

Reliability of Measures of Scapular Protraction Strength in the Supine and Seated Positions

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Abstract. [Purpose] The purpose of this study was to investigate the intra-rater reliability of measures of scapular protraction strength using a novel method. [Subjects] Forty-nine healthy subjects participated in this study. [Methods] Subjects performed maximal isometric scapular protraction on the left and right sides in the supine and seated positions. During scapular protraction, resistance was applied to the olecranon, and the strength of scapular protraction was measured using a load cell. Intra-rater reliability was calculated as the intra-class correlation coefficient (ICC_{3,1}). [Results] High intra-rater reliability scores (0.97–0.98) for scapular protraction strength were observed in the supine and seated positions. [Conclusion] These findings demonstrate that the method described herein may provide a more reliable and convenient method to measure scapular protraction strength than common current practice does.

Key words: Reliability, Scapular protraction, Serratus anterior

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INTRODUCTION

The serratus anterior (SA) has an important role in normal scapulohumeral rhythm during arm elevation^{1–3}. In particular, the SA acts as the prime motive force of upward scapular rotation and protraction^{1, 2} and also contributes to the stability of the scapula by maintaining the medial border of the scapula against the rib cage^{2, 3}. It has been reported that weakness of the SA leads to abnormal kinematics of the scapula and scapular muscle imbalance, which is associated with musculoskeletal problems such as neck and shoulder pain, scapular winging, and impingement^{4–7}. In a clinical setting, therefore, it is important to evaluate muscle strength of the SA for diagnosis and treatment planning⁸.

The manual muscle test (MMT) is frequently used to evaluate muscle strength of the SA^{7, 8}. Kendall et al.⁷ suggested that scapular protraction against manual resistance from an examiner at 90° of shoulder flexion is appropriate as an MMT for SA. However, it is difficult to detect subtle differences in muscle strength because such MMTs generally classify muscle strength into only six grades, which are

based on the subjective evaluation of the examiner^{9, 10}. Furthermore, previous findings showed only poor to fair intra-rater reliability (0.38–0.72) when using an MMT for shoulder muscles¹¹. Thus, other more quantitative and reliable methods for measuring the strength of scapular protraction are needed.

Isokinetic dynamometers¹² and handheld dynamometers⁹ have been suggested as means to quantitatively assess muscle strength. However, although isokinetic dynamometers are useful in this respect, they are not favorable in the clinical setting due to high equipment costs and time requirements¹². Handheld dynamometers are advantageous in terms of providing quantitative data and being relatively inexpensive; however, the reported intra-rater reliability of the measurement of scapular protraction strength using these devices varies from poor (0.26)¹³ to high (0.94)⁹. Williams et al.¹⁴ suggested that the reliability of the handheld dynamometer may be influenced by the strength of the examiners.

Considering the disadvantages of previously used methods and equipment for evaluating SA strength, especially the strength of scapular protraction, a new method is required that provides its own resistance and thus limits the need for subjective assessment. The aim of the present study was to assess the intra-rater reliability of measures of scapular protraction in supine and seated postures using a novel method and apparatus.

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SUBJECTS AND METHODS

In total, 49 healthy subjects (29 men and 20 women) without neck or shoulder pain in the previous 3 months participated in this study. The exclusion criteria were a history of surgery of the neck or shoulder, impingement, and other shoulder injuries. The mean age of the subjects was 20.63 ± 1.84 years, the mean height was 169.61 ± 8.05 cm, and the mean body weight was 61.52 ± 11.47 kg. Prior to participation, informed consent was obtained by requiring all subjects to read and sign a consent form approved by the Inje University Ethics Committee for Human Investigations.

To measure the strength of scapular protraction, a new force-measurement device was used, which consisted of a $700 \times 300 \times 18$ -mm wooden plate for supporting the thorax, a load cell (RSBA-50L, Radian, Seoul, South Korea) that measured the strength of scapular protraction, a nonelastic resistance belt that provided resistance, and a digital indicator (RI-10W, Radian, Seoul, South Korea) that indicated the real-time strength of scapular protraction. The wooden plate and resistance belt were connected by a load cell that measured tension caused by scapular protraction. The analog signal produced by the load cell was converted into a digital signal, which could be displayed on the digital indicator in either newtons or kilograms of force. In this study, the selected unit of force for scapular was kilograms. The range of this force measurement device was 0–45 kg, with a resolution of 0.001 kg and precision of ± 0.003 kg. The frequency of measurement was 100 Hz.

The strength of left and right scapular protraction was measured in the supine and seated positions in randomized order. In the supine position, subjects were asked to lie on the wooden plate, with the axis of the shoulder joint parallel to the load cell. The shoulder and elbow were placed at 90° of flexion⁹⁾, the resistance belt was attached at the proximal ulna and radius, and the length of the resistance belt was adjusted so that it fit along the humerus. Subjects were asked to push on the resistance belt as hard as possible to perform maximal scapular protraction and then maintain maximal scapular protraction for 5 s (Fig. 1). In the seated position, the wooden plate was hung from a wall, and subjects sat on a chair at 90° of hip and knee flexion with the axis of the shoulder joint parallel to the load cell. The thorax was held against the wooden plate, and the shoulder and elbow were held at 90° of flexion. The fitted resistance belt was placed on the olecranon, as in the prone position. Subjects were instructed to perform maximal isometric scapular protraction. They repeated maximal scapular protraction three times, with a rest period of 1 min between trials under each condition.

