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Original article

Quantification of shoulder tightness and associated shoulder kinematics and functional deficits in patients with stiff shoulders

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Abstract

Measurement of anterior/posterior shoulder tightness, humeral external/internal rotation range of motion (ROM), scapular upward rotation/tipping ROM, and functional limitations were made in 46 patients with unilateral stiff shoulders (SSs) using a clinical measurement (shoulder tightness), a three-dimensional electromagnetic tracking device (shoulder ROM), and self-reports of function. Patients with SSs in their dominant shoulder demonstrated statistically greater posterior shoulder tightness compared to nondominant shoulder. Control dominant shoulders demonstrated decreased internal ROM as compared with control nondominant shoulders ($p = 0.021$). In SSs, significant relationships were found between humeral internal rotation ROM and posterior shoulder tightness ($R = 0.49$, $p < 0.0005$), humeral external rotation ROM and anterior shoulder tightness ($R = 0.59$, $p = 0.0002$), scapular tipping and anterior shoulder tightness ($R = 0.57$, $p = 0.004$). Specifically, in patients with dominant SSs, posterior shoulder tightness and functional limitation were related ($R = 0.56$, $p = 0.002$). In patients with dominant involved shoulders, emphasise on posterior tightness stretch may improve functional ability directly. In addition to stretching program in patients with SSs, internal rotation ROM of control dominant shoulder is also important to consider in the rehabilitation of patients with SSs.

Keywords: Stiff shoulder; Tightness; Humeral rotation; Scapula

Stiff shoulder (SS) is a common health problem in various patient populations. SS is characterized by pain and functional restriction of both active and passive shoulder motions (Reeves, 1975; Wadsworth, 1986; Murnaghan 1990). The prevalence of SS in populations has been estimated to be 2 and 5% (Lubiecki and Carr, 2007). Diabetic patients have a higher incidence (10%) than the general population (Bridgman, 1972). SS has been divided into two types: "idiopathic frozen shoulder" and "post-traumatic SS" (Lundberg, 1969; Griggs et al., 2000). Idiopathic contracture and loss of compliance of the glenohumeral joint capsule results in an idiopathic frozen shoulder, while after an injury, soft tissue contracture associated with the glenohumeral joint results in a post-traumatic SS. Specifically, adhesive capsulitis (Murnaghan, 1990) decreased capsular volume (Mao et al., 1997; Vermeulen et al., 2000), capsular contractions (Bunker, 1997), rotator interval thickening and fibrosis (Pearsall et al., 1999), and subscapularis tendon

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thickening (Pearsall et al., 1999) have been reported by arthography and arthoscopy.

Although multiple factors are related to SS, the manifestation of shoulder tightness is thought to be correlated to altered glenohumeral movements. Cyriax (1978) proposed that tightness in a shoulder joint capsule would restrict motion in a predictable pattern, a capsular pattern in which external rotation is more limited than abduction, which in turn is more limited than internal rotation. Other authors have indicated that posterior shoulder tightness is significantly correlated with humeral internal rotation range of motion (ROM) loss in patients with shoulder impingement (Harryman et al., 1990; O'Brien et al., 1990; Warner et al., 1990). Specifically, Harryman et al. (1990) stated that asymmetrical tightness of the shoulder capsule, rather than ligament laxity, affects glenohumeral translations, thus influencing ROM of the shoulder. Clinically, capsular stretching exercises as well as mobilization (manipulation) treatments are thought to decrease shoulder capsule tightness and thus result in improvement of shoulder motion (Griggs et al., 2000; Vermeulen et al., 2000). Asymmetrical tightness of the shoulder is assumed to result in loss of ROM in patients with SSs, subsequently decreasing functional performance.

The purpose of this study was to document anterior/posterior shoulder tightness with clinical measurement and characterize relationships between tightness and associated shoulder kinematics and functional deficits in patients with SSs.

1. Materials and methods

1.1. Subjects

Forty-six patients suffering from unilateral SS (22 male, 24 female) between the ages of 48 and 85 (mean = 58.1, SD = 16.3) years agreed to have measurements taken as part of a routine clinical examinations. The affected shoulders (24 dominant shoulders and 22 nondominant shoulders) of the 46 patients were tested. Descriptive data of the subjects' characteristics are summarized in Table 1. The inclusion criteria of patients with SSs were: (1) a limited ROM of a shoulder joint (ROM losses of 25% or greater compared with the noninvolved shoulder in at least two of the following shoulder motions: glenohumeral flexion, abduction, or internal/external rotation), and (2) pain and stiffness in the shoulder region lasting for at least three months. Exclusion criteria were a history of (1) increased pain and/or stiffness in the past month, (2) surgery on the particular shoulder, (3) rheumatoid arthritis, (4) stroke with residual shoulder involvement, or (5) fracture of the shoulder complex. All subjects reviewed and signed the hospital-approved human subject informed consent document before participating. Additionally, the ethics of the whole study were approved by the hospital. Subsequently, the subjects were examined to determine the ROM, pain, and functional status of their affected shoulders.

Table 1
Patient characteristics

Characteristics	Dominant shoulder involved ($N = 24$)	Non-dominant shoulder involved ($N = 22$)
Gender male (female)	10 (14)	12 (10)
Age (yrs)	58.0 ± 10.1	54.7 ± 12.8
Weight (kg)	61.3 ± 4.2	68.9 ± 12.4
Height (cm)	155.3 ± 7.8	164.9 ± 9.3
Duration of symptoms, range (m)	7.8 ± 4.1, 3–36	6.5 ± 4.2, 3–16
FLEX-SF self-report (normal: 50/50)[a]	28.6 ± 5.2	37.9 ± 7.6

Patients were diagnosed as adhesive capsulitis ($N = 32$), rotator cuff injury ($N = 14$).

[a] The Flexilevel scale of shoulder function (FLEX-SF) was used to assess the functional status of the shoulder.

1.2. Equipment

A hand-held standard universal goniometer was used to measure the range of the shoulder joint motion. This goniometer was a double-armed, full circle protractor made of transparent plastic. Additionally, a fluid type inclinometer (Isomed, Portland, Oregon) was used to assess cross-chest and below-chest shoulder ROM. The inclinometer resembles a flat goniometer with 360 degrees of graduation marked in single-degree increments on the circumference. We determined the angle by comparing the location of the arm on the inside of the inclinometer with the degree markings around the circumference. During the measurement, the inclinometer was held in a vertical position. Thus, the arm (gravity) remained in the downward position, indicating the change in limb position.

The FASTRAK 3-D electromagnetic motion-capturing system (Polhemus Inc., Colchester, VT, USA) was used to detect shoulder ROM. Three sensors for the system were attached to the bony landmarks with adhesive tape. Each sensor was 2.3 cm in length, 2.8 cm in width, 1.5 cm in height, and weighed 17 g. One sensor was attached to the sternum, and one sensor was attached to the flat bony surface of the scapular acromion with adhesive tape. The third sensor was attached to the distal humerus with Velcro straps. Additionally, a fourth sensor, attached to a stylus, was used to digitize palpated anatomical coordinates (bony landmarks: sternal notch, xyphoid process, seventh cervical vertebra, eighth thoracic vertebra, acromioclavicular joint, root of the spine of the scapula, inferior angle of the scapula, lateral epicondyle, and medial epicondyle; glenohumeral