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ORIGINAL ARTICLE

Elasticity of the pronator teres muscle in youth baseball players with elbow injuries: evaluation using ultrasound strain elastography

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Background: Although the pronator teres muscle, a major dynamic stabilizer of elbow valgus stress during throwing, frequently presents stiffness, its relationship with elbow injuries in youth baseball players is unknown. This study investigated the relationship between the elasticity of the pronator teres muscle and elbow injuries in youth baseball players.

Methods: The strain ratio (SR) of 15 individuals with osteochondritis dissecans of the humeral capitellum (OCD group), 67 individuals with medial epicondylar fragmentation (medial injury group), and 115 healthy individuals (control group) was measured as the index of the elasticity of the pronator teres muscle using ultrasound strain elastography. In addition, the forearm and glenohumeral joint rotation range of motion was measured.

Results: The SR of the throwing arm was significantly higher in the OCD and medial injury groups than in the control group (both $P < .001$). In the OCD group, the SR was significantly higher in the throwing arm than in the nonthrowing arm ($P < .001$), whereas in the medial injury group, there was no significant difference between both arms. The glenohumeral joint external rotation range of motion of the throwing arm was moderately negatively correlated with the SR ($r = –0.478$, $P < .001$).

Conclusions: Stiffness of the pronator teres muscle was exhibited only in the throwing arm of individuals with OCD and in both arms in individuals with medial elbow injury. These findings may contribute to an accurate evaluation and prevention of elbow injuries in youth baseball players.

Level of evidence: Level III; Diagnostic Study

Keywords: Elbow injury; youth baseball player; pronator teres muscle; ultrasound strain elastography; elasticity; osteochondritis dissecans

Although baseball is a widely played sport worldwide, regardless of age, elbow injuries are often encountered, especially in youth baseball players. Iwame et al[23] reported that among 1605 players aged 6 to 12 years, 499 players (31.1%) had episodes of elbow pain, of whom 320 players (64.1%) exhibited abnormal findings on physical examination. Pennock

The Akita University Graduate School of Health Sciences Ethics Committee approved this study (study no. 1036).

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et al[41] prospectively investigated Little League players aged 10 to 13 years and showed that magnetic resonance imaging abnormalities of the elbow were present in 35% of players.

Elbow injuries in youth baseball players are mainly observed in the medial and lateral sides of the elbow. The medial side injuries, such as medial epicondylar fragmentation, are most common,[28] and the outcome of nonoperative treatment is relatively good.[18] However, osteochondritis dissecans (OCD) of the humeral capitellum of the lateral side of the elbow has limited indications for nonoperative treatment and requires a long time for lesion repair,[46] although the prevalence is as low as 1.3% to 3.4%.[20,26,32]

Various theories about the etiology of these elbow injuries have been proposed, but evidence shows that repetitive elbow valgus stress during throwing is related to these conditions.[4,8,24,28] Several authors have reported that contraction of the flexor-pronator muscles generates the elbow varus force and acts as a dynamic stabilizer against the elbow valgus stress in anatomic and biomechanical studies.[2,30,40,48] Buchanan et al[7] reported that the pronator teres muscle was the largest contributor of varus moments on static valgus load in an electromyographic study. Stiffness and tenderness of the pronator teres muscle are frequently observed in the clinical setting.

The relationship between the elasticity of the pronator teres muscle and elbow injuries in youth baseball players is poorly understood, however. This study used ultrasound strain elastography to clarify the relationship between the elasticity of the pronator teres muscle and elbow injuries in youth baseball players.

