

Evaluation of Elbow and Shoulder Problems in Professional Baseball Pitchers

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ABSTRACT

When a professional athlete injures an elbow or shoulder, the uninjured joint must receive as much attention as the injured joint. Is there a relationship between injury of one joint and subsequent injury of the other joint?

In the prospective study reported here, we created a database (a) to determine whether injury to one joint was more likely to result in a problem with the other joint and (b) to analyze for trends and correlations. A survey was administered to all pitchers on a professional baseball team to collect data about shoulder and elbow problems during their careers. Eighty-four pitchers (737 seasons of experience, 52 index injuries) were evaluated.

Of the injured players, 27 were treated surgically. Risk for later injury was 4.6 times larger for players who had an index surgery than for those who had not. Of the players who had ulnar collateral ligament (UCL) reconstruction, 42% later sustained a shoulder injury. No player with rotator cuff surgery sustained a subsequent elbow or shoulder injury. There were significantly more upper extremity injuries with right-handed throwers. An elbow injury was more likely to result in shoulder problems, specifically after UCL reconstruction. Players who required surgery were almost 5 times more likely to have a later injury or surgery than players who did not require surgery.

The throw is an integral component of many sports, but it is used most often and effectively in baseball,¹⁻⁵ particularly by professional pitchers, for whom shoulder and elbow injuries are common.⁶ The kinetics of throwing indicate that kinetic energy in the throwing arm is much higher than the kinetic energy

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in the kicking leg, because the rotation and torque of the arm are about twice that of the leg. The pitching arm has 4 times as much kinetic energy as the kicking leg. The result of these conditions is that severe overloading predisposes the upper extremity to injury in throwing.⁷

Authors have described the frequency of elbow and shoulder pain in young athletes.^{6,8-12} Thirty percent to 50% of athletes in youth programs experience elbow and shoulder pain.^{13,14} However, higher-level pitchers produce higher shoulder and elbow angular velocities, which, combined with higher arm angular velocity and a longer arm, result in a higher linear ball velocity.⁶ No one has evaluated the frequency of shoulder and elbow problems in professional baseball pitchers or the possible relationship between such injuries.

In the study reported here, we sought to determine the frequency of shoulder and elbow problems in professional baseball pitchers and to identify any relationship between injury in these joints. The null hypothesis is that an injury of one joint does not make injury in the other joint more

DEMOGRAPHICS Date of Survey: _____					
Age: _____	Dominance: R: _____	L: _____	Years Pitching: _____	Prior to Signing FIS: _____	After Signing Minor League: _____
Primary Position Prior to Signing: _____			College: _____	Other: _____	Major League: _____
Secondary Position Prior to Signing: _____			TOTAL: _____		
INDEX SURGERY - Initial Injury					
Level at which injury occurred: _____					
Age: _____	Elbow _____	Shoulder _____	Date: _____	PreOp Diagnosis: _____	College: _____
Effectiveness on Return: 1 2 3 4 5			Treatment: _____		
			PostOp Diagnosis: _____		
1 = Worse 5 = As effective or Better					
ADDITIONAL SURGERY TO SAME JOINT AS ABOVE					
Level playing when second surgery occurred: _____					
Age: _____	Date: _____				
Effectiveness on Return: 1 2 3 4 5					
			1 = Worse 5 = As effective or Better		
SECOND JOINT FOLLOWUP					
Level at which second injury occurred: _____					
Months/Years after Initial Surgery: _____			PreOp Diagnosis: _____		
Effectiveness on Return: 1 2 3 4 5			Treatment: _____		
			PostOp Diagnosis: _____		
1 = Worse 5 = As effective or Better					
Age: _____	2 nd Joint Problem _____	Date _____	Months _____		
Elbow _____					
Shoulder _____					
Record:					
Prior to Initial Surgery			Post Initial Injury/Prior to Second Surgery		
Won/Loss _____			Won/Loss _____		
ERA _____			ERA _____		
POSITION CHANGE:					
Initial Position	Return as:				
Starter	Starter	Reliever	Position Player		
Reliever	Starter	Reliever	Position Player		
PROSPECTIVE GROUP STUDY					
Single joint problems follow 2 years					
Control = Pitchers with shoulder/elbow surgery					

Figure. Shoulder survey used in this study.

likely. We also sought to establish a database that could be studied prospectively to determine whether injury to one joint was more likely to result in a problem with the other joint.

