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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)

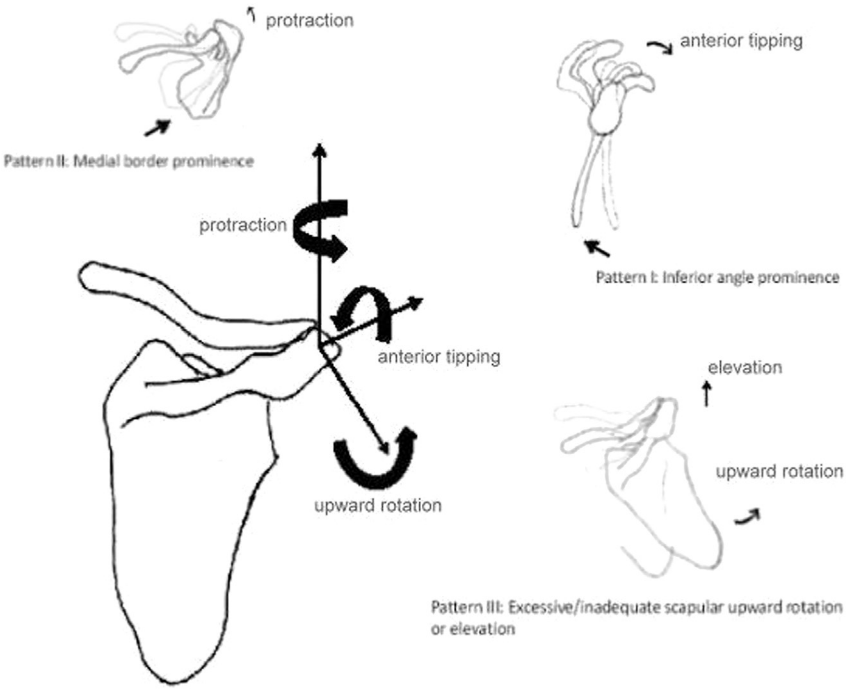

Figure 1 Scapular dyskinesis patterns with specific alteration of scapular kinematics: pattern I (inferior angle of scapular prominence), pattern II (medial border of scapular prominence), pattern III (excessive/inadequate scapular upward rotation or elevation), combination of above patterns, and pattern IV (normal scapular movement).

in the raising and the lowering phases, modified by Kibler's method.[21] The 4 single patterns were inferior angle of the scapula prominence (pattern I), medial border of the scapula prominence (pattern II), abnormal scapular upward rotation/elevation (pattern III), and normal movements (pattern IV; Fig. 1). The mixed patterns were combinations of at least 2 single patterns. We tested the inter-rater reliability of this comprehensive classification test. The κ coefficients of the raising phase reached the moderate level ($\kappa = 0.49$), and those in the lowering phase reached the moderate to substantial level ($\kappa/\kappa_w = 0.57/0.64$).[15]

Procedures

Potential participants were recruited from an outpatient clinic in a university hospital and through local Internet media. All eligible volunteers gave written and informed consent before participation.

Men were asked to remove their shirts, and women were asked to wear haltertops. Subjects were instructed to practice arm elevation in the scapular plane and become familiar with the tempo of a metronome. The starting position was arms at the side of the body, elbow straight, and shoulder in neutral position. Participants were asked to elevate the arms, using the thumb-up position, to the end range over a 3-second count and then to lower them over a 3-second count. The dumbbells in each hand weighed 2.3 kg (5 lb) or 1.4 kg (3 lb), depending on each subject's ability to elevate the arm with visual analog score of <3. After 1 minute of rest, participants performed 6 trials of bilateral, active, weighted arm elevation in the scapular plane, and a therapist classified the scapular motion into specific patterns of scapula dyskinesis.

After the evaluation of scapular dyskinesis, the kinematics and sEMG data were collected during 5 trials of the same arm movements. Then, maximal voluntary isometric contraction (MVIC) was tested and used to normalize the sEMG data during the task. For the upper trapezius muscle, MVIC was measured during resisted shoulder flexion. Participants sat with the arm at flexion of 90°, and resistance was applied to the distal upper arm.[24] For measurement of the MVIC of the middle trapezius muscle, participants lay prone with the arm abducted at 90°. Resistance was applied against the horizontal abduction.[17] For measurement of the MVIC of the lower trapezius, participants lay prone with the arm abducted in line with the muscle fibers. Resistance was applied against further elevation.[17] For measurement of the MVIC of the serratus anterior muscle, participants sat with the arm elevated to 135°. Resistance was applied to the distal upper arm against further elevation.[17] The MVICs were collected for 5 seconds with 1 minute of rest between any 2 trials for a total 3 trials for each muscle.

