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Shoulder Injuries Among United States High School Athletes During the 2005–2006 and 2006–2007 School Years

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Context: The shoulder is one of the most commonly injured body sites among athletes. Little previous research describes shoulder injury patterns in high school athletes.

Objective: To describe and compare shoulder injury rates and patterns among high school athletes in 9 sports (football, soccer, basketball, baseball, and wrestling for boys and soccer, volleyball, basketball, and softball for girls).

Design: Prospective injury surveillance study.

Setting: Injury data were collected from 100 nationally representative US high schools via High School Reporting Information Online.

Patients or Other Participants: Athletes from participating high schools injured while involved in a school-sanctioned practice or competition in 1 of the above sports during the 2005–2006 and 2006–2007 school years.

Main Outcome Measure(s): Shoulder injury rates, diagnoses, severity, and mechanisms.

Results: During the 2005–2006 and 2006–2007 school years, athletes in this study sustained 805 shoulder injuries during 3 550 141 athlete-exposures (AEs), for an injury rate of 2.27 shoulder injuries per 10 000 AEs. This corresponds to an estimated 232 258 shoulder injuries occurring nationwide during this time. Shoulder injuries were more likely to occur during competition than practice (rate ratio = 3.01, 95% confidence interval = 2.62, 3.46). Shoulder injury rates per 10 000 AEs were highest in football (5.09), wrestling (4.34), and baseball (1.90). Common shoulder injury diagnoses included sprains/strains (39.6%), dislocations/separations (23.7%), contusions (11.5%), and fractures (6.6%). Although 44.8% of athletes sustaining a shoulder injury returned to play in less than 1 week, 22.9% were out of play for more than 3 weeks, and 6.2% of shoulder injuries required surgery. Common mechanisms of shoulder injury included player-to-player contact (57.6%) and contact with the playing surface (22.8%).

Conclusions: High school shoulder injury rates and patterns varied by sport. Continued surveillance is warranted to understand trends and patterns over time and to develop and evaluate evidence-based preventive interventions.

Key Words: epidemiology, injury surveillance

Key Points

- The shoulder injury rate was 2.27 per 10 000 athlete-exposures.
- Shoulder injuries were more likely to occur during competition than practice.
- Shoulder injury rates were highest in football, wrestling, and baseball.
- Common shoulder injury diagnoses included sprains/strains, dislocations/separations, contusions, and fractures.

More than half of all US high school students compete on school athletic teams.[1] Although sport participation promotes fitness and better health,[2] athletes are at risk for sport-related injuries. With participation rates in high school sports on the rise,[1] the number of student-athletes exposed to sport-related shoulder injuries is likely to increase unless effective preventive interventions are developed.

Shoulder injuries are the fifth most common injury among high school athletes.[3] The majority of shoulder injuries result from participation in contact sports such as football, in which high-speed collisions and falls are common.[4] However, chronic-overuse shoulder injuries can occur in sports that require the shoulder to perform similar motions repeatedly.[5] Negative effects of shoulder injury can range from a significant reduction in playing time to lifelong shoulder instability or shoulder degeneration over time.

Authors of previous shoulder injury studies have focused on specific sports,[4,6–13] the mechanics of the shoulder in repetitive-action sports,[14–17] risk factors of injuries to multiple body sites in several sports,[3,18–20] diagnosis of different types of shoulder injuries,[5,21,22] or comparisons of surgical procedures in treating different shoulder injuries.[8,23,24] To date, no researchers have described and compared shoulder injury rates and patterns across sports using a nationally representative sample of high school athletes.

Our study goal was to describe and compare the epidemiology of shoulder injuries among US high school athletes participating in 9 high school sports (football, soccer, basketball, baseball, and wrestling for boys and soccer, volleyball, basketball, and softball for girls) using a nationally representative sample. The specific aims were to (1) calculate shoulder injury rates during the 2005–2006 and 2006–2007 academic years, (2) describe shoulder injury patterns, and (3) compare shoulder injury rates and patterns by sport and sex.

Understanding the epidemiology of shoulder injuries is an important first step in developing targeted, evidence-based interventions to reduce such injuries.

METHODS

Data Collection

Reporting Information Online (RIO; The Research Institute at Nationwide Children's Hospital, Columbus, OH), an Internet-based, sports-related injury surveillance system, captured injuries during the 2005–2006 and 2006–2007 school years from 100 nationally representative US high schools. The study methods have been described in detail previously.[25–30] Briefly, eligible schools (ie, US high schools with a National Athletic Trainers' Association [NATA]–affiliated certified athletic trainer [AT] willing to serve as reporter) were categorized by geographic location[31] and school size (enrollment less than or equal to 1000 students or more than 1000 students). Schools were then randomly selected from each stratum to obtain a nationally representative study sample of 100 study schools. If a school dropped out of the surveillance study, a replacement school from the same sampling stratum was enrolled. Participating ATs logged into RIO weekly to report injury and exposure data in 9 high school sports (football, soccer, basketball, baseball, and wrestling for boys and soccer, volleyball, basketball, and softball for girls).

