Does the acromiohumeral distance matter in chronic rotator cuff related shoulder pain?

INTRODUCTION

Shoulder pain is one of the most common musculoskeletal conditions in primary care, with a prevalence fluctuating from 6.9-26% for point prevalence, 18.6–31% for 1-month prevalence, 4.7–46.7% for 1-year prevalence and 6.7–66.7% for lifetime prevalence (Luime et al. 2004) and with 12-month recurrence rates approximately twice the prevalence rates (Luime et al. 2005). In the working population, the prevalence for shoulder pain associated with musculoskeletal disorders is even higher (30-49%) (Roquelaure et al. 2006). The prevalence of shoulder pain is higher in women (Bergman et al. 2010), and increases with age (Linsell et al. 2006). Rotator cuff related shoulder pain (RCRSP) is the most common cause of shoulder pain (Lewis 2016). It is defined as an over-arching term that encompasses a spectrum of shoulder conditions including; subacromial pain (impingement) syndrome, rotator cuff tendinopathy, and symptomatic partial and full thickness rotator cuff tears (Lewis 2016).

Acromiohumeral distance (AHD), defined as the shortest linear distance between the most inferior aspect of the acromion and the adjacent humeral head (Hébert et al. 2003), has been suggested to be related to the presence and severity of some shoulder disorders, such as subacromial impingement syndrome (SIS) and rotator cuff (RC) tendinopathy (Kibler et al. 2013; Timmons et al. 2013). Ultrasound imaging, measuring different parameters, has been used in the assessment of shoulder pain, such as AHD (Hébert et al. 2003; Desmeules et al. 2004; Kalra et al. 2010; Michener et al. 2013; Timmons et al. 2013; Maenhout et al. 2015) and/or shoulder tendon thicknesses, such as supraspinatus (Joensen et al. 2009; Michener et al. 2013). Furthermore, there are other studies that have carried out similar procedures on shoulder pain-free patients (Luque-Suarez et al. 2013; Schneebeli et al. 2014).

However, the relation between AHD values and the severity of pain and disability in patients with RC tendinopathy remains unclear. Desmeules et al (Desmeules et al. 2004) found a strong correlation between AHD and the pain and disability in a small number of patients diagnosed with subacromial impingement syndrome (SIS). Despite this promising result, a recent clinical commentary (Bailey et al. 2015) recommends more quality studies to confirm this connection. Even though it is unclear that a reduction in the subacromial space is a cause or a consequence in shoulder pain disorders (Mackenzie et al. 2015), especially in RC tendinopathy, there is a need to determine whether a correlation between AHD, pain and disability and shoulder ROM exists. If so, clinical practise could be focused on improving AHD and, furthermore AHD could be used by researchers as an outcome measure to report the results of their interventions, in the same manner as pain, function and ROM are used nowadays. Moreover, if there is a correlation between AHD and pain-disability and ROM, it would be possible to determine populations at risk of suffering and/or perpetuating chronic RCRSP.
On the other hand, intra-rater reliability of AHD measurement by ultrasound is well supported in healthy populations. However, there is a scarcity of high quality studies in people with RC pathology (McCreesh et al. 2013).

Hence, the aim of this study is to determine the level of association between AHD, pain-disability and shoulder-ROM in patients with rotator cuff related shoulder pain (RCRSP). As a secondary objective, the study of the intrarater reliability of AHD, measured by ultrasound imaging at both 0 and 60 degrees of shoulder elevation, is proposed.

METHODS

Study design

This was a cross-sectional study. The study was conducted according to the Declaration of Helsinki.

Participants

A convenience sample of 110 participants with chronic RCRSP (more than 3 months of duration) was recruited from three different primary care centres, from April 2014 to December 2015. General practitioners (GPs) carried out the recruitment. Research assistants then assessed participants for eligibility. If participants satisfied the inclusion criteria, they were then studied. Three participants declined to participate, and 10 participants did not meet the inclusion criteria, hence a sample comprised of 97 participants was assessed. Research assistants collected a consent form from every participant.

Participants had to meet at least three of the following inclusion criteria: i) positive Neer test; ii) positive Hawkins-Kennedy test; iii) positive Jobe test; iv) painful arc present during flexion or abduction; v) pain during resisted lateral rotation and/or abduction (Bury et al. 2016). Furthermore, other inclusion criteria had to be met: iv) men or women aged between 18 and 55 years; and (v) no history of significant shoulder trauma, such as fracture or clinically-suspected full thickness cuff tear. Participants were ineligible to participate in this study if any of the following conditions were present: (i) recent shoulder dislocation, systemic illnesses such as rheumatoid arthritis, and evidence of adhesive capsulitis as indicated by passive range of motion loss >50% in 2 planes of shoulder motion; (ii) shoulder pain that was deemed to be originating from any passive and/or neck movement or if there was a neurological impairment, osteoporosis, haemophilia and/or malignancies; iii) corticoid injections during the six months prior to the study and iv) analgesic-anti-inflammatory medication intake 48 hours prior to the assessment.

