

ORIGINAL RESEARCH

SHOULDER AND ELBOW INJURY RATES AND CHARACTERISTICS AMONG COLLEGIATE BASEBALL STUDENT-ATHLETES

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ABSTRACT

Background: Recent research has focused on the epidemiology of shoulder and elbow injuries among high school and professional baseball players. Shoulder and elbow injury data has not been comprehensively reported among college baseball student-athletes.

Purpose: The purpose of this study is to describe shoulder and elbow injury rates and their characteristics among collegiate baseball student-athletes in order to improve injury prevention.

Study Design: Descriptive Epidemiology Study.

Methods: Shoulder and elbow injury data were obtained from the NCAA Injury Surveillance System for baseball from 2004-2014. Incidence rate ratios and descriptive analyses described injury characteristics for the shoulder and elbow, separately.

Results: The injury rate for the shoulder was 4.02/10,000 athlete-exposures and for the elbow was 2.44/10,000 athlete-exposures. During the ten-year period, the injury rate of the shoulder has approximately decreased by 75% and of the elbow by approximately 50%. Injury rates were higher during competitions compared to practice for the shoulder (rate ratio, 1.81;95% CI, 1.51, 2.18) and elbow (rate ratio, 2.19;95% CI, 1.73, 2.78). Freshmen and juniors were most likely to sustain shoulder (F = 40.6%, J = 29%) and elbow (F = 33%, J = 33.7%) injuries. Regarding shoulder injuries, surgery was required for 7.1%, and the outcome was season ending for 14.5%. More elbow injuries (17.5%) ended in surgery, and a greater proportion (28.9%) had season-ending injuries.

Conclusion: In collegiate baseball, shoulder and elbow injury rates have decreased but still result in high morbidity. More granular analyses, especially during Division 1 competitions, are necessary for more specific interventions. While shoulder injuries are more common, elbow injuries result in a longer time to return to play and a higher proportion of surgical interventions.

Level of Evidence: Level 3

Keywords: Baseball, injury surveillance, NCAA, sports injury, throwing

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INTRODUCTION

Baseball is one of the most popular sports in the United States and has shown consistent growth in popularity at all levels of play. For example, at the collegiate level during the 1988-89 season there were 667 school sponsored varsity teams. In 2003-2004 that number had risen to 861, and currently, there are 950 varsity baseball teams in NCAA Divisions I-III combined.¹ Even though the number of participants continues to rise, there has been a lack of epidemiological evidence investigating baseball injuries, especially at the collegiate level.

Given the increasing prevalence of shoulder and elbow injuries among high school baseball players, emphasis in the literature has been on throwing injuries in this population.²⁻⁵ The literature suggests that the incidence rate of shoulder injuries for this population is between 1.39 and 1.72 injuries per 10,000 athlete-exposures (AEs), and the majority of players returned to play within one week.^{2,3} Compared to shoulder injuries, elbow injuries occur at a lower rate of 0.86 injuries per 10,000 AEs, but they more frequently miss one to three weeks of participation.²

Similar to collegiate baseball, there has been limited epidemiological research focused on injuries at the Major League Baseball (MLB) level. Posner et al.⁶ reported that shoulder and elbow injuries accounted for 21.2% and 16.4%, respectively, of all MLB injuries recorded between 2002-2008.⁶ The elbow injury rate among major and minor league baseball players was 1.7 injuries per 1,000 AEs, and the average time missed from practice and competition due to an elbow injury was 27 days.⁴ The injury rate and time lost specific to shoulder injuries among MLB population has not been reported. Conte et al.⁷ highlighted that during the late 1990s shoulder and elbow injuries accounted for the greatest percentage of days that MLB players were placed on the disabled list. Additionally, the number of days on the disabled list due to elbow injuries consistently increased during this period.

A literature review revealed three epidemiological research studies investigating collegiate baseball injuries. Wasserman et al.⁸ most recently described all injuries that occurred among the three Divisions of NCAA baseball from 2004-2014. Shoulder and clavicle injuries were the most frequently reported

injury during competitions (16.0%) and practices (21.1%). Arm and elbow injuries accounted for 14.7% of all injuries during competition and 15.5% during practice.⁸ Dick et al.⁹ performed a similarly in-depth study of NCAA baseball injuries during the 1988-2004 seasons. Their results were similar in that shoulder injuries were among the most common injuries during competitions (16%) and practices (23.4%) and elbow injuries made up fewer competition injuries (9.3%) and practice injuries (10.8%).⁹ A two-year report of baseball injuries at a Division I college had similar findings that the majority of all injuries are to the shoulder (24%), and 12% of all injuries occur to the elbow.¹⁰ While these studies highlight shoulder and elbow injury occurrences, their purposes were to provide a comprehensive analysis of all baseball injuries. So, they do not provide information about the circumstances specific to shoulder and elbow injuries. Furthermore, given the emphasis on shoulder and elbow injury prevention during the past two decades, a reevaluation of injury occurrence and the characteristics of shoulder and elbow injuries are recommended.

Shoulder and elbow injuries have a dramatic impact on the overall injury rate and time lost from participation at all levels of baseball. While recent epidemiological studies at the high school and professional levels have specifically targeted shoulder and elbow injuries to better define and understand the injury causation, no research that specifically analyzes shoulder and elbow injuries among collegiate baseball student-athletes could be found. Therefore, the purpose of this study is to describe shoulder and elbow injury rates and their characteristics among collegiate baseball student-athletes in order to improve injury prevention.

