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Original article

Measurement of glenohumeral joint translation using real-time ultrasound imaging: A physiotherapist and sonographer intra-rater and inter-rater reliability study

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ABSTRACT

Background: Ultrasonography is an economical and non-invasive method for measuring real-time joint movements. Although physiotherapists are increasingly using ultrasound imaging for rotator cuff disorders, there is a lack of evidence on their reliability in using ultrasonography to measure glenohumeral translation.
Objective: The aim of this study was to evaluate the reliability of a physiotherapist in measuring anterior and posterior glenohumeral joint translation with ultrasound.
Methods: Study design: within day reliability.
Anterior and posterior glenohumeral translations were measured at rest, in response to passive accessory motion testing force, and with isometric internal and external rotation in 12 young healthy adults. All the measurements were made in real time by a physiotherapist and an experienced sonographer in two positions (neutral and abducted) and in two views (anterior and posterior). Intra-rater and inter-rater reliability were expressed using intraclass correlation coefficients (ICC) and measurement error (mm).
Results: Intra-rater reliability was good for both raters (ICC_P: 0.86–0.98; ICC_S: 0.85–0.96). The inter-rater reliability between the physiotherapist and sonographer was moderate to good for posterior measurements (ICC 0.50–0.75) and poor to moderate for anterior measurements (ICC 0.31–0.53). For both intra-rater and inter-rater measurements, posterior translation was more reliable than the anterior translation with smaller measurement errors (posterior: 0.1–0.2 mm, anterior: 0.2–0.3 mm).
Conclusion: A physiotherapist with minimal training was reliable in measuring glenohumeral joint translations. The ultrasound method was reliable for repeated measurement of both anterior and posterior glenohumeral translations with posterior measurements being more reliable than anterior. This method is recommended for future research to investigate the stabilising role of rotator cuff muscles.

1. Introduction

Shoulder instability is a common pathologic condition, typically affecting younger people with high rates of recurrence (Kocher et al., 1998; Ellenbecker et al., 2000; Uhorchak et al., 2000; Liavaag et al., 2011). It has been defined as an inability to maintain the humeral head centred in the glenoid cavity during active motion (Matsen et al., 1994). The rotator cuff muscles have been proposed to play an important role as dynamic stabilisers of the shoulder joint (Labriola et al., 2005; Bey et al., 2008). Pathologic changes in these muscles have been reported to cause abnormal translation of the humeral head relative to the glenoid cavity (Itoi et al., 1996; Doukas and Speer, 2000). This may predispose individuals to pain, functional disability and significant medical expense (Smith et al., 2000; MacDermid et al., 2004). Assessment and quantification of glenohumeral joint translation provides an objective quantifiable measure of shoulder instability (Gerber and Ganz, 1984; Hawkins et al., 1996; Ellenbecker et al., 2002; Taylor

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and Bandy, 2005) and is an important part of the comprehensive clinical examination of shoulder pathology (Hawkins et al., 1996; Tillander and Norlin, 2001; Eisenhart-Rothe et al., 2008).

Given that shoulder instability is a common and disabling problem, it is important that clinicians and researchers measuring glenohumeral joint translation have confidence in their measurements. However, the clinical examination of the shoulder, including laxity tests, have demonstrated low sensitivity, specificity and reliability (Levy et al., 1999; Ellenbecker et al., 2002; Park et al., 2005; Hughes et al., 2008; Beaudreuil et al., 2009). A key issue for clinicians that can contribute to poor measurement properties is measurement error and a lack of reliability.

Real time ultrasonography (RTUS) has been recognised as a convenient, economical, radiation-free and non-invasive method for measuring real-time joint movements, making it suitable for objective assessment of glenohumeral translation in laboratory and field-based research (Court-Payen et al., 1995; Krarup et al., 1999; Yeap et al., 2003; Borsa et al., 2005a,b,c; Tsai et al., 2013; Jerosch et al., 1990; Joseph et al., 2014; Mackenzie et al., 2014). RTUS has been reported as reliable in measuring anterior (Krarup et al., 1999; Yeap et al., 2003; Joseph et al., 2014) and posterior (Borsa et al., 2005a,b,c; Jerosch et al., 1990; Mackenzie et al., 2014) glenohumeral joint translations. However, none of these studies tested the reliability of glenohumeral translation measurements with RTUS during isometric contraction of rotator cuff muscles; and all of these studies were carried out by radiologists or sonographers; traditionally considered as experts in accurately diagnosing shoulder disorders using ultrasound imaging (de Jesus et al., 2009; Ottenheijm et al., 2010; Smith et al., 2011).

