

Comparative Analysis of Acromiohumeral Distances According to the Locations of the Arms and Humeral Rotation

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Abstract. [Purpose] The purpose of this study was to compare the potential effects of resistance exercise according to the positions of the arms and the rotation of the humerus on the subhumeral acromial space. [Subjects] The study subjects were 34 subjects without shoulder pain. [Methods] Ultrasonographic measurements of the acromiohumeral distance of the subjects were made at three shoulder positions: 90° flexion, scaption at 90° abduction, and 90° abduction in an upright sitting position. The subjects were instructed to vertically push against a table to the maximum level with the humerus in internal, neutral, and external rotation. The measurements were made three times in each position. [Results] There was a significant difference in acromiohumeral distance between neutral and internal rotation of the humerus, and between external rotation and internal rotation of the humerus. In the scaption position, there was a significant difference between neutral and internal rotation of the humerus, and between external rotation and internal rotation of the humerus. In the 90° flexion position, there was a significant difference between neutral and internal rotation, and between neutral and external rotation. There was a significant difference between the flexion position and the abduction position, and between the flexion position and the scaption position. In terms of the internal rotation of the humerus, there was a significant difference between 90° flexion and 90° abduction. [Conclusion] These findings can be applied in exercises prescribed to increase the acromiohumeral distance and to aid the treatment and evaluation of shoulder dysfunctions.

Key words: Ultrasonographic, Acromiohumeral distance, Humeral rotation

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INTRODUCTION

Stability of the glenohumeral joint is provided by static elements (articular surface and ligament) and dynamic elements (muscles). The rotator cuff stabilizes the glenohumeral joint in different shoulder positions and adjusts the translations of the humeral head¹⁾.

The most common cause of shoulder pain is rotator cuff disease. Rotator cuff tear reduces stability and triggers superior migration of the humeral head in abduction, which may lead to acromial impingement²⁾. Slight upward translation occurs in the humeral head of normal shoulders, but severe rotator cuff tear triggers major upward translation,

which causes subacromial impingement. Superior migration of the humeral head may be measured by the acromiohumeral distance. The cause of upward displacement of the humeral head has not been clearly verified. Laceration of the tendon structure that maintains the space and lack of stability of the rotator cuff are considered to increase traction of the deltoid muscle³⁾.

Scapular dyskinesis refers to an abnormal position or movement of the scapula during active motions⁴⁾. The condition makes the subacromial space smaller⁵⁾, and it sometimes occurs together with subacromial impingement syndrome⁶⁻⁸⁾. Coordinated movement of the scapula is necessary for the motions and functions of the shoulders. Desmeules and his co-researchers recommended ultrasonography as a measurement tool for suspected when shoulder impingement syndrome, and reported that there are changes in the subacromial space according to different positions of the shoulders⁹⁾. It has been reported that patients with rotator cuff disease have a small acromiohumeral distance compared with healthy people¹⁰⁾, and that the acromiohumeral

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Table 1. Intrarater reliability of the acromiohumeral distance of each arm position

	Resting	90° flexion	Scaption	90° abduction
Neutral	0.947 (0.909–0.971) ^a	0.966 (0.941–0.982)	0.954 (0.920–0.975)	0.967 (0.942–0.982)
Ext-rot	-	0.946 (0.907–0.971)	0.864 (0.775–0.924)	0.922 (0.867–0.957)
Int-rot	-	0.925 (0.872–0.959)	0.884 (0.807–0.936)	0.881 (0.802–0.934)

^aICC (95% CI): Intraclass correlation coefficient

distance is smaller in patients with impingement syndrome than in those with healthy shoulders on magnetic resonance images (MRI)¹¹. Ultrasound is less expensive and more practical than MRI, and is a valid radiographic examination method for the measurement of acromiohumeral distance ($r=0.77-0.85$)¹².

Clinically, diagnoses of shoulder impingement and rotator cuff tear are common. The subacromial space is smaller in patients with symptoms of scapular dyskinesia or impingement syndrome. Endo⁷) noted that impingement occurs frequently at a humeral elevation of 90° and named it the impingement zone.

The hypothesis of this study was that resistance exercise will have different effects on the subacromial space according to the location of the arms and the degree of rotation of the humerus. This study performed a comparative analysis of the effects of resistance exercise on the subhumeral acromial space according to the location of the arms and the rotation of the humerus.

SUBJECTS AND METHODS

The subjects of this study were 34 participants, 20 males and 14 females. The average age of the participants was 29.5 (range 25–39) years. The criteria for selection were: no history of orthopedic surgery, no fracture, pain, or neurological damage to the shoulders, and no limitation in the movement of the arms. The acromiohumeral distance of the right side of healthy subjects without shoulder pain was measured with a diagnostic ultrasound system according to the locations of the arms and humeral rotation during resistance exercise. The purpose of this study was sufficiently explained to the subjects and their consent to voluntarily participate in this study was obtained. This study was approved by the Hanmaeum Hospital Institutional Review Board.

