

This is an Accepted Manuscript of an article published by Taylor & Francis in The Physician and Sportsmedicine on 09/03/2017, available online:
<http://www.tandfonline.com/10.1080/00913847.2017.1300505>.

Risk factors for shoulder and elbow pain in youth baseball players

Tetsuya Matsuura¹, Toshiyuki Iwame¹, Naoto Suzue², Kokichi Arisawa³, Koichi Sairyo¹

¹Department of Orthopedics, Institute of Biomedical Sciences, Tokushima University Graduate School, 3-18-15 Kuramoto, Tokushima 770-8503, Japan

²Department of Orthopaedic Surgery, Tokushima Red Cross Hospital, 103 Irinokuchi, Komatsushima-cho, Komatsushima, Tokushima 773-8502, Japan

³Department of Preventive Medicine, Institute of Biomedical Sciences, Tokushima University Graduate School, 3-18-15 Kuramoto, Tokushima 770-8503, Japan

Corresponding author: Tetsuya Matsuura, MD

Department of Orthopedics, Institute of Biomedical Sciences, Tokushima University Graduate School, 3-18-15 Kuramoto, Tokushima, Tokushima 770-8503, Japan

Tel.: +81 88 633 7240

Fax: +81 88 633 0178

E-mail: tmatsu@tokushima-u.ac.jp

1 **Abstract**

2 **Objectives:** This study sought to quantify the 1-year cumulative incidence of shoulder
3 and elbow pain among youth baseball players and identify risk factors associated with
4 the occurrence of shoulder and elbow pain.

5 **Methods:** In total, 900 youth baseball players (aged 7–11 years) were enrolled in a
6 1-year prospective follow-up study. One year later, subjects were asked whether they
7 had experienced episodes of shoulder or elbow pain and the following risk factors for
8 such pain were investigated: age, position, length of baseball experience, training hours
9 per week, and history of shoulder or elbow pain. Data for the groups with and without
10 shoulder or elbow pain were analyzed using multivariate logistic regression models.

11 **Results:** Episodes of shoulder pain were reported by 18.3% of players and episodes of
12 elbow pain were reported by 35.2% of players. Multivariate analysis showed that
13 shoulder pain was associated with playing pitcher, catcher, increasing training hours per
14 week, and history of shoulder and elbow pain, and that elbow pain was associated with
15 increasing age, playing pitcher, catcher, increasing training hours per week, and history
16 of elbow pain. Length of baseball experience was not associated with shoulder or elbow
17 pain.

18 **Conclusion:** History of elbow pain, playing pitcher, catcher and increasing training
19 hours per week were associated with both types of pain. History of shoulder pain was
20 associated with shoulder pain but not elbow pain. Increasing age was associated with
21 elbow pain but not shoulder pain.

22

23 **Keywords:** Youth sports, Joint pain, Athletic injuries, Risk assessment

24 1. Introduction

25 Youth baseball players are at risk of shoulder and elbow problems. Further, reports
26 suggest there has been a rapid increase in shoulder and elbow injury rates among
27 players in this age group since the first decade of the 21st century (1, 2, 3, 4). It is
28 thought that at higher competition levels, shoulder and elbow injuries requiring medical
29 attention are likely the result of cumulative microtrauma starting at the youth level.
30 Serious throwing injuries are most commonly due to the accumulation of microtrauma
31 from repetitive throwing motions (5). Although epidemiological research has
32 increasingly focused on throwing-related risk factors for injuries among youth and
33 adolescent players (2, 6, 7, 8, 9, 10, 11), the factors associated with these problems are
34 not well understood.

