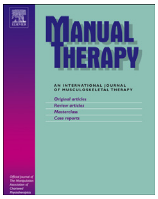
Manual Therapy xxx (2015) 1–5

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math



Technical and measurement report

Test validity and intra-rater reliability in the measurement of scapular position sense in asymptomatic young adults

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ARTICLE INFO

Article history:
Received 10 December 2013
Received in revised form
29 January 2015
Accepted 6 February 2015

Keywords:
Scapula
Joint position sense
Reposition error
Reliability
Validity

ABSTRACT

It is suggested that scapular joint position sense (JPS) contributes to scapular stability. However, there is a lack of studies describing the measurement method for three-dimensional (3D) scapular JPS. The purposes of this study were to investigate the measurement repeatability and validity of the scapular JPS, and examine the effect of arm dominance on the scapular JPS in asymptomatic young adults. Ten subjects participated in this study. The scapular JPS was measured as scapular reposition errors during scapular elevation, depression, protraction, and retraction. Both the 3D scapular kinematics and clinical scale rule measurement were recorded during the test. The results showed that the measurement of scapular reposition errors resulted in moderate to excellent within-day intra-rater reliability with intraclass correlation coefficient $ICC_{(3,2)}$ between 0.60 and 0.99 for 3D scapular rotations, between 0.56 and 0.96 for 3D scapular displacement, and between 0.73 and 0.98 for the clinical scale ruler measurement. Scapular reposition errors measured using a 3D electromagnetic tracking device and using a scale ruler had a significant relationship ($r = 0.74–0.98$). There was no significant difference in scapular reposition errors between the dominant and non-dominant shoulders. Our findings indicated that both the 3D tracking device and scale ruler resulted in a reliable measurement of scapular JPS and the clinical measurement method could be used to provide valid data for scapular JPS evaluation. In addition, arm dominance did not influence the scapular JPS in asymptomatic young adults.

1. Introduction

Proper scapular alignment provides a stable base for the glenohumeral joint (Paine, 1993; Forthomme, 2008). The stability of the scapula relies not only on a balanced functioning of the scapular muscles (Kibler, 1998; Ludewig, 2000; Cools, 2003; Lin, 2006; Myers et al., 2006; Hsu, 2009; Struyf, 2011; Struyf et al., 2014), but also on the fine self-adjustment of the sensorimotor system, including various components of proprioception such as the joint position sense (JPS), kinesthesia, and the sensation of force (Myers et al., 2006). The JPS serves as a neurological feedback control of movement and the information contributing to the JPS comes mainly from mechanoreceptors situated in the muscles and connective tissues surrounding the joints (Dover, 2003; Suprak, 2007).

Various studies have measured shoulder JPS and showed its deficits in individuals with shoulder injury (Lephart, 1994; Dover, 2003; Lee, 2003; Tripp, 2006; Suprak, 2007; Herrington, 2010; Yang, 2010; Balke, 2011; Guo, 2011; Lin, Hung, & Yang, 2011). There have been only a few investigations into the scapular JPS despite its importance in the functioning of the shoulder complex. Tripp et al. (2006) assessed the scapular reposition errors at various positions during overarm throwing. Guo et al. (2011) examined the effect of shoulder internal rotator fatigue on the scapulothoracic JPS. These measurements nevertheless require laboratory instrumentation which is not applicable in the clinical settings. Although some researchers believed that the dominant limb might be less sensitive to joint position change because overuse of limbs could lead to cumulative micro injuries (Lephart, 1994; Balke, 2011), no study examined the effect of arm dominance on scapular proprioception. Therefore, we designed this study (1) to determine the intra-rater repeatability for the 3D measurement of scapular joint

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http://dx.doi.org/10.1016/j.math.2015.02.002

Please cite this article in press as: Deng H-R, Shih Y-F, Test validity and intra-rater reliability in the measurement of scapular position sense in asymptomatic young adults, Manual Therapy (2015), http://dx.doi.org/10.1016/j.math.2015.02.002

position sense (JPS, represented by joint reposition errors) and the clinical scale ruler measurement, (2) to validate the clinical measurement of scapular JPS using the 3D measurement results and (3) to determine whether differences in scapular JPS exist between dominant and non-dominant shoulders.

2. Methods

2.1. Participants

Ten healthy young adults (1 male, 9 females; mean ± SD age, 23.90 ± 0.99 years; height, 1.63 ± 0.09 m; mass, 54.85 ± 11.14; BMI, 20.53 ± 2.51) were recruited for this study. The inclusion criteria were: (1) 18–55 years old; (2) no history of neck-shoulder and thoracic pain in the past 3 months; (3) no surgical history of the upper extremities; (4) no neurological symptoms and signs in the upper extremities; (5) no history of vestibular impairment, ex: motor imbalance, dizziness or vertigo. This study was approved by the Institutional Review Board of National Yang Ming University, Taipei, Taiwan (IRB number: 1000013).