MATERIALS AND METHODS

At the start of spring training for the Chicago White Sox, a professional baseball team, all players provide complete histories and receive physical examinations. During the examinations, we surveyed the team's pitchers about shoulder and elbow problems during their careers. All players' history information is kept in the Major League baseball computerized database, which is available to professional baseball organizations.

We developed the shoulder survey in collaboration with the team's medical personnel (Figure). The survey was conducted with approval of the Human Subjects Institutional Review Board (BSC B03.154). Eighty-four professional baseball pitchers were administered the survey in interview format, and the previous data from their professional baseball careers were included and analyzed. Table I lists the survey results.

SPSS-X software was used to analyze the frequency and χ^2 statistics of the survey data. Frequency distributions provided a description of specific characteristics of this population: demographic information, experience, injury type, surgical treatments, and injury recurrence. We used χ^2 to test independence, to examine the association or lack of association between any 2 categorical variables. Variables in which the test value (χ^2) exceeded the critical value listed in the statistical table for $P \leq .05$ were statistically significant and indicated a significant relationship between the variables.

RESULTS

Demographics

We surveyed 84 pitchers (12 Major League, 72 Minor League). Mean age was 23.5 years (range, 18-37 years). Fifty-eight pitchers were right-handed throwers, and 26 were left-handed throwers. Sixty-three players had a mean of 3.58 years of high school experience, 51 had a mean of 2.7 years of college experience, 79 had a mean of 3.08 years of Minor League experience, and 17 had a mean of 3.94 years of Major League experience. The group of pitchers had a total of 737 seasons of baseball experience (mean, 8.76 seasons/pitcher). Mean number of seasons was 8.21 per left-handed pitcher, 9.05 per right-handed pitcher.

Index Injury

Fifty-two index injuries resulted in days lost. Twenty of these injuries involved shoulder joints; the other 32 involved elbow joints. There were .0839 upper extremity injuries per 100 participants per season—or, .032 shoulder injuries and .0516 elbow injuries per 100 participants per season ($\chi^2_1 = 15.7$, $P < .001$).

Right-handed pitchers ($N = 58$) had 18 index shoulder problems and 24 elbow problems (total, 42). In contrast, left-handed pitchers ($N = 26$) had 2 index shoulder prob-

lems and 8 elbow problems (total, 10). Ten left-handed pitchers (38.5%) and 42 right-handed pitchers (72.4%) reported injuries resulting in days lost. Chi-square analysis of hand dominance and injury incidence showed that right-handed pitchers had significantly more injuries than left-handed pitchers ($\chi^2_1 = 8.775$, $P = .003$).

Left- and right-handed pitchers did not differ with respect to injury type (contusion, inflammation, strain, sprain, bursitis, fracture, nerve compression, ligament tear). On the other hand, there was a statistically significant difference in the relationship between hand dominance and injury site (elbow, shoulder). Of the right-handed pitchers, 24 (41.4%) had elbow injuries, and 18 (31.0%) had shoulder injuries. Of the left-handed pitchers, 8 (30.8%) had elbow injuries, but only 2 (7.7%) had shoulder injuries ($\chi^2_2 = 10.071$, $P = .007$).

The preponderance of injuries occurred during professional-level play. Of the 20 index injuries to the shoulder, 18 occurred in professional leagues, and only 2 in high school. Of the 32 elbow injuries, 23 occurred in professional leagues, 5 in college, and 3 in high school. Mean age of players with shoulder injuries was 22.75 years, and mean age of players with elbow injuries was 24.8 years. Age was not associated with injury incidence in this population ($\chi^2_{16} = 15.941$, $P = .457$).