Definition of Injury and Exposure

An athlete-exposure (AE) consisted of 1 athlete participating in 1 practice or competition. An *injury* met all of the following criteria: (1) occurred as a result of participation in an organized high school practice or competition, (2) required medical attention by an AT or a physician, and (3) resulted in restriction of the student-athlete's participation for at least 1 day beyond the day of the injury. If multiple injuries were sustained during the same injury event, the AT was instructed to use his or her opinion as a sports medicine professional to identify and report only the most serious injury. For each injury, a detailed injury report describing characteristics of the injured player (eg, age, year in school), the injury (eg, site, diagnosis, severity), and the event leading to the injury (eg, mechanism, presence of illegal activity) was completed by the AT. Although the surveillance system captured 29 distinct injury diagnoses, for the purposes of this study, shoulder injury diagnoses were categorized as sprains/strains (including incomplete and complete ligament sprains, muscle strains, and tendon strains), dislocations/separations, contusions, fractures, and other (ie, all other injury diagnoses accounting for less than 5% of all injuries, such as stress fracture and tendinitis). Because all reporters were trained sports medicine professionals, diagnoses, whether made by a physician or an AT, were based on accepted clinical standards. Throughout the study, ATs were able to view all data they submitted and update reports as required (eg, need for surgery, days until return to play). Efforts to ensure high-quality data included weekly data audits during the study and an internal validity check after the first year of data collection.

Statistical Analysis

Data were analyzed using SPSS (version 14.0; SPSS Inc, Chicago, IL) and Epi Info (version 6.0; Centers for Disease Control and Prevention, Atlanta, GA). All rate calculations and rate comparisons used unweighted injury counts. Additional analyses used a weighting factor to produce national estimates, with the standard errors for comparison among sports and between sexes adjusted for the High School RIO sampling plan using the SPSS Complex Samples module. This weighting factor was based on the inverse probability of selection into the study sample, taking into account the total number of US schools by sampling stratum and by sport. Relative standard errors (RSEs), calculated as the standard error of the national estimate divided by the national estimate itself, are presented to demonstrate the reliability of these estimates. A higher RSE indicates less stability, and RSEs higher than 30% are potentially unreliable.

Injury rates were calculated as the ratio of injuries per 10 000 AEs. Rate ratios (RRs) and proportion ratios (PRs) were calculated with 95% confidence intervals (CIs). An RR or PR greater than 1.00 indicates a risk association, whereas an RR or PR less than 1.00 indicates a protective association. Confidence intervals not including 1.00 were considered statistically significant. The following are examples of an RR calculation comparing the rate of competition shoulder injuries to the rate of practice shoulder injuries and a PR calculation comparing the overall proportion of shoulder fractures among boys and girls, respectively:

$$\begin{aligned}\text{RR} = &[(\text{No. competition shoulder injuries}/\\ &\text{No. competition AEs}) \times 10\,000]\\ &\div [(\text{No. practice shoulder injuries}/\\ &\text{No. practice AEs}) \times 10\,000]\end{aligned}$$

$$\begin{aligned}\text{PR} = &[(\text{National estimated No. boys' shoulder fractures}/\\ &\text{National estimated total No. boys' shoulder injuries})]\\ &\div [(\text{National estimated No. girls' shoulder fractures}/\\ &\text{National estimated total No. girls' shoulder injuries})]\end{aligned}$$

This study was approved by the Institutional Review Board at The Research Institute at Nationwide Children's Hospital.

RESULTS

During the 2005–2006 and 2006–2007 school years, athletes in this study sustained 805 shoulder injuries during 3 550 141 AEs, for an injury rate of 2.27 shoulder injuries per 10 000 AEs in sampled sports (Table 1). These 807 injuries correspond to an estimated 232 258 shoulder injuries occurring nationwide during this period. Overall, shoulder injuries accounted for 8.0% of all injuries sustained by high school athletes. Shoulder injuries made up the greatest proportion of all injuries in boys' baseball (17.7%), wrestling (17.5%), and football (11.7%) and in girls' softball (10.4%). Most shoulder injuries occurred during the playing season (72.0%); however, 24.6% occurred during preseason. Shoulder injuries were assessed solely by ATs 45.4% of the time, by ATs and physicians 27.8% of the time, solely by