METHODS

To analyze injury event data of collegiate baseball student-athletes who had sustained a shoulder or elbow injury, data from the National Collegiate Athletic Association (NCAA) Injury Surveillance System (ISS) was used for the 2004-2014 academic years. The ISS is managed by the Datalys Center for Sports Injury Research and Prevention. Data analysis was specific to injury data from the championship segment that occurs from February to June in Division I and

January to May in Division II and III when colleges compete in conference and NCAA championship tournaments. The ISS does not collect injury data during the non-championship segment that occurs in the Fall. A national volunteer sample of Division I, II, and III NCAA institutions provide exposure and injury data via an internet-based application. Participating institutions vary each year and for each sport. Sampling and data collection methods as well as other system details have been previously described.¹¹

Members of the medical staff at each institution input the data for each injury and the daily athlete-exposure (AE) summaries. Each injury is defined by the injured body part and specific type of injury. For data acquired during 2004-2008 academic years, the ISS defined a reportable injury as having occurred during organized collegiate practice or competition that required the attention from an athletic trainer or physician and resulted in the restriction of participation for at least one day beyond the day of injury. Starting in 2009-2010, the ISS also began monitoring non-time-loss injuries which required the student-athlete to be evaluated or treated (or both) by an athletic trainer or physician but did not restrict participation for more than the day of injury. For the purpose of this paper, and to be consistent across all of the academic seasons that were analyzed, the analysis included only injuries that resulted in time lost from participation beyond the day of injury and that were designated as occurring to the shoulder or elbow. The ISS defined a reportable AE as one student-athlete participating, regardless of the amount of time, in a NCAA-sanctioned activity in which he or she was exposed to the possibility of athletic injury. An AE during competition required that the student-athlete have actually acquired playing time.¹¹

The ISS standardizes the characteristics that the medical staff use to describe an injury event in baseball. For this manuscript the following characteristics were analyzed for the 2004-2014 seasons: Division, event type, time of season, injury diagnosis, recurrence type, player position, basic mechanism, specific mechanism, surgery, and outcome. The student-athletes' grade levels (academic year) were collected by the ISS for only the 2009-2014 seasons. The injury rates of the shoulder and elbow were calculated for total exposures, Division exposures,

competition and practice exposures, and time of season exposures using unweighted counts per 10,000 AEs and adjusting for Division and year. Incidence rate ratios (IRRs) and 95% confidence intervals were calculated to compare rates between categories of an exposure variable while also adjusting for Division and year. If the value of one was included in the 95% CI, then the IRR was interpreted as equal rates occurring between the variable's categories. If the 95% CI did not include the value of one then results were considered statistically significant. IRR less than one indicates a decreased injury risk for a variable's category relative to the referent category. IRR greater than one indicates an increased risk of injury in a variable's category relative to the referent category.

RESULTS

Shoulder Injury Incidence Rates

During the 2004-2014 academic years, 463 shoulder injuries and 804,740 AEs were recorded in the ISS. The injury rate for all shoulder injuries was 4.02 (95% CI = 3.50, 4.60) per 10,000 AEs, and the point estimates demonstrate a steady decline of 79% from 8.0 to 1.7 injuries per 10,000 AEs during the period of 2004 to 2014 (Figure 1). Student-athletes playing at the Division I level were significantly more likely to sustain a shoulder injury than those playing in Division II (IRR = 1.49; 95%CI 1.16, 1.92) or Division III (IRR

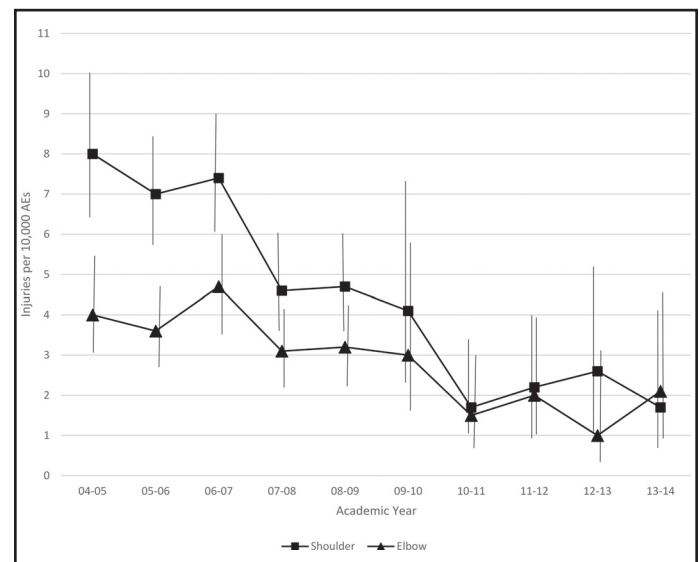


Figure 1. Shoulder and elbow injury rates per 10,000 athlete-exposures and 95% confidence intervals by academic year for all baseball student-athletes.

