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# Shoulder Injuries in US High School Baseball and Softball Athletes, 2005–2008

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## KEY WORDS

surveillance, injury prevention

## ABBREVIATIONS

RIO—Reporting Information Online

ATC—certified athletic trainer

AE—athlete exposure

RR—rate ratio

IPR—injury proportion ratio

CI—confidence interval

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**WHAT'S KNOWN ON THIS SUBJECT:** Baseball and softball are common high school sports with a risk for injury.



**WHAT THIS STUDY ADDS:** Gender differences were found in baseball and softball shoulder injuries.

## abstract

FREE

**OBJECTIVE:** The objective of this study was to determine factors that are involved in shoulder injury rates among high school athletes who participate in organized baseball and softball.

**METHODS:** Baseball- and softball-related injury data were collected during the 2005–2008 academic years from ~74 nationally representative high schools via High School Reporting Information Online.

**RESULTS:** Certified athletic trainers reported 91 baseball shoulder injuries and 40 softball shoulder injuries during 528 147 and 399 522 athlete exposures, respectively. The injury rate was 1.72 injuries per 10 000 athlete exposures for baseball and 1.00 injuries per 10 000 athlete exposures for softball. Muscle strain/incomplete tears were the most common injuries in both baseball (30.8%) and softball (35.0%). In practices, throwing, not including pitching, caused more than half of softball injuries (68.2%) as compared with competition injuries (23.5%; injury proportion ratio [IPR]: 2.90 [95% confidence interval (CI): 1.17–7.15];  $P = .015$ ), whereas pitching was the most common mechanism in causing shoulder injuries during baseball practice (41.9%) compared with competitions (25.6%; IPR: 1.64 [95% CI: 0.88–3.04];  $P = .17$ ). Eighty-one percent of the baseball shoulder injuries and 82.5% of the softball shoulder injuries were new. Ten percent of baseball athletes and 5.3% of softball athletes sustained injuries that required surgery (IPR: 1.40 [95% CI: 0.32–6.10];  $P = .93$ ). Injuries that were sustained while the athlete was on the pitcher's mound were significantly more likely to result in surgery than any other field position (IPR: 2.64 [95% CI: 1.65–4.21];  $P = .0061$ ). Injured baseball players were more than twice as likely to be pitchers.

**CONCLUSIONS:** Although rates and patterns of shoulder injuries are similar between baseball and softball players, injury rates and patterns differ between field positions within each sport, as well as by injury severity and the athletes' year in school. *Pediatrics* 2010;125: 497–501

There are ~7.4 million student athletes in the United States.<sup>1</sup> Although sports participation offers many benefits, sports also pose a risk for injury. A recent study found that boys' baseball and girls' softball players sustained ~1 injury per 1000 practices or competitions.<sup>2</sup> In addition, the number of high school pitchers who require surgery for pitching-related injuries has increased.<sup>3</sup> The number of softball athletes has doubled in the past 2 decades.<sup>4</sup> The Amateur Softball Association of America annually registers more than 83 000 youth girls' fast-pitch softball teams comprising more than 1.2 million girls.

Arm overuse injuries are common in baseball and softball, especially among pitchers.<sup>6</sup> Approximately one fourth of high school baseball players pitch.<sup>7,8</sup> The repetitive, unnatural form of baseball pitching results in a high risk for overuse injuries.<sup>9</sup> It is thought that the underhand, windmill delivery used in fast-pitch softball creates less arm stress compared with the overhand delivery in baseball. In addition, the distance between the pitching mound and the home plate is shorter in softball (40.0 ft) compared with baseball (60.5 ft); however, studies have found that the stress placed on the shoulders of softball pitchers is similar to that placed on baseball pitchers.<sup>10,11</sup> Risk factors for shoulder injuries in adolescent baseball pitchers include pitching more games, months, and pitches per year; more innings and pitches per game; and more warm-up pitches before games than their noninjured counterparts. Injured pitchers were also more frequently started as pitchers, pitched with higher velocity, and pitched more often with arm fatigue and pain.<sup>3,8</sup>

Our objective was to describe and compare high school baseball and softball shoulder injury rates and pat-

terns. As the number of high school athletes grows, the incidence of these injuries is also likely to increase. Improving our knowledge of common injuries and possible means for prevention is crucial for players and coaches to maintain healthy high school athletes.

