RECOVERY OF SCAPULA KINEMATICS AND SHOULDER MUSCLE ACTIVATION FOLLOWING AN ISOMETRIC FATIGUE TASK

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INTRODUCTION

Subacromial impingement syndrome (SIS) of the shoulder is the third most frequent musculoskeletal complaint requiring physician visits. SIS results from mechanical compression of the rotator cuff tendons and/or subacromial bursa between the humeral head and acromion and over time, this compression results in tissue inflammation and pain in the shoulder during arm elevation and often interrupts sleep.

Alterations in the direction and magnitude of 3-dimensional scapulothoracic kinematics in those with SIS have been described [1]. Others have described alterations in activation of the muscles that move the scapula on the thorax [2]. However, it is unknown whether these alterations cause SIS, or if they are in response to the pain experienced with SIS. For this reason, discovery of mechanisms leading to scapula movement or muscle activation alterations may improve prevention and treatment of SIS.

Muscle fatigue is a proposed mechanism for biomechanical alterations because prevalence rates of SIS are high in groups that use their arms overhead repetitively, such as workers or throwing athletes. Our prior work demonstrated both scapula kinematic and muscle activation alterations immediately following an isometric fatigue task [3]. For this experiment, we asked if kinematics and muscle activation levels return to pre-fatigue levels after rest. We hypothesized that kinematics and muscle activation would return to pre-fatigue values after six minutes.

METHODS

Ten healthy male subjects participated. 3-dimensional scapula kinematics and surface electromyographic (EMG) data were collected during scapular plane arm elevation and lowering in standing at four time points: pre-fatigue, immediately post-fatigue, and three and six minutes post-fatigue. Kinematics of the scapula, humerus, and thorax were collected with an electromagnetic motion capture system at 100 Hz per sensor. EMG data from the serratus anterior, upper trapezius, and lower trapezius were collected at 1000 Hz. The fatigue task was an isometric push-up plus with the feet elevated 23cm, held until the subject voluntarily quit.

Muscle fatigue was determined by calculating the percent decline in Median Power Frequency (MPF) over the duration of the fatigue task. **S**capula orientations relative to the trunk during arm elevation/lowering were determined using a Z, Y', X'' Euler sequence. EMG data during arm elevation/lowering were bandwidth filtered from 5 to 500Hz, RMS processed, averaged over 0.1 sec intervals and normalized. Mean orientation and normalized muscle activation at 60°, 90°, 120° of humerus elevation relative to the trunk (Z, Y', Z'') were analyzed during arm elevation and lowering separately with a two-factor (time by angle) repeated measures ANOVA with $p<0.05$ established for statistical significance.

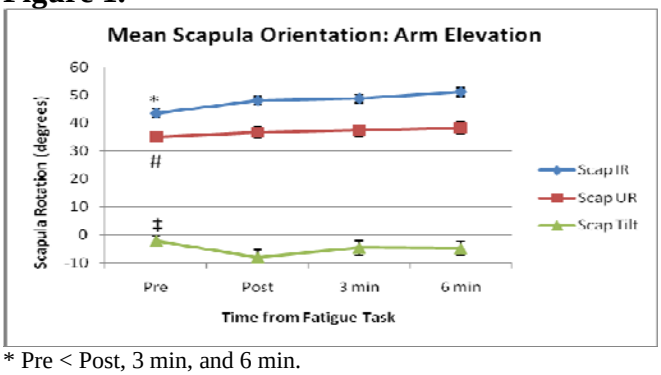
RESULTS and DISCUSSION

The MPF of all three muscles declined during the fatigue task: Serratus Anterior 29.5%; Upper Trapezius 27.6%; and Lower Trapezius 33.6%. There were no statistically significant interaction effects between time and angle during arm elevation or lowering for any of the dependent variables.

During arm elevation, there was a statistically significant effect of time on all three scapula orientations and on lower trapezius activation. Scapula internal rotation angle was greater at all three post-fatigue time points; scapula upward rotation angle was greater at 6 minutes; and scapula

anterior tilting angle was greater at post-task than at pre-task (Figure 1). Normalized activation of the lower trapezius was greater at 3 and 6 minutes than it was immediately post-fatigue (Figure 3: Blue Bars).

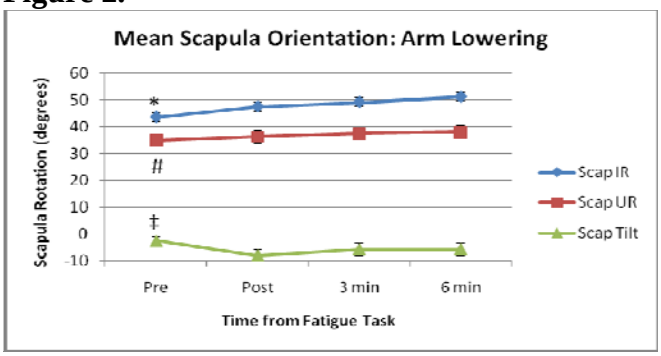
Figure 1.



* Pre < Post, 3 min, and 6 min.
# Pre < 6 min.
‡ Pre < Post.

During arm lowering, there was a statistically significant effect of time on all three scapular rotations. Scapula internal rotation angle was greater at all three post-fatigue time points; scapula upward rotation angle was greater at 6 minutes; and scapula anterior tilting angle was greater at post-task than at pre-task (Figure 2). There was also a statistically significant effect of time on serratus anterior activation with higher activation at 6 minutes than at post-fatigue (Figure 3: Red Bars).

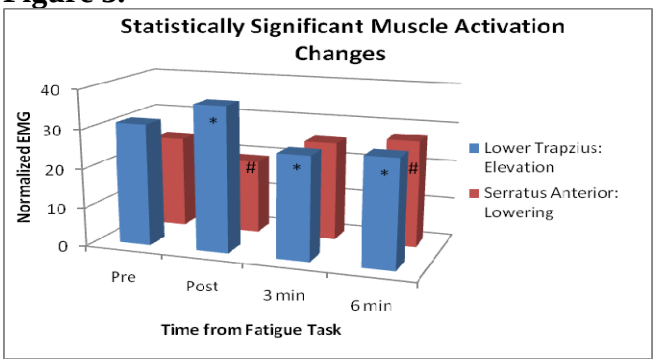
Figure 2.



* Pre < Post, 3 min, and 6 min.
# Pre < 6 min.
‡ Pre < Post.

The isometric task resulted in decreased MPF, indicating acute muscle fatigue. In contrast, the higher muscle activation levels that were expected at post-task were not demonstrated [4].

Figure 3.



* Post > 3 min and 6 min.
# Post < 6 min.

Scapula internal rotation remained increased for 6 minutes, perhaps related to maintaining scapular protraction during the task or to decreased lower trapezius activation. Increased scapula internal rotation may decrease the subacromial space [5] and increase the potential for SIS. Scapula anterior tilting was increased at post-task but was not significantly different from pre-task levels at 3 and 6 minutes. Although not statistically different, post-task serratus anterior activation was lower than pre-task which may explain the increased anterior tilt. Increased internal rotation and anterior tilt of the scapula due to acute fatigue may make overhead workers or athletes susceptible to SIS.

CONCLUSIONS

Fatigue-induced biomechanical alterations did not fully recover even after 6 minutes of rest. In particular, scapula internal rotation remained increased relative to baseline during both arm elevation and lowering. Muscle activation changes do not fully explain the kinematic alterations.

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