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Original Article

Does restriction of glenohumeral horizontal adduction reflect posterior capsule thickening of the throwing shoulder?

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Abstract. [Purpose] Glenohumeral posterior capsule tightness possibly relates to posterior capsule thickness (PCT). The purpose of the current study was to analyze the relationships between PCT and glenohumeral range of motion (ROM) in horizontal adduction (HAdd) and internal rotation (IR). [Subjects and Methods] This study recruited 39 healthy collegiate baseball players. We measured PCT by using ultrasonography and ROM of the glenohumeral joint of the throwing shoulder by using a digital inclinometer. Pearson's correlation coefficients were calculated between PCT and HAdd or IR ROM. [Results] There was no correlation between PCT and HAdd ROM, but PCT was significantly correlated with IR ROM. [Conclusion] This result indicates that posterior shoulder capsule tightness only relates to IR ROM, and that restricted HAdd ROM might reflect tightness of other tissue, such as the posterior deltoid.

Key words: Capsule thickness, Horizontal adduction, Internal rotation

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INTRODUCTION

It is common for throwing athletes to demonstrate limited glenohumeral internal rotation (IR) (Fig. 1A) of their throwing shoulder compared with their non-throwing shoulder. This loss of IR range of motion (ROM) is termed GIRD which is an acronym for glenohumeral IR deficit[1]. There have been several studies to indicate a relationship between GIRD and throwing-related injury, including shoulder and/or elbow problems[2–6]. Furthermore, a previous prospective study demonstrated that professional baseball pitchers with GIRD may have a higher risk of shoulder injury[5].

Burkhurt et al. described the possibility that contracture of the posterior capsule can be led by response to distractive loads during the follow-through phase of throwing motion[1]. Furthermore, previous cadaveric studies demonstrated that simulated posterior capsule contracture caused GIRD[7, 8]. Burkhurt et al. also reported that baseball players with GIRD have a thickened posterior capsule at the posterior band of the inferior glenohumeral joint-ligament complex[1]. Thomas et al. measured posterior capsule thickness (PCT) in their study, and confirmed the reliability and validity of PCT measurement using ultrasonography[9, 10]. In addition, they also revealed that the dominant shoulder has a thicker posterior capsule than the non-dominant shoulder, and that there is a significant correlation between PCT and IR ROM. Based on their study, PCT measurement can be a way to assess posterior capsule tightness in vivo.

Glenohumeral horizontal adduction (HAdd) ROM (Fig. 1B) also can be used to assess posterior capsule tightness as well as measuring IR ROM. Several previous studies have investigated the reliability and validity of HAdd ROM measurement to assess posterior shoulder tightness[11–13]. These studies indicated good to high reliability, and revealed the validity of HAdd by comparing it with IR. However, there has been no study to analyze the relationship between PCT and HAdd ROM. We hypothesized that PCT would correlate with HAdd as well as IR ROM. The purpose of the present study was to analyze the correlations between PCT and IR or HAdd ROM in order to determine which ROMs reflects posterior capsule tightness.

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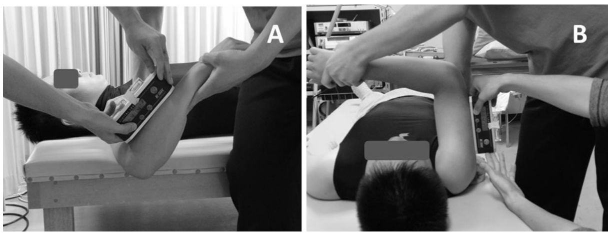

Fig. 1. Measurement of the ROMs
(A) Glenohumeral internal rotation. (B) Glenohumeral horizontal adduction.

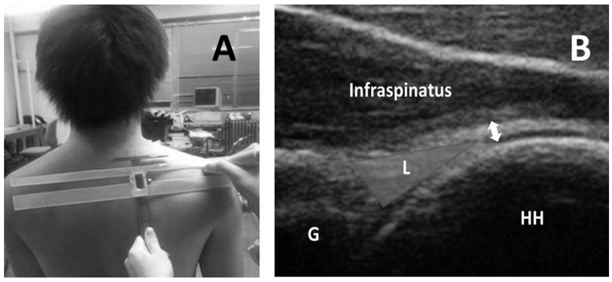

Fig. 2. Measurement of posterior capsule thickness
(A) Photograph, demonstrating how to use our original device to detect height of posterior capsule. (B) Ultrasonographic image, showing PCT (double arrowheads), glenoid (G), humeral head (HH), and labrum (shadow and L).