## METHODS

### Data Collection

We used an Internet-based injury surveillance system (Reporting Information Online [RIO]) to collect injury and exposure data for US high school baseball and softball athletes from 2005 to 2008. The RIO surveillance method has been described in detail previously.<sup>12</sup> Briefly, all US high schools with 1 or more National Athletic Trainers Association–affiliated certified athletic trainers (ATCs) with a valid e-mail address were invited to participate. High schools were categorized into 8 sampling frames. The sampling frames were based on 4 US Census geographic regions and 2 school sizes ( $\leq 1000$  students or  $> 1000$  students). One hundred schools were randomly chosen from each of the 8 sampling frames to create a nationally representative sample. When a school dropped out during the study, another school from the same sampling frame was randomly selected for replacement.

### Definition of Injury and Exposure

Through the High School RIO Web site, participating ATCs logged on weekly to report injury incidence and athlete exposure (AE). A reportable injury was an injury that occurred as a result of an organized practice or competition, required medical attention, and resulted in participation restriction for  $\geq 1$  day after the day of injury. An AE was defined as a single athlete's participation in 1 practice or competition. For each injury, ATCs submitted a detailed injury report describing characteristics of

the adverse event (eg, body site injured, diagnosis, injury mechanism). ATCs were able to view and update all previously submitted cases throughout the school year.

## Statistical Analysis

Data were analyzed using SPSS 14.0 (SPSS Inc, Chicago, IL), with  $P < .05$  considered statistically significant. Injury rates were calculated as the ratio of injuries per 10 000 AEs and were compared by using rate ratios (RRs). For example, the RR comparing baseball and softball injury rates was as follows:

$$RR = (\text{total No. of baseball injuries} / \text{total No. of baseball AEs}) * 10\,000.$$

$$RR = (\text{total No. of softball injuries} / \text{total No. of softball AEs}) * 10\,000.$$

Injury proportion rates (IPRs) compared the proportion of injuries between sports. For example, the IPR comparing the proportion of shoulder injuries that required surgery by sport is as follows:

$$IPR = (\text{No. of softball shoulder surgeries} / \text{total No. of softball shoulder injuries}).$$

$$IPR = (\text{No. of baseball shoulder surgeries} / \text{total No. of baseball shoulder injuries}).$$

The study was approved by the institutional review board of the Research Institute at Nationwide Children's Hospital.

## RESULTS

### Injury Rates

Participating ATCs reported 91 baseball shoulder injuries during 528 147 AEs (1.72 injuries per 10 000 AEs) and 40 softball shoulder injuries during 399 522 AEs (1.00 injuries per 10 000 AEs). The shoulder injury rate was significantly higher in baseball compared with softball (RR: 1.72 [95% confidence interval (CI): 1.19–2.50];  $P < .01$ ).

**TABLE 1** Proportion of Shoulder Injuries in US High School Baseball and Softball Athletes, by Class, Mechanism, Position, and Diagnosis; High School Sports-Related Injury Surveillance Study, 2005–2008 School Years

Parameter	Baseball		Softball	
	%	Frequency	%	Frequency
<b>Class</b>				
Freshman	16	14	20	8
Sophomore	15	13	13	5
Junior	31	27	45	18
Senior	38	33	23	9
<b>Mechanism</b>				
Contact with another person	7	6	17	6
Contact with playing surface	20	18	6	2
Contact with playing apparatus	6	5	0	0
No contact	43	38	39	14
Overuse/chronic	24	21	39	14
<b>Position</b>				
Batter	4	4	5	2
Base runner	3	3	8	3
Pitcher	38	34	15	6
Catcher	9	8	15	6
First base	6	5	15	6
Second base	4	4	8	3
Shortstop	2	2	5	2
Third base	6	5	5	2
Left field	9	8	8	3
Center field	13	12	8	3
Right field	4	4	8	3
Nonfield player	1	1	0	0
<b>Diagnosis</b>				
Contusion	8	6	5	2
Dislocation	8	6	5	2
Fracture (including stress fracture)	4	3	3	1
Inflammation	8	6	15	6
Ligament sprain	10	8	10	4
Muscle strain/incomplete tear	35	28	35	14
Nerve injury	1	1	0	0
Separation	1	1	0	0
Tendon strain	9	7	8	3
Tendonitis	13	10	15	6
Torn cartilage	4	3	5	2

## Characteristics of Injuries and Injury Events

### Injuries

Overall, muscle strains/incomplete tears were the most common shoulder injuries in both baseball (31%) and softball (35%; Table 1). In baseball and softball, a greater percentage of these injuries occurred in practice (37% and 36%, respectively) than in competition (26% and 35%, respectively).

Approximately one-quarter (26%) of softball players returned to play after 1 to 2 days, whereas only 20% of baseball players were able to return in that time (IPR: 1.34 [95% CI: 0.68–2.66];  $P =$

.55; Table 2). Pitching was the most common mechanism of shoulder injuries that lasted >9 days in both sports

(35%). Of injuries that resulted in season medical disqualification, 40% required surgery.

