

Epidemiology of shoulder and elbow pain in youth baseball players

Running title: Shoulder elbow pain youth baseball players

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1 **Abstract**

2 **Objectives:** There are relatively few published epidemiological studies examining the
3 differences in the risk of shoulder and elbow pain in young baseball players. Risk
4 factors for shoulder pain are different from those for elbow pain in child and adolescent
5 baseball players.

6 **Methods:** A total of 1563 players aged 7 to 12 years participated in this investigation.
7 Subjects were asked whether they had experienced episodes of shoulder or elbow pain.
8 We investigated the following risk factors for shoulder and elbow pain: age, position,
9 years of baseball experience, and training hours per week. Data from the groups with
10 and without shoulder and elbow pain were analyzed using multivariate logistic
11 regression models.

12 **Results:** Among the 1563 participants, 15.9% and 29.2% reported episodes of shoulder
13 and elbow pain, respectively. Multivariate analysis showed that shoulder pain was
14 associated with age 10, 11, and 12 years, and that elbow pain was associated with age
15 10, 11, and 12 years, playing catcher, and >2 years of baseball experience. Training
16 hours per week were not associated with either shoulder or elbow pain.

17 **Conclusion:** In over 1000 baseball players aged 7 to 12 years, 15.9% reported episodes
18 of shoulder pain, while 29.2% reported elbow pain in the throwing arm. The associated
19 risk factors were different for each type of pain. Shoulder pain was associated with

20 increased age while elbow pain was associated with increased age, increased years of
21 baseball experience, and playing catcher.

22

23 **Keywords:** Shoulder; Elbow; Epidemiology; Child; Adolescent; Baseball

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25

26 **Introduction**

27 Baseball players are at risk of shoulder and elbow problems, and with the rising
28 incidence of such problems, research has increasingly focused on causes of injury. Pitch
29 counts [1, 2], types of pitch [1], and velocity of pitches [3, 4, 5] have been associated
30 with onset of injuries. Throwing requires a complex series of coordinated motions to
31 efficiently transfer large forces and high amounts of energy from the legs, back, and
32 trunk through individual body segments to the arm and hand [6]. The movement of
33 these individual segments is linked through muscle activity and body position,
34 transferring kinetic energy from the base to the terminal segment and eventually to the
35 ball [6]. This concept is called the kinetic chain. Changes in kinetic chain function can
36 lead to motions and forces that may injure the labrum and rotator cuff and stretch the
37 shoulder capsule [7, 8]. It is believed that at higher competition levels, many shoulder
38 and elbow injuries that require medical attention are a result of cumulative microtrauma
39 that began at the youth level. Such throwing injuries are most commonly due to the
40 accumulation of microtrauma from the repetitive throwing motion [9]. Many
41 experienced sports medicine professionals believe that shoulder or elbow pain in a
42 young player is a warning sign of overuse injury.

43 Lyman et al. [1] followed 298 youth baseball pitchers (9–12 years old) for 2

44 consecutive spring seasons. They found that the frequencies of shoulder and elbow pain
45 were 32% and 26%, respectively, and that the factors associated with shoulder and
46 elbow pain were different. Shoulder pain was associated with pitches thrown per season
47 and pitches thrown per game [1]. On the other hand, the risk factors for elbow pain were
48 increased age, arm fatigue during the game, and pitches thrown per season [1]. A
49 subsequent study by the same authors made several similar conclusions [10]. The risk of
50 shoulder and elbow pain from playing catcher, infield, or outfield without pitching was
51 not examined in that study. There is a paucity of epidemiologic data regarding
52 nonpitchers. Risk factors for shoulder or elbow pain in nonpitchers are expected to be
53 different from those in pitchers. This is because throwing from the infield, outfield, or
54 catcher position is different from pitching, as well as because pitchers accumulate
55 higher numbers of throws. The current study is the first to investigate shoulder and
56 elbow pain in entire teams of young baseball players.

57 **Materials and methods**

58 **Study participants**

59 A total of 1963 players participated in the regional summer championship in July
60 2012. They belonged to youth baseball teams. Of 1963 players, 1563 players (79.6%)
61 completed the survey. Of 1563 players, 1504 were male and 59 were female. No

62 surveys were excluded.

