Comparing Shoulder Kinematics and Muscle Activation in Loaded and Unloaded Tasks: Insights from Individuals with Large-Massive Rotator Cuff Tears

Sarah M. Remedios[1], Ivan Wong[2], Kathleen MacLean[3], Janie Astephen Wilson[4], Derek J. Rutherford[1,4]
[1]School of Physiotherapy, Dalhousie University, Halifax, Canada
[2]Faculty of Medicine, Dept. Orthopeadics, Dalhousie University, Halifax, Canada
[3]School of Health and Human Performance, Dalhousie University, Halifax, Canada
[4]School of Biomedical Engineering, Dalhousie University, Halifax, Canada

Email: sarah.remedios@dal.ca

Summary

This study explores shoulder motion and muscle activity of patients with large-to-massive (>3cm) rotator cuff tears compared to a control group. We underscore minimal altered motion, but increased muscle activation, impacting shoulder function under load in individuals with rotator cuff tears.

Introduction

Many individuals with a rotator cuff (RC) tear have reduced quality of life. Contribution of the RC, shoulder and back muscles help to elicit upper extremity movement, specifically in the frontal (abduction) and sagittal (flexion) planes [1]. Greater contributions are required when greater load is applied to the shoulder (e.g. lifting), with evident scapular adaptations in asymptomatic populations [2]. It remains to be determined however, whether scapulothoracic (ST), glenohumeral (GH) and thoracohumeral (TH) motions and muscle activation levels are altered when greater demands are placed on the shoulder in individuals with massive RC tears.

The study purpose was to evaluate the differences in peak shoulder motion and muscle activation during loaded and unloaded shoulder flexion and abduction in individuals with and without a large-to-massive RC tear.

Methods

Twenty asymptomatic (ASYM) adults (>50yo) without any known past or present shoulder injury and 15 patients with large-massive RC tears (CUFF) were recruited from the local orthopaedic community. Surface electromyography (EMG) was used to monitor muscle activity (Fs=2000Hz) of the supraspinatus (SSP), upper trapezius, lower trapezius (LFT), anterior and lateral deltoids (ADT and LDT). Simultaneously, optical motion capture tracked movements (Fs=100Hz) of the torso, thorax, scapula, and arm during flexion and abduction to shoulder height without load (unloaded) and with a load of 2.5% body mass (loaded). Average peak ST upward rotation, and GH and TH flexion and abduction were calculated from three trials using Cardan rotation sequences. Average peak muscle activity as the percentage of maximum voluntary isometric contraction (%MVIC) was calculated.

Statistical analyses consisted of mixed two-factor (condition x group) ANOVAs, analyzing peak kinematics and %MVIC for flexion and abduction tasks, respectively (alpha = 0.05).

Results and Discussion

ASYM and CUFF groups showed non-significant (p>0.05) demographics differences. All ASYM were able to complete the tasks whereas only 6/15 from the CUFF were able to lift the load to shoulder height. Group X Condition interaction effects were seen for TH, GH, ST peaks during abduction and only TH flexion during flexion. Expectedly, the CUFF group exhibited significantly lower GH and TH angles in both conditions, but only smaller ST peak angles when comparing groups in the loaded condition. Additionally, the CUFF group's peak angles in the unloaded condition closely matched the ASYM group's peak angles in the loaded condition.

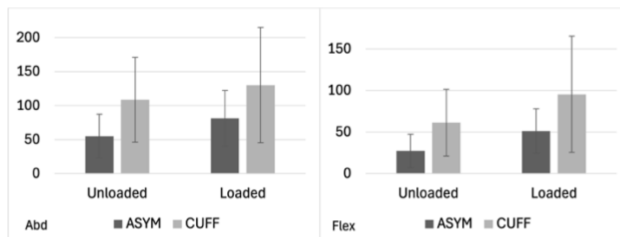

Figure 1: %MVIC of SSP for abduction (left) and flexion (right)

Muscle activity showed interaction effects for SSP only during flexion (p<0.05), and SSP, ADT and LDT (p<0.05) during abduction. Where interaction effects were not present, significant main effects were (p<0.01). Increased load in the CUFF group showed the highest peak %MVIC. SSP demonstrated the greatest peak activity among all the muscles, with the CUFF group.

Conclusions

Individuals with large-to-massive rotator cuff tears exhibit significantly smaller TH and GH peak angles compared to the ASYM group and with increased load, as well as increased muscle activity during loaded movements compared to asymptomatic individuals. These findings highlight adaptations and elevated muscular demands despite their lack of ability to complete the loaded condition.

Acknowledgments

Ewan Galloway and Autum Heukshorst for contribution in data collection and processing.

References

[1] Alenabi et al. (2016). *Clin Biomech*, **32**: 194-200.
[2] Forte et al. (2009). *Phys. Ther. Sport*, **10**: 105-111