Descriptive statistics were used to calculate the mean strength of left and right scapular protraction in the prone and seated positions. The intra-class correlation coefficient ($ICC_{3,1}$) was used to determine intra-rater reliability of scapular protraction in the seated and supine positions. Although ICC values >0.75 are generally considered to indicate good reliability¹⁰⁾, we used more precise criteria, as follows: poor reliability, <0.69 ; fair reliability, 0.70 – 0.79 ; good reliability, 0.80 – 0.89 ; and high reliability, >0.90 ¹⁵⁾.

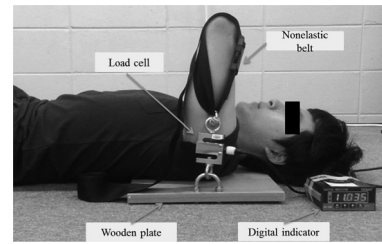


Fig. 1. Measure of the scapular protraction strength using a new force measurement device

Table 1. The intra-class correlation coefficients and 95% confidence intervals for measures of scapular protraction strength

| Side | Supine position | | Seated position | |
|-------|-----------------|-----------|-----------------|-----------|
| | ICC | 95% CI | ICC | 95% CI |
| Left | 0.97 | 0.96–0.98 | 0.98 | 0.97–0.99 |
| Right | 0.97 | 0.96–0.98 | 0.97 | 0.95–0.98 |

ICC, intra-class correlation coefficient; CI, confidence interval

The data were analyzed using SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA).

RESULTS

The mean (\pm standard deviation, SD) strengths of scapular protraction on the left and right sides in the supine position were 12.21 ± 6.28 kg and 12.80 ± 6.59 kg, respectively. In the seated position, these values were 14.87 ± 6.80 kg and 15.84 ± 7.93 kg on the left and right sides, respectively. The $ICC_{3,1}$ and 95% confidence interval for these measures of strength of scapular protraction are shown in Table 1. High intra-rater reliability was observed in the supine position (0.97) and in the seated position (0.97–0.98).

DISCUSSION

This study examined the intra-rater reliability of measures of scapular protraction strength using a new method that eliminates the need for subjective assessment of force. This method showed high intra-rater reliability (0.97–0.98) in both the seated and supine positions when assessing the strength of scapular protraction.

In previous work, the reliability of measures of strength of scapular protraction using a handheld dynamometer was good to high (0.83–0.94)^{9, 10)}. However, these findings were not consistent with the results reported by Donatelli et al.¹³⁾, who found poor intra-rater reliability (0.26) for measures of scapular protraction strength. This inconsistency in previous findings may be due to differences between the maximal strength of the subject and the resistance applied by the examiner when using a handheld dynamometer. In MMT methods, muscle strength is generally measured by maximal isometric contraction of the target muscle against resistance from the examiner. As a result, inaccurate data

may result if the subject can apply greater force than the resistance provided by the examiner. Therefore, the poor intra-rater reliability for measures of scapular protraction strength observed in the previous study by Donatelli et al.¹³⁾, who examined professional baseball pitchers, may be attributable to insufficient resistance from the examiner. In line with this, components such as resistance belts that provide constant resistance are required as part of a quantitative force-measurement device to obtain accurate and reliable measures of muscle strength. In our study, we attributed the high reliability scores obtained in both the supine and seated positions (0.97–0.98) to the use of a resistance belt rather than a human examiner.

Although Wang et al.¹⁰⁾ used a customized apparatus that included an adjustable chain for providing resistance, the intra-rater reliabilities of measures of scapular protraction strength (0.83–0.89) were lower than those reported here (0.97–0.98). This is likely because the subjects in that study performed scapular protraction with the elbow extended, and resistance was applied to the hand. In contrast, our subjects performed scapular protraction with 90° of elbow flexion, and resistance was applied at the olecranon. The elbow-flexed position decreases the number of joints across which the scapular protraction force is applied⁹⁾, which may help to more accurately measure strength of scapular protraction. Therefore, modifying the position in which scapular protraction strength is measured may also contribute to the improved intra-rater reliability observed in the present study compared with previous findings.

Regarding the potential limitations of this study, the intra-rater reliability of measures of scapular protraction strength was only assessed in healthy individuals. Future studies should examine inter-rater reliability of measures of scapular protraction strength using our method. Moreover, additional studies are required to determine whether there are differences in scapular protraction strength, as measured by this method, in individuals with and without neck or shoulder pain or scapular winging.

In conclusion, our findings provide clinicians with a reliable and convenient method for more accurately assessing and comparing scapular protraction strength. Moreover, assessing scapular protraction strength using this method may be useful for determining prognosis as well as in treatment planning.

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