63 **Study procedures**

64 This study was approved by the institutional review board of [REDACTED]
65 [REDACTED], and all parents and coaches provided informed consent.

66 Questionnaires were distributed to team coaches and were filled out by subjects with
67 the assistance of coaches and/or parents. Subjects were asked whether they had
68 experienced episodes of shoulder or elbow pain that resulted in participation restriction
69 for ≥ 1 day. The questionnaire was also used to gather data on age, position, years of
70 baseball experience, and training hours per week. The position that was chosen was the
71 one that was played most. **Training hours per week included hours spent in practice, the
72 bullpen, and games.** Data were collected by mail. The first author ([REDACTED]) reviewed the
73 questionnaire with each subject to increase the players' understanding of the questions
74 and checked the accuracy of the information. We investigated the following risk factors
75 for shoulder and elbow pain: age, position, years of baseball experience, and training
76 hours per week.

77

78 **Statistical analysis**

79 Data were analyzed by multivariate logistic regression and presented as odds ratio

80 (OR) and profile likelihood 95% confidence interval (CI) values. The likelihood-ratio
81 test was also performed. A two-tailed P value $<.05$ was considered significant. All
82 analysis was done using the SAS software package (version 8.2).

83 **Results**

84 Of the 1563 subjects, 249 (15.9%) reported episodes of shoulder pain and 456
85 (29.2%) reported elbow pain in the throwing arm.

86 Potential risk factors associated with shoulder pain are summarized in Tables 1 and
87 2. Univariate analysis showed that shoulder pain was significantly associated with age
88 10 ($p<.05$), 11 ($p<.0001$), and 12 years ($p<.0001$); playing pitcher ($p<.01$), catcher
89 ($p<.01$), and infielder ($p<.01$); and baseball experience of ≥ 2 but <3 years ($p<.05$), ≥ 3
90 but <4 years ($p<.01$), ≥ 4 but <5 years ($p<.001$), and ≥ 5 years ($p<.0001$) (Table 1). The
91 number of training hours per week was not significantly associated with shoulder pain.
92 Multivariate analysis of these variables showed that age 10 (OR, 1.95; 95% CI, 1.04–
93 3.81), 11 (OR, 3.12; 95% CI, 1.71–6.01), and 12 years (OR, 3.14; 95% CI, 1.64–6.29)
94 were risk factors significantly associated with shoulder pain (Table 2). Playing position
95 and years of baseball experience were not significantly associated with shoulder pain.

96 Potential risk factors associated with elbow pain are summarized in Tables 3 and 4.
97 Univariate analysis showed that elbow pain was significantly associated with age 10

98 (p<.0001), 11 (p<.0001), and 12 years (p<.0001); playing pitcher (p<.0001), catcher
99 (p<.0001), and infielder (p<.0001); and baseball experience of ≥ 2 but <3 years
100 (p<.0001), ≥ 3 but <4 years (p<.0001), ≥ 4 but <5 years (p<.0001), and ≥ 5 years
101 (p<.0001) (Table 3). The number of training hours per week was not significantly
102 associated with elbow pain. Multivariate analysis of these variables showed that age 10
103 (OR, 3.02; 95% CI, 1.60–6.15), 11 (OR, 5.05; 95% CI, 2.73–10.14), and 12 years (OR,
104 6.78; 95% CI, 3.57–13.88); playing catcher (OR, 1.56; 95% CI, 1.01–2.39); and
105 baseball experience of ≥ 2 but <3 years (OR, 1.69; 95% CI, 1.09–2.65), ≥ 3 but <4 years
106 (OR, 2.56; 95% CI, 1.63–4.12), ≥ 4 but <5 years (OR, 2.60; 95% CI, 1.55–4.42), and ≥ 5
107 years (OR, 3.55; 95% CI, 1.93–6.62) were risk factors significantly associated with
108 elbow pain (Table 4). Playing pitcher or infielder was not significantly associated with
109 elbow pain.

110 No sex differences were found regarding potential risk factors associated with
111 shoulder and elbow pain.

112 Discussion

113 This is the first study to report shoulder and elbow pain in entire teams of young
114 baseball players aged 7 to 12 years old. The frequencies of shoulder and elbow pain
115 were 15.9% and 29.2%, respectively. Associated factors for each area of pain appeared

116 to be different, suggesting diverse etiologies. Shoulder pain was associated with
117 increased age. Elbow pain was associated with increased age, increased years of
118 baseball experience, and playing catcher.

