



ELBOW

Sufficient duration of off-season decreases elbow disorders in elementary school-aged baseball players



Kenichi Otoshi, MD, PhD^{a,b,*}, Shinichi Kikuchi, MD, PhD^c, Kinshi Kato, MD, PhD^c, Yota Kaneko, MD^c, Ryosuke Mashiko, MD^c, Ryohei Sato, MD, PhD^c, Takahiro Igari, MD, PhD^c, Takahiro Kaga, MD, PhD^a, Shinichi Konno, MD, PhD^c

^aDepartment of Sports Medicine, Fukushima Medical University, Fukushima, Japan

^bOtoshi Orthopaedic Clinic, Fukushima, Japan

^cDepartment of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima, Japan

Background: Several guidelines for the prevention of throwing injuries recommend a sufficiently long off-season; however, few studies providing scientific evidence to support these recommendations exist. Our study aimed to clarify the association between off-season duration and throwing elbow injuries among elementary school-aged baseball players.

Methods: This study enrolled 680 elementary school-aged baseball players who underwent medical checkups. The experience with elbow pain and the off-season duration were investigated via the administration of a self-completed questionnaire. Ultrasonographic assessment of the elbow joint was performed on the day of the medical checkup to assess for morphologic abnormalities.

Results: The prevalence of elbow pain and morphologic abnormalities of the medial epicondyle (medial epicondyle lesions) was significantly decreased when the subjects' off-season duration was longer. Multivariate analysis revealed that the risk of elbow pain was significantly lower in the group whose off-season lasted 1 to 2 months (odds ratio [OR], 0.32; 95% confidence interval [CI], 0.15-0.62; $P = .0006$) and in the group whose off-season lasted longer than 2 months (OR, 0.59; 95% CI, 0.37-0.95; $P = .0316$). The risk of medial epicondyle lesions was also significantly lower in the group whose off-season lasted 1 to 2 months (OR, 0.39; 95% CI, 0.22-0.67; $P = .0005$) and in the group whose off-season lasted longer than 2 months (OR, 0.36; 95% CI, 0.23-0.56; $P < .0001$). On the contrary, no significant correlation was found between capitellar osteochondritis dissecans and off-season duration.

Conclusion: Off-season duration has a significant correlation with elbow pain and morphologic abnormalities of the medial elbow joint in elementary school-aged baseball players.

Level of evidence: Level III; Cross-Sectional Design; Epidemiology Study

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Keywords: Elbow pain; morphologic abnormality; medial epicondyle; off-season length; elementary school-aged baseball players

The study design and protocol were approved by the research ethics committee of Fukushima Medical University School of Medicine (Nos. 2063 and 2064), and written informed consent was obtained from the parents of all participants.

*Reprint requests: Kenichi Otoshi, MD, PhD, Department of Sports Medicine, Fukushima Medical University, 1 Hikarigaoka, Fukushima City, Fukushima, 960-1276, Japan.

E-mail address: kotoshi@fmu.ac.jp (K. Otoshi).

It has been reported that the elbow joint is the joint that is most likely to develop injuries due to overuse, especially in juvenile baseball players.⁷ In a study by Grana and Rashkin⁶ in 1980, over 50% of older adolescent pitchers experienced elbow pain during baseball season, and the occurrence of elbow pain tended to increase with age. In Japan, Matsuura et al¹⁴ reported that 30.5% of 7- to 11-year-old baseball players complained of elbow pain over the course of a single season, and a large epidemiologic study previously reported that elbow pain started to increase in prevalence at 8 years of age and the rate dramatically rose at the age of 9 years, reaching approximately 50% at 12 years.¹⁵ Repetitive valgus stress on the elbow during overhead throwing has been considered the main cause of elbow injury. In youth baseball players, the demand on the medial ulnar collateral ligament during the acceleration phase is estimated to be 18 to 28 newton-meters, and a maximum of 233 N of compressive force is applied to the humeral capitellum.^{5,16} This tremendous stress induces age-specific bone and cartilage injuries in the skeletally immature elbow.

