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Acromio-Humeral Distance in Athletes' Shoulders

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- Acromio-humeral distance
- Ultrasound
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Abstract

Preservation of the acromio-humeral distance in athletes is important to prevent impingement of the rotator cuff tendons in the subacromial space. It is hypothesised that during arm abduction, the acromio-humeral distance is maintained in the athletic population, manifesting in a smaller percentage reduction of this measure when compared with non-athletes. This study investigates whether differences exist in percentage reduction of this space during arm abduction when comparing athletes and non-athletes. Thirty male controls and 93 sportsmen met the inclusion criteria. Thirty female controls and 30 sportswomen met the inclusion criteria. Measurements of acromio-humeral distance in the coronal plane were taken with ultrasound in two arm positions: one, shoulder neutral; and two, 60° of active abduction. Results show a greater percentage reduction in acromio-humeral distance in male controls compared with sportsmen when the arm is abducted to 60°, this does not achieve significance in the dominant shoulder (Δ=0.80% STD 2.60%, p=0.77) but is significant in the non-dominant shoulder (Δ=5.90% STD 2.50%, p = 0.02).A greater percentage reduction in acromio-humeral is present in female controls compared with sportswomen (Δ=10.76% STD 0.06%, p=0.01 dominant shoulder, Δ=15.54% STD 0.07%, p=0.02 non-dominant shoulder). The finding that elite athletes of both genders have a smaller percentage reduction in acromio-humeral distance during 60° arm abduction when compared with non-sporting controls may indicate an adaptive response in order to maintain acromio-humeral distance in the shoulder of athletes.

INTRODUCTION

From cadaveric studies it has been concluded that contact between the supraspinatus tendon and the biceps tendon with the coracoacromial ligament occurs between 45° and 60° of shoulder abduction [1] and this contact may cause compression of the subacromial structures against the coracoacromial arch. Preservation of the acromio-humeral distance is important in athletes to prevent impingement of the rotator cuff tendons in the subacromial space. Reduced acromio-humeral distance has been associated with subacromial impingement syndrome participants compared with healthy participants in studies using ultrasound, MRI and x-ray [2–6], and has been proposed as a predictive marker[7]. The sporting shoulder adapts to enhance sporting performance and cope with extremes of load [8,9]. 'It is important to elucidate the correlation between sport adaptation and acromio-humeral distance'[10]. Few previous authors have quantified acromio-humeral distance in athletes[6,10–13]. One of these papers included non-skeletally mature athletes[11] and another included symptomatic and asymptomatic shoulders[6]. It is therefore open to question whether differences in acromio-humeral distance were due to adaptation to demand in the athlete's shoulder, or to other factors such as skeletal immaturity or pathology. (Table1). Summarises the previous three studies investigating acromio-humeral distance in asymptomatic muscular skeletally mature athletes. When compared with controls, two studies report that the acromio-distance in athletes is greater[10,13], with one study finding this to be the case in female athletes in the coronal plane[10] and the other in male athletes in these caption plane[13].Only one previous study evaluated percentage reduction in acromio-humeral distance during arm abduction, reporting that this reduction was less in the elite female athletes' shoulder[10]. Variation in populations and methods between studies make conclusions difficult to collate. From this limited literature, it can be concluded that further study is warranted to ascertain if maintenance of the acromio-humeral distance is an adaptive response in the shoulder of athletes. It has been reported that posture influenced acromio-humeral distance [14]. It was therefore decided to measure the acromio-humeral distance in standing, as the standing position approximates more closely to athletic use, in contrast with the seated position adopted by previous authors.

In a systematic review of literature reporting on reliable and clinically applicable methods to assess acromio-humeral distance, McCressh et al. 2013[15] concluded that there was strong evidence for the reliability of ultrasound for measuring the acromio-humeral distance when compared with other radiological methods. Previous authors have established intra-rater reliability [16,17,14,18,19,10,4,20,21]and inter-rater reliability[4,22]of ultrasound as a tool to measure acromio-humeral distance. Ultrasound to measure this two-dimensional linear measure of the smallest distance between the under surface of the acromion and the most anterior part of the humerus has also been validated and construct validity established with a phantom model [23].

It is hypothesised that the acromio-humeral distance is maintained in the athletic population, manifesting in a smaller percentage reduction of the acromio-humeral distance during arm abduction than in the non-athletic population.