119 Although there have been numerous reports on throwing injuries in young baseball
120 players from North America, data from North America may not necessarily be
121 applicable to other countries, and it is important to compare the data from other
122 countries with those from North America. In our study, the frequencies of shoulder and
123 elbow pain were 15.9% and 29.2%, respectively, whereas in Lyman's study, they were
124 32% and 26% [1]. Although the elbow results in the two studies are similar, the results
125 for shoulder pain are markedly different. One possible explanation for this difference is
126 the older population of Lyman's study (aged 9–12 years) compared to ours (aged 7–12
127 years).

128 Increased age had the strongest association with both shoulder and elbow pain. The
129 relationship between age and risk of arm problems and/or injuries has been frequently
130 reported in previous studies, in which increased age was shown to be associated with a
131 higher incidence of arm pain [1, 11, 12, 13]. One possible explanation is that older
132 players may be more skillful and thus, they may have thrown at a higher frequency per
133 game [2, 3, 10]. Older players are also likely to be stronger and capable of generating

134 greater loads on the joint/soft tissue structures.

135 We found that years of baseball experience appeared to be an important risk factor
136 for elbow pain but not shoulder pain. Many throwing-related injuries are believed to be
137 a result of cumulative microtrauma from the repetitive, dynamic, overhead throwing
138 motion that is used to throw a baseball [3]. Combined with the fact that the frequency of
139 elbow pain is higher than that of shoulder pain, it may be considered that the elbow is
140 more susceptible to stress than the shoulder.

141 In our study, catchers were noted to have a higher incidence of elbow pain compared
142 with pitchers and fielders. Previous studies demonstrated comparatively high rates of
143 elbow pain in young catchers, which might be explained by the fact that the number of
144 throws made by catchers is probably as high as that of pitchers, and more than that of
145 fielders [14, 15]. In addition, due to the nature of the catching posture, catchers typically
146 are moving from the crouched position to a throwing position in an attempt to execute a
147 quick ball release, thus possibly rushing the throwing motion and abbreviating the
148 sequentiality of the pelvis and trunk. Younger catchers had greater upper extremity
149 segmental velocity, which is postulated to be attributed to the decrease in pelvis and
150 trunk separation. Improper sequence of these events in young catchers might induce
151 elbow pain.

152 In this study, being a pitcher was not associated with shoulder or elbow pain. One
153 possible explanation is that players chose the position that they played the most. Child
154 and adolescent players play more than one position or switch positions. Being a pitcher
155 might become a risk factor if we had included players who had experience playing
156 pitcher.

157 This study provides new data on young players. Multiple risk factors were identified,
158 but there are several limitations to the study. One major limitation is that our figures are
159 based on self-reporting by young participants (some as young as 9 years old). There
160 might have been some recall bias when the players were asked about their history of
161 shoulder and/or elbow pain. Another possibility is that some players, parents, and
162 coaches underestimated or underreported the number of hours each child plays per week,
163 given the recent push to limit children's exposure to potential injuries. Furthermore, it
164 would have been ideal for a person who was uninvolved in the study or blinded to the
165 results/hypotheses to have gone over the questionnaire with each player. The study
166 would also have yielded richer information if the questionnaire had also included
167 information on additional factors such as characteristics of pain, intensity, and duration,
168 and treatment, time to return the baseball, or prior surgeries. These factors should be
169 included in future studies. Another limitation was that all players were from the same

170 geographic region ([REDACTED]). It is unknown whether the identified risk factors
171 in the present study are different from those in other regions or countries. Another
172 limitation was that other potential risk factors were not studied, such as pitching
173 mechanics and physical conditioning. Davis et al. [16] analyzed 5 biomechanical
174 pitching parameters (leading with the hips, hand-on-top position, arm in throwing
175 position, closed-shoulder position, and stride foot toward home plate) in youth pitchers.
176 They concluded that youth pitchers with better pitching mechanics generate lower
177 humeral internal rotation torque, lower elbow valgus load, and greater efficiency than
178 pitchers with improper mechanics [16]. It is important to realize that the current study
179 was designed to identify risk factors associated with shoulder and elbow pain in young
180 players, but was not designed to prove cause and effect. Future studies with a
181 longitudinal design are needed to draw firm conclusions regarding causality.