Data reduction

Raw kinematic data were low-pass filtered at a 6-Hz cutoff frequency and converted into anatomically defined rotations. We generally followed the International Society of Biomechanics guidelines for constructing a shoulder joint coordinate system.[43] The absolute axes defined by the FASTRAK device sensors were converted to anatomically defined axes. Scapular orientation relative to the thorax was described using a Euler angle sequence of rotation about Z_s (protraction/retraction), rotation about Y'_s (downward/upward rotation), and rotation about X''_s (posterior/anterior tipping). Scapular elevation was defined as the vertical displacement of the scapular sensor during arm elevation. Humeral orientation relative to the scapula was described using a

Euler angle sequence in which the first rotation represented the plane of elevation, the second rotation defined the amount of elevation, and the third rotation described the amount of axial rotation. Full bandwidth sEMG data, captured by data AcqKnowledge acquisition software (BIOPAC Systems Inc), were reduced using a root mean square algorithm to produce sEMG envelopes with an effective sampling rate of 50 samples per second and normalized to the MVIC. The EMG data for each muscle were averaged for each phase of the middle 3 trials. A phase was defined by a trigger marked and synchronized on sEMG data and scapular kinematics data. The mean sEMG amplitude of each phase is reported as a percentage of the MVIC.

To quantitatively characterize the scapular kinematics and muscular activities, the kinematic data at 30°, 60°, 90°, and 120° and EMG data for the ranges of 0° to 30°, 30° to 60°, 60° to 90°, 90° to 120°, and >120° in the raising and lowering phases of arm movement in the scapular plane were used as dependent variables. The mean of multiple trials from outcomes was used for data analysis. According to previous research, a sample size of 15 participants each group was needed to detect differences of upward rotation angle (9°) between dyskinesis and normal groups.[37] Because great variety exists in the patterns in clinical conditions, we primarily focused on comparisons of participants with inferior angle or medial border of scapular prominence, which are the most common dyskinesis patterns seen during the lowering phase of arm elevation. As a result, we stopped the recruitment when 15 volunteers with inferior angle or medial border of scapular prominence were first reached.

Statistical analyses

SPSS 17.0 software (IBM Inc, Armonk, NY, USA) was used for data analysis. The Shapiro-Wilk test was performed to confirm normal distribution of the kinematics and EMG data. If the result showed non-normal distribution, then nonparametric analysis was used. For data with normal distribution, two-way analysis of variance with factors of group and angle was used to determine the differences in kinematic data at 30°, 60°, 90°, and 120° and those in EMG data for the ranges of 0° to 30°, 30° to 60°, 60° to 90°, 90° to 120°, and >120° during the arm raising and lowering phases between volunteers with specific scapular dyskinesis patterns and the normal pattern. Bonferroni corrections were used to adjust for multiple pair-wise comparisons using significant α levels as low to 0.0125 for kinematics data and 0.01 for EMG data. For nonparametric data, the Mann-Whitney U test was used in each angle during the arm raising and lowering phases to compare participants with specific scapular dyskinesis patterns and the normal pattern. If no significant difference was revealed, a clinical difference with an effect size of 0.5 was reported.