Table 1. Shoulder Injury Rates by Sport and Exposure Type, National High School Sports–Related Injury Surveillance Study, United States, 2005–2006 and 2006–2007 School Years

Sport	Exposure Type	n	Athlete-Exposures	Injury Rate (per 10 000 Athlete-Exposures)	Rate Ratio (95% Confidence Interval)[a]
Boys' football	Overall	475	933 340	5.09	5.97 (4.98, 7.15)
	Competition	266	164 102	16.2	
	Practice	209	769 238	2.72	
Boys' soccer	Overall	19	332 919	0.57	3.94 (1.55, 10.7)
	Competition	12	100 858	1.19	
	Practice	7	232 061	0.30	
Boys' basketball	Overall	20	423 239	0.47	3.01 (1.23, 7.53)
	Competition	11	122 224	0.90	
	Practice	9	301 015	0.30	
Boys' wrestling	Overall	140	322 373	4.34	3.34 (2.40, 4.65)
	Competition	74	81 061	9.13	
	Practice	66	241 312	2.74	
Boys' baseball	Overall	65	341 883	1.90	1.46 (0.89, 2.38)
	Competition	29	121 718	2.38	
	Practice	36	220 165	1.64	
Girls' soccer	Overall	12	304 527	0.39	4.70 (1.42, 17.9)
	Competition	8	90 879	0.88	
	Practice	4	213 648	0.19	
Girls' volleyball	Overall	30	279 880	1.07	0.58 (0.23, 1.31)
	Competition	7	96 707	0.72	
	Practice	23	183 173	1.26	
Girls' basketball	Overall	16	357 412	0.45	2.41 (0.87, 6.67)
	Competition	8	104 683	0.76	
	Practice	8	252 729	0.32	
Girls' softball	Overall	28	254 568	1.10	1.61 (0.75, 3.42)
	Competition	13	89 041	1.46	
	Practice	15	165 527	0.91	
Girls' sports	Overall	86	1 196 387	0.72	1.54 (1.00, 2.36)
	Competition	36	381 310	0.94	
	Practice	50	815 077	0.61	
Boys' sports	Overall	719	2 353 754	3.05	3.58 (3.09, 4.15)
	Competition	392	589 963	6.64	
	Practice	327	1 763 791	1.85	
Overall	Overall	805	3 550 141	2.27	3.01 (2.62, 3.46)
	Competition	428	971 273	4.41	
	Practice	377	2 578 868	1.46	

[a] Practice was used as the referent category.

physicians 25.9% of the time, and by another medical professional the remaining 1.0% of the time.

Injury Rates

Overall, shoulder injuries were 3 times more likely to occur during competition (4.41 per 10 000 AEs) than during practice (1.46 per 10 000 AEs) (RR = 3.01, 95% CI = 2.62, 3.46) (Table 1). Only volleyball had a higher shoulder injury rate during practice than competition. The highest shoulder injury rates per 10 000 AEs occurred in football (5.09), wrestling (4.34), and baseball (1.90) for boys and in softball (1.10) and volleyball (1.07) for girls. Shoulder injuries were 13 times more likely to occur in football, the sport with the highest shoulder injury rate, than in girls' soccer, the sport with the lowest rate (RR = 12.9, 95% CI = 7.28, 22.9) (Table 2). In the 3 boys' sports with the highest injury rates, shoulder injuries were more likely to occur in football than in baseball (RR = 2.68, 95% CI = 2.07, 3.47), but differences between football and wrestling, the sports with the highest shoulder injury rates, were not significant (RR = 1.17, 95% CI = 0.97, 1.41). Among girls, shoulder injuries were more likely to occur in softball, the sport with the highest shoulder injury rate, than in soccer (RR = 2.79, 95% CI = 1.42, 5.49) and basketball (RR = 2.46, 95% CI = 1.33, 4.54). However, differences between softball and volleyball were insignificant (RR = 1.03, 95% CI = 0.61, 1.72).

When considering sex differences in comparable sports (ie, soccer, basketball, and baseball/softball), boys had a higher shoulder injury rate (0.95 per 10 000 AEs) than girls (0.61 per 10 000 AEs) (RR = 1.55, 95% CI = 1.12, 2.15). More specifically, boys' baseball had a higher shoulder injury rate than girls' softball (RR = 1.73, 95% CI = 1.11, 2.69); boys' soccer had a higher rate than girls' soccer (RR = 1.45, 95% CI = 0.70, 2.98), although it was statistically insignificant; and girls' basketball had a similar rate to boys' basketball (RR = 1.06, 95% CI = 0.55, 2.04).