Medial epicondyle (MEC) apophysitis is one of the most common throwing injuries in adolescents and is strongly associated with elbow pain. Adams¹ reported that the radiographic appearance of the elbow joint showed medial epicondylar apophyseal fragmentation in about half of Little League pitchers in California. In addition, it has been reported that morphologic changes of the MEC started to increase in prevalence at the age of 10 years, and about half of players in that study had bony abnormalities at age 12 years.¹⁵ Although it is a less common injury than MEC apophysitis, osteochondritis dissecans (OCD) of the humeral capitellum sometimes induces severe elbow dysfunction, with a prevalence of 2% to 4%.^{10,13,15} Several studies have reported that capitellar OCD increases the risk of elbow osteoarthritis.^{3,22} To prevent such throwing injuries in juvenile baseball players, several guidelines have been proposed and recommended to both avoid excessive amounts of practice and set a maximum number of pitches per game according to age. These guidelines also recommend a sufficient off-season duration in a year.^{2,12,18} The Pitch Smart guidelines recommend taking at least 4 months off from throwing every year, with at least 2 or 3 of those months being 1 continuous period.¹² Recently, the Japanese Orthopaedic Association and the Baseball Federation of Japan proposed taking at least 3 months a season off from throwing maximally²; however, players taking 4 months or longer off from baseball per year have been reported to have the same incidence of shoulder and elbow pain as those taking 3 months or shorter off.²¹ As previously described, no consensus has yet been reached on this matter among the authorities concerned. The purpose of this study was to investigate the effectiveness of taking a certain length of time off per season to aid in the prevention of not only elbow pain but also morphologic abnormalities of the elbow joint among juvenile baseball players.

Materials and methods

Of 1035 elementary school-aged baseball players aged 10 years or older, 680 were enrolled in this study (Fig. 1). All subjects participated in annual medical checkups immediately after the seasons ended in the period between 2016 and 2018. The annual medical checkups consisted of 3 items: self-completed questionnaire, physical examination, and ultrasonographic assessment of the elbow joint. The questionnaire included questions on age, school grade, playing position, total amount of practice per week (days and hours), duration of off-season, and elbow pain during the previous season. Elbow pain was assessed using the following question: “Did you feel pain or discomfort in your dominant elbow while throwing during the last baseball season?” To obtain an accurate answer, we recommended the players to answer the question with the help of their parents. In this study, the “off-season” was defined as the winter period during which there were no competitions and baseball activity was suspended. Because our survey was conducted in northeast Japan, most of our study participants were unable to play baseball outside because of snow or cold weather during the winter season. However, there were some areas where the climate was relatively mild and the players were able to play baseball outside regardless of the season. Ultrasonography was performed on the day of the medical checkup to assess for morphologic abnormalities of the anteroinferior aspect of the MEC (MEC lesions) and osteochondral lesions of the humeral capitellum. Several well-trained and experienced orthopedic surgeons assessed the morphologic changes using the methods described by previous studies.^{10,15,23} The morphologies of the MEC lesions were classified into 4 types according to a previous study²³: normal, irregular, fragmented, and hypertrophic. The morphology of the humeral capitellum was also assessed by ultrasonography. A diagnosis of capitellar OCD was made based on the irregularity or fragmentation of the subchondral bone of the capitellum.^{10,13,15} Ultrasonographic assessment, patient groupings, and outcome measurements were performed by researchers who were blinded to the patient’s dominant arm and history of pain.

Statistical analysis

The Cochran-Armitage trend test was used to investigate the associations of both elbow pain and morphology with age, years of baseball experience, total amount of practice per week (days and hours), and off-season duration. The χ^2 test was used to investigate the associations of elbow pain and morphology with playing position. Multivariate logistic regression analysis adjusted for age,

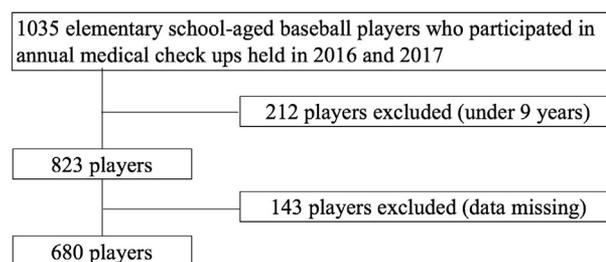


Figure 1 Study flowchart.

years of baseball experience, playing position, and total amount of practice per week was conducted to investigate the effects of off-season duration on elbow pain and morphology, and odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. All of these analyses were performed using JMP software (version 10.0.2; SAS Institute, Cary, NC, USA), and $P < .05$ was considered statistically significant.