Table 1. Shoulder injury rates per 10,000 athlete-exposures (AEs) among collegiate baseball student-athletes by division

	Injuries (n)	AEs (n)	Injury Rate* (per 10,000 AEs)	aIRR* (95% CI)
Total	463	804739 [§]	4.0	
Division I	245	356202	4.9	Referent
Division II	82	177757	3.3	0.67 (0.52, 0.86) 1.49 (1.16, 1.92) [†]
Division III	136	269745	3.5	0.71 (0.57, 0.88) 1.41 (1.14, 1.74) [†]
				DII vs DIII [‡] : 0.94 (0.71, 1.24)

* Adjusted by year and division;
[†] aIRR expressed as inverse ratio for interpretation of injuries in Division I relative to Division II and Division III, as appropriate.
[‡] Referent category for specific aIRR
[§] Total exposures and yearly exposures are greater than division exposures summary because of undefined division exposures
aIRR = adjusted injury rate ratio

Table 2. Shoulder injury rates per 10,000 athlete-exposures (AEs) among collegiate baseball student-athletes by event type

	Injuries (n)	AEs (n)	Injury Rate* (per 10,000 AEs)	aIRR* (95% CI)
Practices	236	524720	3.0	Referent
Competitions	227	280021	5.4	1.81 (1.51, 2.18)

* Adjusted by year and division
aIRR = adjusted injury rate ratio

= 1.41; 95% CI 1.14, 1.74). There was no difference in the incidence rate of shoulder injuries between Division II and Division III (Table 1). Shoulder injuries were 81% more likely to occur during competition (IRR = 1.81; 95% CI 1.51, 2.18) (Table 2). Compared to the postseason, significantly higher incidence rates occurred during the preseason (IRR = 2.34; 95% CI 1.35, 4.06), and in-season (IRR = 1.94; 95% CI 1.21, 3.34). However, there were no differences in the incidence rates between preseason and the in-season (IRR = 1.19; 95% CI 0.98, 1.44) (Table 3).

Shoulder injury characteristics

Among all Divisions between 2004-2014 academic years, a national estimate of 11,575 shoulder injuries (95% CI, 10,554, 12,597) occurred. The five most commonly reported injuries are listed in Table 4. The most common positions sustaining shoulder injuries were pitchers (45.9%) and fielders (24.6%). The majority of injuries (78.5%) were classified as new injuries. Of the recurrent injuries, 13.9% were recurrences from a previous season. 72.8% of the shoulder injuries

Table 3. Shoulder injury rates per 10,000 athlete-exposures (AEs) among collegiate baseball student-athletes by season

	Injuries (n)	AEs (n)	Injury Rate* (per 10,000 AEs)	aIRR* (95% CI)
Preseason	169	257185	4.4	Referent
Inseason	285	514582	3.7	0.83 (0.68, 1.00) 1.21 (1.00, 1.46) [†]
Postseason	10	32974	1.9	0.42 (0.25, 0.74) 2.34 (1.35, 4.06) [†]
				Inseason vs Postseason [‡] 1.94 (1.12, 3.35)

* Adjusted by year and division
[†] aIRR expressed as inverse ratio for interpretation of the preseason relative to the inseason and postseason, as appropriate.
[‡] Referent category for specific aIRR
aIRR = adjusted injury rate ratio

Table 4. Cases, national estimates (NE) and percentage of national estimate (%NE) of all shoulder injuries, 95% confidence interval, of most common shoulder injuries

Diagnosis	Cases (N)	NE	%NE (95% CI)
Rotator Cuff Strain / Tendinitis	160	3527	30.7 (25.3, 36.1)
Impingement	70	2003	17.5 (12.2, 22.7)
Anterior Dislocation / Subluxation	50	1381	12.0 (7.4, 16.7)
Acromioclavicular Joint Injury	16	726	6.3 (2.4, 10.3)
Glenoid Labrum	38	841	7.3 (4.2, 10.5)

were non-contact, and of these 33.4% were classified as being an overuse injury or having a gradual onset. 52% of shoulder injuries resulted in a loss of playing time for two weeks or less while 14.5% of injuries

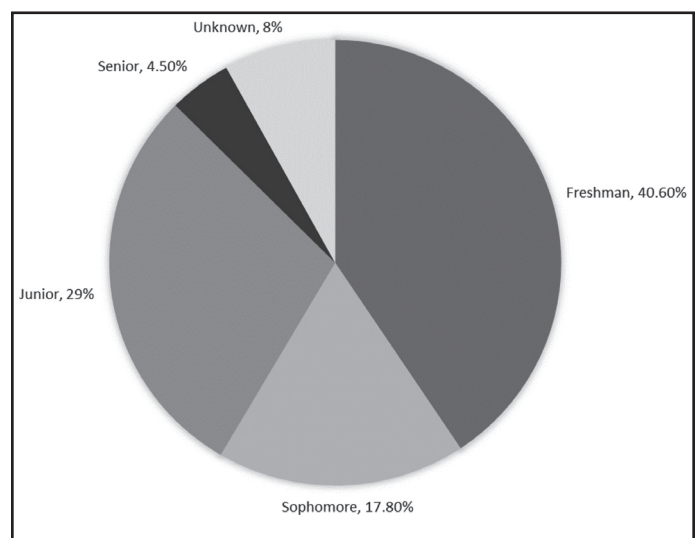


Figure 2. Shoulder injury frequency by the student-athlete's academic year in school. Data available only for 2009-2014.