182 **Conclusion**

183 In over 1000 baseball players aged 7 to 12 years, 15.9% reported episodes of
184 shoulder pain while 29.2% reported elbow pain in the throwing arm. The associated
185 factors for each area of pain appeared to be different. Shoulder pain was associated with
186 increased age. Elbow pain was associated with increased age, increased years of
187 baseball experience, and playing catcher.

189 **References**

- 190 1. Lyman S, Fleisig GS, Andrews JR, et al. Effect of pitch type, pitch count, and
191 pitching mechanics on risk of elbow and shoulder pain in youth baseball pitchers.
192 Am J Sports Med. 2002; 30: 463-468.
- 193 2. Fleisig GS, Andrews JA, Cutter GR, et al. Risk of serious injury for young baseball
194 pitchers: a 10-year prospective study. Am J Sports Med. 2011; 39: 253-257.
- 195 3. Olsen SJ II, Fleisig GS, Dun S, et al. Risk factors for shoulder and elbow injuries in
196 adolescent baseball pitchers. Am J Sports Med. 2006, 34: 905-912.
- 197 4. Parks ED, Ray TR. Prevention of overuse injuries in young baseball pitchers. Sports
198 Health. 2009; 1: 514-517.
- 199 5. Bushnell BD, Anz AW, Noonan TJ, et al. Association of maximum pitch velocity
200 and elbow injury in professional baseball pitchers. Am J Sports Med. 2010; 38:
201 728-732.
- 202 6. Kibler WB. The role of the scapula in athletic shoulder function. Am J Sports Med.
203 1998; 26: 325-337.
- 204 7. Greiwe RM, Ahmad CS. Management of the throwing shoulder: cuff, labrum and
205 internal impingement. Orthop Clin North Am. 2010; 41: 309-323.
- 206 8. Knesek M, Skendzel JG, Dines JS, et al. Diagnosis and management of superior

- 207 labral anterior posterior tears in throwing athletes. *Am J Sports Med.* 2012; 41:
208 444-460.
- 209 9. Oberlander MA, Chisar MA, Campbell B. Epidemiology of shoulder injuries in
210 throwing and overhead athletes. *Sports Med Arthrosc Rev.* 2000; 8: 115-123.
- 211 10. Lyman S, Fleisig GS, Waterbor JW, et al. Longitudinal study of elbow and shoulder
212 pain in youth baseball pitchers. *Med Sci Sports Exerc.* 2001; 33(11): 1803-1810.
- 213 11. Sabick MB, Kim YK, Torry MR, et al. Biomechanics of the shoulder in youth
214 baseball pitchers: implications for the development proximal humeral epiphysis and
215 humeral retrotorsion. *Am J Sports Med.* 2005; 33: 1716-1722.
- 216 12. Walton J, Paxinos A, Tzannes A, et al. The unstable shoulder in the adolescent
217 athlete. *Am J Sports Med.* 2002; 30: 758-767.
- 218 13. Zaremski JL, Krabak BJ. Shoulder injuries in the skeletally immature baseball
219 pitcher and recommendations for the prevention of injury. *PMR.* 2012; 4(7):
220 509-516.
- 221 14. Hang DW, Chao CM, Hang YS. A clinical and roentgenographic study of Little
222 League elbow. *Am J Sports Med.* 2004; 32: 79-84.
- 223 15. Matsuura T, Suze N, Kashiwaguchi S, et al. Elbow injuries in youth baseball players
224 without prior elbow pain. A 1-year prospective study. *Orthop J Sports Med.* 2013; 1:

225 doi:10.1177/2325967113509948.

226 16. Davis JT, Limpisvasti O, Fluhme D, Mohr KJ, Yocum LA, ElAttrache NS, Jobe FW.

227 The effect of pitching biomechanics on the upper extremity in youth and adolescent

228 baseball pitchers. Am J Sports Med. 2009; 37: 1484-1491.