Primary outcome

Acromiohumeral distance

A diagnostic ultrasound unit, Sonosite M-turbo (GE Healthcare, Wauwatosa, WI) with a 6–13MHz linear transducer was used to capture images in grey scale. Ultrasound images were obtained by a single examiner, who was a licensed physiotherapist with advanced training in musculoskeletal ultrasound imaging, and 4-years of experience. Acromiohumeral distance was measured at 0 and 60 degrees of active shoulder elevation in the scapular plane, with the participant seated in an upright position. The process to evaluate AHD has been previously used in different populations, such as healthy volunteers (Luque-Suarez et al. 2013) and patients with shoulder pain (Seitz et al. 2012). Patients were seated upright without back support, their feet flat on the ground. To guarantee 0 and 60 degrees shoulder elevation, a hydro-goniometer was placed on the patient's arm (figure 1 and 2). This was made in that way because shoulder elevation greater than 60 degrees means a difficulty to capture ultrasound images for the AHD. Furthermore, recent work shows that the level of humeral elevation at which the rotator cuff becomes vulnerable to extrinsic impingement, originally described by Neer, is much lower than previously believed (Bailey et al. 2015). Consequently, from 60° to 120° of elevation ("painful arc" of motion), the rotator cuff tendons have likely moved medially beyond the anterior-inferior aspect of the acromion and are no longer susceptible to extrinsic impingement. Therefore, ultrasound imaging, to measure acromiohumeral distance in this patient population, might be considered during active contraction and for up to 60° of glenohumeral elevation to assess the relationship of this anatomic region to extrinsic impingement.

AHD was defined as the shortest linear distance between the most inferior aspect of the acromion and the adjacent humeral head (Desmeules et al. 2004). The ultrasound transducer was placed on the most anterior aspect of the acromion edge, with the long axis of the transducer placed in the plane of the scapula and parallel to the flat surface of the acromion. AHD was measured in milimetres, using the callipers on the ultrasounds' screen. Three AHD measurements were taken by the examiner, in order to calculate the intrarater reliability. The examiner did assess both sides without knowing which of them was the affected shoulder. The intra-rater reliability was, then, calculated for the affected shoulder in this study. An interval of one minute was provided between the three measurements, during which the patient was encouraged to move freely. The ultrasound examiner was blinded to all measurements (values were obscured by placing a shield on the ultrasound screen), and a research assistant registered the data and put them into a database for later calculation. Both examiner and research assistant were blinded to the previous condition of each patient (shoulder function and pain severity), as well as to the affected side and hand dominant. All the ultrasound measurements were expressed in milimetres.

Active ROM-free of pain at shoulder elevation in the scapular plane

Active range of movement free of pain at shoulder elevation in the scapular plane was taken using the same procedure as used for AHD ultrasonography measurements, except–for a change in the patient's position, in which the patient was asked to stand standing position. Three measurements were taken at one minute intervals, and the mean was calculated. ROM was expressed in degrees.

Shoulder pain and disability index (SPADI)

The Shoulder Pain and Disability Index (SPADI) (Roach et al. 1991) is a self-administered questionnaire that consists of two scales, one for pain and the other for functional activities. SPADI total score fluctuates from 0 to 100, where 0 is the best and 100 is the worst. The SPADI has shown a good internal consistency with a Cronbach's alpha of 0.95 for the total score, 0.92 for the pain subscale and 0.93 for the disability subscale as well as the ability to detect change over time (MacDermid et al. 2006). An adapted version of the SPADI was obtained following the International recommendations (Wild et al. 2005) since English was not the native language for all the participants.

Data analysis

The Statistical Package for the Social Sciences (version 23.0 for Mac; SPSS Inc. Chicago, IL) was used to analyse the collected data. Normality of the variables was visually tested for a Gaussian distribution and additionally tested with a 1-sample Kolmogorov-Smirnov goodness-of-fit test. A null-hypothesis was rejected and, so, a non parametric distribution was accepted, when p-values >0.05 for Kolmogorov-Smirnoff test were found.

For the calculation of intrarater reliability of ultrasound measurements (AHD at 0 and 60 degrees), the 3,1 model or a 2-way mixed consistency intraclass correlation coefficient (ICC) model was used.

