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Adaptation of muscle activity in scapular dyskinesis test for collegiate baseball players

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Background: The characteristics of scapular muscle activities in elevation and descent exercises have yet to be elucidated to assess scapular dyskinesis. The purpose of this study was to identify the adaptation of electromyograph (EMG) activities of the upper trapezius (UT), lower trapezius (LT), serratus anterior (SA), and anterior deltoid (AD) muscles with different weight loads in flexion (FLX) and abduction (ABD) in collegiate baseball players.

Materials and methods: Twenty eight individuals, including 13 pitchers, were tested. Normalized EMG signals for the UT, LT, SA, AD muscle of the both the dominant (DOM) and nondominant (NON) side were blocked at every 1 second during each of the exercises. A 3-way repeated analysis of variance design was used to identify differences in the mean values between DOM and NON and between FLX and ABD for DOM.

Results: The mean EMG value of the UT in the DOM was significantly less than that of the NON for all joint angles ($P < .01$), whereas the mean EMG value of the LT in the DOM was significantly greater than that of the NON ($P < .01$). In contrast, no difference in the SA EMG activity was determined between DOM and NON. However, the mean EMG value of SA in FLX was significantly greater than in ABD ($P < .01$).

Conclusion: This study identified an apparent adaptation of scapular muscle activities in the currently advocated scapular dyskinesis test for healthy active overhead athletes who are vulnerable to shoulder pathologies.

Level of evidence: Basic Science Study; Kinesiology

Keywords: Scapular dyskinesis test; EMG; Baseball players; Muscular adaptation; Bilateral comparison; Lower trapezius; Upper trapezius

A dynamic test of scapular dyskinesis has been of interest to clinicians and researchers for the purposes of diagnosis and rehabilitation in the symptomatic shoulder.[2,4,5,7,8,10,12,15-18,20,23,25,28,30] Scapular dyskinesis is defined as altered scapular position in dynamic motion such as excessive internal rotation and anterior tilt of the scapula in the scapulohumeral rhythm (SHR).[7,9,12]

The Institutional Review Board at San José State University (IRB Protocol #F1304025) approved this study.

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Scapular dyskinesis has been reported to be associated with overhead throwing injuries, including labral tears, internal impingement, and elbow injuries.[7,23] One possible mechanism for this is that scapular dyskinesis is related to a decrease in subacromial space width, scapular muscle activation, and glenohumeral (GH) joint congruency problems.[7,15]

The scapular dyskinesis test[12,16,18,25] and scapulohumeral rhythm have been examined by 3-dimensional motion analysis using digitized bony landmarks in shoulder flexion and abduction.[15,17,30] Scapular upward rotation constantly occurs while the arm is elevated, whereas most posterior tilting occurs beyond 90° of arm elevation.[17] Most external rotation of the scapula also occurs beyond 90° of arm elevation, with very little taking place in the internal rotation position.[17]

SHR was evaluated as visual dynamic assessment for 57 active uninjured pitchers and 14 catchers from a professional baseball club using a 0.9-kg dumbbell held in each hand before an upcoming season of professional baseball. All participants were instructed to elevate their arms for a 4-second count to complete maximal scapular plane elevation, followed by eccentrically lowering the arms for another 4-second count. Unlike other previous studies,[16,25,30] low inter-rater reliability was found in classifying each scapula into the currently established 4 types of scapular dyskinesis[5]: prominence of the inferior angle (type I), prominence of the medial border (type II), prominence of the superior border (type III), and symmetrical scapulohumeral rhythm (type IV).[12]

With regard to scapular muscle activities in SHR, nonathletic patients with shoulder impingement significantly increase both the upper trapezius (UT) and lower trapezius (LT) muscle activation at joint angles from 61° to 120° when elevating the arm in the scapular plane with a handheld load of 4.6 kg compared with matched control participants without symptoms.[15] However, we observed that a symptomatic collegiate baseball pitcher with type II scapular dyskinesis showed inhibition of the LT muscle along with hyperactivity of the UT during the descent phase of shoulder flexion with a wrist cuff weight of 3.2 kg.[28]

In overhead athletes, the posterior tilt of the scapula controlled by the LT is important to be synchronized with GH external rotation during the cocking phase of the tennis serve.[11,13] Consequently, previous literature has emphasized optimization of the ratio of UT to LT muscle activity in rehabilitation exercises for symptomatic shoulders.[3,4,10] Nevertheless, the characteristics of scapular muscular activity during the elevation and descent phases from a standing position have yet to be elucidated. Therefore, the purpose of this study was to identify any difference in the muscle activity of the UT, LT, SA and anterior deltoid (AD) at different joint angles of SHR between the dominant (DOM) and nondominant (NON) side using the currently advocated scapular dyskinesis test with different weight loads. The purpose of this study was also to compare these muscular activities between shoulder flexion (FLX) and abduction (ABD) movements for the DOM side of asymptomatic collegiate baseball players.

Materials and methods

Participants

The study included 28 active college baseball players (height, 182.3 ± 5.6 cm; weight, 82.8 ± 6.0 kg, age, 19.2 ± 1.4 years), including 13 pitchers, who volunteered to be tested. All subjects belonged to the National Collegiate Athletic Association Division I conference in the United States and gave informed consent to the procedures.

The subjects indicated neither history of neurologic and physiologic deficits in the upper body nor thoracic kyphosis on a preliminary screening questionnaire. All subjects demonstrated symmetrical scapular motions during shoulder ABD and FLX, regardless of weight loads (no apparent scapular dyskinesis), while UT, LT, SA, and AD muscle activities were examined. Each subject was tested for approximately 45 minutes on 1 day at a randomly assigned test time, and all tests were conducted in a quiet room. The examination was conducted before an upcoming season of collegiate baseball.

Clinical measures

This study measured 4 different muscle activities of both the DOM and NON extremity during shoulder FLX and ABD movements, and compared among 3 different weight loads. The use of different weight loads allowed the study to identify the modulation of muscular activity due to compensation from other muscles during similar movements with different weight loads.[29]

Electrode placement

Raw electromyograph (EMG) amplitudes of the UT, LT, SA, and AD muscle were collected in accordance with our previous study.[28,29] To measure EMG amplitudes, bipolar surface EMG electrodes (Ag) with a bar length of 10 mm, a width of 1 mm, and a distance of 1 cm between active recording sites (Bagnoli-8; Delsys, Natick, MA, USA) were used.

Electrode placements for the UT, LT, SA, and AD muscles were determined according to previous reports.[11,28,29] The electrodes were placed centrally over the muscle bellies as follows: the UT, halfway between the occipital bone and the lateral border of the clavicle at the level of the C7 spinous process; LT, an oblique angle 5 cm down from the scapular spine and just outside the medial border of the scapula; the SA, below the axilla at the level of the inferior angle of the scapula; the AD, 2 cm inferior to the lateral border of the clavicle and angled parallel to the muscle fibers.

The EMG electrodes were preamplified (10×) and routed through the EMG mainframe, which further amplified (100×), a total gain of 1000× and band-pass filtered (20-450 Hz) signals. A metal reference electrode was placed between the superior angles of the scapulae. To ensure that EMG activities were analyzed similarly between subjects, the timing of shoulder movements from the initiation to completion was controlled by a metronome.

Procedures

For the isotonic contraction measurement of FLX of the GH joint, the subject performed bilateral shoulder FLX from the lateral side