35 Lyman et al. followed 298 youth baseball pitchers (aged 9–12 years) for 2
36 consecutive spring seasons (7). They found that the frequency of shoulder pain and
37 elbow pain was 32% and 26%, respectively, and that the factors associated with each
38 type of pain were different. Shoulder pain was associated with pitches thrown per
39 season and pitches thrown per game (7); elbow pain was associated with increasing age,
40 arm fatigue during the game, and pitches thrown per season (7). The risk of shoulder
41 and elbow pain from playing catcher, infield, or outfield without pitching was not
42 examined in that study. Matsuura et al. investigated 1563 players aged 7–12 years
43 including pitchers and nonpitchers, and found that 15.9% and 29.2% of the players
44 reported episodes of shoulder pain and elbow pain, respectively (9). Again, the
45 associated risk factors were different for each type of pain. There was a significant
46 association between shoulder pain and increasing age; elbow pain was associated with
47 increasing age, increasing length of baseball experience, and playing catcher (9).

48 However, that study did not clarified risk factors because study design was
49 cross-sectional study. To our knowledge, no study has assessed the risk factors for
50 shoulder and/or elbow pain in youth baseball players, either in pitchers or in position
51 players.

52 The aim of this study was to determine the cumulative incidence of shoulder and
53 elbow pain in youth baseball players within a 1-year period. We hypothesized that the
54 risk factors for shoulder pain would be different from those for elbow pain in youth
55 baseball players.

56

57 2. **Materials and Methods**

58 This study was approved by the institutional review board at our institution, and all
59 parents and coaches provided informed consent. All **team players** gave their assent to
60 participate.

61 Baseline data were collected by questionnaire from 1020 players who participated in
62 a regional summer championship for youth baseball teams in July 2012. The
63 questionnaire was distributed to team coaches, and the players completed them with the
64 assistance of their coaches and/or parents. Players were asked whether they had
65 experienced episodes of shoulder or elbow pain that resulted in restriction of
66 participation for ≥ 1 day. The questionnaire was also used to gather data on age, playing
67 position, length of baseball experience, and training hours per week. Players reported
68 their most often played position. Training hours per week included hours spent in
69 practice, the bullpen, and games.

70 The same subjects were re-investigated for shoulder and/or elbow pain 1 year later
71 using a follow-up questionnaire sent out by mail. The subjects were not contacted by the

72 study investigators during the intervening year. Of the 1020 players, 900 (88.2%; mean
73 age 9.5 [range 7–11] years) completed the survey. Of these 900 players, 122 had
74 reported prior shoulder pain and 187 had reported prior elbow pain on the initial
75 baseline questionnaire completed at the beginning of the study. No completed
76 questionnaires were excluded. Subjects were asked at follow-up whether they had
77 experienced episodes of shoulder or elbow pain that resulted in restriction of
78 participation for ≥ 1 day. The first author reviewed the questionnaire returned by mail
79 with each subject to confirm their understanding of the questions and to check the
80 accuracy of the information provided.

81 We investigated the following potential risk factors for shoulder and elbow pain:
82 age (four categories), position (four categories), length of baseball experience (five
83 categories), training hours per week (four categories), and history of shoulder or elbow
84 pain (binary). The data were analyzed by multiple logistic regression analysis. First, the
85 potential risk factors were analyzed one by one, followed by multivariate analysis that
86 included all potential risk factors in the models. Dummy variables were created and
87 those except for reference categories were included in the models. Odds ratios (ORs)
88 with profile likelihood 95% confidence intervals (CIs) are presented relative to the
89 reference categories. A two-tailed P -value < 0.05 (Wald test) was considered
90 statistically significant. The statistical analysis was performed using PROC LOGISTIC
91 PC SAS version 8.2 software (SAS Institute Inc., Cary, NC).