A reliability coefficient less than 0.50 was an indication of "poor" reliability; "moderate" being between 0.50 and 0.75, "good" between 0.76 and 0.90; and "excellent" over 0.90 (Portney and Watkins 2000). The Standard Error of Measurement (SEM) and the minimal detectable change with 95% confidence bounds (MDC_{95}) were calculated.

To determine the correlation between AHD at 0 and 60 degrees with SPADI, and ROM-free of pain in the scapular plane, a Pearson correlation coefficient was calculated for a

normal data distribution, or a Spearman´s coefficient in the case of absence of normality. Weak correlation was defined as values between 0.3 and 0.5; between 0.5 and 0.7 correlation was considered moderate; strong was considered greater than 0.7 (Mukaka 2012).
Due to the fact that pain perception seems to be influenced by gender (Henderson et al. 2008; Alabas et al. 2012), sample characteristics for SPADI and ROM-free of pain values were shown based on this, in order to identify any bias in the homogeneity of the sample.

RESULTS

Sample characteristics

Sample characteristics are shown in Table 1. There were no significant differences between gender for demographic characteristics (with the exception of height), AHD, SPADI-score and active ROM-free of pain in scaption movement. Regarding the duration of symptoms, 31% of the participants presented with shoulder pain which had lasted between 3-6 months ~~at~~ prior to the start of this study; 18.6% between 6-12 months; and 50.4% greater than one year.

Table 1: sample characteristics expressed by mean and standard deviation.

	n=97	Female (n=63)	Male (n=34)	p-value
Age, years	45.42 (8.87)	46.08 (7.59)	44.21 (10.88)	0.519
Height, cm	165.74 (7.43)	162.34 (5.92)	171.77 (5.87)	<0 .05*
AHD 0° (mm)	9.6 (1.4)	9.5 (1.5)	9.8 (1.6)	0.523
AHD 60° (mm)	6.5 (1.9)	6.6 (2.2)	6.3 (0.1)	0.599
SPADI	62.63 (18.31)	62.70(17.47)	62.51 (20.04)	0.710
VAS-pain	7.75 (1.81)	7.67 (1.88)	7.91 (1.68)	0.53
ROM-free of pain	91.09 (34.91)	89.29 (36.57)	94.41 (31.85)	0.590

SPADI (shoulder pain and disability index)

Active ROM (range of movement) free of pain (degrees)

* Differences statistically significant ($p < .05$)

Reliability

Intrarater reliability was excellent for AHD at 0 and 60 degrees (Table 2).

Table 2: Intrarater reliability: ICC= intraclass correlation coefficient

n (97)	Mean (SD)	ICC*	ICC**	SEM	MDC_{95}
AHD at 0 degrees	9.6 (1.5)	0.93 (0.91-0.95)	0.98 (0.97-0.98)	0.04	0.11
AHD at 60 degrees	6.6 (1.8)	0.95 (0.93-0.96)	0.98 (0.98-0.99)	0.04	0.11

(*single measure; **average measure); SEM = Standard error of measurement - based on single measure ICC; MDC95 = Minimal Detectable Change with 95% CI -based on single measure ICC.

Association between AHD and SPADI/shoulder ROM

Correlations between AHD and SPADI/shoulder ROM are shown in Table 3. No correlations were found between AHD at both 0 and 60 degrees, and SPADI. Also, no correlation was found between AHD measurements and active ROM-free of pain at shoulder elevation.

Table 3: correlation of AHD at 0 and 60 degrees of shoulder elevation with SPADI and shoulder ROM free of pain.

	SPADI	ROM
AHD 0 degrees	-0.215*	-0.080
AHD 60 degrees	-0.148	0.163

*: statistically significant $p < .05$

DISCUSSION

This study aimed to investigate the level of association between AHD, pain-disability and shoulder-ROM in patients with chronic RCRSP. There was no correlation between AHD at 0 degrees of shoulder elevation and pain and disability measured by SPADI. When active ROM-free of pain was analysed, no correlation was found with AHD at 0 and 60 degrees. The results showed excellent intrarater reliability for both AHD measurements.