Results

Of the 680 players, 211 were aged 10 years, 248 were aged 11 years, and 221 were aged 12 years. Regarding the average years of baseball experience, 146 players had less than 1 year of experience, 362 had 2 to 3 years of experience, and 172 players had 4 or more years of experience. Regarding playing position, 195 players were pitchers, 80 were catchers, and 405 were fielders. The total amount of practice per week was 3.2 ± 1.4 days (range, 2-7 days), and the total amount of practice time per week was 13.5 ± 4.8 hours (range, 2-30 hours). Regarding the off-season duration, 204 players (30%) did not have any off-season time.

Of the remaining 476 players, 87 (12.8%) had less than 1 month, 101 (14.8%) had 1 to 2 months, and 288 (42.4%) had more than 2 months of off-season time per season.

Associations of elbow pain and morphology with age, years of baseball experience, playing position, total amount of exercise per week, and off-season duration

Age

The prevalence of elbow pain ($P < .0001$) and the prevalence of MEC lesions ($P < .0001$) were both significantly increased according to age (Table I). However, no association was observed between capitellar OCD and age.

Years of baseball experience

The prevalence of elbow pain significantly corresponded to the number of years of baseball experience ($P = .008$). The prevalence of MEC lesions also significantly corresponded to the number of years of baseball experience ($P < .0001$),

Table I Associations of elbow pain and morphology with age, years of baseball experience, playing position, total amount of exercise per week, and off-season duration

	Total players, n	Players with elbow pain during previous season		Players with MEC lesion		Players with capitellar OCD	
		n (%)	<i>P</i> value	n (%)	<i>P</i> value	n (%)	<i>P</i> value
Age							
10 yr	211	33 (15.6)	<.0001	56 (26.5)	<.0001	9 (4.3)	.5337
11 yr	248	49 (19.8)		104 (41.9)		7 (2.8)	
12 yr	221	74 (33.5)		117 (52.9)		7 (3.2)	
Years of baseball experience							
≤1 yr	146	18 (12.3)	.0008	27 (18.5)	<.0001	4 (2.7)	.9701
2-3 yr	362	89 (24.6)		153 (42.3)		14 (3.9)	
≥4 yr	172	49 (28.5)		97 (56.4)		5 (2.9)	
Position							
Pitcher	195	56 (28.7)	.0337	98 (50.3)	.0007	10 (5.1)	.1334
Catcher	80	21 (26.3)		38 (47.5)		4 (5.0)	
Fielder	405	79 (19.5)		141 (34.8)		9 (2.2)	
Total amount of practice per week							
≤2 d	291	63 (21.7)	.1963	98 (33.7)	.0002	10 (3.4)	.4126
3 d	120	23 (19.2)		49 (40.8)		2 (1.7)	
4 d	168	43 (25.6)		77 (45.8)		5 (3.0)	
≥5 d	101	27 (26.7)		53 (52.5)		6 (5.9)	
Total amount of practice per week							
<10 h	141	24 (17.0)	.0955	52 (36.9)	.0001	4 (2.8)	.5501
10-14 h	255	67 (26.3)		86 (33.7)		12 (4.7)	
15-19 h	201	37 (18.4)		88 (43.8)		5 (2.5)	
≥20 h	83	28 (33.7)		51 (61.5)		2 (2.4)	
Off-season duration							
None	204	60 (29.4)	.0079	113 (55.4)	<.0001	6 (2.9)	.2488
<1 mo	87	24 (27.6)		41 (47.1)		0 (0.0)	
1-2 mo	101	13 (12.9)		33 (32.7)		5 (5.0)	
>2 mo	288	59 (20.5)		90 (31.3)		12 (4.2)	

MEC, medial epicondyle; OCD, osteochondritis dissecans.

whereas no association was found between capitellar OCD and years of baseball experience.

