Manual Therapy 23 (2016) 1–8

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

Original article

Relationship between extrinsic factors and the acromio-humeral distance

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ARTICLE INFO

Article history:
Received 19 August 2015
Received in revised form
19 December 2015
Accepted 14 February 2016

Keywords:
Impingement
Shoulder
Acromio-humeral distance

ABSTRACT

Background: Maintenance of the subacromial space is important in impingement syndromes. Research exploring the correlation between biomechanical factors and the subacromial space would be beneficial.
Objectives: To establish if relationship exists between the independent variables of scapular rotation, shoulder internal rotation, shoulder external rotation, total arc of shoulder rotation, pectoralis minor length, thoracic curve, and shoulder activity level with the dependant variables: AHD in neutral, AHD in 60° arm abduction, and percentage reduction in AHD.
Design: Controlled laboratory study.
Method: Data from 72 male control shoulders (24.28years STD 6.81 years) and 186 elite sportsmen's shoulders (25.19 STD 5.17 years) were included in the analysis. The independent variables were quantified and real time ultrasound was used to measure the dependant variable acromio-humeral distance.
Results: Shoulder internal rotation and pectoralis minor length, explained 8% and 6% respectively of variance in acromio-humeral distance in neutral. Pectoralis minor length accounted for 4% of variance in 60° arm abduction. Total arc of rotation, shoulder external rotation range, and shoulder activity levels explained 9%, 15%, and 16%–29% of variance respectively in percentage reduction in acromio-humeral distance during arm abduction to 60°.
Conclusion: Pectorals minor length, shoulder rotation ranges, total arc of shoulder rotation, and shoulder activity levels were found to have weak to moderate relationships with acromio-humeral distance. Existence and strength of relationship was population specific and dependent on arm position. Relationships only accounted for small variances in AHD indicating that in addition to these factors there are other factors involved in determining AHD.

1. Introduction

The exact cause of shoulder impingement syndrome remains controversial, and possibly the causes are multifactorial (Wilk et al., 2009). Reduced acromio-humeral distance (AHD) has been associated with subacromial impingement syndrome participants compared to healthy participants in studies using RTUS, MRI and x-ray (Graichen et al., 1999; Hebert et al., 2002; Girometti et al., 2006; Pijls et al., 2010), and proposed as a predictive marker (Cholewinski et al., 2008). If maintenance of the subacromial space is important in impingement syndromes regardless of whether it is a cause or consequence, research exploring the correlation between biomechanical factors and the subacromial space, using the latter as the outcome measure, would be beneficial (Mackenzie et al., 2015). Ultrasound (US) measures of the acromial humeral distance have been used to quantify the subacromial space and construct validity established with a phantom model (McCreesh et al., 2014a). Extrinsic factors considered to influence the AHD, and often targeted in rehabilitation programs, include scapular rotation, shoulder rotation ranges, pectoralis minor length, thoracic curve, and load.

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http://dx.doi.org/10.1016/j.math.2016.02.005