Results

Figure 2 shows the flow chart of volunteer recruitment and scapular dyskinesis pattern. Eighty-two subjects were classified into different types of scapular dyskinesis. For the raising phase, scapular dyskinesis was identified in 52 volunteers with normal scapular movement (pattern IV), 24 with excessive/inadequate scapular upward rotation or elevation (pattern III), and so on. For the lowering phase,

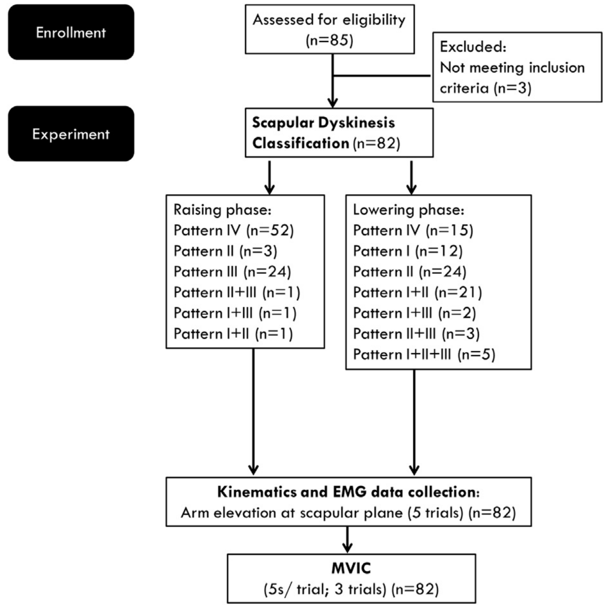

Figure 2 Flow chart of study participants. *EMG*, electromyogram; *MVIC*, maximal voluntary isometric contraction.

scapular dyskinesis was identified in 15 volunteers with normal scapular movement (pattern IV), 12 with inferior angle of scapular prominence (pattern I), 24 with medial border of scapular prominence (pattern I), 21 with mixed pattern (pattern I + II), and so on. The demographic data are reported in Table I. No significant difference was noted in basic data between the dyskinesis group and the normal group, except for the weight between the groups with patterns I and IV.

Differences in kinematics data between the dyskinesis group and the normal group are reported in Table II. Significant differences were only found in the lowering phase. Owing to the absence of interaction effects in each type of kinematics data, main effects were analyzed between the dyskinesis group and the normal group. More scapular internal rotation was found in pattern II dyskinesis (4°) and pattern I + II dyskinesis (4°) than in pattern IV during arm lowering ($P = .009$ and $P = .023$, respectively). In addition, scapular posterior tipping was less pronounced in patients with pattern I dyskinesis (3°) during arm lowering ($P = .028$).

Table III summarizes the difference in EMG data between the 2 groups. Significant differences were also found in the lowering phase only. Analysis of upper trapezius activity revealed a group and angle interaction effect ($P = .028$). Subsequently, the effects of group were investigated at each angle. At an angle above 120°, upper trapezius activity was significantly higher in patients with pattern II dyskinesis (14%) than in the normal group during arm lowering ($P = .01$).

Except for upper trapezius activity, there were no interaction effects in the other EMG data. Main effects were analyzed between the dyskinesis group and the

Table I Participant demographic data for final analysis

Raising phase		Pattern III (n = 24)		Pattern IV (n = 52)
		(Mean ± SD)		(Mean ± SD)
Male sex		18		40
Age, y		22.2 ± 2.7		23.0 ± 3.5
Height, cm		172.6 ± 8.8		172.3 ± 8.0
Weight, kg		63.8 ± 8.9		66.2 ± 11.6
Duration of symptoms, mo		26.5 ± 35.7		24.6 ± 34.8
Dominant side, right		23		48
Involved side, right		21		44
Lowering phase	**Pattern I (n = 12)**	**Pattern II (n = 24)**	**Pattern I + II (n = 21)**	**Pattern IV (n = 15)**
	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)
Male sex	8	21	15	12
Age, y	22.2 ± 2.3	23.0 ± 2.2	22.2 ± 2.1	23.5 ± 5.0
Height, cm	169.0 ± 10.8	172.5 ± 7.3	171.8 ± 8.1	175.3 ± 7.6
Weight, kg	60.2* ± 6.9	66.9 ± 12.6	62.9 ± 9.1	69.6 ± 8.9
Duration of symptoms, mo	16.5 ± 16.8	17.6 ± 17.4	30.4 ± 46.2	34.2 ± 36.4
Domiant side, right	11	21	21	14
Involved side, right	11	17	20	11

SD, standard deviation.
* Significant difference between dyskinesis pattern and normal pattern (*P* = 0.006) inferior angle of scapula prominence (pattern I), medial border of scapula prominence (pattern II), combined inferior angle and medial border of scapula prominence (pattern I + II), excessive/inadequate scapular upward rotation or elevation (pattern III), normal movement (pattern IV).