SUBJECTS AND METHODS

Thirty-nine collegiate baseball players, including 11 pitchers and 28 position players (age, 20.0 ± 1.36 years; height, 174.59 ± 5.47 cm; weight, 71.89 ± 7.61 kg; duration of playing baseball, 10.89 ± 2.30 years), volunteered to participate in this study. All participants were members of a baseball team that belongs to a division one collegiate league in a local region of Japan. Participants who were not able to throw at the time of measurement, and who had orthopedic and/or neurologic problems, were excluded from this study. All participants read and signed an informed consent form prior to their inclusion in this study. This study was approved by the Institutional Review Board of the Faculty of Health Sciences of Hokkaido University (12-9).

As measurement posture, the participant was seated upright in a chair, with one arm beside his body and the shoulder internally rotated. Our pilot study of 25 anterior-posterior shoulder radiographs showed that the middle region of the posterior capsule is located at the upper 21% between the superior and inferior angles of the scapula. Therefore, we measured the length between the scapular superior and inferior angles, and calculated 21% of the length from the superior angle as the middle region of posterior capsule height. Then, we measured PCT by using a MyLab 25 ultrasound unit (Biosound Esaote, Indianapolis, IN, USA) using a modified method of a previously reported technique[9, 10]. Our original device was placed on the posterior aspect of the scapula along the scapular medial border, and the ultrasound transducer, which was applied standard acoustic coupling gel, was placed between the two bars of the device to visualize the posterior capsule (Fig. 2A). The posterior capsule was identified as the tissue found immediately lateral to the glenoid labrum, between the humeral head and rotator cuff (Fig. 2B)[9, 10]. When the capsule was identified, the image was paused and stored to the hard drive of the ultrasound machine, and PCT was measured. We carried out another pilot study that analyzed the side-to-side difference in PCT in collegiate baseball players (n = 9; age, 23.9 ± 4.5 years; height, 173.2 ± 5.5 cm; weight, 67.2 ± 7.9 kg), which revealed a significantly thickened posterior capsule of the throwing shoulder compared with the non-throwing shoulder. This result is consistent with a previous study[9]. Taking our pilot study and the previous study into account, thickening of the posterior capsule could be a specific alteration of the throwing shoulder in baseball players. Therefore, in this study, we measured PCT of the throwing shoulder only. This measurement procedure was conducted twice in every shoulder, and the average of the measurements was used for statistical analysis. We also analyzed the reliability of this method using 16 healthy collegiate baseball players (age, 19.4 ± 1.0 years; height, 169.0 ± 6.6 cm; weight, 62.3 ± 5.2 kg) in order to evaluate intra- and inter-rater reliability. In the reliability study, all subjects had once undergone the procedure described above by two examiners (T. I. and T. K.). Seven days after the first observation, they visited our laboratory again, and underwent the same procedure by one examiner (T. K.).

For assessment of HAdd and IR ROM, participants were asked to lie down on a table and relax. All measurements were conducted by two experienced physical therapists (T. I. and T. K.) using a digital inclinometer (Survey Techno-Science, Nagoya, Japan). For HAdd ROM measurement, one investigator put his hand on the lateral border of the subject's scapula to restrict any scapular motion, and moved the subject's arm to a horizontally adducted position until the investigator perceived movement of the subject's scapula. Another investigator placed the inclinometer on the subject's arm to measure the HAdd angle. For IR ROM measurement, the subject's shoulder was placed at 90° abduction with the elbow flexed to 90° and the forearm in a middle position between pronation and supination. One investigator put his palm on the subject's coracoid, while the other hand internally rotated the subject's arm. Another investigator placed the inclinometer on the subject's forearm to measure the IR angle.

