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Ultrasound measurements on acromio-humeral distance and supraspinatus tendon thickness: Test–retest reliability and correlations with shoulder rotational strengths

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Abstract

Objectives: To establish the test–retest reliability of ultrasound measurements on acromio-humeral distance (AHD) and supraspinatus tendon thickness; and to explore their relationships with shoulder rotational strengths.
Design: Test–retest observational study.
Methods: Thirty-seven individuals (age: 21.5 ± 1.4 years) participated in this study. Twenty-four were University volleyball players with 15 healthy and 9 players with shoulder impingement syndrome (SIS). Thirteen participants were healthy untrained individuals. Ultrasound measurements of AHD and supraspinatus tendon thickness were taken, and isokinetic testing of concentric shoulder internal rotation (IR) and external rotation (ER) at a speed of 90°/s was performed.
Results: The measurement of the AHD and the supraspinatus tendon thickness indicated excellent reliability (ICC = 0.922, and ICC = 0.933 respectively), and the minimum detectable difference (MDD) were 2.10 mm and 0.64 mm respectively. A cut-off AHD distance of 23.9 mm had a sensitivity of 0.67 and specificity of 0.71 (area under curve (AUC): 0.70; $p = 0.05$) in identifying individuals with and without SIS. Hence, individuals with AHD larger than 23.9 mm had greater possibility of having SIS. Positive correlations were found in AHD with supraspinatus tendon thickness ($r = 0.36$, $p < 0.05$) and shoulder external rotational strengths ($r = 0.47$–0.62, all $p < 0.05$) and ER/IR ratios ($r = 0.56$–0.58, all $p < 0.05$).
Conclusions: Ultrasound measurements of AHD and tendon thickness have excellent reliability. The reported cut-off AHD highlighted the potential role of ultrasound measurements in volleyball players for early identification of SIS. The AHD was related to the supraspinatus tendon thickness and shoulder external rotation strengths. Our findings provide a scientific basis for muscle training in overhead athletes such as volleyball players.

Keywords: Overhead athletes; Rotator cuff; Shoulder impingement syndrome; Subacromial space; Tendon; Ultrasonography

1. Introduction

Shoulder impingement syndrome (SIS) is one of the most common shoulder musculoskeletal disorders found in orthopedics and sports medicine, particularly in the overhead athletes. SIS is defined as the mechanical entrapment of the rotator cuff (mainly the supraspinatus tendon) or the subacromial bursa in the subacromial space between the humeral head and acromion or coracoacromial ligament.[1,2] The etiology of SIS is multifactorial, and the narrowing of the subacromial space and the enlargement of the subacromial tissues (bursae/tendons) were believed as the two main contributing factors.[3,4]

The subacromial space (SAS) or acromio-humeral distance (AHD) could be measured by magnetic resonance imaging (MRI),[5–7] computed tomography (CT), X-rays,[8] and ultrasound.[9–11] Among these various imaging

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modalities, ultrasonography was found to be a technique that is non invasive, radiation free and has high validity when compared with X-ray ($r > 0.8$).[12] In addition, the AHD was found greater in males,[5] and reduced with shoulder elevation.[5,6,8] The AHD and its dynamic control when the arm is elevated thus plays an important role in the etiology of SIS. Note that the rotator cuff muscles stabilize and prevent superior migration of the humeral head,[13,14] any deficit in the strength of the shoulder external rotators or an imbalance in the ratio of the shoulder external and internal rotators, might thereby reduce the AHD and increase the likelihood of impingement to the supraspinatus tendon or subacromial tissues.

Isokinetic muscle testing has been used to examine the concentric contractions of shoulder internal rotators (IR) and external rotators (ER) in overhead athletes and patients with shoulder pathologies. The ER/IR strength ratio was lower in the dominant arm than non-dominant arm,[13–15] and in throwers than non-throwers.[16] The effect of these muscles on the AHD however, await for investigation. The aims of the present study were (1) to establish the reliability of ultrasound measurement in the AHD and supraspinatus tendon thickness and the minimum detectable differences (MDD) of the AHD distance and tendon thickness; (2) to detect optimal cutoff points of AHD and supraspinatus tendon thickness to identify people with and without SIS; (3) to find the associations among AHD, supraspinatus tendon thickness and shoulder rotational strengths. Findings from the study could not only establish the reliability of the testing procedures but also only provide smallest differences that would reflect a real changes and optimal cut-off points for early identification of individuals at risk of having SIS.