Table 1
Univariate analysis of the risk factors for shoulder pain

	n (%)	Odds Ratio	95% Confidence Interval	P Value
Age (years)				
≤9	248 (15.9)	1		
10	306 (19.6)	2.01	1.09–3.87	.03
11	466 (29.8)	3.52	2.04–6.46	<.0001
12	543 (34.7)	4.08	2.40–7.44	<.0001
Position				
Pitcher	140 (9.0)	2.13	1.34–3.32	<.01
Catcher	126 (8.1)	1.96	1.20–3.13	<.01
Infielder	552 (35.3)	1.57	1.15–2.14	<.01
Outfielder	745 (47.7)	1		
Experimental years				
<2	65 (4.2)	1		
≥2 but <3	183 (11.7)	1.67	1.08–2.62	.02
≥3 but <4	306 (19.6)	1.98	1.29–3.12	<.01
≥4 but <5	466 (29.8)	2.46	1.53–4.01	<.001
≥5	543 (34.7)	3.96	2.27–6.92	<.0001
Training hours per week				
<11	261 (16.7)	1		
≥11 but <13.5	353 (22.6)	1.06	0.68–1.64	.81
≥13.5 but <16.5	449 (28.7)	0.83	0.54–1.28	.39
≥16.5	500 (32.0)	1.18	0.79–1.78	.43

Table 2
Multivariate analysis of the risk factors for shoulder pain

Variable	Odds Ratio	95% Confidence Interval	P Value
Age (years)			
≤9	1		
10	1.95	1.04–3.81	.04
11	3.12	1.71–6.01	<.001
12	3.14	1.64–6.29	<.001
Position			
Pitcher	1.31	0.77–2.18	.31
Catcher	1.28	0.75–2.13	.36
Infielder	1.25	0.90–1.75	.18
Outfielder	1		
Experimental years			
<2	1		
≥2 but <3	1.13	0.71–1.83	.62
≥3 but <4	1.04	0.62–1.77	.88
≥4 but <5	1.14	0.63–2.07	.66
≥5	1.82	0.92–3.61	.08
Training hours per week			
<11	1		
≥11 but <13.5	1.06	0.68–1.67	.79
≥13.5 but <16.5	0.80	0.52–1.24	.31
≥16.5	1.13	0.75–1.72	.57

Table 3
Univariate analysis of the risk factors for elbow pain

	n (%)	Odds Ratio	95% Confidence Interval	P Value
Age (years)				
≤9	248 (15.9)	1		
10	306 (19.6)	4.03	2.17–8.08	<.0001
11	466 (29.8)	8.79	4.96–17.07	<.0001
12	543 (34.7)	16.53	9.42–31.87	<.0001
Position				
Pitcher	140 (9.0)	4.01	2.78–5.86	<.0001
Catcher	126 (8.1)	3.66	2.47–5.42	<.0001
Infielder	552 (35.3)	1.77	1.37–2.28	<.0001
Outfielder	745 (47.7)	1		
Experimental years				
<2	65 (4.2)	1		
≥2 but <3	183 (11.7)	2.63	1.75–4.04	<.0001
≥3 but <4	306 (19.6)	5.97	4.02–9.07	<.0001
≥4 but <5	466 (29.8)	7.37	4.80–11.57	<.0001
≥5	543 (34.7)	11.55	6.89–19.74	<.0001
Training hours per week				
<11	261 (16.7)	1		
≥11 but <13.5	353 (22.6)	0.92	0.64–1.33	.65
≥13.5 but <16.5	449 (28.7)	1.17	0.84–1.65	.36
≥16.5	500 (32.0)	1.31	0.94–1.83	.11

Table 4
Multivariate analysis of the risk factors for elbow pain

Variable	Odds Ratio	95% Confidence Interval	P Value
Age (years)			
≤9	1		
10	3.02	1.60–6.15	<.01
11	5.05	2.73–10.14	<.0001
12	6.78	3.57–13.88	<.0001
Position			
Pitcher	1.47	0.96–2.25	.08
Catcher	1.56	1.01–2.39	.04
Infielder	1.08	0.82–1.43	.58
Outfielder	1		
Experimental years			
<2	1		
≥2 but <3	1.69	1.09–2.65	.02
≥3 but <4	2.56	1.63–4.12	<.0001
≥4 but <5	2.60	1.55–4.42	<.001
≥5	3.55	1.93–6.62	<.0001
Training hours per week			
<11	1		
≥11 but <13.5	0.87	0.58–1.29	.47
≥13.5 but <16.5	1.07	0.74–1.55	.72
≥16.5	1.14	0.80–1.63	.49