92

93 **3. Results**

94 Of the 900 subjects, 165 (18.3%) reported episodes of pain in the throwing shoulder
95 during the 1-year study period. Potential risk factors associated with shoulder pain are

96 summarized in Tables 1 and 2. Univariate analysis showed that shoulder pain was
97 significantly associated with age 10 years ($P < 0.01$), age 11 years ($P < 0.01$). There
98 was no statistically significant association between 9 years and shoulder pain. There
99 was a statistically significant association between shoulder pain and playing pitcher (P
100 < 0.0001) or catcher ($P < 0.001$). Infielder position was not significantly associated
101 with shoulder pain. There was a statistically significant association between shoulder
102 pain and lengths of baseball experience of > 4.5 but ≤ 6 years ($P < 0.05$). Training
103 hours per week were not significantly associated with shoulder pain. There was a
104 statistically significant association between shoulder pain and history of shoulder and
105 elbow pain ($P < 0.0001$; Table 1). Multivariate analysis of these variables showed that
106 the risk factors significantly associated with shoulder pain were playing pitcher (OR
107 2.99; 95% CI 1.65–5.43), catcher (OR 2.02; 95% CI 1.07–3.76), training hours per
108 week of > 16 but ≤ 36 h (OR 2.00; 95% CI 1.07–3.92), history of shoulder pain (OR
109 3.34; 95% CI 2.16–5.17), and history of elbow pain (OR 1.53; 95% CI 1.00–2.31; Table
110 2). Age 10 years (OR 1.31; 95% CI 0.69–2.57), 11 years (OR 1.26; 95% CI 0.60–2.71)
111 and lengths of baseball experience of > 4.5 but ≤ 6 years (OR 1.60; 95% CI 0.43–7.90)
112 were not significantly associated with shoulder pain..

113 Of the 900 subjects, 317 (35.2%) reported episodes of pain in the throwing elbow
114 during the season. Potential risk factors associated with elbow pain are summarized in
115 Tables 3 and 4. Univariate analysis showed that elbow pain had a significant association
116 with age 9 ($P < 0.0001$), age 10 ($P < 0.0001$), or age 11 ($P < 0.0001$) years. Playing
117 pitcher ($P < 0.0001$), catcher ($P < 0.0001$), or infielder ($P < 0.01$) was significantly
118 associated with elbow pain. Lengths of baseball experience of > 2.5 but ≤ 3.5 years ($P <$
119 0.01), > 3.5 but ≤ 4.5 years ($P < 0.001$), and 4.5 but ≤ 6 years ($P < 0.001$) were

120 significantly associated with elbow pain. Training hours per week of > 16 but ≤ 36 h (P
121 < 0.01) was significantly associated with elbow pain. There was a significant
122 association between elbow pain and history of shoulder and elbow pain ($P < 0.001$;
123 Table 3). Multivariate analysis of these variables showed that the following risk factors
124 were significantly associated with elbow pain: age 9 (OR 3.19; 95% CI 1.76–6.02), age
125 10 (OR 3.18; 95% CI 1.76–6.00), or 11 (OR 3.93; 95% CI 2.01–7.95) years; playing
126 pitcher (OR 2.62; 95% CI 1.53–4.50), and catcher (OR 2.29; 95% CI 1.33–3.96);
127 training hours per week of > 16 but ≤ 36 h (OR 2.33; 95% CI 1.34–4.15; Table 4);
128 history of elbow pain (OR 5.70; 95% CI 3.91–8.41) . Infielder (OR 1.41; 95% CI 0.96–
129 2.06), length of baseball experience of > 2.5 but ≤ 3.5 years (OR 1.65; 95% CI 0.59–
130 5.91), > 3.5 but ≤ 4.5 years (OR 1.64; 95% CI 0.56–6.03) and > 4.5 but ≤ 6 years (OR
131 2.39; 95% CI 0.73–9.48) of baseball experience and episodes of shoulder pain (OR
132 1.20; 95% CI 0.77–1.88) were not significantly associated with elbow pain.

133

134 4. Discussion

135 This study investigated the risk factors for shoulder and/or elbow pain in youth
136 baseball players. Unique aspects of this study were the inclusion of **pitchers and**
137 **position players** and a Japanese study population. Baseball is the most popular sport in
138 Japan, and many problematic throwing injuries in young players are recognized (6, 9,
139 10).