Most baseball and softball shoulder injuries were new (81% and 83%, respectively) and had not occurred previously during the season or during previous seasons. Similar proportions of baseball and softball shoulder injuries were a seasonal recurrence (7% and 8%, respectively). In both sports, 10% of all shoulder injuries were a recurrence from the previous year. One quarter (27%) of recurring shoulder injuries were sustained by pitchers. Muscle strains/incomplete tears were the most common (23%) recurring injury.

A greater proportion of baseball shoulder injuries required surgery compared with softball shoulder injuries (10% and 5%, respectively; IPR: 1.90 [95% CI: 0.43–8.38];  $P = .60$ ). (Because of the small number of shoulder injuries that required surgery, the remainder of this paragraph combines baseball and softball.) The majority of shoulder injuries that required surgery occurred among pitchers (73%). Most surgeries occurred among juniors or seniors (80%) and were evenly divided between the preseason (46%) and the regular season (55%). The most common diagnoses were torn cartilage (27%), followed by bursitis

**TABLE 2** Proportion of Shoulder Injuries in US High School Baseball and Softball Athletes, by Injury Severity: High School Sports-Related Injury Surveillance Study, 2005–2008 School Years

Parameter	Returned to Competition or Practice in						Medical Disqualification for the Season	Season Ended Before Athlete Returned to Activity
	<1 d <sup>a</sup>	1–2 d	3–6 d	7–9 d	10–21 d	≥22 d		
<b>Baseball</b>								
Frequency	1	17	22	13	15	9	7	1
%	1	20	26	15	18	11	8	1
Cumulative %	99	20	46	61	79	90	98	100
<b>Softball</b>								
Frequency	0	10	9	6	7	4	3	0
%	0	26	23	15	18	10	8	0
Cumulative %	100	26	49	64	82	92	100	100

<sup>a</sup> Chosen only for fractures and reported only during 2007–2008.

(18%), dislocation (18%), and ligament sprain (18%). Only 30% were recurrent injuries from the previous year, 60% were new injuries, and 1 (10%) was a recurrent injury from the same year. Noncontact and overuse/chronic injuries accounted for 36% of shoulder surgeries. Almost half (46%) occurred while pitching, and an additional 9% occurred while throwing.

### Events

The majority of baseball (65%) and softball (55%) shoulder injuries occurred in practice. In softball, throwing (excluding pitching) caused a higher proportion of practice injuries (68%) than competition injuries (24%; IPR: 2.90 [95% CI: 1.17–7.15];  $P = .015$ ). In baseball, pitching resulted in shoulder injury more frequently during practice (42%) compared with competition (26%; IPR: 1.64 [95% CI: 0.88–3.04];  $P = .17$ ).

In both sports, the most common general mechanism of shoulder injury was no contact, which includes pulled muscles (42%) and overuse (35%; Table 1). A greater proportion of baseball shoulder injuries compared with softball injuries resulted from contact with the playing surface (20% and 5%, respectively; IPR: 3.96 [95% CI: 0.96–16.25];  $P = .06$ ). Compared with baseball (7%), a greater proportion of softball shoulder injuries resulted after contact with another person (15%; IPR: 2.28 [95% CI: 0.78–6.62];  $P = .23$ ), although this was not statistically significant.

In baseball, pitchers accounted for the greatest proportion of shoulder injuries (38%). In softball, pitchers (15%), first basemen (15%), and catchers (15%) were most likely to sustain a shoulder injury. Compared with softball, baseball pitchers accounted for a greater proportion of shoulder injuries (IPR: 2.52 [95% CI: 1.15–5.52];  $P = .017$ ; Table 1). More than half of the shoulder injuries in both baseball (69%) and softball (68%) occurred in juniors and seniors.

## DISCUSSION

We found that shoulder injury rates differed between high school baseball and softball players, with baseball players having 70% higher injury rates. Shoulder injuries occurred most frequently among pitchers and were more common in juniors and seniors. This ratio of male sport injuries (baseball) compared with female sport injuries (softball) is congruent with previous studies that indicated that injury rates for boys are 80% higher than for girls.<sup>2</sup> The large population of young baseball and softball athletes, especially considering the high percentage of pitchers, underscores the need to lay the foundation for developing and implementing evidence-based, targeted preventive interventions.