Table 5. Cases, national estimates (NE) and percentage of national estimates (%NE), 95% confidence interval, for shoulder injury characteristics

	Total		
	Cases	NE	%NE (95% CI)
Injury Recurrence			
New	355	9015	78.5 (73.6, 83.5)
Recurrent from Previous Season	66	1605	13.9 (9.9, 17.9)
Recurrent from Same Season	36	854	7.6 (4.3, 10.9)
Baseball Position			
Pitcher	194	5281	45.9 (39.6, 52.3)
Infield	56	1763	15.2 (10.1, 20.4)
Outfield	41	1078	9.4 (5.4, 13.4)
Catcher	7	247	2.1 (0.1, 4.2)
Baserunner	31	616	4.0 (2.1, 5.8)
Batter	23	376	1.8 (0.7, 2.8)
Other	105	2112	21.5 (17.1, 26.0)
Basic Injury Mechanism			
Acute – Contact	97	2704	23.8 (18.0, 29.7)
Acute – Noncontact	177	4533	39.4 (33.3, 45.5)
Gradual / Overuse	177	3872	33.4 (27.9, 39.4)
Other	6	365	3.2 (0.1, 6.2)
Specific Injury Mechanism			
Pitching	180	4415	39.3 (33.2, 45.5)
Throwing	121	3019	26.9 (21.1, 32.7)
Non-throwing	153	3782	33.7 (27.6, 39.9)
Surgery			
Yes	42	806	7.1 (4.1, 10.1)
No	411	10192	88.6 (83.8, 93.5)
Unknown / Missing	4	475	4.3 (0.0, 8.7)
Outcome (Time Loss)			
1-6 days	148	3868	33.7 (27.7, 39.7)
7-13 days	75	2108	18.3 (12.9, 23.8)
14-29 days	79	1973	17.2 (12.4, 22.0)
30 + days	63	1434	12.5 (8.7, 16.3)
Season Ending	70	1671	14.5 (9.9, 19.2)
Career Ending*	1	12	0.1 (0.0, 0.3)
Athlete chooses to depart team*	16	301	2.6 (1.3, 3.9)
Athlete released from team*	5	107	0.9 (0.1, 1.8)

*Only reported for 2004-2009 seasons

ended the student-athlete's season. Freshmen made up the largest cohort (40.6%) of student-athletes with shoulder injuries (Figure 2). A summary of shoulder injury characteristics is provided in Table 5.

Elbow injury incidence rates

During the previously mentioned time-period, 281 elbow injuries in association with the same 804,740 AEs were reported to the ISS. The injury rate of all elbow injuries was 2.44 (95% CI = 2.09, 2.85) per 10,000 AEs, and during the period 2004 to 2014, the injury rate decreased by 48% from 4.0 to 2.1 injuries per 10,000 AEs (Figure 1). Division I student-athletes had a significantly higher rate of elbow injuries than those who play Division II. There were no other significant differences between Divisions (Table 6). Elbow injuries were more than twice as likely to occur during competitions compared to practice (IRR = 2.19; 95% CI 1.73, 2.78), (Table 7) and there were no differences in the injury rates between the times of season (Table 8).

Table 6. Elbow injury rates per 10,000 athlete-exposures (AEs) of elbow injuries among collegiate baseball student-athletes by division

	Injuries (n)	AEs (n)	Injury Rate* (per 10,000 AEs)	aIRR* (95% CI)
Total	281	804,740 ^d	2.4	
Division I	141	356202	3.1	Referent
Division II	48	177757	2.1	0.68 (0.49, 0.79) 1.47 (1.26, 2.04) [†]
Division III	92	269745	2.6	0.86 (0.66, 1.12) 1.16 (0.89, 1.51) [‡]
				DII vs DIII [‡] : 0.80 (0.56, 1.14)

* Adjusted by year and division;
[†] aIRR expressed as inverse ratio for interpretation of Division I relative to Division II and Division III, as appropriate
[‡] Referent category for specific aIRR
^d Total exposures and yearly exposures are greater than division exposures summary because of undefined division exposures
aIRR = adjusted injury rate ratio

Table 7. Elbow injury rates per 10,000 athlete-exposures (AEs) among collegiate baseball student-athletes by event type

	Injuries (n)	AEs (n)	Injury Rate* (per 10,000 AEs)	aIRR* (95% CI)
Total				
Practice	132	524720	1.6	Referent
Competitions	149	280021	3.6	2.19 (1.73, 2.78)

* Adjusted by year and division
aIRR = adjusted injury rate ratio

Table 8. Elbow injury rates per 10,000 athlete-exposures (AEs) among collegiate baseball student-athletes by season

	Injuries (n)	AEs (n)	Injury Rate* (per 10,000 AEs)	aIRR* (95% CI)
Preseason	88	257185	2.6	Referent
Inseason	182	514582	2.5	1.00 (0.77, 1.30) 1.00 (0.77, 1.29) [†]
Postseason	11	32974	3.1	1.19 (0.74, 2.0) 0.84 (0.50, 1.35) [‡]
				Inseason vs Postseason [‡] 0.82 (0.51, 1.32)

* Adjusted by year and division
[†] aIRR expressed as inverse ratio for interpretation of the preseason relative to the inseason and postseason, as appropriate.
[‡] Referent category for specific aIRR
aIRR = adjusted injury rate ratio