2. Methods

Thirty-seven university students aged between 18 and 25 years participated in this study. Twenty-four were volleyball players recruited from the university volleyball teams, and thirteen controls were healthy individuals without participating in any overhead ball game. Players with history of shoulder fractures, shoulder instability or dislocation, shoulder surgery or clinical treatment for a shoulder injury were excluded. The study was approved in accordance with the guidelines of the Human Subjects Ethics Sub-committee by the ethical review of the Departmental Research Committee, The Hong Kong Polytechnic University, and all participants gave their written consent before the study.

Demographic information such as age, gender, height, weight, arm dominance (the side on which they throw a ball), and the number of years in volleyball training were recorded. Clinical tests were conducted by an experienced physiotherapist to group the participants into healthy players or players with SIS. In the present study, SIS was defined as (1) shoulder pain present for more than 4 weeks, (2) painful arc in flexion or abduction, (3) positive impingement sign (Neer or Kennedy-Hawkins sign), (4) pain in isometric external rotation, or abduction or positive Jobe test.[11] The grouping of the participants was blinded to the second operator who performed ultrasound scanning. Eleven control individuals attended 2 assessment sessions within 7–10 days apart for test–retest reliability of the measurements.

Ultrasonographic measurement for each participant's AHD and supraspinatus tendon thickness were scanned by using a Toshiba Nemio Ultrasound machine in conjunction with a 8–12 MHz linear transducer (Toshiba, Otawara, Japan). The protocol of the ultrasound measurement was designed by an experienced sonographer with more than ten years of clinical experience in musculoskeletal ultrasound scanning. All ultrasound scanning was done by a sports physiotherapist who attended ultrasound training course and had practiced the measurement protocol under the supervision with the experienced sonographer intensively for 3 months prior to the testing. First, the AHD measurement was taken with the participant in sitting position. His/her head was in a neutral position, arm in 0° of flexion, elbows were in full extension and forearms were in neutral position. The transducer was placed on the lateral surface of the shoulder along the longitudinal axis of the humerus and the AHD was scanned in the longitudinal view and was measured from the infero-lateral edge of acromion to the apex of the greater tubercle.[3] For each shoulder, three measurements were taken and the mean value was recorded. Second, the supraspinatus tendon thickness was taken with the participant in sitting position. His/her head was in neutral position, with the palmar side of the hand on the superior aspect of the iliac crest, with the elbow flexed and directed posteriorly towards the midline. The supraspinatus tendon thickness was scanned in the transverse view and the thickness of the tendon was measured at 10, 20 and 30 mm lateral to the long head of the biceps tendon.[3,17] The averaged value from the 3 measurements was recorded as the supraspinatus tendon thickness. Both shoulders were measured for analysis.

For the isokinetic testing of the shoulder rotational strengths, a Cybex Norm isokinetic dynamometer (Lumex, Inc., Ronkonkoma, New York, USA) was used. The participant was asked to sit upright on the upper body exercise table (UBXT) and the trunk and pelvis were stabilized firmly with straps. The shoulder was abducted at 45° in scapular plane, and the elbow was flexed at 90° with wrist in neutral and the hand grasping the handle of the upper limb test adapter. The other hand held onto the stabilizing handle on the UBXT during the tests.[18] The testing range was the participant's available shoulder external and internal rotation without elicited shoulder pain. Testing was performed at a slow speed of 90°/s in concentric contractions of IR and ER for more sensitive evaluation and for fewer artifacts at slower speed than faster speed.[18] Each participant performed 5 submaximal contractions as a practice trial to familiarize the movements followed by 5 maximal contractions for each testing condition. One-minute rest was given in between each practice trial and test. Both dominant and non-dominant arms were tested and verbal encouragement was given during the