We found that baseball pitchers sustained similar proportions of shoulder injuries (38%) as found previously (29%–35%).<sup>8</sup> We also found that pitchers were the most common position with shoulder injuries that required surgery, possibly because of the repetitive motions. We found that softball pitchers were injured only half as often as baseball pitchers. This could be attributable to differences in musculoskeletal development and maturity between the genders,<sup>10,13</sup> the average speed at which the pitches are thrown, or the length of time that the pitchers have been pitching.<sup>3</sup> Boys tend to have greater upper body strength than girls, allowing them to accelerate their arm faster and throw faster, putting greater stress on the rotator cuff in the deceleration phase. Also, baseball pitchers use the same overhand motion from very early on in the baseball career, whereas softball players go through a progression of pitching styles before being able to pitch successfully by using the windmill technique. Paradoxically, softball pitchers may pitch six 7-inning games during a weekend tournament, resulting in 1200 to 2000 pitches being thrown during a

3-day period,<sup>4,11</sup> whereas baseball pitchers are typically rested for several days before competing<sup>10</sup> and only 100 to 150 pitches are thrown in a 3-day period.<sup>4,11</sup> The significant difference in the number of pitches thrown between baseball and softball pitchers could be attributed to the pitch count rules that are strictly enforced in baseball and the lack of these rules in official softball leagues. Typically, fewer pitchers are developed for softball than for baseball teams, which could be a result or a cause of a lack of pitch count regulations.<sup>4</sup>

This study found that a higher proportion of baseball shoulder injuries lasted 7 to 21 days (42%) compared with a previous study that found that 27% of shoulder injuries resulted in >5 days' time loss.<sup>8</sup> Although this may suggest that baseball shoulder injuries are increasing in severity over time, additional research is needed.

We also found a significantly higher incidence of softball practice injuries that resulted from throwing rather than pitching. This could be attributable to softball teams having fewer pitchers and softball pitchers not pitching everyday, but all or most of the teammates probably do throw everyday, increasing the risk for throwing- but not pitching-related injuries. In addition, pitchers probably do not throw as hard or as fast during practices as they do in competitions, which would decrease the likelihood of practice injuries that result from pitching.

In softball, we found that there were just as many injured pitchers as there were first basemen and catchers (15%). This difference could be explained by the overall fitness of the athletes, because many first basemen are the larger players that provide a bigger target for plays. Usually relieved pitchers continue to play, often at first base. Possibly, after being relieved, the injury occurred at first base instead of on the mound, and the position was

documented as first base, not pitcher. It is interesting to note that despite being involved in every play and not receiving as many deliberate rest days as pitchers do, baseball catchers do not have a higher injury incidence than many other positions.

We found that baseball shoulder injuries were more likely than softball shoulder injuries to occur from contact with the playing surface, which was probably caused by sliding. Although it is becoming more common for softball players to slide head first, it is much more typical of baseball players, which could lead to shoulder injuries if the slide is done improperly and the athlete lands on his shoulder instead of his chest with his arm outstretched to reach the base.

This study is not without limitations. Only high schools with a National Athletic Trainers Association–affiliated ATC were eligible for the study. Although this may limit generalizability, the use of only medically trained personnel increased data quality and consistency. Because high school ATCs were not asked to report minor injuries that did not result in time loss, these data are an underestimation of the true injury burden; however, this limitation was necessary to re-

duce the time burden on ATCs. In addition, uninjured athletes were not part of this analysis, prohibiting modifiable risk factors from being able to be identified.

This study highlights areas in which preventive interventions can have a large impact. Because of the increased rate and severity of shoulder injuries, baseball and softball coaches should monitor athletes, especially pitchers, to make sure that they are not being injured through shoulder overuse<sup>3,6,7,8</sup> and that athletes are properly conditioned.<sup>5,6</sup> Pitchers should focus on biomechanics to ensure that they are not putting unnecessary stress on the rotator cuff and the shoulder.<sup>3,6,7,8</sup> In addition, coaches should encourage proper stretching and conditioning (eg, weight training) to strengthen the shoulder joint and prevent injuries.<sup>3,6,10</sup> Because baseball and softball are physically demanding sports, coaches should ensure that all athletes are in adequate physical shape before they are permitted to engage in any activity.

## CONCLUSIONS

We found that shoulder injury rates and patterns are similar between baseball and softball practices and

competitions and that muscle strains make up a large proportion of shoulder injuries. Continued prospective surveillance is necessary to monitor injury rates and patterns over time and assess the effectiveness of rule and equipment changes. Video analysis of specific shoulder injury mechanisms, such as pitching mechanics, could provide coaches and athletic trainers with scientifically based evidence to develop targeted interventions and correct improper throwing techniques to prevent injury.<sup>4</sup> To maximize the benefits that can be gained from athletic participation in sports such as baseball and softball, physicians, coaches, athletic trainers, and researchers must work collaboratively to develop interventions to enhance the safety of our athletes.

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