MATERIALS AND METHODS

Participants

Thirty male controls and 93 sportsmen met the inclusion criteria. Sportsmen consisted of 45 professional golfers playing on the European Challenge Tour, 15 national gymnasts, 18 national boxers, 8 national canoeists, and 6 national archers. Thirty female controls and 30 sportswomen met the inclusion criteria. Sportswomen consisted of: 12 national water polo players, 5 national boxers, 8 national canoeists, and 5 national archers. National athletes were representatives of Team GB (Great Britain) Olympic and podium potential teams.Participants included in the study were of full musculoskeletal development, and had healthy shoulders. Participants were excluded from the study if they had: cervical, shoulder, or elbow pain within six months before testing; previous shoulder girdle or spinal fractures; shoulder surgery; or dislocation of the upper limb; scoliosis; leg length discrepancy; or a rheumatologic condition.

Instrumentation

A portable dynamic ultrasound scanner Micro Maxx system, with a 13-6 MHz linear transducer (HFL38/13-6 MHz, Fujifilm Sonosite Limited. Hitchen, UK) was used for ultrasound image capture. Preset parameters were used for musculoskeletal shoulder settings.

Procedure

In a pilot study, inter-reliability of capturing the ultrasound image as well as reliability of reading the image itself was established with consistency of performing the technique confirmed with intra class correlation ($ICC_{2.1}$) scores that were fair to good in both of the shoulder positions tested (image capture: $ICC_{2.1}$=0.88 neutral, $ICC_{2.1}$=0.68 active arm abduction) (image analysis: 0.88 neutral, 0.81 active arm abduction). The minimal detectable change ($MDC_{95\%}$) in acromio-humeral distance was found to be 0.27mm in neutral and 0.25mm in 60° abduction.

Participants stood in a relaxed posture. In order to evaluate normal habitual scapular posture, no attempt was made to require the participant to conform to a single standardised posture. Measurements of acromio-humeral distance in the coronal plane were taken in 2 arm positions: one, shoulder neutral, and two, 60° of active abduction in the coronal plane. For the 60° of arm abduction position, the arm was abducted to 60° of abduction by the examiner as determined by a goniometer (Baseline plastic 360 ISOM Goniometer 12 inch) and the participant was then asked to maintain this position actively. Once 60° of abduction was determined for each participant, in order to assist the participant in maintaining the correct angle of arm abduction, a marker tape was placed on an adjacent wall at the level of the participant's finger tips. The examiner could then visually ensure that the correct angle was being maintained by the participant during ultrasound image capture. Between each measurement the participant rested the arm by the side to avoid the effects of fatigue. Three ultrasound images of the acromio-humeral distance were captured in each shoulder position.

The ultrasound transducer was placed in the coronal plane, (Figure 1) parallel with the longitudinal axis of the humerus and positioned to visualize the shortest tangential distance between the hyper echoic landmarks of the most superior aspect of the humerus and acromion on the ultrasound screen (Figure 2).The transducer was removed from the shoulder between repeated image capture.

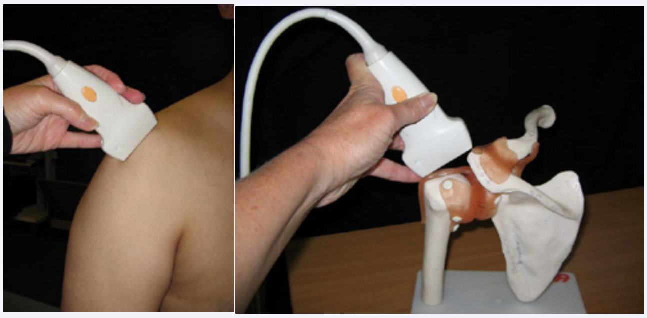

Figure 1 The ultrasound transducer was placed in the coronal plane parallel with the longitudinal axis of the humerus.

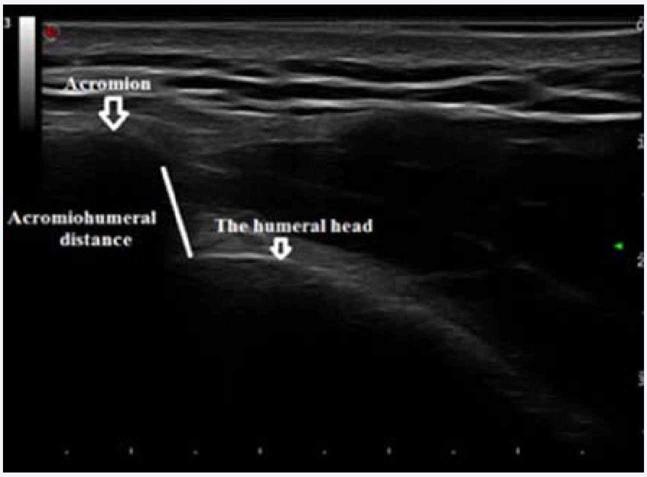

Figure 2 The shortest tangential measurement between the hyper echoic landmarks of the most superior aspect of the humerus and acromion (the acromio-humeral distance) is shown on the ultrasound image.