The ultrasound equipment used was a HDI 5000 of ALTPHILIPS machine, with a linear probe transducer operated at a frequency at 7.5 MHz¹³). To determine the acromiohumeral distance, the shortest distance between the humeral head and the subacromial area was measured using the Picture Archiving and Communication System.

The participants were seated upright on a chair, with their hips and knees flexed to 90° and their feet resting flat on the ground, looking forward (straight ahead). To measure the acromiohumeral distance at rest, three ultrasound measurements were obtained of the subjects with their upper limbs placed in a position of 0° abduction, with a neutral shoulder rotation, 90° elbow flexion, and their forearms in a mid-prone position. The subjects adopted three shoulder positions: 90° flexion, scaption with 90° abduction, and 90°

abduction in an upright sitting posture. Ultrasound images were obtained of the three different humeral rotations, neutral rotation, external rotation, and internal rotation, in the following three Shoulder positions, 90° flexion, scaption with 90° abduction, 90° abduction, in an upright sitting posture. The subjects were instructed to vertically push the table to the maximum level with the humerus in internal, neutral, and external rotation. In each position, internal rotation of the humerus was measured with the thumb downward, and external rotation of the humerus was measured with the thumb outward to the maximum level, with the shoulder not elevated. Scaption was defined as 30° anterior to the frontal plane, and the angle was verified with a goniometer.

The ultrasound transducer was placed parallel to the flat surface at the most anterior aspect of the acromion, with the long axis of the probe in the plane of the scapula to scan the shoulder. The acromiohumeral distance was defined as the shortest distance in a straight line connecting the most inferior aspect of the acromion and the humeral head.

SPSS ver 12.0 statistical program was used for the analysis of the study data. Repeated measures analysis of variance was employed to examine the significance of differences in the subacromial space distance according to the locations of the arms of the subjects and the degree of humeral rotation. A posthoc test (Bonferroni test) was conducted when of a significant difference in the measured values of the different postures was found. To analyze the intra-rater reliability of the ultrasonographic measurements, the intraclass correlation coefficient for the measured values was calculated. A significance level of $\alpha = 0.05$

RESULTS

The subacromial space was compared among the locations of the arms of the subjects and the degree of rotation of the humerus. In the measurements of the distance of the subacromial space, intra-rater reliability was high (0.881 minimum to 0.967 maximum) (Table1).

The acromiohumeral distance was significantly different among the positions of humeral rotation and the different locations of the arms. The acromiohumeral distance was largest when the humerus was internally rotated in 90° abduction. When the acromiohumeral distance was compared among the rotations of the humerus (Table 2), the difference in the distance between the neutral rotation and the internal rotation of the humerus in the 90° abduction position was significant (0.2726, $p < 0.05$). The difference in the distance between external rotation and internal rotation was also significant (0.3244, $p < 0.05$).

In the scaption position, the difference in the distance

Table 2. Comparison of acromiohumeral distances of the arm postions and humerus rotation

	Flexion 90	Scaption	Abduction 90	
Rest	0.808±0.038	0.972±0.038	0.986±0.043	*
Ext-rot	0.998±0.041	0.962±0.043	0.934±0.037	
Int-rot	1.123±0.043	1.216±0.044	1.259±0.039	*
	*	*	*	

*Significant difference ($p < 0.05$). Unit: cm
Mean(\pm)SD

between neutral rotation and internal rotation was significant (0.2435, $p < 0.05$) and the difference in the distance between external rotation and internal rotation was significant (0.2542, $p < 0.05$).

In the 90° flexion position, the difference in the distance between neutral rotation and internal rotation of the humerus was significant (0.1906, $p < 0.05$), and the difference in the distance between the neutral and the external rotation of the humerus was significant (0.3153, $p < 0.05$).

The difference in the distances of the subacromial space in relation to the position of the shoulder were compared, and the distance was greater in internal rotation than in neutral and external rotation. The distance of the subacromial space was greatest in the neutral position without rotation of the humerus. The variation, in the distance between the flexion position and the scaption position was significant (0.164), and the variation in the distance between the flexion position and the abduction position was also significant (0.178, $p < 0.05$). There was a significant difference (0.1356) between the 90° flexion and 90° abduction with the internal rotation of the humerus ($p < 0.05$).