Elbow injury event characteristics

Throughout the study period among all Divisions, a national estimate of 7,375 elbow injuries (95% CI, 6,575, 8,175) were reported. The four most common injuries are listed in Table 9. Pitchers were identified for 62.1% of all elbow injuries, fielders made up 12.4% and offensive players claimed 12.9% of all elbow injuries. The majority of injuries (76.4%) were reported as new injuries, and 12.9% were recurrences from a previous season. The vast majority (82%) of the elbow injuries were non-contact. 47.4% were classified as an acute non-contact injury, and specifically, the majority of elbow injuries (56.3%) occurred while the student-athlete was pitching. 39.9% of elbow injuries resulted in a loss of playing time for two weeks or less while 28.9% ended the student-athlete's season. 17.5% of elbow injuries resulted in surgery. Freshmen (33%) and juniors (33.7%) made up approximately equal proportions of student-athletes with elbow injuries (Figure 3). A summary of elbow injury characteristics is provided in Table 10.

Table 9. Cases, national estimate (NE), and percentage of national estimate (%NE) of all elbow injuries, 95% confidence interval, of most common elbow injuries

Diagnosis	Cases	NE	%NE (95% CI)
Ulnar Collateral Ligament Sprain	127	3085	42.1 (34.2, 50.0)
Medial Epicondylitis	43	892	12.2 (8.2, 16.1)
Contusion	34	828	11.3 (7.0, 15.6)
Tendonitis	9	676	9.2 (3.2, 15.2)

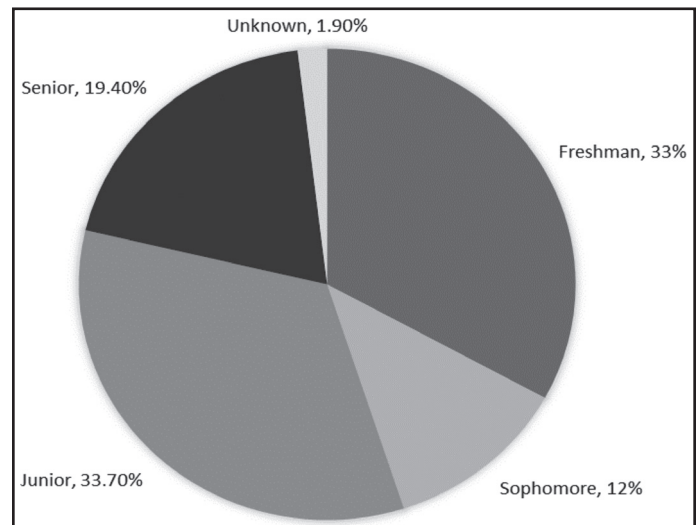


Figure 3. Elbow injury frequency by the student-athlete's academic year in school. Data available only for 2009-2014.

Discussion

This study used the National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISS) to analyze shoulder and elbow injuries among baseball student-athletes for a 10-year period from the 2004-2005 academic year through the 2013-2014 academic year. During this time, the overall injury rate for the shoulder was 4.02 (95% CI = 3.50, 4.60) per 10,000 AEs. Wasserman et al⁸ used the same data set as the current study, so the rates for comparison between shoulder or elbow injuries were not estimated. Dick et al.⁹ reported the injury rate for all body parts during competition and practice, separately, for NCAA baseball seasons between 1988-2004. Using the data provided, an overall shoulder injury rate of approximately 5.6 /10,000 AEs was estimated for that era. In comparison, the shoulder injury rate among high school baseball players is significantly lower at 1.4 - 2.3 injuries / 10,000 AEs.^{3,5} The literature describing major and minor league baseball shoulder injuries is less descriptive.^{6,12,13} However, the incidence of shoulder injuries is very comparable as 15% of all reported NCAA baseball injuries were shoulder injuries as compared to 19-21% among professional baseball.^{6,12,13}

The injury rate found in this investigation for the elbow was 2.44 (95% CI = 2.09, 2.85) / 10,000 AEs. A very similar rate of approximately 2.9 elbow injuries per 10,000 AEs was estimated for NCAA baseball student-athletes between 1988-2004.⁹ Similar to the

Table 10. Cases, National Estimate (NE), Percentage of national estimate (%NE), 95% Confidence Interval, for elbow characteristics

	Total		
	Cases	NE	%NE (95% CI)
Injury Recurrence			
New	219	5605	76.5 (69.5, 83.6)
Recurrent from Previous Season	32	945	12.9 (6.9, 18.9)
Recurrent from Same Season	27	773	10.6 (5.9, 15.2)
Baseball Position			
Pitcher	176	4556	62.3 (54.2, 70.2)
Infield	8	463	6.3 (0.6, 11.9)
Outfield	12	438	6.0 (11.6, 10.6)
Catcher	7	201	2.8 (0.0, 5.8)
Baserunner	4	117	1.6 (0.0, 3.4)
Batter	29	814	11.1 (6.1, 16.6)
Other	41	720	9.8 (6.5, 13.0)
Basic Injury Mechanism			
Acute – Contact	47	1283	17.5 (11.5, 23.8)
Acute – Noncontact	142	3482	47.6 (39.5, 55.3)
Gradual / Overuse	88	2533	34.6 (26.6, 42.7)
Other	1	25	0.3 (0.0, 1.0)
Specific Injury Mechanism			
Pitching	170	4130	56.4 (48.2, 64.4)
Throwing	54	1516	20.7 (14.0, 27.4)
Non-throwing	54	1677	22.9 (15.5, 30.5)
Surgery			
Yes	52	1282	17.5 (11.6, 23.4)
No	218	5654	77.2 (70.2, 84.2)
Unknown / Missing	8	386	5.3 (0.0, 8.7)
Outcome (Time Loss)			
1-6 days	59	1586	21.7 (3.5, 14.8)
7-13 days	38	1336	18.2 (11.0, 25.5)
14-29 days	46	1413	19.3 (12.9, 25.7)
30 + days	35	720	9.8 (6.2, 13.5)
Season Ending	92	2121	20.9 (22.1, 35.9)
Career Ending*	1	12.4	0.2 (0.0, 0.5)
Athlete chooses to depart team*	5	108	1.5 (0.17, 2.8)
Athlete released from team*	2	25	0.3 (0.0, 0.8)