140 This is the first study to report the cumulative incidence of shoulder and elbow pain
141 in entire teams of youth baseball players aged 7–11 years within a 1-year period. The
142 1-year cumulative incidence of shoulder and elbow pain at either site was 18.3% and
143 35.2%, respectively. **History of shoulder or elbow pain was the strongest risk factors for**

144 pain at each site. Picher was also strong risk factors for both shoulder and elbow pain.
145 Some factors associated with pain at these sites appeared to be different, suggesting
146 diverse etiologies. Increasing age was strong risk factor for elbow pain but not for
147 shoulder pain.

148 History of shoulder or elbow pain was the strongest risk factors for pain at each site.
149 These results suggest that players with a previous history of shoulder or elbow pain
150 were required attention. Interestingly, in our study, a history of elbow pain was
151 associated with a higher incidence of shoulder pain. However, a history of shoulder pain
152 was not associated with a higher incidence of elbow pain. Taken together with the fact
153 that the frequency of elbow pain was higher than that of shoulder pain, elbow injury in
154 youth baseball players might often precede a shoulder injury. It may be that, in players
155 who develop an elbow injury, throwing mechanics are altered to alleviate the stress on
156 the elbow and lead to decreased performance, thereby increasing the stress on the
157 shoulder, although there is no direct evidence that this occurs (12).

158 Multivariate logistic regression revealed that **pitching** was associated with shoulder
159 pain and elbow pain. The risk factor with the association with injury was **pitching**,
160 suggesting that pitching is a strong risk factor for developing pain at the shoulder and
161 elbow. In a cross-sectional study of risk factors for elbow injuries in baseball players
162 aged 9–12 years, Harada et al. showed that **pitching** was a strong risk factor for elbow
163 injury (6). In our study, catcher was also risk factor for shoulder and elbow pain.
164 Previous studies have demonstrated comparatively high rates of arm pain in young
165 catchers, which might be explained by the fact that the number of throws made by
166 catchers is comparable to that of pitchers and more than that of position players (10,
167 13).

168 Increasing age, but not length of baseball experience, had a strong association with
169 elbow pain. The relationship between age and risk of arm problems and/or injuries has
170 frequently been reported in earlier studies, where increasing age was shown to be
171 associated with a higher incidence of arm pain (7, 9, 14, 15, 16). Because this increase
172 was found for 2–3 years between the ages of 8 and 11 years, it might have important
173 implications. It is possible that older players are more skillful and thus may make more
174 throws per game (2, 8, 11). Older players are also likely to be stronger and capable of
175 generating a greater load on the joint/soft tissue structures. A further hypothesis focuses
176 on the secondary ossification centers (8), which start to ossify between the ages of 2 and
177 11 years and do not fuse to the long bones until as late as 17 years of age. There may be
178 up to six secondary ossification centers present in the elbow of an 11-year-old boy.
179 These centers are the most vulnerable points in the young elbow and can become
180 inflamed and irritated by the throwing motion (8). However, increasing age was not
181 associated with shoulder pain in this study. Lyman et al. reported similar results, that is,
182 a relationship between increasing age and elbow pain but not with shoulder pain (7).

183 Training hours per week of > 16 but ≤ 36 h was also associated with both shoulder
184 and elbow pain. Harada et al. showed that ≥ 14 h of training per week tended to be an
185 associated risk factor (6). The results of our longitudinal study confirm that increasing
186 training hours per week are risk factors for arm pain.

187 It is expected that increasing length of baseball experience would be associated with
188 arm pain because throwing injuries result in the accumulation of microtrauma from
189 repetitive throwing motion (5). However, in this study, length of baseball experience
190 was not associated with the incidence of shoulder pain or elbow pain. A possible
191 explanation for this lack of a significant finding is that most (72.3%) of the participants

192 in our study had < 3.5 years of baseball experience. Combined with the fact that
193 increasing training hours per week was associated with shoulder and elbow pain, it
194 might be that increasing length of baseball experience is associated with shoulder and/or
195 elbow pain in players who are older than those in the present study.