Acromiohumeral distance has been considered as one of the possible extrinsic mechanisms for developing RCRSP, which resulted in the so-called shoulder impingement syndrome theory. However, whether the perpetuation of symptoms in advanced stages (chronicity) is associated with a lasting decreased AHD remains unclear, so it is crucial to establish the possible association between the AHD and pain and disability, as well as active ROM-free of pain in chronic shoulder pain. Our AHD-mean values were 9.6 mms at 0 degrees. The normal AHD, measured on ultrasound in the neutral shoulder position, ranges between 9 mm and 12 mm (McCreesh et al. 2013), and reduced values ranging from 6 mm to 10 mm in people with varying degrees of tendon pathology (McCreesh et al. 2015). Our results did not show significative associations between AHD at both 0 and 60 degrees and SPADI. To our knowledge there are few studies investigating this association. Desmeules et al (Desmeules et al. 2004) found a significant correlation between increases in the AHD and function after a physical therapy program applied to seven patients with SIS in the acute-subacute stage, for 4 weeks, in a pre-post rehabilitation analysis. Comparisons with our findings are difficult due to the small sample size (7 patients) of the aforementioned study, and for the acute-subacute stage of the patients included. In a recent clinical study (Savoie et al. 2015) an increase in the AHD of 25 patients with subacromial pain syndrome (chronic pain) after a rehabilitation program centered on movement training was found, as well as an improvement in shoulder function. However, the degree of correlation between AHD and shoulder function findings was not reported. Regarding the association between AHD measurements and ROM-free of pain in shoulder elevation in scapular plane, no correlations were found with AHD measurements at 0 and 60 degrees of shoulder elevation. To our knowledge, there are no studies correlating AHD measured by ultrasonography to active shoulder ROM in patients with RCRSP.

There are several potential reasons that could explain the small association between AHD, pain-function and ROM found in this study. Shoulder impingement syndrome (SIS) is not a homogenous entity. SIS appears to be a combination of intrinsic factors

(age, tendon histology and genetics), and extrinsic factors, which are those more closely related to AHD, such as acromion shape, glenohumeral and scapular kinematic factors, and also ergonomic adaptation factors and/or muscle extensibility and performance factors (Seitz et al. 2011; Mackenzie et al. 2015). It is reasonable that there is controversy with regard to the exact pathomechanics and biomechanical causes of subacromial pain syndrome (SAPS) (Mackenzie et al. 2015), due to its multifactorial character, and, hence, a controversy about the real role of AHD in the explanation of pain, disability and shoulder ROM in SAPS. In fact, there was an evolution in this terminology, shifting from SIS to the label of SAPS (Michener and Kulig 2015). However, this labelling kept the subacromial space as a key contributing factor, which might not be the case in all patients with mechanical shoulder pain. Therefore, the present study emphasises the use of RCRSP to better describe this condition, as current evidence supports RCRSP terminology instead of the subacromial or impingement based terminology (Lewis 2016).

There are some limitations that should be taken into account. Firstly, inter-rater reliability for ultrasonography measurements was not calculated; hence, care should be taken into with the psychometric properties of this diagnostic tool. Secondly, the difficulty of classifying shoulder pain disorders, even though a recognized guideline to identify SIS/RC tendinopathy through–a combination of orthopaedic and movement tests were used in this study as inclusion criteria could mean that the sample analysed presented heterogeneity. Previous studies have highlighted the lack of uniformity and reliability of the current diagnostic classification system for shoulder pain (Schellingerhout et al. 2008; Klintberg et al. 2015) suggesting the need to reconsider the use of these diagnostic labels (i.e., SIS). Thirdly, the results regarding the relation between AHD and chronic shoulder pain only show the level of association and not a cause-effect relation. Moreover, the AHD is a two dimensional measurement of a three dimensional space. Therefore, it is difficult to view the undersurface of the acromion due to the acoustic shadow when the AHD is assessed. Furthermore, the results of this study must be taken with caution, as this study has been carried out in a population aged 18 to 55 years-old, so that, these results should not be extrapolated to other populations. Finally, mean values for AHD in this study were around 9.6 mms, that means values close to exceeds the proposed abnormal range (6-10 mms)(McCreesh et al. 2015), so that, the results may not be generalizable to other populations.

This study is a first step showing the absence of any weak/moderate/strong correlation between chronic RCRSP and AHD measured by ultrasonography. Future studies should be conducted to determine the real scope of AHD within clinical practise, in patients suffering from chronic RCRSP. Furthermore, more research is needed to determine the amount of improvement in the AHD that could be functionally and clinically meaningful for populations with different shoulder disorders, e.g. RCRSP, as this represents a key gap in the available literature. Future studies should also investigate the AHD values, not only at predetermined position (0 and 60 degrees of shoulder elevation), but also at the start of painful arc, as this could provide outstanding information, and whether these results are found in older populations.

CONCLUSIONS

In patients with chronic RCRSP, the association between AHD and shoulder pain and function, as well as with shoulder ROM-free of pain, is small. Hence, clinicians should consider other possibilities rather than focus their therapies only on increasing the AHD when patients with chronic RCRSP are treated.

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