Index Surgeries

Of 52 injured players, 27 were treated surgically. Surgical treatment was required for inflammation, fracture, nerve injury or compression, ligament reconstruction, and rotator cuff tear. Of the 27 index surgeries, 4 involved shoulders (management of internal impingement by débridement of rotator cuff tear and repair of slap lesion), and 23 involved elbows (12 ulnar collateral ligament [UCL] reconstructions, 3 ulnar nerve transpositions, 3 arthroscopic débridements of loose bodies, 1 open reduction and internal fixation of a radial head fracture, 1 repair of fractured radius/ulna, 1 radial nerve decompression, 2 arthroscopic synovial débridements). Mean age of players who had elbow surgery was 23.4 years, and mean age of players who had shoulder surgery was 23.5 years.

Injury After Index Injury or Surgery

There were 12 injuries (23.1%) after the index injury or surgery. Ten of 27 players who underwent surgery had a subsequent injury, whereas only 2 of 25 players who did not undergo surgery had another injury ($\chi^2_1 = 6.16$, $P = .013$). There were 4 elbow injuries and 8 shoulder injuries. Of the elbow injuries, 1 occurred after shoulder surgery, 2 after elbow surgery, and 1 after forearm surgery. Of the shoulder injuries, 6 occurred after elbow surgery and 2 after shoulder surgery. Five of the 8 shoulder injuries occurred after UCL reconstruction. Players who had index surgery were substantially more likely than no-surgery players to have a subsequent injury (relative risk, 4.63). More surgically treated players reported shoulder injury ($N = 7$, 25.9%) than elbow injury ($N = 3$, 11.1%) after their

Table I. Survey Results of Elbow and Shoulder Problems in Professional Baseball Pitchers