196 This prospective study identified multiple risk factors for “throwing injuries” in
197 youth baseball players and adds new information to the available data. However, the
198 study has several limitations. One major limitation is that our data are based on
199 self-reporting by young participants. There might have been some recall bias when the
200 players were asked about their history of shoulder and/or elbow pain. Moreover, it
201 would have been ideal for someone who was not involved in the study or was blinded to
202 the study hypothesis to have reviewed the questionnaires with each player. The study
203 would also have yielded more robust information if the questionnaire had included
204 information on factors such as additional or secondary positions, the characteristics,
205 intensity, and duration of pain and treatment, time to return to baseball, and prior
206 surgical treatment. A further limitation was that no physical examination was
207 undertaken to rule out conditions such as glenohumeral internal rotation deficit, loss of
208 total range of motion at the shoulder, rotator cuff weakness, scapular dysfunction,
209 muscle tightness in the lower extremities, and deficits in single-leg standing balance.
210 The final limitation was that all the players were from the same geographic region in
211 Japan. It is unclear whether the risk factors identified in this study are different from
212 those for players in other regions or countries. Future multicenter studies are needed to
213 draw firm conclusions regarding the causes of pain and the risk of injury to the shoulder
214 and elbow in youth baseball players.

215

216 **5. Conclusion**

217 History of shoulder or elbow pain, and pitcher are strong risk factors for arm pain.

218 Increasing age is strong risk factor for elbow pain not for shoulder pain. Training hours

219 per week should be restricted less than 16 hours. Players with history of elbow pain

220 were paid attention to occurrence of shoulder pain.

221

References

- 222 1. Fleisig GS, Andrews JA. Prevention of elbow injuries in youth baseball pitchers.
223 Sports Health. 2012;4:419–24.
- 224 2. Fleisig GS, Andrews JA, Cutter GR, et al. Risk of serious injury for young baseball
225 pitcher: a 10-year prospective study. *Am J Sports Med.* 2011;39:253–7.
- 226 3. Hodgins JL, Vitale M, Arons RR, Ahmad CS. Epidemiology of medial ulnar
227 collateral ligament reconstruction. *Am J Sports Med.* 2016;44:729–34.
- 228 4. Petty DH, Andrews JR, Fleisig GS, Cain EL. Ulnar collateral ligament
229 reconstruction in high school baseball players: clinical results and injury risk
230 factors. *Am J Sports Med.* 2004;32:1158–64.
- 231 5. Oberlander MA, Chisar MA, Campbell B. Epidemiology of shoulder injuries in
232 throwing and overhead athletes. *Sports Med Arthrosc Rev.* 2000;8:115–23.
- 233 6. Harada M, Takahara M, Mura N, Sasaki J, Ito T, Ogino T. Risk factors for elbow
234 injuries among young baseball players. *J Shoulder Elbow Surg.* 2010;19:502–7. doi:
235 10.1016/j.jse.2009.10.022.
- 236 7. Lyman S, Fleisig GS, Andrews JR, Osinski ED. Effect of pitch type, pitch count,
237 and pitching mechanics on risk of elbow and shoulder pain in youth baseball
238 pitchers. *Am J Sports Med.* 2002;30:463–8.
- 239 8. Lyman S, Fleisig GS, Waterbor JW, et al. Longitudinal study of elbow and shoulder
240 pain in youth baseball pitchers. *Med Sci Sports Exerc.* 2001;33(11):1803–10.
- 241 9. Matsuura T, Suzue N, Iwame T, Arisawa K, Fukuta S, Sairyō K. Epidemiology of
242 shoulder and elbow pain in youth baseball players. *Phys Sportsmed.* 2016;44:97–
243 100.
- 244 10. Matsuura T, Suze N, Kashiwaguchi S, Arisawa K, Yasui N. Elbow injuries in youth