Playing position

Regarding playing position, significant differences in the prevalence of elbow pain and prevalence of MEC lesions were noted according to position ($P = .0337$ for elbow pain and $P = .0007$ for MEC lesions). Pitchers and catchers were at higher risk of both elbow pain and MEC lesions, whereas no significant difference in the prevalence of capitellar OCD was found regarding position.

Total amount of exercise per week

The prevalence of MEC lesions was significantly increased when the number of practice days increased ($P = .0002$), whereas no significant associations of elbow pain and capitellar OCD with the number of practice days were found. As for practice hours per week, the MEC lesion prevalence directly corresponded to the number of practice hours ($P = .0001$), whereas no significant associations of elbow pain and capitellar OCD with the number of practice hours were observed.

Duration of off-season

The prevalence of elbow pain was significantly decreased when the subjects' off-season duration was longer ($P = .0079$), and the prevalence of MEC lesions was significantly decreased when the subjects' off-season length was longer ($P < .0001$). No significant associations of capitellar OCD with off-season duration were observed.

Multivariate analysis for associations of elbow pain and morphology with off-season duration

Multivariate logistic regression analysis, adjusted for age, years of baseball experience, position, and total amount of practice per week, revealed that the risk of elbow pain was significantly low in the group whose off-season lasted 1 to 2 months (OR, 0.32; 95% CI, 0.15-0.62; $P = .0006$) and in the group whose off-season lasted more than 2 months (OR, 0.59; 95% CI, 0.37-0.95; $P = .0316$) (Table II). The risk of MEC lesions was also significantly low in both groups: OR of 0.39 (95% CI, 0.22-0.67) with $P = .0005$ for the group

whose off-season lasted 1 to 2 months and OR of 0.36 (95% CI, 0.23-0.56) with $P < .0001$ for the group whose off-season lasted more than 2 months. On the contrary, no significant association was found between capitellar OCD and off-season duration.

Comparison of prevalence of each type of MEC lesion according to off-season duration

The prevalence of the irregular type and hypertrophic type of MEC lesions was significantly decreased when the subjects' off-season length was longer ($P < .05$) (Fig. 2). On the other hand, the prevalence of the fragmented type showed an almost constant rate (5%-7%) regardless of off-season duration.

Discussion

There have been several reports on the risk factors for elbow injuries. Height, playing position (pitcher and catcher), older age, amount of practice and pitch count, number of games per year, thoracic kyphosis, and deficit in shoulder and elbow range of motion have all been reported to be risk factors for elbow pain among juvenile baseball players.^{8,14,17,21} The amount of practice has been found to be one of the most important and modifiable risk factors for elbow disorders. Harada et al⁸ reported that 14 or more hours of training per week and training every day tended to be associated with elbow injuries. According to our study, the prevalence of MEC lesions was significantly increased when the total amount of practice (both days and hours) per week increased. Our results reinforce how important it is to regulate the amount of practice to prevent elbow injuries in elementary school-aged players.

In this study, we found that an off-season of adequate length was also beneficial in the prevention of throwing injuries due to overuse. This finding is consistent with the recommendations of several guidelines; however, until now, no evidence showing the preventive effect of a sufficient off-season duration on elbow injury among juvenile baseball players had been reported.²¹ The most important observation in our study was that not only the prevalence of

Table II Multivariate analysis for associations of elbow pain and morphology with off-season duration

Off-season duration	Elbow pain during previous season		MEC lesion		Capitellar OCD	
	OR	95% CI	OR	95% CI	OR	95% CI
None	1		1		1	
<1 mo	0.98	0.53-1.76	0.86	0.50-1.51	—	—
1-2 mo	0.32*	0.15-0.62	0.39*	0.22-0.67	1.74	0.46-6.41
>2 mo	0.59*	0.37-0.95	0.36*	0.23-0.56	1.36	0.47-4.40

MEC, medial epicondyle; OCD, osteochondritis dissecans; OR, odds ratio; CI, confidence interval.

* $P < .05$.

