulder abduction and horizontal contact point when contacting the ball may predispose to labral damage or subacromial impingement.[26] Unlike other overhead sports such as baseball, there are no rules regulating overhead swing counts in volleyball and athletes underestimate total swing count.[6] Given that athletes with dominant shoulder pain are 9 times more likely to develop further pain and shoulder injuries constitute the largest amount of playing time lost, proper prevention protocols should be implemented to reduce the initial onset of shoulder symptoms.[9,17,26]

Unlike other overhead sports, elbow injuries were less prevalent in this study, constituting only 6.7% of overall injuries.[12,27,28] This is likely due to the mechanics of the elbow acting as a fulcrum for the load in the hand.[29] Given that the load in the upper extremity is limited to the weight of the hand in volleyball, there is lower stress placed at the elbow compared to that of baseball or tennis in which the athlete is holding a baseball or tennis racket throughout the range of motion.[26] Subsequently, it is unsurprising that elbow injuries are less prevalent in volleyball players compared to that of other overhead sports given the decreased load in the upper extremity and stress placed on the elbow.

As mentioned previously, various individual and organizational measures can be taken to reduce the incidence and burden of volleyball injuries. With the advancement of club teams to augment off-season training, more athletes specializing in volleyball at an earlier age. In baseball, pitch count, inning count, and

rest-day regulations were implemented to reduce the strain on the shoulder and elbow.[6,30-32] Volleyball players may derive benefit from swing count regulations, decreasing chronic stress on the upper extremity. Although the data are limited regarding the utility of arm sleeves and wrist and finger taping, these prophylactic measures may be beneficial at reducing contusion/abrasion injuries and finger sprains and fractures, respectively.

Limitations

There are several limitations of this study, largely inherent to retrospective review of a national database. Narratives are dependent on provider and trained coders to input information pertinent to the injury. A large proportion of volleyball injuries (53.3%) did not delineate the mechanism of injury (eg, "injured playing high school volleyball") and were labeled "not specified." These data were included, rather than excluded, to better represent overall injury profiles. In addition, not specified injuries were the only mechanism of injury that demonstrated a significant decline during the study period. Thus, it is possible that had specific detail been provided in the narrative, subsequent distribution may have led to significant findings for other mechanisms. Third, due to the nature of the NEISS, these data are limited to athletes presenting to the ED and does not encompass athletes who were diagnosed and treated by athletic trainers, urgent cares, or physicians, or did not seek care due to the low severity of injury. In turn, this study represents injuries of higher severity warranting ED presentation despite a large proportion not requiring hospitalization. With the burgeoning presence of urgent care clinics, more patients may be seen and treated prior to the ED. Lastly, these results are based on data stratified across 100 US hospitals and may not be perfectly representative of all upper extremity volleyball injuries presenting to EDs. However, national estimates are the most reliable and representative sample.

Conclusions

Youth volleyball players are at risk of upper extremity injury, particularly involving the fingers, wrist, and shoulder. Despite increasing national participation in youth volleyball, there is a decreasing incidence of upper extremity injuries.

Disclosure

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: W.N.L. reports a relationship with Zimmer Biomet Holdings that includes: consulting or advisory. R.L.P. reports a relationship with American Orthopaedic Society for Sports Medicine that includes: board membership; a relationship with Arthrex that includes: consulting or advisory; a relationship with Arthroscopy Association of North America that includes: board membership; a relationship with Eastern Orthopaedic Association that includes: board membership; a relationship with *Journal of Cartilage and Joint Preservation* that includes: board membership; a relationship with *Journal of Sport Rehabilitation* that includes: board membership; a relationship with New England Orthopaedic Society that includes: board membership; a relationship with The Society of Military Orthopaedic Surgeons that includes: board membership; a relationship with *Arthroscopy* that includes: board membership. R.L.P. (co-author) was appointed to editorial board for *Arthroscopy* (after initial manuscript submission). B.O.P. reports a relationship with American Academy of Orthopaedic Surgeons that includes: board membership; a relationship with Arthrex that includes: consulting or advisory and speaking and lecture fees; and a relationship with *Journal of Bone and Joint Surgery* that includes: board membership and consulting or advisory. D.P.T. reports a relationship with Gotham Surgical Solutions that includes: funding grants. All other authors (K.K.O., P.S., N.K.N.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

References

1. NFHS Releases First High School Sports Participation Survey in Three Years. National Federation of State High School Associations. Published October 10, 2022, https://www.nfhs.org/articles/nfhs-releases-first-high-school-sports-participation-survey-in-three-years. Accessed June 18, 2023.
2. Four Positive Trends in Junior Volleyball. SportsEngine. Published June 2, 2023, https://www.sportsengine.com/article/volleyball/four-positive-trends-junior-volleyball. Accessed June 18, 2023.
3. Pollard KA, Shields BJ, Smith GA. Pediatric volleyball-related injuries treated in US emergency departments, 1990-2009. *Clin Pediatr (Phila)* 2011;50:844-852.
4. Kerr ZY, Gregory AJ, Wosmek J, et al. The first decade of web-based sports injury surveillance: Descriptive epidemiology of injuries in US high school girls' volleyball (2005-2006 through 2013-2014) and National Collegiate Athletic Association women's volleyball (2004-2005 through 2013-2014). *J Athl Train* 2018;53:926-937.
5. Sandler CB, Green CK, Scanaliato JP, Sandler AB, Dunn JC, Parnes N. Comparison of volleyball-related injuries at US emergency departments between high school and collegiate athletes: A 10-year NEISS database study. *Orthop J Sports Med* 2023;11:23259671231180536.
6. Ness BM, Tao H, Javers D, et al. Development of an upper extremity "swing count" and performance measures in