Table II Kinematics data between dyskinesis and normal group in lowering phase

Variable	120° (Mean ± SD)	90° (Mean ± SD)	60° (Mean ± SD)	30° (Mean ± SD)
Posterior tipping				
Pattern I	5. ± 8*	4. ± 6*	3 ± 4*	1 ± 2*
Pattern IV	10 ± 5	8 ± 4	6 ± 4	3 ± 2
Internal rotation				
Pattern II	4 ± 12*	2 ± 7*	2 ± 6*	1 ± 5*
Pattern I + II	5 ± 10*	5 ± 7*	−1 ± 5*	−1 ± 4*
Pattern IV	−1 ± 8	−3 ± 5	−3 ± 4	−2 ± 4

SD, standard deviation.
* Main effect between dyskinesis pattern and normal pattern (*P* < .05).

normal group. Significantly decreased lower trapezius activity was found in patients with pattern I + II dyskinesis (5%) during arm lowering (*P* = .025). In addition, serratus anterior activity was significantly lower in patients with pattern I + II dyskinesis (10%) than in the normal group during arm lowering (*P* = .004). EMG data during the lowering phase with clinical differences having an effect size of at least 0.5 are presented in Table III. More upper trapezius activation was also found in patients with pattern I + II dyskinesis group (effect size, 0.67-0.94), and less serratus anterior activity was found in the pattern I dyskinesis (effect size. 0.56-0.81) and pattern II dyskinesis groups (effect size, 0.50-1.10) than in the normal group.

Discussion

Scapular kinematics and associated muscle activation patterns are thought to influence various shoulder conditions and outcomes such as pain, restricted range of motion, and functional disability. On the basis of these propositions, previous studies have identified inadequate posterior tipping, external rotation, and upward rotation, and decreased serratus anterior and lower trapezius/increased upper trapezius muscle activities in individuals with shoulder impingement.[3,23,39] Understanding the scapular kinematics and associated muscle activity corresponding to specific types of scapular dyskinesis is of value if the

Table III Electromyogram data between dyskinesis and normal group in lowering phase

Variable	>120° (Mean ± SD)	120°-90° (Mean ± SD)	90°-60° (Mean ± SD)	60°-30° (Mean ± SD)	30°-0° (Mean ± SD)
Upper trapezius (% MVIC)					
Pattern II	41 ± 17*	39 ± 14‡	34 ± 13§	23 ± 10§	10 ± 7
Pattern I + II	34 ± 15	35 ± 10§	35 ± 10‡	19 ± 7	8 ± 4
Pattern IV	27 ± 13	28 ± 11	26 ± 9	18 ± 7	8 ± 5
Lower trapezius (% MVIC)					
Pattern I + II	16 ± 9†	15 ± 6†	14 ± 5†	9 ± 5†	5 ± 3†
Pattern IV	21 ± 10	21 ± 9	19 ± 8	13 ± 6	7 ± 3
Serratus anterior (% MVIC)					
Pattern I	44 ± 13	38 ± 8	29 ± 12	14 ± 8‡	7 ± 4§
Pattern II	46 ± 12	36 ± 14§	26 ± 10§	13 ± 6‡	6 ± 5
Pattern I + II	40 ± 12†	32 ± 7†	22 ± 6†	13 ± 6†	7 ± 5†
Pattern IV	51 ± 15	43 ± 14	33 ± 14	21 ± 9	13 ± 14

MVIC, maximal voluntary isometric contraction.
* Significant difference between dyskinesis pattern and normal pattern in specific lowering angle ($P < .01$).
† Main effect between dyskinesis pattern and normal pattern ($P < .05$).
‡ Large 0.7 effect between dyskinesis pattern and normal pattern.
§ Medium 0.5 effect between dyskinesis pattern and normal pattern.

consequences of such changes are related to clinical outcomes and the injury mechanism. Furthermore, such insight may guide treatment strategies and improve clinical outcomes. Our results provide an examination method and changes in the kinematics and muscular activities related to scapular dyskinesis.