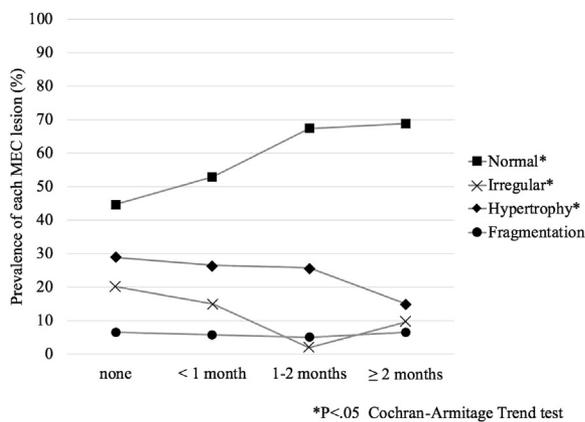


Figure 2 Comparison of prevalence of each type of medial epicondyle (MEC) lesion according to off-season duration. The prevalence of the irregular and hypertrophic types was significantly decreased when the subjects' off-season length was longer ($P < .05$). However, the prevalence of the fragmented type was at an almost constant rate (5%-7%) regardless of off-season duration.

elbow pain but also the prevalence of MEC lesions was significantly decreased in players who had an off-season of more than 1 month. This finding suggests that an off-season of more than 1 month per season might be a minimal requirement for preventing elbow disorders in elementary school-aged baseball players.

Regarding MEC lesions, it has been reported that the irregular type suggests minimal avulsion whereas the fragmented type suggests large avulsion of the MEC; the hypertrophic type was reported to indicate the healing status of these bony avulsion injuries.²³ According to our study, the prevalence of the irregular and hypertrophic types was significantly decreased with the increase in off-season duration, whereas no significant correlation was found with the fragmentation type. These results suggest that early and minimal avulsion of the MEC might heal completely without residual bony abnormalities if the players are able to take enough time off in the off-season.

Although the precise etiology of OCD remains unclear, it has been widely recognized that repetitive mechanical stress on the radiocapitellar joint contributes to the development of OCD.^{4,22} However, in a study by Matsuura et al,¹³ no significant differences were reported in the prevalence of OCD by age or playing position. In our study, age, years of baseball experience, playing position, amount of practice time per week, and off-season duration were not found to be associated with capitellar OCD prevalence. These findings suggest the possible involvement of internal factors, such as a genetic predisposition^{19,20} or micro-blood flow disturbance of the capitellum,⁹ in the development of OCD. Further studies are required to confirm these findings.

There were several limitations to this study. The first limitation involves the definition of the off-season. The term "off-season" is quite vague. Generally, it is defined as the

period of the year between the end of one season and the start of the next, during which activity is reduced or suspended. In this study, we defined the off-season as the winter period, during which there are no competitions and all baseball activity is suspended. We assumed that almost all players did not throw during this period. However, whether players actually allowed their elbows to rest adequately during off-season periods might not be clear because our questionnaire did not include any questions on the presence of throwing during the off-season. Future studies should include the amount of off-season physical activity to clarify the significance of rest during the same period. The second limitation is that other proposed risk factors for elbow injury, such as pitch type, pitch count, pitching mechanics, and number of games per season, were not included in our analysis.^{11,14,21} Takagishi et al²¹ reported that the incidence of shoulder and elbow pain in players who throw over 50 balls per day was 1.282-fold higher than that in players who do not, and Matsuura et al¹⁴ reported that playing more than 100 games per year was a risk factor for elbow pain. These known risk factors should be included in any future studies. The third limitation is our study design. Because our study was a cross-sectional one, the causal relationships between elbow disorders and the other associated factors are unknown. To clarify the precise influence of the off-season on elbow injury, a prospective cohort study is required. The last limitation is the methods of data collection. A self-completed questionnaire is one of the standard methods of data collection in such large epidemiologic studies regardless of age.^{8,10,13-15,17,21} However, there is a concern that answers may sometimes be unreliable if the subject is too young. Although we recommended that subjects answer the questionnaire with the help of their parents to obtain accurate answers, some biases (reporting bias, recall bias, and so on) that may potentially influence the outcome could exist.

Conclusion

Off-season duration has a significant correlation with elbow pain and morphologic abnormalities of the MEC in elementary school-aged baseball players, whereas no association was found with capitellar OCD. We believe that an off-season of at least 1 month is a minimal requirement for the prevention of elbow pain and morphologic abnormalities of the MEC in juvenile baseball players.

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