As the arm elevates, the scapula has been shown to rotate progressively upwardly in healthy individuals (Ludewig et al., 1996; Groot et al., 1999), in contrast, in impingement subjects it has been noted that the scapula has decreased upward rotation (Flatow et al., 1994; Kibler, 1998; Ludewig and Cook, 2000; Endo et al., 2001; Hebert et al., 2002; Thigpen et al., 2006; Struyf et al., 2011). These authors suggest that scapular upward rotation lifts the acromion for increased subacromial space. The relationship between scapular position and AHD has been explored by two previous authors (Silva et al., 2010; Thomas et al., 2013). One of the articles (Silva et al., 2010) investigate this relationship in a non-skeletally mature population and the other article (Thomas et al., 2013) reported no relationship in resting and in 90° of arm abduction. However, previous authors have reported that the measure of AHD in 90° of arm abduction with US is unreliable due to acoustic shadowing (Duerr, 2010). On manual upward rotation of the scapula during the Scapular Assistance Test the AHD was reported to increase although not significantly (Seitz et al., 2012). It was deemed necessary to evaluate if a significant relationship existed between scapular upward rotation and the AHD in a skeletally mature population and in an arm position which has a high reported reliability for the measure of AHD with US. Decrease in shoulder internal rotation has been associated with shoulder impingement in overhead athletes (Harryman et al., 1990; Tyler et al., 2000; Borich et al., 2006), an increase in internal rotation after stretching was found to increase the AHD in female athletes (Maenhout et al., 2012) this was a pre-test post-test study and as such association between shoulder internal rotation and AHD has not yet been reported. A possible explanation for why internal shoulder rotation influences the AHD is that increased tension in the posterior shoulder capsule may cause anterior superior migration of the humeral head thus reducing the subacromial space, alternately this increased tension may restrict scapular motion and cause depression of the acromion further reducing the subacromial space. The instability theorem proposes that athletes requiring greater shoulder ranges of external rotation in order to perform develop occult or subtle shoulder instability (Jobe and Lannotti, 1995). In theory, this capsular laxity may have a contagion effect as excess humeral head translations may compromise the subacromial space. For optimal scapular function the pectoralis minor must lengthen during arm elevation in healthy individuals (Ludewig and Cook, 2000; Borstad and Ludewig, 2002; McClure et al., 2004), but if this muscle has an increase in passive tension, this will restrict scapular upward rotation (Flatow et al., 1994; Ludewig and Cook, 2000; Borstad and Ludewig, 2002; Kibler and Sciascia, 2009; Lucado, 2011) which may restrict upward motion of the acromion during arm elevation and in turn could result in loss of AHD (Borstad and Ludewig, 2002). Studies found that scapular position is in part influenced by pectoralis minor muscles but as yet, a direct relationship between the resting position variables of pectoralis minor length and AHD has not been established. Previous authors (Greenfield et al., 1995; Lewis et al., 2005) evaluating the relationship between thoracic posture and the presence of pathology in impingement patients found no relationship. Despite these results, in practice an increase in thoracic kyphosis is associated with impingement syndromes and possibly to subacromial width (Gumina et al., 2008; Kalra, 2010). Lastly, it is asserted that the biomechanics of the shoulder girdle are influenced by load and sport demands with two previous authors (Thompson et al., 2011; McCreesh et al., 2014b) reporting that AHD reduced further with load. Although these extrinsic factors have been proposed as predictive of the AHD, no previous authors have tested the cause–effect relationship of this group of factors on AHD in a variety of sportsman whose shoulders are exposed to varying sporting demands and skills.

The aim of this study is to establish if relationship exists between the independent variables of scapular rotation, shoulder rotation, pectoralis minor length, thoracic curve, and shoulder activity level with the dependant variables: AHD in neutral, AHD in 60° arm abduction, and percentage reduction in AHD.

2. Method

2.1. Participants

Based on pilot study data it was calculated that 37 subjects were required to achieve a 70% power to show that the correlation is greater that 0.4 (which indicates that the correlation is at least substantial) and a 0.05 significance level, assuming the true correlation is 0.8. Data from 72 male control shoulders (24 STD 7 years) and 186 elite sportsmen's shoulders (25 STD 5 years) were included in analysis (Table 1.). Sportsman consisted of golfers professionals playing on the (European) Challenge tour other athletes represented the Great Britain team Olympians (podium and podium potentials). 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. XXXXXX Research Ethics Committee granted ethical approval for the study.

2.2. Procedures

In a pilot study intra-rater reliability 24 h apart was established for all instruments and procedures (Table 2). ICC3.1 values for all protocols and instrumentation used were more than 0.9, indicating excellent inter-session intra-rater reliability.

Participant position for the procedures: PALM to quality scapular rotation, flexicurve to quantify thoracic curve, and US to measure AHD.

Participants removed their shoes and assumed a normal standing posture looking ahead. No attempt was made to modify the participants' posture during testing or to make any participant conform to a single standardised posture. Two arm positions were used during testing: one, shoulder neutral, and two, 60° of active arm abduction in the coronal plane. For the neutral position, participants allowed the arm to hang naturally at the side of the body. For the 60° of arm abduction position, the participant's arm was abducted to 60° as determined by an inclinometer, the thumb pointing forwards. The participant maintained this position actively. In order to ensure that the participant maintained 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 while measuring. Between each measurement the participant rested the arm by the side to avoid the effects of fatigue.

Table 1
Summary participants included in the study. Golfers were professionals playing on the (European) Challenge tour. The other athletes represented the Great Britain team Olympians (podium and podium potentials).

Group	Total n = shoulders	Subgroup n = shoulders
Male controls	72	
Male sportsman	186	90 golfers
		30 gymnasts
		16 canoeists
		36 boxers
		14 archers