SCAPULOTHORACIC MOTION AND MUSCLE ACTIVITY DURING THE RAISING AND LOWERING PHASE OF AN OVERHEAD REACHING TASK

D. David Ebaugh, PT, PHD 1 and Bryan A. Spinelli, PT, MS, OCS1

1 Rehabilitation Sciences Research Laboratory, Drexel University, 245 North 15th Street MS 502, Philadelphia, PA, 19102
Email: debaugh@drexel.edu

INTRODUCTION

Scapulothoracic muscle activity is essential for the production and control of scapulothoracic motion as well as normal upper extremity function [1]. While previous research has furthered the understanding of scapulothoracic motion and muscle activity during the raising phase of motion, a gap exists with respect to the lowering phase. Clinically abnormal scapulothoracic motion (scapular dyskinesis) tends to be more pronounced, and patients note more pain when they lower their arm from a raised position [2]. Studies that investigate differences in scapulothoracic motion and muscle activity between arm raising and lowering in healthy individuals would provide a foundation for better understanding scapular dyskinesis in individuals with shoulder pain. The purpose of this study was to compare scapulothoracic motion and scapulothoracic muscle activity between the raising and lowering phases of an overhead reaching task.

METHODS

Twenty individuals (10 female and 10 male) without a history of shoulder pain or pathology volunteered to participate in the study (mean age = 22.5 years, SD = 3.4 years). Electromagnetic sensors on the scapula, humerus, and thorax were used to collect 3-D scapulothoracic and glenohumeral motion during the raising and lowering phases of scapular plane elevation. Surface electromyography (EMG) was used to simultaneously assess muscle activity from the upper trapezius, lower trapezius, and serratus anterior muscles. Scapulothoracic kinematic variables and EMG root mean square (RMS) values were the dependent variables. A 2-way repeated measures analysis of variance (ANOVA) with within factors of phase (raising and lowering) and arm angle (30°, 50°, 90°, 130°) was performed on each dependent variable. Post-hoc comparisons were conducted using paired t-tests with Bonferroni correction (p=.01).

RESULTS AND DISCUSSION

KINEMATICS: A significant phase by arm elevation angle interaction existed for scapular external rotation, clavicular elevation, and scapular posterior tilt (p<.05). During the lowering phase there was significantly more scapular external rotation (3.3°) and less clavicular elevation (1.7°) at 130° of arm elevation (p <.01). There was no significant difference in scapular posterior tilt between the raising and lowering phases at any of the selected arm elevation angles. There was a significant main effect of phase for clavicular retraction (p <.05). Collapsed across arm elevation angles, subjects demonstrated greater clavicular retraction (1.7°) during the lowering phase of motion.

EMG: Significant main effects of phase and arm angle were noted for EMG activity of all muscles. Collapsed across arm elevation angles, there were significantly lower EMG RMS values during the lowering phase of motion for all muscles (Figure). During the lowering phase motion, there was 61%, 42%, and 39% reduction of EMG activity for the upper trapezius, lower trapezius, and serratus anterior muscles, respectively.

Overall, scapulothoracic motion was similar for the raising and lowering phases of the overhead reaching task with the largest difference between phases being 3.3° for scapular external rotation. These findings are in agreement with those of McClure et al. [3] who reported similar amounts of scapulothoracic motion (within 5°) during the raising and lowering phases of an overhead reaching task.
Conversely, significantly lower EMG amplitude values existed during the lowering phase across all muscles. The reduced EMG activity levels may partially be explained by gravities effect on the motion and the resultant loads imposed to the scapulothoracic musculature. During the raising phase, muscles contracted concentrically in order to overcome gravitational forces and elevate the arm. When the arm was lowered back to the side, gravity assisted the motion and less muscle activation was required. However, lower levels of muscle activation have been reported for eccentric contractions of the elbow flexor muscles during an elbow flexion/extension task performed in a gravity minimized position [4]. This suggests that factors other than gravity contribute to differences in muscle activation levels between eccentric and concentric contractions. We believe that lower levels of muscle activity during the lowering phase may reflect differing neuromuscular control strategies associated with eccentric and concentric contractions [5].

CONCLUSIONS

The findings from this study suggest that scapulothoracic muscle activation levels during eccentric contractions may be closer to an activation threshold below which their ability to control scapulothoracic motion may be compromised subsequently leading to scapular dyskinesis. This provides a possible explanation for why scapular dyskinesis is more notable during the lowering phase of motion.

REFERENCES


Figure: Mean and standard error of the mean for upper trapezius, lower trapezius, and serratus anterior muscle activity at select arm elevation angles for the raising and lowering phases of an overhead reaching task. Numeric symbol (#) indicates a significant main effect for phase (repeated-measures ANOVA; p<.05).