NCAA Division I volleyball players over a competitive season. *Int J Sports Phys Ther* 2019;14:582-591.
7. Reeser JC, Verhagen E, Briner WW, Askeland TI, Bahr R. Strategies for the prevention of volleyball related injuries. *Br J Sports Med* 2006;40:594-600.
8. Challoumas D, Stavrou A, Dimitrakakis G. The volleyball athlete's shoulder: Biomechanical adaptations and injury associations. *Sports Biomech* 2017;16:220-237.
9. Forthomme B, Wieczorek V, Frisch A, Crielaard JM, Croisier JL. Shoulder pain among high-level volleyball players and preseason features. *Med Sci Sports Exerc* 2013;45:1852-1860.
10. Kugler A, Krüger-Franke M, Reininger S, Trouillier HH, Rosemeyer B. Muscular imbalance and shoulder pain in volleyball attackers. *Br J Sports Med* 1996;30:256-259.
11. Velarde-Sotres Á, Bores-Cerezal A, Mecías-Calvo M, Barcala-Furelos M, Aparicio-Obregón S, Calleja-González J. Detection of upper limb asymmetries in athletes according to the stage of the season—a longitudinal study. *Int J Environ Res Public Health* 2022;19:849.
12. Trofa DP, Obana KK, Swindell HW, et al. Increasing burden of youth baseball elbow injuries in US emergency departments. *Orthop J Sports Med* 2019;7:2325967119845636.
13. Obana KK, Mueller JD, Saltzman BM, et al. Targeting rule implementation decreases concussions in high school football: A national concussion surveillance study. *Orthop J Sports Med* 2021;9:23259671211031190.
14. Jacobson NA, Buzas D, Morawa LG. Concussions from youth football: Results from NEISS hospitals over an 11-year time frame, 2002-2012. *Orthop J Sports Med* 2013;1:2325967113517860.
15. Van Tassel D, Owens BD, Pointer L, Moriatis Wolf J. Incidence of clavicle fractures in sports: Analysis of the NEISS Database. *Int J Sports Med* 2014;35:83-86.
16. Muhonen EG, Kafle S, Torabi SJ, Abello EH, Bitner BF, Pham N. Surfing-related craniofacial injuries: A NEISS database study. *J Craniofac Surg* 2022;33:2383-2387.
17. Wasser JG, Tripp B, Bruner ML, et al. Volleyball-related injuries in adolescent female players: An initial report. *Phys Sportsmed* 2021;49:323-330.
18. Knobloch K, Rossner D, Gössling T, Richter M, Krettek C. Volleyball sport school injuries. *Sportverletz Sportschaden* 2004;18:185-189 [in German].
19. Williams RM, Huxel Bliven KC, Morris SN, et al. Non-time-loss and time-loss injuries in secondary school girls' volleyball athletes: A report from the National Athletic Treatment, Injury, and Outcomes Network Surveillance Program. *J Sport Rehabil* 2022;31:536-543.
20. Watkins J, Green BN. Volleyball injuries: a survey of injuries of Scottish National League male players. *Br J Sports Med* 1992;26:135-137.
21. High school volleyball players in the U.S. 2021/2022. Statista. https://www.statista.com/statistics/268009/participation-in-us-high-school-volleyball/. Accessed October 23, 2023.
22. VolleyGirl. The best volleyball elbow pads and arm sleeves. Ace VolleyBall. Published October 31, 2022, https://acevolleyball.org/best-volleyball-elbow-pads-and-arm-sleeves/. Accessed July 2, 2023.
23. Hakozaki M, Iwabuchi M, Otani K, Konno S, Kikuchi S. Unusual fracture of the humerus in a volleyball player: A case report. *Int J Sports Med* 2007;28:977-979.
24. Bhairo NH, Nijsten MW, van Dalen KC, ten Duis HJ. Hand injuries in volleyball. *Int J Sports Med* 1992;13:351-354.
25. Seminati E, Minetti AE. Overuse in volleyball training/practice: A review on shoulder and spine-related injuries. *Eur J Sport Sci* 2013;13:732-743.
26. Reeser JC, Fleisig GS, Bolt B, Ruan M. Upper limb biomechanics during the volleyball serve and spike. *Sports Health* 2010;2:368-374.
27. Hassebrock JD, Patel KA, Makovicka JL, et al. Elbowi in National Collegiate Athletic Association athletes: A 5-season epidemiological study. *Orthop J Sports Med* 2019;7:2325967119861959.
28. Shanley E, Thigpen CA, Boes N, et al. Arm injury in youth baseball players: A 10-year cohort study. *J Shoulder Elbow Surg* 2023;32:S106-S111.
29. Islam SU, Glover A, MacFarlane RJ, Mehta N, Waseem M. The anatomy and biomechanics of the elbow. *Open Orthop J* 2020;14(1).
30. Matsuura T, Takata Y, Iwame T, et al. limiting the Pitch Count in Youth Baseball Pitchers Decreases Elbow Pain. *Orthop J Sports Med* 2021;9:2325967121989108.
31. Manzi JE, Kunze KN, Estrada JA, et al. Variability in pitch count limits and rest day requirements by state: Implications of season-long pitch counts in high school baseball pitchers. *Am J Sports Med* 2022;50:2797-2804.
32. Mair H, Kenney NA, Uhl TL, Ullery LR, Hosey RG. Effect of pitching restrictions and mound distance on youth baseball pitch counts. *Orthop J Sports Med* 2022;10:23259671221110548.