The RSEs were fairly low in most sports: football (3.9%), wrestling (9.5%), baseball (14.6%), volleyball (22.1%), softball (23.0%), boys' basketball (24.2%), boys' soccer (27.7%), and girls' basketball (27.8%). Because of a relatively high RSE in girls' soccer (44.5%), analyses using nationally estimated girls' soccer shoulder data should be interpreted cautiously.

Diagnoses

Common shoulder injury diagnoses included sprains/strains (39.6%), dislocations/separations (23.7%), contu-

Table 2. Shoulder Injury Rate Comparisons by Sport, National High School Sports–Related Injury Surveillance Study, United States, 2005–2006 and 2006–2007 School Years

Sport	Overall Injury Rate (per 10 000 Athlete-Exposures)	Rate Ratio (95% Confidence Interval)[a]
Boys' football	5.09	12.9 (7.28, 22.9)
Boys' wrestling	4.34	11.0 (6.11, 19.9)
Boys' baseball	1.90	4.82 (2.61, 8.93)
Girls' softball	1.10	2.79 (1.42, 5.49)
Girls' volleyball	1.07	2.72 (1.39, 5.31)
Boys' soccer	0.57	1.45 (0.70, 2.98)
Boys' basketball	0.47	1.20 (0.59, 2.45)
Girls' basketball	0.45	1.14 (0.54, 2.40)
Girls' soccer	0.39	1.00

[a] Girls' soccer was used as the referent category.

sions (11.5%), and fractures (6.6%) (Figure 1). Other diagnoses reported included tendinitis (3.5%), nerve injuries (2.5%), inflammation (2.8%), and torn cartilage (1.9%). Most shoulder injuries were new (85.2%), with 14.8% being recurrent injuries. Recurrent shoulder injuries were most common in boys' basketball (27.0%), baseball (22.0%), girls' basketball (18.6%), and softball (18.6%).

Sprains/strains were most common in girls' soccer (69.0% of all girls' soccer shoulder injuries), volleyball (58.7%), baseball (55.3%), softball (52.9%), and wrestling (50.1%). Dislocations/separations were most common in girls' basketball (38.9%), boys' soccer (35.7%), football (29.0%), and wrestling (25.8%). Contusions were most common in girls' basketball (19.7%), football (15.9%), and boys' soccer (15.5%). Fractures were most common in boys' soccer (33.7%).

Diagnoses differed by sport and sex, although most differences between the sexes were not statistically significant (Figure 1). In soccer, boys sustained a higher proportion of fractures (PR = 3.47, 95% CI = 0.57, 21.1), while girls sustained a higher proportion of sprains/strains (PR = 12.9, 95% CI = 2.79, 59.7). In basketball, boys sustained a higher proportion of sprains/strains (PR = 1.43, 95% CI = 0.36, 5.67), while girls sustained a higher proportion of dislocations/separations (PR = 2.69, 95% CI = 0.56, 13.0). In baseball/softball, softball players had 4 times the proportion of dislocations/separations (PR = 4.03, 95% CI = 0.55, 29.8).

Severity of Injury

Although shoulder injuries commonly allowed athletes to return to play in less than 1 week (44.8%), 22.9% of injuries kept athletes out of play for more than 3 weeks. Athletes in volleyball (66.0%), boys' basketball (60.2%), girls' basketball (59.1%), and softball (51.1%) most frequently returned to play less than 1 week after the injury (Figure 2). Athletes in girls' soccer (56.2%), boys' soccer (49.2%), boys' basketball (32.0%), and wrestling (31.8%) most frequently required longer recovery periods (more than 3 weeks) after their injuries.

Injuries that required time loss of less than 1 week were most frequently sprains/strains (42.7%), contusions (20.9%), and dislocations/separations (15.8%). Dislocations/separations (33.7%), fractures (27.5%), and sprains/strains (21.2%) were diagnoses that most frequently resulted in time loss of more than 3 weeks. Surgery was required for 6.2% of all shoulder injuries, with dislocations/separations accounting for 53.4% of all surgeries. Sports with the largest percentage of shoulder injuries requiring surgery were wrestling (8.5%), girls' basketball (7.8%), and football (7.0%).

Although they were statistically insignificant, potentially clinically significant sex differences existed. In soccer, time loss did not vary between boys and girls. Compared with girls, boys were more likely to miss more than 3 weeks of playing time in basketball (PR = 4.13, 95% CI = 0.49, 34.6) and baseball/softball (PR = 1.49, 95% CI = 0.46, 4.79). When combining all 3 sports, boys were more likely to sustain a shoulder injury requiring surgery (PR = 1.48, 95% CI = 0.27, 8.01).

