Shoulder Kinematic and Neuromuscular Adaptations during Forward Flexion and Abduction for Adults with Large to Massive Rotator Cuff Tears

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Summary

Rotator cuff tears can be highly debilitating, and this study aimed to identify their impact on shoulder function. Findings show that individuals with large-to-massive rotator cuff tears (>3 cm) exhibit significantly reduced motion and increased muscle activity during maximal shoulder abduction and flexion compared to asymptomatic individuals.

Introduction

Rotator cuff (RC) tears cause extreme limitations to daily activities and are highly prevalent [1]. These activities rely on shoulder function, namely, motion and neuromuscular activity. Adaptations in shoulder motion and muscle activity have been seen for individuals with symptoms of shoulder impingement, [2] but is not as well known for individuals with large-to-massive (>3cm) RC tears. Specifically, during shoulder elevation in clinically relevant movements (flexion and abduction), adaptations of glenohumeral (GH) or scapulothoracic (ST) articulations, as well as muscle activity remains unclear. The purpose is to determine shoulder kinematic and muscle activation differences between individuals with and without large-to-massive full thickness RC tears during maximum shoulder flexion and abduction.

Methods

Twenty asymptomatic (ASYM) adults (>50yo) without any known past or present shoulder injury were recruited and 15 patients with large-to-massive RC tears were recruited from an orthopaedic clinic (CUFF). Surface electromyography (EMG) (Fs=2000Hz) was used to monitor muscle activity of the supraspinatus (SSP), upper (UFT) and lower trapezius (LFT), and anterior (ADT) and lateral deltoids (LDT). Simultaneously, movements of the torso, thorax, scapula, and arm were tracked using optical motion capture during maximal abduction and flexion (Fs=100Hz). Average ST rotation, as well as GH and thoracohumeral (TH) flexion and abduction across three trials were calculated using Cardan rotation sequences. These averages were determined during intervals of 30° from 0°-120° of TH flexion or abduction. Average muscle activity presented as the percentage of maximum voluntary isometric contraction (%MVIC) were calculated for each of the four bins. Two-way mixed ANOVAs were calculated for each outcome (Bin x Group) for maximal flexion and abduction, respectively ($\alpha = .05$).

Results and Discussion

During *maximal flexion*, a Group × Bin interaction showed smaller GH angles in the CUFF group at >60° flexion (Fig 1). ST angles did not differ between groups but increased with flexion ($p<0.001$). Overall, muscle activation increased with arm angle (Bin; $p<0.001$), whereas UFT showed a Group × Bin interaction ($p<0.001$). All muscles except ADT had higher activation in the CUFF group ($p<0.05$).

During maximal abduction, a Group × Bin interaction ($p<0.01$) showed smaller GH angles in the CUFF group at higher abduction (Fig 1). ST angles had a Bin effect, with increased scapular upward rotation at greater abduction ($p<0.01$). SSP showed a Group × Bin interaction ($p<0.05$), while UFT and LDT had higher %MVIC in the CUFF group ($p<0.05$). Other muscles increased activation with abduction but showed no group differences below 60°.

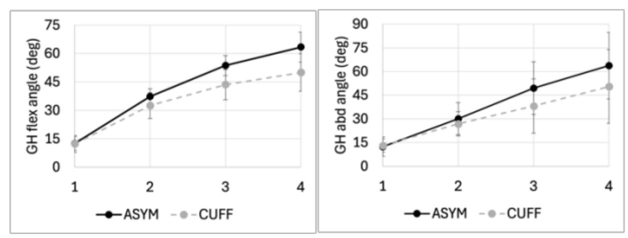

Figure 1: GH angles during bins 1 (0-30), 2 (30-60), 3 (60-90), 4 (90-120) of max shoulder flexion (left) and abduction (right).

Conclusions

This study highlights the altered shoulder mechanics in individuals with large-to-massive RC tears, demonstrating reduced GH motion and increased muscle activation, particularly in UFT and LDT, during flexion and abduction. These findings suggest possible compensatory strategies involving the interaction between GH and ST articulations and heightened muscle activity to maintain function. Understanding these adaptations may help refine rehabilitation approaches to optimize movement patterns and reduce strain on secondary stabilizers.

Acknowledgments

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

References

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