Index	Age (y)	Dominant Hand	Index Injury	Injury Type	High School	College	Professional	Index Surgery	Injury/ Procedure	Age (y) at Surgery
1	25	R	Elbow	Inflammation			Elbow	Elbow	UCL reconstruct	21
2	22	R						N/A		
3	26	R	Shoulder	Inflammation			Shoulder	N/A		
4	22	L						N/A		
5	22	L	Elbow	Inflammation			Elbow	Elbow	UCL reconstruct	20
6	24	R	Elbow	UN transpose		Elbow		Elbow	UCL reconstruct	23
7	19	L						N/A		
8	23	L						N/A		
9	22	L						N/A		
10	23	L						N/A		
11	29	R	Elbow	Sprain			Elbow	N/A		
12	28	R	Shoulder	Inflammation			Shoulder	Shoulder	Lab-SLAP/RTC	22
13	22	L	Shoulder	Inflammation			Shoulder	N/A		
14	25	R	Elbow	Inflammation			Elbow	Elbow	UCL reconstruct	23
15	21	R	Elbow	Strain			Elbow	N/A		
16	22	R	Shoulder	Inflammation			Shoulder	N/A		
17	27	R	Shoulder	Inflammation			Shoulder	N/A		
18	23	R						N/A		
19	18	R	Elbow	Inflammation	Elbow			N/A		
20	23	R	Elbow	Inflammation			Elbow	Elbow	UN transpose	21
21	22	R	Elbow	Inflammation			Elbow			
22	23	R	Elbow	Contusion			Elbow	N/A		
23	23	R	Shoulder	Inflammation			Shoulder	N/A		
24	25	R						N/A		
25	26	R						N/A		
26	19	R	Elbow	Inflammation			Elbow	N/A		
27	35	R	Shoulder	Inflammation			Shoulder	Elbow	UCL reconstruct	31
28	19	R	Shoulder	Inflammation			Shoulder	N/A		
29	19	L						N/A		
30	37	R	Elbow	Inflammation			Elbow	Elbow	Bone chips	25
31	20	R	Forearm	Strain	Forearm			N/A		
32	22	R	Elbow	Olecranon fx			Elbow	Elbow	Olecranon screw	24
33	19	R	Shoulder	Inflammation	Shoulder			N/A		
34	27	L	Elbow	Inflammation		Elbow	Elbow	Elbow	UCL reconstruct	26
35	27	R	Shoulder	Inflammation			Shoulder	Shoulder	Lab-SLAP/RTC	26
36	24	R	Elbow	Radial head fx			Elbow	Elbow	Radial head fx	22
37	28	R	Elbow	Strain			Elbow	Elbow	UCL reconstruct	22
38	22	R						N/A		
39	23	R						N/A		
40	31	R	Shoulder	Inflammation			Shoulder	Elbow	Bone chips	23
41	18	R						N/A		
42	23	R	Elbow	Inflammation			Elbow	N/A		
43	22	L	Elbow	Inflammation			Elbow	N/A		
44	28	L	Elbow	Strain			Elbow	Elbow	UN transpose	24
45	19	R						N/A		
46	21	L						N/A		
47	23	R	Shoulder	Inflammation			Shoulder	N/A		
48	24	L						N/A		
49	28	R	Elbow	Inflammation		Elbow		Elbow	Débride	19
50	20	R	Elbow		Elbow			Elbow	Bursa débride	18
51	21	R	Shoulder	Inflammation			Shoulder	N/A		
52	20	L						N/A		
53	24	L	Elbow	Inflammation			Elbow	N/A		
54	18	L						N/A		
55	23	R	Elbow	Inflammation			Elbow	Elbow	Spur/loose bodies	21
56	20	R	Shoulder	Inflammation			Shoulder	N/A		
57	23	R	Shoulder	Inflammation			Shoulder	N/A		
58	25	L						N/A		
59	24	R	Shoulder	Inflammation	Shoulder			N/A		
60	22	L						N/A		
61	20	L	Shoulder	Inflammation			Shoulder	N/A		
62	30	L						N/A		
63	25	R	Elbow	Inflammation	Elbow			Elbow	UCL reconstruct	24
64	24	R	Shoulder	Inflammation			Shoulder	Shoulder	Lab-SLAP/RTC	22
65	21	R						N/A		
66	22	L						N/A		
67	22	L						N/A		
68	18	L	Forearm	Forearm fx	Forearm			Forearm	Radius/ulna fx	
69	20	R						N/A		
70	23	R	Elbow	Inflammation		Elbow		Elbow	RN decompress	21
71	23	L	Elbow	Inflammation			Elbow	N/A		
72	24	L						N/A		
73	21	R	Elbow	Inflammation			Elbow	Elbow	UCL reconstruct	19
74	22	L						N/A		
75	22	R						N/A		
76	21	L	Shoulder	Inflammation			Shoulder	N/A		
77	22	R	Shoulder	Inflammation			Shoulder	N/A		
78	23	R	Elbow	Sprain		Elbow		Elbow	UCL reconstruct	19
79	34	R	Elbow	Sprain			Elbow	Elbow	UCL reconstruct	26
80	24	R	Shoulder	Inflammation			Shoulder	Shoulder	Lab/RTC	22
81	25	R	Elbow	Sprain			Elbow	N/A		
82	30	L	Elbow	Inflammation			Elbow	Elbow	UN transpose	24
83	26	R	Elbow	Inflammation			Elbow	Elbow	UCL reconstruct	22
84	29	R						N/A		

*N/A indicates not applicable; UN transpose, ulnar nerve transposition; fx, fracture; débride, débridement; UCL reconstruct, ulnar collateral ligament reconstruction; lab, labrum; SLAP,