Images were saved to the ultrasound scanner hard drive and retrieved for analysis one week later. Images were converted and saved as jpeg files, and were randomised by an independent party. As a result, the investigator was blinded to participant identity, order of collection of images, side and shoulder position the image was captured in. The stored images were reviewed using Image J 1.32 software. Hyper echoic landmarks were consistently marked to identify the inferior edge of the acromion and the most superior aspect of the humerus, thus yielding the shortest distance between the two hyper echoic landmarks on ultrasound images (Figure 2). Electronic line callipers were used to make the measurements.

Data analysis

Statistical Package for Student Statistics for Windows version 20.0 (SPSSinc. Chicago, IL), was used for statistical analysis. Shoulders included in analysis were sorted according to dominant and non-dominant sides. Data from genders were analysed separately. The mean of three measures was calculated to reduce the variance of estimates, allowing statistical inference to be made with fewer subjects.Outliers were removed. Normality of distributions was ensured with Shapiro Wilk and Kolmogorov-Smirnow tests. A repeated measures ANOVA was used to detect between-group differences in the sports groups. Descriptive analysis was run and independent t-tests used for between group analyses (significance level set at 0.05).

RESULTS AND DISCUSSION

Data from 30 male asymptomatic controls and 93 male asymptomatic sportsmen were used in analyses (controls: 24 STD 7 years, sportsmen: 25 STD 5 years).Data from 30 female controls and 30 female athletes were used in analyses (controls 24 STD 4 years: sportswomen: 27 STD 6 years).

Descriptive statistics for percentage reduction in acromio-humeral distance in male controls and sportsman are reported in Table 2. A repeated measures ANOVA used to detect between-group differences found no significant differences in acromio-humeral distance between varying disciplines of sport in sportsmen ($p>0.05$). Results show a greater percentage reduction in acromio-humeral distance in male controls compared with sportsmen when the arm is abducted to 60°, this does not achieve significance in the dominant shoulder (Δ=0.80% STD 2.60%, $p=0.77$) but is significant in the non-dominant shoulder (Δ=5.90% STD 2.50%, $p = 0.02$).

Descriptive statistics for percentage reduction in acromio-humeral distance in female controls and sportswomen are reported in Table 3. A repeated measures ANOVA used to detect between-group differences found no significant differences in acromio-humeral distance between varying disciplines of sport in sportswoman ($p>0.05$). A greater percentage reduction in acromio-humeral is bilaterally present in female controls (Δ=10.76% STD0.06%, $p=0.01$ dominant shoulder, Δ=15.54% STD0.07%, $p=0.02$ non-dominant shoulder)

There is a larger percentage reduction in acromio-humeral distance in male controls when the arm is abducted to 60°. This does not achieve significance in the dominant shoulder but is significant in the non-dominant shoulder. The lack of significant difference in reduction in acromio-humeral distance in the dominant shoulder of male controls when compared with sportsmen may be attributable to the fact that, although male controls were non-sportsmen, the dominant shoulder is nevertheless subject to higher loads and activity than the non-dominant shoulder and hence may likewise adapt to preserve the acromio-humeral distance. Female controls have a significantly greater percentage reduction in acromio-humeral distance bilaterally when compared with sports women. It is conjectured that female controls' shoulders are exposed to less load than their male counter parts. This would explain why bilateral significance was achieved when comparing the percent reduction in acromio-humeral distance in the female population in both shoulders but only in the non-dominant shoulder in the male population. Results concur with those of Maenhout al., 2012, [10] who report that percentage reduction in acromio-humeral distance was less in the elite female athlete compared with recreational athletes.

The two previous studies measure AHD in 90 abduction[12,13]. The current study used the 60 degree arm abducted position because the 90° arm position for measuring AHD with RTUS has been reported to have poor reliability by previous authors [17]. Accordingly, the results of the current study cannot be compared directly with the two previous studies.

Table 1: Acromio-humeral distance reported in the literature in skeletally mature asymptomatic sports populations.

Author	Population	N	Authors concluded	Position of participant	Active vs passive	Plane	Position of GHJ degrees	Transducer position
Thomas et al., [12]	baseball male	24	No bilateral differences in AHD	seated	active	coronal	0/90 abd & 90 ER.	Mid-lateral acromion
Maenhout et al., [10]	overhead athletes female	29 elite handball 33 recreational overhead athletes	↑ AHD in dominant side. ↑AHD in athletes. < % reduction in AHD with45° abd in athletes	seated	active	coronal	0/60	smallest AHD
Wang et al., [13]	baseball male	42 baseball 16 controls	↑AHD athletes in scapular plane No difference in AHD between groups in the coronal plane.	seated	passive	coronal and frontal	0/90	Mid-lateral acromion

Abbreviations: AHD = acromio-humeral distance; ↑= greater ;< =less; abd =abduction; N= number of participants; ER=external rotation; %= percentage; °=degrees

Table 2: Percentage reduction in acromio-humeral distance in male controls and sportsmen.