DISCUSSION

A recent study has shown that the acromiohumeral distance is related to functional disorder resulting from shoulder disease and pain¹⁴. Karduna and his co-researchers reported that there was a correlation between abnormalities in the acromiohumeral distance and abnormal scapular movement¹⁵. Others have reported a correlation between the location and the movement of the humerus and rupture of the rotator cuff and impingement syndrome symptoms^{8, 16-18}. Ludewig and Cook¹⁷ noted that subacromial impingement is associated with a decrease in upward rotation of the scapula.

Dewhurst asserted that muscular function changes in patients with impingement syndrome aggravat the condition, and that the subacromial space is affected by shortened pectoral and levator scapulae muscles, thoracic kyphosis, and bad posture¹⁹. That study further noted that strengthening of the supraspinatus muscle, glenohumeral joint, infraspinatus muscle, teres minor muscle, and subscapularis muscle, in other words, muscles affecting the stability and mobility of the rotator cuff, was required in addition to interactions among the serratus anterior muscle, upper trapezius muscle, and lower trapezius muscle, for effective scapular rotation.

At 0° shoulder abduction, Liu and his co-researcher reported that the abductor role of the deltoid did not affect²⁰.

According to Hughes and An²¹) at 90° of shoulder abduction, the deltoid plays a significant role in abduction. In general, muscle activities of the anterior and middle part of the deltoid are high at scaptions of 60° and 90°, and the activities of the supraspinatus, infraspinatus, and subscapularis are high between 30° and 60°²²).

Jobe and Pink²³) observed that the subacromial space became smaller during abduction and elevation of the arms, and that a decreased subacromial space increased the load on the rotator cuff tendons, possibly triggering impingement in tennis players. During the initial action of abduction, the humeral cephalad moves toward the acromion process and the subscapularis forces the head of the humerus downward²⁴). The infraspinatus and teres minor comprise the posterior cuff and provide posteroinferior force to the humeral head, and resistance against superior and anterior translation of the humeral head²⁵).

Azzoni and Cabitza¹²) noted that the ultrasonographic method was easy and useful for diagnosing patients with musculoskeletal damages, but it had disadvantages in that results depend on the skill of the measurer who requires in its use. However, in the present study, the intraclass correlation coefficient of the ultrasonographic method used to measure the acromiohumeral distance was high (0.88 to 0.97). This level of reliability is similar to that reported in other studies. In a study by Cotty and his coresearcher²⁶), the acromiohumeral distance of a normal shoulder was 10.5 mm. In the present study, the acromiohumeral distance while the subjects were at rest was 11.0 mm. The average value for females was 10.6 mm and that of males was 11.3 mm, and no significant difference between the two groups was found by the independent t-test.

This study also applied isometric resistance exercise in a vertical downward direction in 90° abduction, 90° flexion and scaption with 90° abduction, in which impingement commonly occurs. The acromiohumeral distances of the postures of the shoulders with the humerus in a neutral position were significantly different, with the distance largest in 90° abduction. The actions of the subscapularis, infraspinatus, and teres minor may have caused inferior translation of the humeral head, and decreased the acromiohumeral distance. According to a study by Sharkey and Marder²⁵), When isometric resistance exercise was conducted with the shoulder in a 90° shoulder abduction position, the scapularis and infraspinatus were activated simultaneously. According to Hughes and An²¹) to resist superior translation of the humeral head, abductor moments should be made in an inferior direction, because the teres minor below the scapu-

la and the humerus create weak adductor torque.

In addition, in each position, the acromiohumeral distance was significantly larger with internal rotation of the humerus. As the subscapularis, an internal rotator, aids the activities of the latissimus dorsi, pectoralis major, and the teres major, it provides medial rotation of the humerus. This enhances, the activity of the anterior and posterior fibers of the deltoid, the triceps long head, the teres major, and the pectoralis major and triggers adduction, of the humerus, thereby increasing the acromiohumeral distance. The increase in the acromiohumeral distance decreased pressure on the subhumeral acromial space.

The amount of change in the acromiohumeral distance necessary to influence a patient's symptom and shoulder function remains unclear. A limitation of this study was that it did not monitor scapular motion or muscle activity. Research that complements the current work is therefore considered necessary.

This study used a diagnostic ultrasound system to comparatively analyze the effects of resistance exercise on the subhumeral acromial space according to the locations of the arms and the rotation of the humerus. The subhumeral acromial space was largest in 90° abduction with the humerus internally rotated, and smallest in 90° flexion without humeral rotation. Overall, the subhumeral acromial space was large when the humerus was internally rotated. Therefore, the subhumeral acromial space appears to differ according to the amount of humeral rotation and the locations of the arms. The larger size of the subhumeral acromial space during internal rotation is due to the internally rotated muscles triggering inferior translation of the humerus increasing the space.

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