- 245 baseball players without prior elbow pain. A 1-year prospective study. *Orthop J*
246 *Sports Med.* 2013;1(5):2325967113509948. doi:10.1177/2325967113509948.
- 247 11. Olsen SJ II, Fleisig GS, Dun S, Loftice J, Andrews JR. Risk factors for shoulder and
248 elbow injuries in adolescent baseball pitchers. *Am J Sports Med.* 2006;34:905–12.
- 249 12. Fleisig GS, Leddon CE, Laughlin WA, et al. Biomechanical performance of
250 baseball pitchers with a history of ulnar collateral ligament reconstruction. *Am J*
251 *Sports Med.* 2015;43:1045–50.
- 252 13. Hang DW, Chao CM, Hang YS. A clinical and roentgenographic study of Little
253 League elbow. *Am J Sports Med.* 2004;32:79–84.
- 254 14. Sabick MB, Kim YK, Torry MR, Keims MA, Hawkins RJ. Biomechanics of the
255 shoulder in youth baseball pitchers: implications for the development proximal
256 humeral epiphysis and humeral retrotorsion. *Am J Sports Med.* 2005;33:1716–22.
- 257 15. Walton J, Paxinos A, Tzannes A, et al. The unstable shoulder in the adolescent
258 athlete. *Am J Sports Med.* 2002;30:758–67.
- 259 16. Zaremski JL, Krabak BJ. Shoulder injuries in the skeletally immature baseball
260 pitcher and recommendations for the prevention of injury. *PM R.* 2012;4:509–16.
- 261

Table 1 Univariate analysis of risk factors for shoulder pain

	n (%)	OR	95% CI	P-value
Age (years)				
≤ 8	153 (19.7)	1		
9	200 (25.7)	1.55	0.79–3.15	0.21
10	310 (39.8)	2.24	1.24–4.31	0.01
11	115 (14.8)	1.61	0.75–3.48	0.22
Position				
Pitcher	80 (10.3)	2.82	1.49–5.29	< 0.01
Catcher	75 (9.6)	2.12	1.05–4.13	0.03
Infielder	339 (43.6)	1.43	0.89–2.34	0.15
Outfielder	284 (36.5)	1		
Length of baseball experience (years)				
≤ 1.5	30 (3.9)	1		
> 1.5 but ≤ 2.5	270 (34.7)	1.95	0.55–12.41	0.38
> 2.5 but ≤ 3.5	279 (35.9)	2.07	0.59–13.18	0.33
> 3.5 but ≤ 4.5	150 (19.3)	3.80	1.06–24.28	0.08
> 4.5 but ≤ 6	49 (6.2)	4.05	0.99–27.54	0.08
Training hours per week (h)				
≤ 10.5	87 (11.2)	1		
> 10.5 but ≤ 13	197 (25.3)	2.24	0.95–6.17	0.09
> 13 but ≤ 16	249 (32.0)	2.06	0.89–5.63	0.12
> 16 but ≤ 36	245 (31.5)	3.20	1.42–8.62	0.01
History of elbow pain				
Negative	637 (81.9)	1		
Positive	141 (18.1)	1.99	1.25–3.12	0.01

Potential risk factors were examined one by one. Statistically significant values (Wald test) are shown in bold. Abbreviations: CI, confidence interval, OR, odds ratio