	Sportsmen mean(STD)cm	Male controls mean(STD)cm	Mean difference (STD)cm	Independent t test p value
% reduction dominant	31.14(13.24)%	30.62(12.13)%	0.80(2.60)%	0.77
% reduction non-dominant	30.06(15.82)%	35.24(10.23)%	5.90(2.50)%	0.02

Abbreviations: %=percentage; cm = centimetres; STD=standard deviation; °=degrees arm abduction

Table 3: Percentage reduction in acromio-humeral distance in female controls and sportswomen.

	Sportswomen mean(STD)cm	Female controls mean(STD)cm	Mean difference (STD)cm	Independent t test P value
% reduction dominant	28.78(0.19)%	39.54(0.24)%	10.76(0.06)%	0.01
% reduction non-dominant	27.78(0.28)%	43.32(0.22)%	15.54(0.07)%	0.02

Abbreviations: %=percentage; cm = centimetres; STD=standard deviation; °=degrees arm abduction

Previous authors have reported that short term loading decreased the acromio-humeral distance [24] in non-sportsmen by as much as 11% [25], a process that, if not counteracted, could be pathogenic in impingement syndrome. Preservation of the acromio-humeral distance in athletes is important to prevent impingement of the rotator cuff tendons in the subacromial space[1]. The finding that elite athletes of both genders have a smaller percentage reduction in acromio-humeral distance during arm abduction when compared with non-sporting controls may indicate an adaptive response to maintain acromio-humeral distance in the shoulder of athletes. Factors which influence the subacromial space are considered to be multifactorial [26,27] and it may be that adjustment of these factors occurs in the athlete's shoulder. For example, hyper-hypnosis[28] has been associated with acromio-humeral distance and athletes may sustain a more upright posture during arm abduction.Seitz et al., 2012[29] noted a non-significant increase in the acromio-humeral distance with manual upward rotation and posterior tilting of the scapula, so another explanation could be that athletes develop scapular kinematics which preserve the acromio-humeral distance. A third explanation could be that athletes evolve neuro-muscular dynamic shoulder control to preserve this space. The operation of these extrinsic mechanical factors is conjectures and requires further research. An intrinsic cause for a smaller percentage reduction in acromio-humeral distance may be that the biceps tendon and the supraspinatus tendon are thicker as has been noted in a study comparing college baseball athletes with controls[13]. The thickness of the tendon may restrict the extent to which the subacromial space can be reduced.

Limitations

The results of this study must be interpreted in the light of its limitations. Acromio-humeral distance is a 2 dimensional measurement of a 3 dimensional space. Compromise of this volume cannot be totally quantified by measurement of acromio-humeral distance lone; it can only be used as a guide. A second limitation is that the range of arm elevation in which the ultrasound measurement of acromio-humeral distance is possible is limited to a maximum of 60° of elevation because of acoustic shadows in higher ranges of arm elevation. To what extent the measurement of acromio-humeral distance in 60° of abduction can be extrapolated to influence the subacromial space in higher ranges of arm elevation is unclear. Limiting the extrapolation of these results is the fact that asymptomatic subjects were used in this study; thus, a direct relationship between impairment cannot be assumed. Furthermore, muscle contractions around the humeral head produce larger translations during arm movement and can therefore impact on the acromio-humeral distance. In this study, acromio-humeral distance was evaluated during an isotonic hold of the arm; this may not represent true influence of load on the acromio-humeral distance. Variety in athletic population is paradoxically a strength and weakness in this thesis. It is a strength, in as much as it allowed for the investigation of the acromio-humeral distance in a range of sporting disciplines but although it was determined via ANOVA analysis that no differences in acromio-humeral distance existed between sporting disciplines, it can be argued that the numbers per sporting discipline were not sufficient to ensure adequate power for such analysis. The population in this study was representative of sports which place high demands on the shoulder and the results of this study may not necessarily apply to all sportspersons, since forces in the shoulder are sport-specific [30].

CONCLUSION

Preservation of the acromio-humeral distance in athletes is important to prevent impingement of the rotator cuff tendons in the subacromial space. The finding that elite athletes of both genders have a smaller percentage reduction in acromio-humeral distance during arm abduction when compared with non-sporting controls may indicate an adaptive response to maintain acromio-humeral distance in the shoulder of athletes.

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