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Specific kinematics and associated muscle activation in individuals with scapular dyskinesis

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Background: Knowledge of the kinematics and associated muscular activity in individuals with scapular dyskinesis may provide insight into the injury mechanism and inform the planning of treatment strategies. We investigated scapular kinematics and associated muscular activation during arm movements in individuals with scapular dyskinesis.
Methods: A visual-based palpation method was used to evaluate 82 participants with unilateral shoulder pain. Scapular movements during arm raising/lowering movements were classified as abnormal single pattern (inferior angle prominence, pattern I; medial border prominence, pattern II; excessive/inadequate scapular elevation or upward rotation, pattern III), abnormal mixed patterns, or normal pattern (pattern IV). Scapular kinematics and associated muscular activation were assessed with an electromagnetic motion-capturing system and surface electromyography.
Results: More scapular internal rotation was found in pattern II subjects (4°, $P = .009$) and mixed pattern I and II subjects (4°, $P = .023$) than in control subjects during arm lowering. Scapular posterior tipping (3°, $P = .028$) was less in pattern I subjects during arm lowering. Higher upper trapezius activity (14%, $P = .01$) was found in pattern II subjects during arm lowering. In addition, lower trapezius (5%, $P = .025$) and serratus anterior activity (10%, $P = .004$) were less in mixed pattern I and II subjects during arm lowering.
Conclusions: Specific alterations of scapular muscular activation and kinematics were found in different patterns of scapular dyskinesis. The findings also validated the use of a comprehensive classification test to assess scapular dyskinesis, especially in the lowering phase of arm elevation.
Level of evidence: Basic Science Study, Kinesiology.

Keywords: Scapula; dyskinesis; kinematics; electromyography; clinical assessment; movement patterns

Scapular dyskinesis is defined as the alteration of scapular position and motion.[19] These include an abnormal scapula medial border and inferior angle prominences relative to the thoracic cage in the static position or dynamic motion, early scapula elevation or shrugging during arm elevation, as well as inadequate upward and downward rotation of the scapula during arm elevation/lowering.[20]

The National Taiwan University Hospital Human Subject Research Ethics Committee approved this study (approval number: NCT01962727 from clinicaltrials.gov).

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Although scapular dyskinesis is not directly related to shoulder disorders, it has been reported in 68% to 100% of individuals with shoulder disorders, including glenohumeral instability, rotator cuff disorders, and labral tears.[2,32,41] Dyskinesis is observed in patients with various shoulder disorders that are related to changes in glenohumeral strain, subacromial space dimension, shoulder muscle activation, and muscle strength.[36,38,42]

Evidence suggests that individuals with shoulder disorders present scapular kinematic abnormalities such as decreased scapular upward rotation, decreased scapular posterior tipping, and external rotation.[23,27,39] Researchers have also proposed that abnormal scapular motion may be linked to weakness of periscapular muscles.[6,7] Specifically, excessive activation of the upper trapezius with inhibited activation of the lower trapezius and serratus anterior has been proposed to be related to altered scapular kinematics. Given that shoulder disorders and scapular movement patterns are related, identifying the specific characteristics of the different scapular movement patterns to help guide treatment strategies may be important.

The clinical evaluation of scapular motion is challenging because of the 3-dimensional (3-D) movement and the soft tissues surrounding the scapula, which prevent direct measurement of scapular motion. Despite these difficulties, methods of identifying scapular dyskinesis have been described in previous studies, including visual observation, linear measurement, and manual correction maneuvers.[21,26,30,35,40] Visually based dynamic assessments classify dyskinesis by the degree of dyskinesis, presence or not of dyskinesis, or pattern.[21,26,40] For the degree of dyskinesis, scapular motion during bilateral weighted shoulder elevation is observed, and the dyskinesis is classified as normal, subtle, or obvious.[26] Uhl et al[40] classified scapular motion as having dyskinesis or not with a simple "yes" or "no." Kibler et al[21] classified scapular dyskinesis into 4 movement patterns: inferior medial scapular border, medial border of scapula, superior scapular border, and symmetric pattern.