Mechanism of Injury

Common mechanisms of shoulder injuries included player-to-player contact (57.6%), contact with the playing surface (22.8%), no contact (eg, improper shoulder rotation) (10.0%), overuse/chronic (4.6%), and contact with a playing apparatus (eg, tackling dummy, soccer goal, basketball hoop) (2.9%). Player-to-player contact was the primary mechanism for shoulder injuries that required surgery (59.8% of shoulder injuries requiring surgery), followed by contact with the playing surface (20.0%).

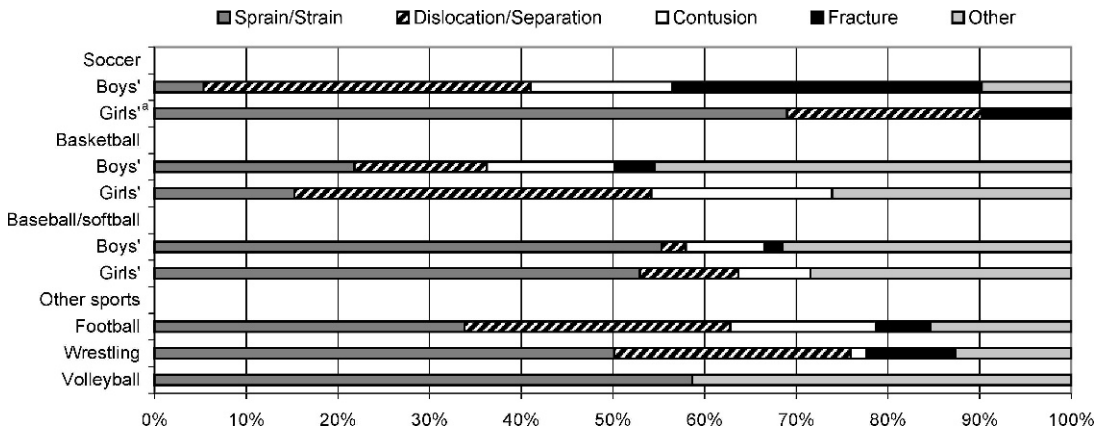

Figure 1. Diagnoses of athletes with shoulder injuries by sport and sex, National High School Sports–Related Injury Surveillance Study, United States, 2005–2006 and 2006–2007 school years. Data are based on weighted national estimates and include competition and practice exposures. [a] Caution should be used when interpreting national estimates for girls' soccer, because they are based on small case counts and have a relative standard error greater than 30%.

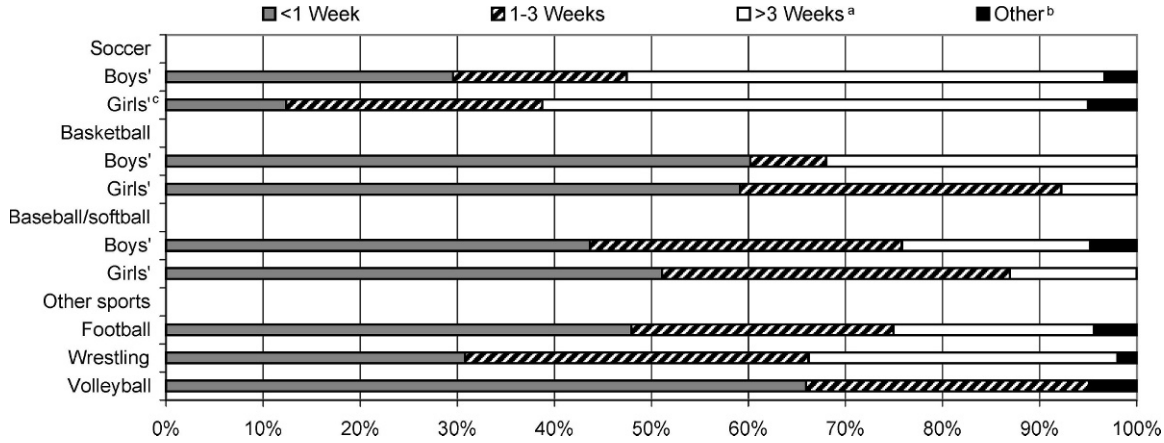

Figure 2. Time loss due to shoulder injury by sport and sex, National High School Sports–Related Injury Surveillance Study, United States, 2005–2006 and 2006–2007 school years. Data are based on weighted national estimates and include competition and practice exposures. [a] Includes season-ending and career-ending injuries. [b] Includes injuries with which the athlete continued playing and for which the athlete had surgery after the season or injuries with which the athlete continued playing, but with modified activities to accommodate the injury. [c] Caution should be used when interpreting national estimates for girls' soccer, because they are based on small case counts and have a relative standard error greater than 30%.