Materials and methods

Participants

This was a controlled experimental study. From 2015 to 2017, 197 male youth baseball players from local baseball clubs in Japan participated in our study. All participants were recruited from the community via university- and hospital-based advertisements. The study population was divided into 3 groups according to their ultrasonographic findings, and Table I summarizes the demographic characteristics of each group. The OCD group consisted of 15 individuals (mean age, 11.5 years; range, 10-14 years) with OCD of the humeral capitellum of their throwing arm. The medial injury group consisted of 67 individuals (mean age, 11.3 years; range, 9-13 years) with medial epicondylar fragmentation of their throwing arm. Inclusion criteria were (1) being a baseball player aged 9 to 15 years and (2) confirmation of OCD diagnosis of the humeral capitellum or medial epicondylar fragmentation by an orthopedic surgeon based on ultrasonographic results. The ultrasonographic examination was performed according to a previously described manner,[20,46,47] and the accuracy and reliability of ultrasonography for diagnosis of these elbow injuries has been demonstrated in several reports.[19,20,26,47] Exclusion criteria were (1) a history of elbow surgery and (2) a previous shoulder injury or pain. None had a previous elbow surgery in each group. The same exclusion criteria were applied to the participants in the control group.

Table I Characteristics of participants in the 3 groups

Variables	OCD group (n = 15)	Medial injury group (n = 67)	Control group (n = 115)	*P* value
Age, yr	11.5 ± 1.1	11.3 ± 0.9	11.2 ± 0.7	.340
Height, cm	149.4 ± 9.4	146.7 ± 7.8	146.4 ± 8.4	.509
Weight, kg	42.4 ± 9.2	40.3 ± 7.9	39.7 ± 8.9	.587
Dominant limb				.501
Right	12 (85.7)	40 (95.2)	76 (91.6)	
Left	2 (14.3)	2 (4.8)	7 (8.4)	
Months of experience	31.0 ± 9.4	33.7 ± 13.9	31.4 ± 13.1	.477
Position				.167
Pitcher	4 (26.7)	20 (29.9)	31 (27.0)	
Catcher	2 (13.3)	7 (10.4)	10 (8.7)	
Infielder	9 (60.0)	28 (41.8)	38 (33.0)	
Outfielder	0 (0.0)	12 (17.9)	36 (31.3)	

OCD, osteochondritis.
Data are expressed as mean ± standard deviation or as number (%).

According to the classification of the OCD lesion using the ultrasonographic image proposed by Takahara and colleagues,[31,47] 3 of the 15 individuals were type I (subchondral bone flattening and cartilaginous thickening), 7 were type II (nondisplaced fragments and an intact articular surface), and the other 5 were type III (displaced fragments). None was classified as type IV (osteochondral defects). In the medial injury group, none had an avulsion fracture of the medial epicondyle or ulnar collateral ligament tear on ultrasonographic results.

The control group consisted of 115 healthy youth baseball players (mean age, 11.2 years; range, 9-12 years) matched to the OCD and medial injury groups by age, height, weight, dominant limb, months of experience, and position. None of the players chosen for the control group had any histories of major elbow injury or surgery, pain of elbow and shoulder, or abnormal elbow findings on ultrasonography.

Written informed consent for the collection and use of the information was obtained from all participants and their guardians in accordance with the Declaration of Helsinki.

Elasticity of the pronator teres muscle

The elasticity of the pronator teres muscle of the throwing and nonthrowing arms was measured on ultrasound strain elastography (Hi VISION Avius; Hitachi, Ltd., Tokyo, Japan) using a linear-array transducer with a frequency of 10 MHz (EUP-L65; Hitachi, Ltd., Tokyo, Japan). As a reference of the elasticity, an acoustic coupler (EZU-TECPL1; Hitachi, Ltd.) with an elastic modulus of 22.6 ± 2.2 kPa was placed onto the transducer with a plastic attachment (EZU-TEATC1; Hitachi, Ltd).[21,34] A short-axis image of the pronator teres muscle was obtained while participants were seated on the chair. The elbow was flexed 30°, and the forearm was supinated on the arm stand. The participant was instructed to relax his arm. For imaging of the pronator teres muscle, the transducer was placed on the trochlea of the humerus at first, and the transducer