The types of scapular dyskinesis are the focus of this report. The purpose of this study was to investigate scapular kinematics and associated muscular activation during arm raising/lowering movements in individuals with scapular dyskinesis. We hypothesized that each type of scapular dyskinesis would have unique scapular kinematics and associated muscle activation during arm movements.

Materials and methods

This cross-sectional investigation of scapular kinematics in individuals with scapular dyskinesis recruited 82 volunteers (65 men, 17 women) who were a mean age of 22.9 ± 3.3 years a mean height of 173.1 ± 7.7 cm, and a mean weight of 65.9 ± 9.5 kg. Subjects were included if they were aged 18 to 50 years and had unilateral shoulder pain around the shoulder complex, including the glenohumeral, scapulothoracic, sternoclavicular, and acromioclavicular regions, while performing shoulder movement. Subjects were excluded if they had a history of shoulder dislocation, fracture, or shoulder surgery within 1 year or a history of direct contact injury to the neck or upper extremities within 1 month. Also excluded were individuals who had scoliosis or excessive kyphosis, neurologic disorders, or demonstrated pain (visual analog score >3) during the overall testing procedure.

The surface electromyogram (sEMG) assemblies included pairs of silver chloride circular (10 mm recording diameter) surface electrodes (The Ludlow Company LP, Chicopee, MA, USA) with an interelectrode (center-to-center) distance of 20 mm, and a Grass alternating current/direct current amplifier (Model 15A12; Astro-Med Inc, West Warwick, RI, USA) with a gain of 1000, a common mode rejection ratio of 86 dB at 60 Hz, and a bandwidth (–3 dB) of 10 to 1,000 Hz. The sEMG data were collected at 1000 Hz per channel using a 16-bit analog-to-digital converter (Model MP 150; BIOPAC Systems Inc, Goleta, CA, USA). An impedance meter (Model F-EZM5; Astro-Med Inc) was used to measure the impedance between the electrodes over the muscle. The impedance of each electrode was controlled to <10 kΩ. The electrodes were placed over the upper, middle, and lower parts of the trapezius and serratus anterior muscles using previously established methods.[14,33] Electrodes for the upper trapezius muscle were placed midway between the spinous process of the seventh cervical vertebrae and the posterior tip of the acromion process. The middle of the trapezius was defined as midway on the horizontal line between the third thoracic spine and the root of the spine of the scapula. The electrodes for the lower trapezius muscle were placed obliquely upward and laterally along the line between the intersection of the spine of the scapula and the seventh thoracic spinal process. The serratus anterior electrodes were placed anterior to the latissimus dorsi and posterior to the pectoralis major. A reference electrode was placed on the ipsilateral clavicle.

The 3Space FASTRAK system (Polhemus Inc, Colchester, VT, USA), an electromagnetic-based motion-analysis system, was used for collecting 3-D kinematic data of the scapula. The manufacturer claims the accuracy of the FASTRACK system is 0.8 mm and 0.15°. Karduna et al[16] validated scapular kinematics between skin-based sensor and bone-pinned methods and confirmed that the skin-based method is valid when arm elevation is below 120°. The details of the methodology can be found in a previous report.[22] The sensors were placed in locations where the skin motion artifact was minimized. One sensor for the system was attached to the sternum, one was attached to the flat bony surface of the scapular acromion with adhesive tape, and the third was attached to the distal humerus with Velcro (Velcro USA Inc, Manchester, NH, USA) straps. Anatomic landmarks (sternal notch, xiphoid 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) were palpated and marked with a white pen by a physical therapist. These marks were used for subsequent receiver mounting and landmark digitization. The transmitter served as a global reference frame and was fixed to a rigid plastic base and oriented such that it was level and its coordinate axes were aligned with the cardinal planes of the human body.

Classification of scapular dyskinesis

Visual combined palpation was used for the classification of the scapular position and movement pattern (single or mixed patterns)