*Only reported for 2004-2009 seasons

shoulder, when using a large national database, high school elbow injury rates were much lower at 0.86 /10,000 AEs.² The incidence of elbow injuries among professional baseball players has been reported to be 7.8-16.4% of all Major League injuries^{6,13,14} and 9.8-11.3% of all Minor League injuries.^{12,14} Our results are comparable as 9.1% of all injuries were to the elbow.

The injury rates of shoulder and elbow demonstrated similar trends as they marginally increased from 2004-2006 before peaking in 2006-2007 and then steadily decreased until a large reduction in 2009-2010. From 2009 through 2014 the injury rates have remained consistent (Figure 1). While differences in school participation rate and the data collection procedures may have created a reporting bias, thereby influencing the observed rate changes, the cause of the decline is uncertain. Starting in the early 2000s, attention was brought in the literature to the increasing rate of shoulder and elbow injuries among youth baseball players.¹⁵⁻¹⁷ As a result, the American Sports Medicine Institute released a position statement, which has since been updated, to address the increased rate of shoulder and elbow injuries among youth baseball players.¹⁸ Among high school baseball players, the shoulder injury rate decreased by approximately 50% from 2005 to 2007 and has since remained relatively stable.⁶ Elbow injury rates have slightly increased but have become consistent at approximately one elbow injury / 10,000 AEs.⁶ The attention given to the prevalence of upper extremity injuries in youth baseball may have increased the emphasis on injury prevention for the young players which translated into decreased injury rates of collegiate baseball players in subsequent years.

Division I baseball student-athletes showed a statistically significant increase of injury rate compared to Division II and III student-athletes for shoulder injuries (Table 1). Elbow injury rates are not as consistent as Division I student-athletes had significantly more injuries than only Division II student-athletes (Table 6). There were no differences between Division II and III for either shoulder or elbow injury rates. Similar differences of injury rates between NCAA Divisions in various sports and between the levels of professional sports have been reported.^{8,9,19-21} The cause of this difference between Divisions is multifactorial but most likely impacted

by the increased skill level and intensity of play in Division I athletics. Although many major league players transition directly from high school or from other countries into the minor league system, professional players who attended college are predominantly from Division I schools. As such, players who are more highly skilled and opt to go to college are more likely to play at Division I schools. These student-athletes, therefore, may have been exposed to more year-round baseball specific training and enter college with predisposing factors for shoulder and elbow injuries. Meanwhile, Division II and III baseball athletes may have been more diverse in their sports participation during high school which maintained the integrity of shoulder and elbow structures and decreased the opportunity for injury.

Distinctions in the regulations that govern practice and competition scheduling between Divisions do not appear responsible for injury rate differences. Divisions I and II have similar structures; however, Division I schools have significantly higher injury rates than Division II schools for shoulder and elbow injuries. For Division III schools, NCAA bylaws permit fewer exposure opportunities as they have fewer competitions, shorter durations of the non-championship segment season and preseason, and no organized off-season practices. However, Division III schools reported significantly lower injury rates only from Division I schools for shoulder injuries. There does not appear to be any consistent pattern to indicate that NCAA regulations influence the differences in shoulder and elbow injury rates between Divisions.

In the current study, injury rates were higher in competition versus practice for both shoulder and elbow injuries (Tables 2 and 6). These findings have been commonly described within other collegiate sports and high school baseball.^{2,5,8,9,19} It is hypothesized that the overall increase in injury rates during competition is due to many factors. During competition, there is an increase in speed and intensity of play as well as uncontrolled scenarios. Players exhibit riskier behavior such as aggressive base running, diving for balls, jumping and running into walls, and this is especially noteworthy when considering that the injury rate of contact injuries is approximately five times greater in competitions than practice for

Table 11. Acute contact injury rates per 10,000 athlete-exposures (AEs) among collegiate baseball players by event type

	Injuries (n)	AEs (n)	Injury Rate* (per 10,000 AEs)	aIRR* (95% CI)
Shoulder				
Practices	71	524720	0.36	Referent
Competitions	26	280021	1.85	5.10 (3.24, 8.02)
Elbow				
Practices	14	524720	0.020	Referent
Competitions	33	280021	0.088	4.44 (2.36, 8.33)