A visually based evaluation of scapular dyskinesis is applicable to the assessment of alterations of scapular position and motion in clinical use.[21,26,40] This study showed that corresponding alterations of scapular kinematics could be found in specific scapular dyskinesis patterns assessed by our method. For example, more scapular internal rotation was found in participants with medial border of scapular prominence, and less scapular posterior tipping was found in those with an inferior angle of scapular prominence. These results validate the observation/palpation method compared with a 3-D motion capture system, especially during the arm-lowering phase.

The serratus anterior is the primary muscle that stabilizes the medial border and inferior angle of scapula to prevent scapular winging and anterior tipping.[11,29] Muscle weakness, fatigue, and abnormal firing patterns of the serratus anterior, as well as long thoracic nerve injury, can result in scapular winging and anterior tipping.[20,25] Consistent with previous studies, our results demonstrated decreased serratus anterior activity in participants with medial border and inferior angle of scapula prominence. In addition, the lower trapezius generates scapular posterior tipping and upward rotation and operates at a constant length to stabilize the axis of rotation of the humerus about the glenoid during arm elevation.[3,17] Inhibited activation of the lower trapezius may cause problems with controlling scapular motion. The present study also demonstrated a decrease in lower trapezius activity during arm lowering in participants with combined inferior angle and medial border of scapula prominence. An increase in scapular winging during arm elevation, common in individuals with anterior shoulder impingement and anterior glenohumeral instability, may increase the risk of posterior shoulder impingement.[23,28,31] As a result, training of the serratus anterior and lower trapezius is a focus of rehabilitation in individuals with scapular winging.[1]

The upper trapezius has been reported to function as a scapular elevator and upward rotator.[29,34] In the present study, we found a significant increase in upper trapezius activity during the arm-lowering phase in participants with medial border of scapula prominence. On the basis of anatomical orientation, the upper trapezius does not function as a scapular external rotator to correct the medial border of scapula. We propose that the increase in upper trapezius activity may correspond to the decrease in the serratus anterior as force couples needed for controlling scapular motion.[10] Thus, exercises for selectively activating the serratus anterior with minimal activation of the upper trapezius should also be considered in subjects with medial border of scapula prominence.[4] Further study to validate this proposition is needed.

Scapular dyskinesis is more prominent in the lowering phase of arm movements.[18] The present study found lower EMG activity in the scapular muscles during the lowering phase than during the raising phase of arm movements, which is consistent with previous studies investigating differences in muscular activation between raising (concentric) and lowering (eccentric) contraction.[9,12,13] Reduced EMG activity levels may be partially explained by the gravity effects on the load of scapular muscles. However, lower levels of muscle activation have been reported in tasks with a gravity-minimized position; thus, factors other than gravity influence the decreasing level in eccentric contraction.[12,13] The findings of reduced muscle activation may explain why scapular dyskinesis is more prominent in the lowering phase of arm elevation. In addition in present study, comparison of the dyskinesis group and the normal group showed that most of the EMG alterations were found in the lowering phase of arm elevation. Ebaugh et al[8] suggested that an activation threshold of scapulothoracic muscle is necessary to control scapular movement. Decreasing scapular muscle activation during the lowering phase may be prone to falling below the activation threshold.[8] As a result, evaluation of scapular motion needs to be emphasized in the lowering phase of arm elevation.

Limitations of this study should be noted. First, the kinematics data were measured under 120° of humeral elevation to reduce the error of the skin-based method.[16] Second, the use of surface electrodes during dynamic movements cannot exclude the influence of movement artifacts and cross talk. However, a 6-Hz filter and less than 10 kΩ skin resistances of the EMG data reduce the potential influence.[5] In addition, adjacent electrodes pairs were placed more than 2 cm apart to minimize the effect of cross talk from the other muscles.[14] Moreover, we focused only on 4 superficial scapulothoracic muscles, including 3 parts of the trapezius and serratus anterior, which have been shown to play primary roles in scapulothoracic motion.[5,9,23] Finally, the participants were mostly young and participated in overhead sports. The generalization of this study to elderly or sedentary individuals is uncertain.

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. To restore normal scapular movements, it may be necessary to inhibit the upper trapezius and activate the lower trapezius and serratus anterior in patients with medial border and inferior angle of scapular prominence. Because most of the changes occurred during the arm lowering phase, assessing scapular dyskinesis in this phase is especially important.

Disclaimer

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