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ORIGINAL ARTICLE

Reproducibility of isometric shoulder protraction and retraction strength measurements in normal subjects and individuals with winged scapula

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Background: The strength of the shoulder protractors and retractors may be compromised in individuals with winged scapula (IwWS). However, no standard approach to measuring the strength of these muscles has been described. The aim of this study was to study the intra-rater and inter-rater reproducibility of a fixed-base isometric dynamometer and to describe cutoff scores for clinically meaningful change for protraction and retraction isometric strength.
Method: Twice during a week, 20 normal subjects and 20 IwWS were tested by 2 independent raters.
Results: IwWS were significantly weaker ($P < .001$) than control subjects in their protraction and retraction isometric strength. Excellent intra-rater and inter-rater correlations were obtained in most combinations, leading to low cutoff scores for meaningful change expressed in terms of the smallest real difference.
Conclusion: When it is properly used, the technique described in this paper is recommended as an effective clinical tool for the quantitative assessment of protraction and retraction isometric strength, both for status determination and for monitoring of change in IwWS during and after rehabilitation.
Level of evidence: Level IV; Case-Control Design; Diagnostic Study

Keywords: Protraction; retraction; reproducibility; shoulder; strength; winged scapula

Subacromial impingement syndrome (SIS) is thought to be the most common diagnosis of shoulder dysfunction, constituting 74% of shoulder pain cases.[10,27] Patients with SIS present with pain, dysfunction,[2] and limitation of range of motion.[18] One of the main sources of secondary SIS, described as a relative decrease in the subacromial space, is abnormal scapular motion.[10,16] Under normal conditions, the coordinated activity of muscles responsible for scapular motion results in the so-called normal scapulohumeral rhythm, which ensures a viable subacromial space that may in turn enable a pain-free functional glenohumeral joint as well as prevent SIS.[15,16] Thus, well-controlled scapular motion is one of the critical elements in understanding SIS and its treatment.

The main scapulothoracic muscles include the serratus anterior, trapezius, rhomboid major and minor, and levator scapulae, and they take part in both open and closed kinetic chain movements like elevation of the arm and wall pushup,

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respectively.[11] Moreover, when high compressive or tensile forces are exerted through the hand and elbow on the shoulder complex, typically during object pushing or pulling with the hands, the major protractors and retractors must be recruited to prevent disruption of the scapulohumeral rhythm. This disruption may lead to the condition of winged scapula, which is attributed most commonly to paralysis of the long thoracic nerve.[14] However, it can masquerade as multiple other disorders, including thoracic outlet syndrome; instability and disorders of the rotator cuff, peripheral nerve, acromioclavicular joint, and spine; and those of unknown or unspecified origin.[23] Clinically, winged scapula is assessed by a bilateral comparison of scapular position; evaluation of scapular motion and dyskinesia or asymmetry; and assessment of muscle weakness in forward flexion, extension, wall pushup, and shoulder shrugs.[11,25]

As the strength of the scapulothoracic muscles, particularly that of the protractors and retractors, is a major functional factor, and given the increasing reliance on quantitative assessment, the use of dynamometry for measuring scapulothoracic muscle strength has been studied by applying hand-held, fixed-base or isokinetic dynamometers. The strength of the lower, middle, and upper trapezius and the serratus anterior using a digital hand-held dynamometer (HHD) has been measured in patients with shoulder pain and functional loss.[17] Very high intra-tester intraclass correlation coefficients (ICCs) were reported for all muscles; but because normal subjects were not tested, neither reference values nor strength ratios were reported. In another study,[24] an analog-type HHD has been used to measure the strength of the rhomboids in normal subjects. An initial inter-tester reproducibility study (N = 16) has revealed moderate to high ICCs. Unilateral strength ratios were 1.25:1, 1.5:1, and 2.5:1 for protraction/retraction, upward/downward rotation, and elevation/depression, respectively.

Fixed-base isometric dynamometry refers to isometric muscle strength measurements whereby the subject exerts a static effort against a load cell that is commonly connected through a mechanical interface to a wall or another solid base. Using a custom-made frame for upper extremity closed kinetic chain bilateral push-pull efforts, Garner and Shim[9] have reported protraction strength (PS) of around 800 N and 1400 N in women and men, respectively; for retraction strength (RS), the parallel figures were about 600 N and 1100 N. A much simpler fixed-base dynamometer was recently reported by our group[13] and used to measure PS in normal subjects and patients with winged scapula. A significant difference was observed with a mean maximal PS of 203 N vs 137 N, respectively.

Isokinetic dynamometry has been used in a closed kinetic scapular plane configuration to measure concentric PS and RS in normal subjects. Mixing of genders in 1 study[4] does not allow estimation of the respective strengths. In another study, the isokinetic strength of the scapular muscles was compared between elite adolescent gymnasts and nonathletic adolescents.[5] The PS/RS ratio stood at around 1.24 and around 1.0 for the slower and faster speeds, irrespective of group participation.

Given the diversity of measurement instruments, experimental groups, and testing protocols, alongside the relative dearth of clinical studies relating to the reproducibility of strength findings in patients with scapulothoracic muscle involvement, this study aimed to profile individuals with winged scapula (IwWS). The objectives of this study were therefore to examine the intra-examiner and inter-examiner reproducibility PS and RS in apparently healthy subjects and IwWS, using the above-mentioned dynamometer,[13] to establish cutoff values for PS and RS as guidelines for clinical evaluation and rehabilitation follow-up.

Materials and methods

Subjects

This is a case-control study relating to shoulder protraction and retraction strength. In total, 20 men with SIS and a matched group of 20 apparently healthy men were recruited from a workplace-based work-conditioning center in South Korea. Patients with unilateral shoulder pain compatible with a medical diagnosis of SIS were screened for eligibility criteria by a physician. Patients were included if they had a history of shoulder pain of >3 months' duration; pain localized at the proximal anterolateral shoulder region (visual analog scale score of 4 to 8); medical diagnosis of SIS with at least 2 positive impingement test results, including Neer, Hawkins, or Jobe test; and positive winged scapula finding, namely, at least a 2-cm difference in depth between the inferior angle of the scapula and the thorax using a scapulometer. Subjects were excluded if they had a history of shoulder surgery, symptoms related to the cervical spine, frozen shoulder, disorders of the acromioclavicular joint, degenerative arthritis of the glenohumeral joint, and shoulder instability.

Scapular winging

All subjects stood with neutral shoulder position, 90° of elbow flexion, and neutral forearm position. A cuff weighing 5% of the body weight of each subject was placed on the distal wrist to measure static scapular winging. The extent of scapular winging was determined as the depth between the inferior angle of the scapula and the thorax using a scapulometer.[26]

PS and RS

PS and RS were assessed using a custom-made fixed-base dynamometer consisting of a load cell (RSBA-50L; Radian, Seoul, Korea) connected through a resistance belt and a digital indicator for displaying the measured force value, respectively (Figs. 1 and 2). In addition, a wooden plate (702 × 300 × 18 mm) was included to support the upper trunk. The measurement range of the device was 0 to 490 N, with a resolution of 0.01 N, a precision of ±0.03 N, and a sampling rate of 100 Hz.[13] During both PS and RS measurement, the trunk was stabilized with belts to minimize compensation. For measuring PS, the subject was in a supine position, with 90° flexion of the shoulder and elbow (Fig. 1). A resistance belt was placed on the olecranon along the vertical axis of the humerus. The length