2.2. Instrumentation

The Liberty electromagnetic tracking system (Polhemus, Colchester, VT, USA) with three sensors attached to the upper-trunk (between the 7th cervical and 1st thoracic spinous process) and to both scapula (posterior-lateral surfaces of the acromion), was used to collect the 3D scapular/glenohumeral motion with a sampling rate of 120 Hz (Shih and Kao, 2011). This tracking system had an accuracy of 0.3°–0.7°and 0.4 cm, and the measurement repeatability between 0.68 and 0.91 (Shih and Kao, 2011). The clinical measurement of scapular JPS was carried out using a scale ruler which measured the displacement of the middle finger during scapular protraction/retraction and scapular elevation/depression. The scale ruler was attached to a wooden pole next to the testing arm for measuring the scapular elevation/depression movement, and attached to a 4-wheeled arm-supporting device which ran in two rails and was used to keep the testing arm at 90° elevation in the scapular plane (Fig. 1).

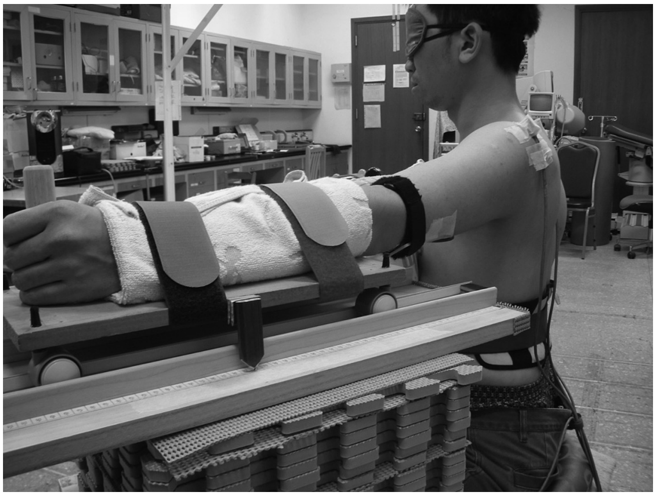

Fig. 1. Measurement of scapular reposition errors during protraction and retraction tasks.

2.3. Procedures

Subjects first signed an informed consent and performed 5-min warm-up range of motion and stretching exercises for the shoulder girdle. The subjects were then seated and stabilized by a belt, followed by the palpation and digitization of the bony landmarks using a stylus (Lewis et al., 2002).

All the measurement was performed by a licensed physical therapist with one year experience of our testing method. The tester was not blind to the purpose of the study. The scapular JPS was measured as the joint reposition errors in four movement tasks: elevation, depression, protraction and retraction. When testing scapular elevation and depression, we asked subjects to hang their arm naturally beside the body with elbow and fingers extended. To test scapular protraction and retraction, the testing arm was positioned at 90° elevation with an arm-supporting device. In our pilot study, the protraction and retraction movement was performed without arm support. Because most subjects reported tiredness and soreness during and after the non-supported test, and the testing reliability correlation coefficients ranged from 0.00 to 0.98, we manufactured a supporting device with two rails and 4 wheels to keep the testing arm at 90 degrees of elevation in the scapular plane for the protraction and retraction tasks (Fig. 1). The 90° arm elevation was measured using a universal goniometer. While holding the stylus, the subject was asked to perform the maximum protraction, retraction, depression and elevation three times and the average total displacement was calculated. Scapular movement is mainly controlled by the surrounding musculature and thus mid-range proprioception would be a more appropriate target for its proprioception measurement. We nevertheless chose 90% of the total movement as the target because subjects felt it was too difficult to perform the test if the target was set below 85% owing to the small total range of scapular movement. Afterwards, the subjects were guided to the target position and held that position for 5–10 s to remember it, and returned their scapula to the resting position, followed by actively repositioning their scapula to the target position. As the target position was reached, the subjects pushed the switch on the stylus held in the testing arm to record the kinematic data, and the displacement value was also recorded on the scale ruler. Vision and hearing were shielded by eye-masks and earplugs throughout the experiment. Three testing trials were performed for the calculation of repeatability coefficients for each movement direction.

2.4. Data reduction

The Motion Monitor® software (TMM; Innovative Sport Training, Inc., Chicago. IL. USA) was used to record and analyze the 3D kinematic data. The bony landmarks were digitized to define the anatomical joint coordinate system, based on the recommendations of International Society of Biomechanics (ISB) (Wu et al., 2005). Scapular movement relative to the thorax was defined as internal/external (Y-axis) rotation (IR/ER), upward/downward (Z-axis) rotation (UR/DR), posterior/anterior (X-axis) tilt, and displacement between the acromion angle and incisura jugularis in the directions of X (+: lateral), Y (+: superior) and Z (+: posterior) of the thorax coordinate system (Wu et al., 2005). The joint reposition error is the absolute value of the differences between the original target position and the repositioned scapular position during the four movement tasks. The outcome variables of this study were the 3D scapular reposition errors including the scapular tilt, UR/DR, and ER/IR, and scapular displacement along the X, Y, and Z axes, and the clinical measurement of the scapular reposition

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