Player-to-player contact accounted for 58.0% of injuries resulting in more than 3 weeks of time loss.

Player-to-player contact resulting in shoulder injuries was most frequently seen in football (76.2% of all football shoulder injuries), girls' basketball (66.6%), wrestling (59.5%), and boys' soccer (53.2%). Shoulder injuries that resulted from contact with the playing surface were most common in girls' soccer (87.7%), boys' soccer (45.8%), wrestling (30.5%), and girls' basketball (24.6%). Noncontact shoulder injuries were most commonly seen in baseball (43.7%), volleyball (37.2%), softball (30.2%), and boys' basketball (13.9%). Shoulder injuries caused by contact with a playing apparatus were most common in boys' basketball (30.2%) and volleyball (26.3%).

Sprains/strains were frequently caused by player-to-player contact (50.1%), contact with the playing surface (23.5%), and no contact (17.1%). Dislocations/separations were frequently caused by player-to-player contact (64.1%) and contact with the playing surface (29.5%). All contusions resulted from either player-to-player contact (83.8%) or contact with the playing surface (16.2%). Similarly, all fractures resulted from player-to-player contact (56.7%) or contact with the playing surface (42.3%).

As seen in Table 3, there was little overall difference in shoulder injury mechanism by sex when combining comparable sports. However, sport-specific differences existed. In soccer, boys were more likely to sustain shoulder injuries after contact with another player (PR = 5.91, 95% CI = 1.07, 32.7), whereas girls were more likely to sustain a shoulder injury after contact with the playing surface (PR = 1.92, 95% CI = 1.00, 3.68). In basketball, boys were more likely to sustain shoulder injury after contact with a playing apparatus (PR = 9.91, 95% CI = 1.05, 93.2), while girls were more likely to sustain shoulder injuries after contact with the playing surface (PR = 2.90, 95% CI = 0.51, 16.5) and player-to-player contact (PR = 1.41, 95% CI = 0.74, 2.68), although the latter were statistically insignificant. In baseball/softball, boys were more likely to sustain a shoulder injury after contact with the playing surface (PR = 3.26, 95% CI = 0.59, 18.1) or via noncontact mechanisms (PR = 1.45, 95% CI = 0.67, 3.14), while girls sustained a higher proportion of shoulder injuries as a result of overuse/chronic mechanisms (PR = 1.38, 95% CI = 0.50, 3.81) and contact with another player (PR = 1.65, 95% CI = 0.42, 6.47), although these differences were statistically insignificant.

Specifically, the most common activities leading to football shoulder injury were tackling (36.7%), being tackled (26.0%), and blocking (20.6%). The most common activities leading to boys' soccer shoulder injuries were goaltending (35.9%), chasing a loose ball (21.7%), and defending (17.6%). In girls' soccer, the most common activities leading to shoulder injuries were ball handling/dribbling (46.2%) and goaltending (20.4%). In volleyball, the most common activities leading to injury were serving (44.7%) and spiking (30.7%). In boys' and girls' basketball, the most common activities leading to shoulder injury were defending (20.9% and 37.8%, respectively) and rebounding (16.2% and 40.9%, respectively). In wrestling, takedowns (32.4%), near falls (15.8%), and sparring (14.1%) caused the majority of shoulder injuries. In baseball and softball, most shoulder injuries resulted from throwing (excluding pitching) (24.3% and 50.2%, respectively), pitching (32.6% and 12.5%, respectively), and fielding (25.2% and 9.2%, respectively).

DISCUSSION

In this study, the first in a decade to compare shoulder injury rates and patterns across 9 high school sports (football, soccer, basketball, baseball, and wrestling for boys and soccer, volleyball, basketball, and softball for girls), we found nearly a quarter of a million shoulder injuries occurred among high school athletes nationwide during the 2005–2006 and 2006–2007 school years. Shoulder injury rates and patterns varied by sport and sex. With more than half of all US high school students competing in high school sports,[1] it is important to understand sport-specific shoulder injury patterns to assist coaches, ATs, physicians, and policy makers in developing targeted interventions to prevent shoulder injuries in this population.

Shoulder injuries occurred at an overall rate of 2.27 per 10 000 AEs (4.41 for competition and 1.46 for practice).