* Adjusted by year and division
aIRR = adjusted injury rate ratio

shoulders (rate ratio, 5.10; 95% CI, 3.24, 8.02) and elbows (rate ratio, 4.44; 95% CI, 2.36, 8.33) (Table 11). Two of the most common shoulder injuries are anterior dislocation/subluxation and acromioclavicular joint injuries which comprise 18.3% of all injuries (Table 4). Of these, 79.5% occurred during competition, and of those occurring in competition 57.6% were the result of contact with an “apparatus”, another person, or a surface. The majority of competition injuries occurred at first base, the outfield and second base. Although not specified, it may be inferred that the contact may frequently have been the result of a fielder diving for a ball or the interaction between a baserunner and the fielder or the environment. Camp et al.²² report that among MLB and minor league players shoulder injuries are the third most commonly injured body part with a sliding mechanism during competitions, specifically sliding head first. While not specifying the body region, Dick et al.⁹ emphasize the importance of sliding on NCAA injury rates as 13% of all competition related injuries were associated with a sliding

Table 12. Acute noncontact injury rates per 10,000 athlete-exposures (AEs) among collegiate baseball players by event type

	Injuries (n)	AEs (n)	Injury Rate* (per 10,000 AEs)	aIRR* (95% CI)
Shoulder				
Practices	91	524720	1.04	Referent
Competitions	86	280021	1.86	1.78 (1.32, 2.40)
Elbow				
Practices	63	524720	0.074	Referent
Competitions	79	280021	0.17	2.35 (1.68, 3.28)

* Adjusted by year and division
aIRR = adjusted injury rate ratio

mechanism. While much has been accomplished in attempt to reduce the number of sliding injuries, such as rule changes and the encouragement to use break-away bases and slide feet first, additional research to investigate their efficacy is necessary.

Interestingly, the injury rate of acute non-contact mechanisms occur almost twice as often during competition compared to practice for shoulders (rate ratio, 1.78; 95% CI, 1.32, 2.40) and elbows (rate ratio, 2.35; 95% CI, 1.68, 3.28) (Table 12). Acute non-contact injuries include those with a specific moment of onset while throwing, pitching or batting. Multiple causative factors may be responsible for this difference. Specific to pitchers, fatigue related changes in throwing mechanics have been demonstrated to occur during²³ a game and throughout a season.²³ Such changes in pitching mechanics may predispose the athlete to a shoulder or elbow injury. In contrast among fielders, specific game-related circumstances requiring increased throwing intensity or maximal effort throws across long distances, which occur infrequently, may result in throwing injuries. However, these factors are conjecture and have yet to be supported in the literature. Since 2009 the ISS has collected data specific to the time during the competition that an injury occurs, but there are currently too few cases to analyze. Continued accumulation and analysis of competition data is required to determine the circumstances during a competition that acute-noncontact shoulder and elbow injuries occur.

Shoulder and elbow injury rates are very similar during the preseason and the in-season. Wasserman et al.⁸ reported the same finding for all musculoskeletal injuries. This is in contrast to Dick et al.⁹ who found preseason rates to be significantly greater than the in-season rates for all musculoskeletal injuries. Since the end of the data collection by Dick et al, the Division I baseball preseason has been mandated to be a maximum of three weeks, which is very similar to Division II. During the period of this study, Division III baseball did not have specific guidelines for the championship segment. Given the natural history of overuse disorders, symptom onset from an overuse injury that started during the preseason may not manifest until the regular season. Thus, it would be designated as occurring during the in-season. Injury reports including time specific data

such as the month of the season or numbered week of the in-season would permit a clearer assessment of injury causation. Comparison of injury rates during the preseason and in-season across different eras may be inappropriate due to the differences in the duration of exposure and injury acquisition.

Prior to the 2007-2008 season the NCAA provided no specific guidelines regarding the start date of official practice or competitions during the championship segment of collegiate baseball in NCAA Division I. Effective 2007, the NCAA adopted bylaws specifically defining the practice and competition start dates during the championship segment (spring season). The first date that a team was permitted to play its first contest against outside competition was “the Friday in February that is 13 weeks before the Friday immediately preceding Memorial Day”. In addition, preseason practice was not permitted to start prior to February 1.²⁴ In 2009, the bylaws were revised to prevent the first contest against outside competition until “the Friday that is 14 weeks before the Friday immediately preceding Memorial Day” with caveats. The start of preseason practice during the championship segment was defined as “the Friday that is three weeks prior to the first permissible contest date”.²⁵ As a consequence of the initial revision in 2006, there was concern that the preseason would be shortened and the same number of games would be consolidated into a shorter in-season. Dick et al.⁹

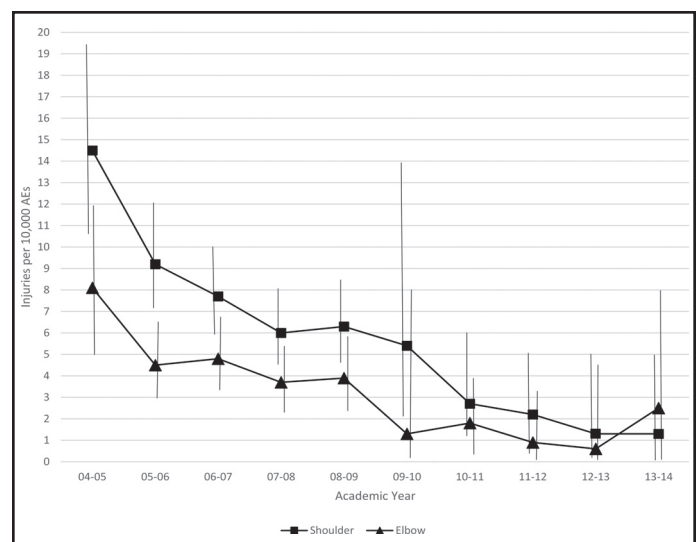


Figure 4. Shoulder and elbow injury rates per 10,000 athlete-exposures and 95% confidence intervals by academic year for Division I baseball student-athletes.