Table 2 Multivariate analysis of risk factors for shoulder pain

Variable	OR	95% CI	P-value
Age (years)			
≤ 8	1		
9	1.22	0.61–2.56	0.58
10	1.42	0.71–2.96	0.34
11	0.94	0.40–2.25	0.90
Position			
Pitcher	2.12	1.05–4.23	0.03
Catcher	1.61	0.77–3.28	0.19
Infielder	1.26	0.76–2.10	0.38
Outfielder	1		
Length of baseball experience (years)			
≤ 1.5	1		
> 1.5 but ≤ 2.5	1.59	0.44–10.25	0.54
> 2.5 but ≤ 3.5	1.40	0.38–9.13	0.66
> 3.5 but ≤ 4.5	2.03	0.52–13.53	0.37
> 4.5 but ≤ 6	2.40	0.53–17.28	0.30
Training hours per week (h)			
≤ 10.5	1		
> 10.5 but ≤ 13	2.05	0.86–5.71	0.13
> 13 but ≤ 16	1.87	0.80–5.16	0.18
> 16 but ≤ 36	2.98	1.30–8.09	0.02
History of elbow pain			
Negative	1		
Positive	1.60	0.98–2.59	0.06

All five potential risk factors were included in the model. Statistically significant values (Wald test) are shown in bold. Abbreviations: CI, confidence interval, OR, odds ratio

Table 3 Univariate analysis of risk factors for elbow pain

	n (%)	OR	95% CI	P-value
Age (years)				
≤ 8	152 (21.3)	1		
9	194 (27.2)	3.42	1.86–6.69	< 0.001
10	265 (37.2)	4.34	2.43–8.28	< 0.0001
11	102 (14.3)	6.10	3.16–12.39	< 0.0001
Position				
Pitcher	74 (10.4)	4.59	2.62–8.10	< 0.0001
Catcher	64 (9.0)	4.48	2.48–8.12	< 0.0001
Infielder	306 (42.9)	1.88	1.25–2.87	< 0.01
Outfielder	269 (37.7)	1		
Length of baseball experience (years)				
≤ 1.5	32 (4.5)	1		
> 1.5 but ≤ 2.5	264 (37.0)	1.76	0.65–6.13	0.31
> 2.5 but ≤ 3.5	250 (35.1)	2.56	0.96–8.89	0.09
> 3.5 but ≤ 4.5	120 (16.8)	3.63	1.31–12.88	0.02
> 4.5 but ≤ 6	51 (6.6)	4.75	1.55–18.00	0.01
Training hours per week (h)				
≤ 10.5	89 (12.4)	1		
> 10.5 but ≤ 13	180 (25.3)	0.95	0.51–1.83	0.88
> 13 but ≤ 16	224 (31.4)	1.13	0.63–2.12	0.69
> 16 but ≤ 36	220 (30.9)	2.30	1.30–4.22	< 0.01
History of shoulder pain				
Negative	637 (89.3)	1		
Positive	76 (10.7)	1.80	1.08–2.95	0.02

Each potential risk factor was examined one by one. Statistically significant values (Wald test) are shown in bold. Abbreviations: CI, confidence interval, OR, odds ratio

Table 4 Multivariate analysis of risk factors for elbow pain

Variable	OR	95% CI	P-value
Age (years)			
≤ 8	1		
9	2.87	1.50–5.79	< 0.01
10	3.03	1.58–6.13	< 0.01
11	4.17	1.97–9.16	< 0.001
Position			
Pitcher	3.30	1.78–6.13	< 0.001
Catcher	3.35	1.78–6.33	< 0.001
Infielder	1.68	1.09–2.62	0.02
Outfielder	1		
Length of baseball experience			
≤ 1.5	1		
> 1.5 but ≤ 2.5	1.48	0.52–5.32	0.50
> 2.5 but ≤ 3.5	1.35	0.47–4.90	0.60
> 3.5 but ≤ 4.5	1.39	0.46–5.22	0.58
> 4.5 but ≤ 6	1.49	0.44–6.12	0.55
Training hours per week			
≤ 10.5	1		
> 10.5 but ≤ 13	0.98	0.51–1.96	0.96
> 13 but ≤ 16	1.17	0.62–2.25	0.64
> 16 but ≤ 36	2.44	1.33–4.66	< 0.01
History of shoulder pain			
Negative	1		
Positive	1.40	0.81–2.38	0.22

All five potential risk factors were included in the model. Statistically significant values (Wald test) are shown in bold. Abbreviations: CI, confidence interval, OR, odds ratio