Since limiting humeral head translation is potentially the most important stabilising characteristic of rotator cuff muscles (Sangwan et al., 2015), it is important to determine the contribution of these muscles in limiting humeral head translation. Also, as ultrasound units are becoming more affordable and accessible (Speed and Bearcroft, 2002), physiotherapists are increasingly using this technique for clinical and research purposes (Henry and Westervelt, 2005; Blackledge, 2006; McKiernan et al., 2010; Potter et al., 2012). Recent studies have suggested that physiotherapists can reliably identify and measure various static shoulder bony landmarks like humeral head position (Bdaiwi et al., 2014), acromiohumeral distance (Bdaiwi et al., 2014; Mackenzie et al., 2014) and acromion-greater tuberosity distance (Kumar et al., 2011) using RTUS. However, there is little data available concerning the reliability of physiotherapists measuring glenohumeral joint movements with passive accessory motion testing using RTUS (Mackenzie et al., 2014; Joseph et al., 2014). Hence, it is important to establish the reliability of the method before such testing can be performed by physiotherapists.

Only two studies have been located that reported the reliability of glenohumeral translation measurements with RTUS by physiotherapists, however both of these studies have potential limitations. Mackenzie et al. (2014) reported good intra-rater reliability for posterior glenohumeral translation measurements (ICC 0.76–0.94) but did-not measure inter-rater reliability. Evaluating both intra-rater and inter-rater reliability is important to indicate whether the same clinician can reliably assess the progress of a patient over several occasions or whether different clinicians can reliably monitor the same patient. These authors also reported other methodological limitations including using manual, non-standardised passive accessory motion testing force and non-blinding of examiner to testing conditions (Mackenzie et al., 2014). Joseph et al. (2014) reported good inter-rater reliability (ICC 0.92) between 2 physiotherapists in measuring anterior humeral head translation from the same image. However, an experienced radiologist captured the ultrasound images, and hence this result does not indicate a physiotherapist's skill in using RTUS to identify important bony landmarks for glenohumeral translation measurements. Further investigation is warranted as no studies have compared the reliability of physiotherapists to sonographers or radiologists in measurement of glenohumeral translations.

Therefore, the aim of this study was to evaluate the reliability of a physiotherapist in measuring anterior and posterior glenohumeral joint translation with RTUS. To achieve this, the translation measurements of the physiotherapist were compared to the measurements of an expert sonographer to calculate inter-rater reliability. To determine intra-rater reliability, repeated measurements of the two raters were compared under different clinical parameters (with and without each of passive accessory motion testing and isometric rotator cuff contractions).

2. Materials and methods

2.1. Design

This study involved repeated RTUS measurements of humeral head translation in two arm positions by two raters within same day. The study was approved by the University Human Ethics Committee (14–079). Written informed consent was obtained prior to participation.

2.2. Participants

The dominant shoulder (preferred for throwing) was assessed in 12 healthy young adults (four men, eight women with mean age of 21.4 ± 2.5 years; weight, 64.6 ± 12.0 kg and height, 168.5 ± 7.9 cm). Sample size estimates indicated that a sample size of 12 would be appropriate if reliability coefficients were expected to be between 0.6 and 0.9 (Joseph et al., 2014). The participants were recruited consecutively through advertisements on university notice boards. Participants had no previous or current history of shoulder symptoms and had full range of shoulder motion.

2.3. Instrumentation

Humeral head translation was measured using RTUS (model no 75L53 EA, Mind Ray 6500 Ultrasound System, North America) on B mode using a 50 mm 10 MHz linear transducer based on an established protocol (Jerosch et al., 1990; Court-Payen et al., 1995; Krarup et al., 1999). The passive accessory motion testing force of 60 N was similar to the force used in a previous study (Yeap et al., 2003) and was applied by an assistant in a slow sustained manner with force monitored through a hand held dynamometer (Lafayette, USA).

2.4. Procedures

Participants were seated upright in a chair with both feet on the floor to ensure maximum stability during testing. The upper limb was held in one of two positions (see below) without the need for any muscular activity using Velcro straps, and an elbow, hand and wrist orthosis. A vertical board strapped across the chest stabilized the trunk to the chair, so that passive accessory motion testing forces were isolated to the humeral head rather than the torso.

Participants were tested in two shoulder positions; 1: shoulder at neutral: shoulder neutral adduction and internally rotated, 90° elbow flexion, forearm mid-prone and hand and wrist in neutral fixed to desktop with orthosis and straps (Fig. 1A); 2: shoulder abducted to 90° and externally rotated, 90° elbow flexion, forearm mid-prone and hand and wrist in neutral fixed to raised platform with orthosis and straps (Fig. 1B).