Level	Postsurgical Injury	Follow-Up Surgery	Age (y)	Diagnosis	Level	Years of Experience				
						High School	College	Other	Minor	Major
A	N/A	N/A				4 1	3 3 2		4 2 5	
A A	N/A	N/A				4 2 2	3 1 2	2 8	3 6 2	2
A	N/A	N/A				2	2	5	5.5 6	5.5 1
A	Shoulder	N/A				4 4 4	3 4 3		4 1 5	
A	N/A	N/A				3 3	4 2	3	7 2	
A	N/A	N/A				4 4	3	6	Rookie 4 1	
	Elbow	N/A				4 4 4	3		3.5 2	2.5
Major	Shoulder	N/A				4 4 4			1.5 7	1.5 2
Major	Elbow	Elbow	36	Bone chips	Major	4 4 4	4		2 2	15
Rookie						4 3 3	4		1 1	
AAA	N/A	N/A				4	2		7	1
AAA	N/A	N/A				4	1		5	
Rookie	N/A	N/A				4	4		3	4
A	N/A	N/A				4 4 4	3 4		1 1 1	
AA	N/A	N/A				4 3 4			4 1 5	7
Major	N/A					2 3 4	6	3	5 1	
						4 4 4	1		1 1	
						2 3 2	2		2 6	
College High school	Shoulder N/A	N/A N/A				3 4	4		1 1	
						4	4	0.3	4	
A	N/A	N/A					1	3	Rookie 3 1	2
	Shoulder	N/A				4 4 4	3 4 1		7 4 2	
AA	N/A	N/A				4	3		9	1.5
AAA	N/A	N/A				4 3	3		4 3.5	0.5
						3		2	3 2	
Age 10	Elbow	N/A				4 4	3		1 1	
College	Elbow	Elbow	22	RN decompress	Rookie	4 4 4	2 3		1 1 4	
A	Shoulder	Shoulder	20	RTC/débride		4 4	3 3		4 4 1	
						4 4 4			1 3 4	
College Major A	N/A Shoulder N/A	N/A N/A N/A				4 4 4	5 3 3		1 4 5	8
A	Shoulder	Shoulder	29	Lab-SLAP/RTC	Major	3	3		2	1.5
A	Shoulder	Shoulder	25	Lab-SLAP/RTC	AAA	4 1	3 4		7 4	3
						1	4	2	Rookie	

SLAP lesion; RCT, rotator cuff repair; RN decompress, radial nerve decompression.

Table II. Survey Results of Elbow and Shoulder Problems in Professional Baseball Pitchers (2003 Chicago White Sox, Major and Minor Leagues)*

	n
Major League pitchers	12
Minor League pitchers	72
Total	84
Injuries resulting in days lost	49
Shoulder	
Index injuries	18
Index surgeries	4
Elbow	
Index injuries	28
Index surgeries	22
Forearm injuries	3
Surgeries after index surgeries	5
Shoulder-shoulder	0
Shoulder-elbow	0
Elbow-shoulder	3
Elbow-elbow	2
Injuries after surgery	9

*Index injury = first reported injury resulting in time lost; index surgery = first surgical procedure.

index surgery ($\chi^2_2 = 6.33, P = .042$).

The joint treated with index surgery was not significantly associated with postoperative injury to shoulder or elbow, but χ^2 analysis of postoperative injury site and index surgery type revealed a significant difference between outcome by surgery type ($\chi^2_{26} = 52.98, P = .001$). There were more shoulder injuries after UCL reconstruction ($N = 5$) than after all other procedures combined ($N = 2$). Of the players who had UCL reconstruction, 5 (41.7%) sustained a shoulder injury after recuperation. By contrast, no player who underwent rotator cuff repair sustained a subsequent elbow or shoulder injury.

Follow-Up Surgery

The 84 pitchers had a total of 32 surgical procedures, 27 of which were index surgeries. After the index surgery, 5 additional surgeries were performed: 3 shoulder surgeries after index elbow surgery and 2 elbow surgeries after index elbow surgery (there were no elbow surgeries after index shoulder surgery and no shoulder surgeries after index shoulder surgery). No player in the no-index-surgery group ($N = 25$) required surgery later.

Neither the relationship between index injury and postsurgical injury nor the relationship between index injury and additional surgery was statistically significant. However, college A-level players and professional players had an injury or additional surgery after index surgery, whereas AA, AAA, and other Minor League players did not. Table II summarizes all the results for these pitchers.

