Fatigue-Mediated changes in Shear Wave Velocity and Muscle Activity of the Scapular Stabilizer Muscles

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Summary

This study used ultrasonographic shear-wave velocity (SWV) to determine whether fatigue-mediated viscoelastic muscle stiffness changes may offer unique variance towards explaining scapulothoracic (SCT) kinematics changes. While previous research has reported stiffness decreases following isometric muscle fatigue tasks, our concentric/eccentric protocol revealed significant increases in stiffness at submaximal exertions below 50%.

Introduction

Considerable variation in kinematic and muscular responses to shoulder fatigue has been frequently reported between and within individuals [1]. Specifically, fatigue-induced SCT kinematic changes appear related to scapular stabilizer muscle activity, yet much variability remains unexplained [2].

The purpose of this study was to determine if fatigue-mediated changes in muscle stiffness, evaluated with (SWV), would be present following a targeted scapular stabilizer fatigue task, and whether these changes would explain some fatigue-mediated SCT kinematic variability.

Methods

Fifteen male (27.5±4.7 y; 25.3±3.1 kg/m^2) and fifteen female (23.7±2.7 y; 20.0±1.6 kg/m^2) (N = 30) participants were recruited. SWV and electromyography (EMG) were recorded during submaximal (30%, 50%, 70%), maximal (100%; EMG only) and resting (0%; SWV only) isometric contractions of the scapular stabilizer muscles (upper trapezius, middle trapezius, lower trapezius, serratus anterior) before and after performing a muscle fatigue task. Static SCT kinematics were also collected while holding a 1kg hand load at 30°, 60°, 90°, and 120° thoracohumeral elevation in the scapular plane (40° anterior to frontal) before and after the muscle fatigue task. EMG signal was decomposed into root-mean-square (RMS) amplitude and mean power frequency (MPF) for each trial.

4x4 repeated measures ANOVA models compared the fatigue-mediated difference in SWV, RMS amplitude, and MPF (post fatigue minus pre fatigue) as the dependent variable across muscle and contraction intensity factors. 95% confidence intervals (CI) were computed for all main effects and interactions to determine whether these fatigue-mediate changes surpass a threshold of 0 (no significant change).

Results and Discussion

ANOVA results revealed significant fatigue-mediated changes in normalized SWV ([post-fatigue SWV/baseline SWV] – [pre-fatigue SVW/baseline SWV]) by muscle ($F_{(3,44)}$ = 4.76, $p \leq 0.001$) and contraction intensity ($F_{(3,44)}$ = 58.91, $p \leq 0.001$; Figure 1.). 95% CI margins for muscle contraction intensity were 0% = [-11.7 6.6] , 30% = [82.7 110.9], 50% = [38.9 57.1], and 70% = [-10.4 7.9].

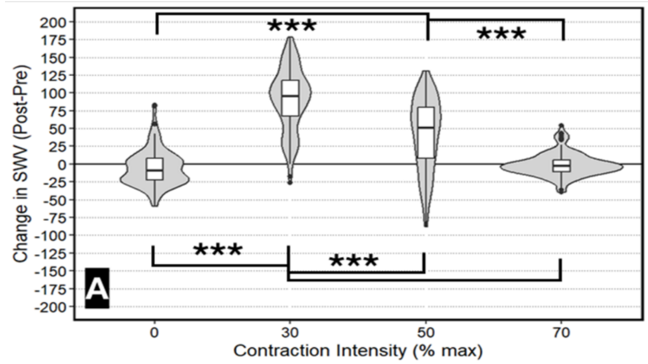

Figure 1: Fatigue-mediated change in scapular stabilizer muscle SWV at different submaximal contraction intensities. *** indicates significance at $p \leq 0.001$.

Changes in normalized EMG RMS amplitude ([post-fatigue RMS/baseline RMS] - [pre-fatigue RMS/baseline RMS]) were significant by contraction intensity ($F_{(3,43)}$ = 34.9, $p \leq 0.001$); 95% CI margins were 30% = [-10.4 9.3], 50% = [0.9 20.2], 70% = [6.4 35.2], 100% = [41.1 60.3]. A significant EMG MPF interaction effect ($F_{(9,42)}$ = 4.99, $p \leq 0.001$) was observed for serratus anterior muscle at 100% contraction intensity, indicating a fatigue-mediated decrease of 9.5% (± 14.2; 95% CI = [-11.2 -1.3]). These findings suggest significant neuromuscular fatigue specific to serratus anterior.

Despite literature reporting decreases in SWV and muscle stiffness at rest and submaximal contraction due to fatigue [3, 4], the present study observed stark increases in SWV at 30% and 50% intensity. Previous studies reporting fatigue-mediated decreases in muscle stiffness implemented static or isometric muscle fatigue protocols, in contrast to a concentric/eccentric protocol used in the present study.

Conclusions

Fatigue-mediated changes in SWV and muscle stiffness are dependent on the type of muscle contraction stimulus (isometric, concentric, eccentric) [3, 4]. Isometric decreases in SWV are likely consequent of viscoelastic creep, while concentric/eccentric increases in SWV are likely consequent of exercise-induced muscle edema [5].

References

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