Table 3. Shoulder Injury Diagnosis, Injury Mechanism, Year in School, and Need for Surgery for Sports Played by Both Sexes (Soccer, Basketball, and Baseball/Softball), National High School Sports–Related Injury Surveillance Study, United States, 2005–2006 and 2006–2007 School Years[a]

	Boys, % (n = 36 213)	Girls, % (n = 22 727)	Proportion Ratio (95% Confidence Interval)[b]
Diagnosis			
Sprain/strain	**38.9**	48.1	1.24 (0.78, 1.98)
Dislocation/separation	**12.1**	19.6	1.62 (0.66, 4.00)
Contusion	10.9	**8.7**	1.25 (0.32, 4.86)
Fracture	9.8	**2.3**	4.32 (0.86, 21.7)
Other[c]	28.3	**21.2**	1.33 (0.65, 2.74)
Total	100	100	
Injury mechanism			
Contact with playing surface	**25.1**	29.6	1.18 (0.58, 2.41)
Player-to-player contact	**25.6**	26.4	1.03 (0.53, 2.02)
No contact[d]	29.2	**18.4**	1.59 (0.74, 3.45)
Overuse/chronic	**9.9**	11.8	1.19 (0.42, 3.37)
Contact with playing apparatus	7.5	**0.7**	10.9 (1.25, 95.0)
Other	**2.7**	13.2	4.93 (0.90, 27.1)
Total	100	100	
Year in school			
Freshman	**11.7**	21.2	1.82 (0.76, 4.36)
Sophomore	**16.2**	22.6	1.39 (0.55, 3.56)
Junior	**31.9**	32.1	1.01 (0.55, 1.84)
Senior	40.2	**24.0**	1.67 (0.88, 3.17)
Total	100	100	
Surgery			
Yes	4.6	**3.1**	1.48 (0.27, 8.01)
No	95.4	96.9	
Total	100	100	

[a] Data based on weighted national estimates and include competition and practice exposures.
[b] Bolded group used as referent (for example: for sprains/strains, boys were used as the referent group).
[c] Other diagnoses accounting for less than 5% of all injuries (eg, stress fracture, tendinitis).
[d] No-contact mechanisms include improper shoulder rotation, etc.

This is less than half the shoulder injury rate reported in a prior study[3] of high school athletes (5.4). Additionally, the percentage of all injuries accounted for by shoulder injuries was slightly lower in our study (8.1%) than in the prior study (10.2%).[3] Part of this decrease may be due to study design variables, such as a slightly broader definition of injury in the previous study or differences in the relative amount of competition and practice exposures between studies. However, at least part of this decrease is likely due to improved prevention efforts (eg, protective equipment, practice methods, rule modifications) and improvements in early diagnosis and treatment of minor injuries that may prevent more serious time-loss shoulder injuries.[5,8,14,21,24,32] For example, new detection methods for rotator cuff tears have led to multiple arthroscopic techniques for shoulder injury repair.[24,32]

In our study, the sports in which shoulder injuries accounted for large proportions of total injuries (baseball, wrestling, football, and softball) were also shown recently to have high percentages of shoulder injuries at the collegiate level.[12,13,33,34] Similar to our findings, collegiate shoulder injuries are predominately sprains/strains and tendinitis,[12,13,33–35] with football and wrestling shoulder injuries often resulting from player-to-player contact, whereas baseball and softball injuries occurred most often from noncontact mechanisms.[12,13,33,35] Also similar to our findings, shoulder injuries in collegiate baseball often resulted in longer periods of time loss than did collegiate softball shoulder injuries.[12,13]

Sport-Specific Differences

Shoulder injury rates in this study were higher in competition than in practice for 8 of the 9 sports studied. This result confirms findings previously reported at both the high school and collegiate levels and was expected, as competitions tend to be more physically demanding, with greater risk taking and, thus, higher injury rates.[12,33,36] Volleyball was the exception, with a 1.7 times greater shoulder injury rate in practice. Although this finding is similar to that of a previous study[3] in which volleyball injury rates were 2.3 times greater in practice than competition, prior results have been inconsistent, with at least one previous group[37] reporting no difference between collegiate practice and competition volleyball shoulder injury rates. One potential explanation for the difference between volleyball and the other sports studied may be the no-contact nature of volleyball competitions. Additionally, compared with competitions, volleyball practices consist of many more repetitions of various skills, such as serving, spiking, and blocking, that may lead to chronic and overuse injuries as well as acute injuries.