DISCUSSION

The biomechanics of throwing indicate that shoulder and elbow angular velocities are produced by high-level pitchers through the arm-cocking and acceleration phases of throwing. The combination of higher angular velocity and a longer arm resulted in higher linear ball velocity for the higher-level pitcher.^{6,7,15} The speculation has been that proper mechanics and adequate strength helped to prevent injury from these stronger forces.⁶ As noted, the ability to generate sufficient elbow varus torque may result in medial tension, lateral compression, or posteromedial impingement injury. The lateral humeral joint forces can cause anterior glenolabral tear or tensile rotator cuff failure. Apparently, any event or injury that alters these normal mechanics may lead to new or recurrent injury.¹⁵

Previous investigators of throwers' injuries have examined individual shoulder and elbow problems. They have studied the effect of pitching type, number of pitches, and the mechanics of throwing on the risk for elbow and shoulder problems.^{13,16,17} With some younger pitchers, applied forces apparently can be counteracted by altering pitching type, pitching frequency, and mechanics.^{5,13} With older or professional athletes, however, forces and throw frequency overcome the intrinsic integrity of the shoulder and elbow. It appears that the majority of problems in younger athletes do not result in permanent injury or need for surgery.^{6,8-10} On the other hand, in older athletes, reconstructive surgery for elbows and shoulders has been relatively common,^{2,4} possibly the result of factors that include social and economic pressure to return to play more quickly and to play injured. No previous work indicates what the relationship is between shoulder and elbow injuries in a group of professional baseball pitchers.

The purpose of this study was to try to evaluate this relationship and to determine if an injury in one joint was more likely to produce an injury in another joint. We saw significantly more injuries overall in right-handed throwers. In addition, there were significantly more shoulder injuries in right-handed pitchers than in left-handed pitchers. In both groups, there were more elbow problems than shoulder problems. Right-handed pitchers were almost twice as likely as left-handed pitchers to experience upper extremity injury. We hypothesize that left-handed throwers reach a higher competitive level, meaning they are able to get to the professional level, at a younger age and can reach a higher level without the force of velocity of pitches because of the advantage that left-handed throwers have in professional baseball.

Second, elbow injury was more likely to result in shoulder problems, particularly after UCL reconstruction. In addition, more than half the surgical procedures ($N = 23$) performed for elbow problems were UCL reconstructions ($N = 12$). Players who required surgery were almost 5 times more likely to have a later injury than players who did not require surgery.

We can speculate why elbow problems were more often associated with shoulder problems and, in particular, why

UCL reconstruction was more often associated with shoulder problems. Elbow surgery may change the biomechanics of throwing and put more tensile load on the shoulder, or more external rotation of the shoulder may be required, resulting in more anterior laxity and increasing the likelihood of internal impingement and rotator cuff injury. The results of medial overload at the elbow include injuries to the UCL and the flexor pronator group as well as inflammation and neuritis of the ulnar nerve with compression syndrome and permanent deformity, which may include medial side spurs on the epicondyle, the coronoid, or the olecranon, resulting in elbow flexion contracture.⁵ When the elbow is constrained as the result of injury or surgery (with resultant tightening of the medial side) or of elbow flexion contracture, stronger forces may be applied to the shoulder.

Severe injury may lead to additional injury or need for surgery. However, it seems unusual to find such a dramatic association between UCL reconstruction and additional injury or surgery. Therefore, it is important to maintain good strength, flexibility, and mechanics in the shoulder and not ignore this part of the kinetic chain after such complex reconstructive surgery. It is also possible that unrecognized weakness of the shoulder girdle was the weak link in the kinetic chain, leading to elbow injury. Again, this emphasizes the importance of addressing the entire kinetic throwing chain in preventing and treating such injuries.

The information collected in this study provides a database that we can continue to follow, as some players who had elbow problems did not sustain additional injury or require shoulder or elbow surgery. According to our search of the literature, there are no other reports on injury rates in professional baseball players or on the relationship between elbow and shoulder injuries. This study provides unique information that can delineate these functional relationships and better define the epidemiology of upper extremity injury in throwing athletes. It appears that the null hypothesis has been disproved and that there is a rela-

tionship between elbow injury and shoulder problems both after injury and after surgery.

AUTHORS' DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

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