Descriptive data included means ± SDs. In order to reveal test-retest reliability of our PCT measurements, intraclass correlation coefficients (ICC) were calculated for both intra- and inter-rater reliability. $ICC_{(1, 2)}$ and $ICC_{(2, 2)}$ were calculated to demonstrate intra- and inter-rater reliability, respectively. Pearson's correlation coefficients were calculated to reveal the relationships between PCT and each ROM measurement. PASW Statistics version 18 software (IBM, Chicago, IL, USA) was used for statistical analyses, and coefficients were considered significant at $p < 0.05$.

RESULTS

Mean PCT, HAdd and IR were 1.24 mm ± 0.29 mm, 96.04° ± 9.97°, and 43.05° ± 9.93°, respectively.

Reliability analysis of 16 baseball players demonstrated an almost perfect intra-rater reliability ($ICC_{(1, 2)} = 0.95$, $p < 0.01$) and an almost perfect inter-rater reliability ($ICC_{(2, 2)} = 0.98$, $p < 0.001$).

There was a significant relationship between PCT and IR ROM ($r = -0.351$, $p = 0.028$), but there was no significant relationship between PCT and HAdd ROM ($r = 0.156$, $p = 0.343$).

DISCUSSION

The present study was conducted to test the hypothesis that PCT correlates with not only IR ROM but also HAdd ROM. We found there was no significant relationship between PCT measured by using ultrasonography and HAdd ROM, but we did find a significant correlation between PCT and IR ROM. Therefore, results of the present study clearly denied our hypothesis. Findings of the present study suggest that IR ROM deficit relates to posterior capsule tightness, even though previous studies have reported a significant correlation between IR and HAdd[11–13].

We do not know the exact reason why we failed to show a significant relationship between PCT and HAdd ROM in the present study. However, there is a study that compared the effects of stretching on posterior shoulder tightness, such as restriction of IR and HAdd ROM, between sleeper stretch, including IR motion, and cross-body stretch, including HAdd motion. This previous study reported that cross-body stretch was more effective to reduce posterior shoulder tightness compared with sleeper stretch[14]. In addition, other previous studies have demonstrated that the posterior deltoid muscle was stretched with HAdd, whereas both the posterior shoulder capsule and the middle and inferior regions of the infraspinatus were not stretched with HAdd[15, 16]. Therefore, considering the results of this study and these previous studies, IR ROM deficit may reflect stiffness of both the posterior capsule and other soft tissue, whereas HAdd ROM restriction may reflect stiffness of only soft tissue, such as the posterior deltoid muscle, rather than the posterior capsule.

There are a few limitations in this study. First, the value of PCT in this study was relatively smaller than that in a previous study[9, 10]. Body mass of participants in the previous study was larger than that of participants in this study (previous study, 88.14 kg ± 4.81 kg; present study, 71.86 ± 7.5 kg). It has been reported that body mass can affect ball velocity in baseball pitching[17]. The difference in ball velocity might affect the distraction load, which causes posterior shoulder tightness, and, thus, PCT in this study was relatively smaller than that in the previous study. Second, the correlation coefficient obtained in the present study represents a weak correlation between PCT and IR ROM, though it is similar to that in a previous study[9]. Hence, there is some possibility that other tissue, such as the rotator cuff tendon or posterior deltoid muscle, restricts IR ROM. Third, humeral retroversion was not considered in this study, even though it is known to decrease IR ROM. Thomas et al. also reported that humeral retroversion is related to PCT[10]. Therefore, further study should consider humeral retroversion when measuring glenohumeral ROM.

Concerning clinical relevance, previous cadaveric studies have demonstrated that posterior capsule tightness augments subacromial pressure during arm elevation[8, 18]. Furthermore, Maenhout et al. suggested that healthy overhead-throwing athletes with GIRD demonstrate a smaller acromiohumeral distance[19], which represents two-dimensional assessment of the subacromial space. Thus, posterior capsule tightness might affect shoulder problems by reducing the subacromial space and by scapular dyskinesis. Although baseball players demonstrate greater IR ROM deficit, induced by posterior shoulder tightness, of the throwing shoulder, identifying which tissue restricts posterior shoulder flexibility is reasonable to prevent throwing-related problems, because strategies to improve posterior shoulder tightness would differ depending on the tissue that induces the tightness. Therefore, we believe the results of this study can be helpful to identify the cause of posterior shoulder tightness.

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