recommended a future evaluation of injury rates to determine if the rule change had impacted the injury occurrence. The results of this study indicate that since the 2006-2007 season, there have been appreciable and progressive decreases for both shoulder and elbow injury rates in Division I (Figure 4). Given our report, the 2006 and 2009 revisions in scheduling of the championship segment does not appear to have resulted in an increase of shoulder or elbow injury rates.

The distribution of shoulder and elbow injuries among the student-athlete academic years represents a unique characteristic for college baseball (Figures 2 and 3). As may be expected the injury frequency is greatest among freshmen as 40.6% of all shoulder injuries and 33% of all elbow injuries occur among this grade level. The cumulative increase in the volume and intensity of throwing, compared to high school, may account for this high proportion. Interestingly, the frequency drops significantly to 17.8% of shoulder injuries and 12% of elbow injuries for sophomores before escalating to 29% and 33.7%, respectively, among juniors. Similar proportions have been reported specifically for ulnar collateral ligament injuries.²⁶ As the student-athletes progress to their sophomore year, their throwing arms may become acclimated to the demands of a higher workload.

However, during the summer between the sophomore and junior seasons, more baseball student-athletes participate in summer leagues as they become draft eligible after the junior season. Also, as they become established in their respective college programs, the volume and intensity of throwing may increase during the junior year due to increased playing time. This accumulation of workload during the summer, and potentially during the season, may result in the relatively elevated injury frequency during the junior year. Another source of variability for activity level among juniors could be transfer students. During the period of this study, 18-23% of all Division I and II baseball players had transferred from a community college or a two-year college.^{27,28} This transition may be comparable to a freshman with a significant increase in volume and intensity of throwing. Consequently, coaches and the sports medicine staff should be

sensitive to the potential for shoulder and elbow injuries among freshmen and juniors. Extra vigilance should be given to the management of upper extremity stress from throwing and pitching during these times.

Shoulder and elbow injuries have distinct characteristics with regard to return to play (Tables 5 and 10). 52% of shoulder injuries returned to play within two weeks, and 14.5% qualified as a season-ending injury. Of the student-athletes who injured their elbow, 39.9% returned to play in 2 weeks, and the injury ended the season for 28.9% of them. Only 7% of shoulder injuries resulted in surgery. The majority of surgeries addressed superior labral injuries (32.3%), anterior dislocation/subluxation injuries (23.4%), and rotator cuff injuries (21.2%). Over twice as many elbow injuries (17.5%) resulted in surgery, and the most common injuries resulting in surgery was to the UCL (68.7%), capsular sprains (8.8%), olecranon fractures (6.5%) and medial epicondylitis (4.7%). While shoulder injuries have a higher injury rate, elbow injuries have greater morbidity resulting in a greater impact on lost playing time.

LIMITATIONS

Although this is one of the most extensive reports on shoulder and elbow injuries among NCAA student-athletes who play baseball, there are limitations which are inherent to surveillance systems. The participants are volunteer, so they comprise a convenience sample that may not be representative of all NCAA baseball programs. Various information biases must also be acknowledged. Specifically, since the sports medicine staff enters the data without diagnostic criteria, the requirement of physician evaluation or diagnostic testing, there is a risk of misclassification of specific injury types. Due to changes in the ISS methodology that occurred during the 2004-2005 and 2009-2010 academic years, there has been a significant decrease in participants¹¹ which is exemplified by the large confidence intervals. Given these concerns for the assessment of injury rates, the influence of Division and academic year were statistically controlled, and national estimates that weighted the data based on the variation in school participation between

Divisions and years were also used. Because the ISS does not collect injury data during the non-championship segment of the baseball season, the results only describe injuries that occurred during the championship segment. Injury data from the non-championship segment may provide a more complete description of injury incidence among collegiate baseball student-athletes. Given the high quality control of the data¹¹ and the good validity of the ISS²⁹, it appears to provide valid injury estimates which are, at this time, the most descriptive data collection of NCAA baseball injuries.

CONCLUSION

This study is the first comprehensive analysis of shoulder and elbow injuries in college baseball student-athletes. Although injury rates to these body regions appear to have decreased in the past decade, the morbidity of injuries to the throwing arm, especially the elbow, demands special consideration by sports medicine personnel. Analyzing these trends will lead to a better understanding of possible mechanisms or deficiencies leading to the injuries. Also, consideration of the increased occurrence of injury to freshmen and juniors may lead to prevention programs specific to changes in the workload on their throwing arm. While workload recommendations have been made for youth and adolescent pitchers and catchers to prevent injuries,¹⁸ future research may investigate possible throwing recommendations for collegiate student-athletes and all positions.

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