Shoulder injury rates were highest in football and wrestling, sports with frequent player-to-player contact and frequent impacts with the playing surface. This result is consistent with the findings of Powell and Barber-Foss.[3] Shoulder injury rates were also high in baseball, softball, and volleyball. Although baseball, softball, and volleyball tend not to involve the player-to-player contact associated

with football and wrestling, continued stress on the shoulder as a result of repetitive movements in these sports likely plays a crucial role in shoulder injury.[7,9,10,17]

Sport-specific preventive interventions incorporated into the practice setting may reduce the high competition shoulder injury rates. For example, because most football shoulder injuries were sustained while the players were tackling or blocking, football coaches should emphasize proper tackling and blocking techniques during practice. Similarly, wrestling coaches should focus on safe, effective takedown maneuvers. Because athletes in baseball, softball, and volleyball typically spend large amounts of practice time performing repetitive motions that involve the shoulder (eg, throwing, pitching, serving, spiking), coaches and ATs in these sports should ensure that players do not overuse their shoulders. One way to do this may be to place increased emphasis on the quality of the player's technique rather than the number of repetitions.[34] Continued research in developing high-quality, impact-attenuating protective gear (such as football shoulder pads that lessen the force of high-impact blows to the shoulder) could also be effective in decreasing shoulder injury rates in contact sports.

Sex Differences

Consistent with prior research,[3] shoulder injury rates in soccer, basketball, and baseball/softball were higher among boys than girls (0.95 and 0.61 per 10 000 AEs, respectively). This could be due to boys using their shoulders more forcibly and more often in contact situations.

We found that 6.2% of all shoulder injuries required surgery, with boys who sustained a shoulder injury being 48% more likely to require surgery than girls. This comparison was statistically insignificant, but this finding is likely clinically important. Because dislocations/separations accounted for almost half of all shoulder surgeries, research focusing on causes and preventive interventions for shoulder dislocations and/or separations would have a large effect in decreasing the high monetary and participation-related cost of shoulder surgeries.

Shoulder injury patterns differed within sex-comparable sports. In soccer, girls were more likely to sustain sprains/strains, and their shoulder injuries were more likely to result from contact with the playing surface. Conversely, boys were more likely to sustain fractures, and their shoulder injuries were more likely to result from player-to-player contact, indicating that boys may be more likely to use their shoulders during aggressive, physical play.[24] In basketball, boys were more likely than girls to incur shoulder injuries resulting from contact with a playing apparatus. In baseball/softball, boys were more likely to sustain shoulder injuries from contact with the playing surface.

Because males and females differ both in shoulder anatomy and in the way they use their shoulders, coaches and ATs should consider implementing shoulder strength and flexibility programs that are sex, sport, and position specific. For example, because the pitching motion is very different between baseball and softball, and because baseball and softball pitchers put different stresses on their shoulders compared with their teammates, baseball and softball pitchers would likely benefit from tailored shoulder strength and flexibility programs. In addition, continued research to identify the biomechanics leading to shoulder injury among males and females in specific sports should provide coaches with further insights into preventing these injuries.

Limitations

Like all studies, this study had limitations. Only schools with an NATA-affiliated AT were eligible for participation, so the findings may not be generalizable to US high schools without an AT. However, data quality was improved by including only trained sports medicine professionals, NATA-affiliated ATs, as reporters. Our definition of an AE as a single athlete's participation in 1 practice or 1 competition is less precise than a time-based measure. However, our definition was more feasible for high school ATs, who cannot be present to record minutes of participation for all athletes in all practices and competitions in 9 sports, and an athlete is at risk for injury any time he or she practices or competes. Another potential limitation was that almost half of all injury diagnoses were made solely by the AT and not a physician. Yet because NATA-affiliated ATs are trained sports medicine professionals, we have confidence in the accuracy of their diagnoses. Additionally, this study relied on the reporting AT to choose the most appropriate shoulder injury diagnosis from the 29 diagnosis categories provided by the surveillance system. Finally, although we used data collected from only the first 2 years of a continuing national study, the nationally estimated number of shoulder injuries in most sports had RSEs measuring less than 30%, indicating relatively high data stability. However, caution should be used when interpreting PRs that have wide 95% CIs. In particular, the nationally estimated number of girls' soccer shoulder injuries has a high RSE and thus is potentially unstable. However, we believe the clinical significance of these data outweigh the potential data instability, as this study presents the largest, most comprehensive epidemiologic investigation of shoulder injuries across high school sports to date.

CONCLUSIONS

The shoulder is one of the 5 most frequently injured body sites among high school athletes.[3] Although sport-related shoulder injuries will never be completely eliminated, identifying shoulder injury rates and patterns among sports will increase our understanding of shoulder injury risk factors and lead to the development of targeted injury prevention strategies. Such efforts will provide high school athletes with the opportunity to compete in sports with minimized risk of shoulder injury. Thus, continued surveillance of shoulder injury among high school sports must be conducted to understand trends, to drive development and evaluation of evidence-based intervention strategies, and to gain further knowledge of shoulder injuries (eg, risk factors for chronic shoulder injuries in adolescent athletes).

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DISCLAIMER

The content of this report is solely the responsibility of the authors and does not necessarily reflect the official views of the CDC.

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