IMPACT OF ROTATOR CUFF TEARS ON MUSCLE FORCES IN WEIGHT-BEARING SHOULDERS

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Introduction

Rotator cuff (RC) tears are associated with glenohumeral (GH) joint instability. In clinical practice, the critical shoulder angle (CSA) is commonly used to predict RC tear risk. Nyffeler et al. [1] demonstrated that a laterally positioned acromion (affecting the CSA) results in a more superior orientation of the deltoid line of action. However, there remains a gap in understanding the detailed relationships between GH muscle forces. The purpose of this study was to evaluate the shoulder muscle forces in weight-bearing shoulders with RC tears during a 30° abduction test.

Methods

A GH simulator [2] using cable systems to mimic ten muscle forces (anterior, middle, and posterior portions of the deltoid, superior and inferior portions of the subscapularis (SSC), supraspinatus (SSP), infraspinatus (ISP), teres minor, pectoralis major, and latissimus dorsi) was used to simulate 30° scaption. An artificial humerus (Sawbones, USA) was used along with five specimen-specific scapular anthropometries. Six types of RC tears (tear of the superior portion of the SSC (SSC_{sup}), SSP, ISP, SSP & SSC_{sup}, SSP & ISP, and SSP & SSC_{sup} & ISP), two weight-bearing loads (1 and 2 kg), and variations in deltoid origin (adjusted to different ±5° CSA) were tested. Statistical analysis was performed using linear mixed-effects models with CSA, RC tear types and loads as fixed effects, and specimen and sex as random effects, to evaluate differences in GH muscle forces.

Results

The middle deltoid force increased marginally with increasing CSA at 30° scaption ($p=0.028$) and increased with increasing weight-bearing load and in all multi-tendon RC tear types (Figure 1). A change in CSA did not influence RC muscle forces at 30° scaption ($p\geq0.184$). The intact anterior RC compensated for anterior tears, and the intact posterior RC compensated for posterior tears at 30° scaption ($p<0.001$; Figure 1).

Discussion

In a laboratory setting, the increase in the CSA and the presence of RC tears and additional weights increased muscle forces, particularly in the deltoid and intact RC muscles. However, it appears that the additional load mainly determines the forces of the deltoids. Furthermore, tears of the SSP alone or SSP & SSC_{sup} appear to influence the muscle forces more than the other tears. These results confirmed that there are altered shoulder biomechanics in RC tears and suggest that the biomechanics of the shoulder are affected in RC tears and that the potential overloading of the compensating muscles should be carefully monitored in affected patients.

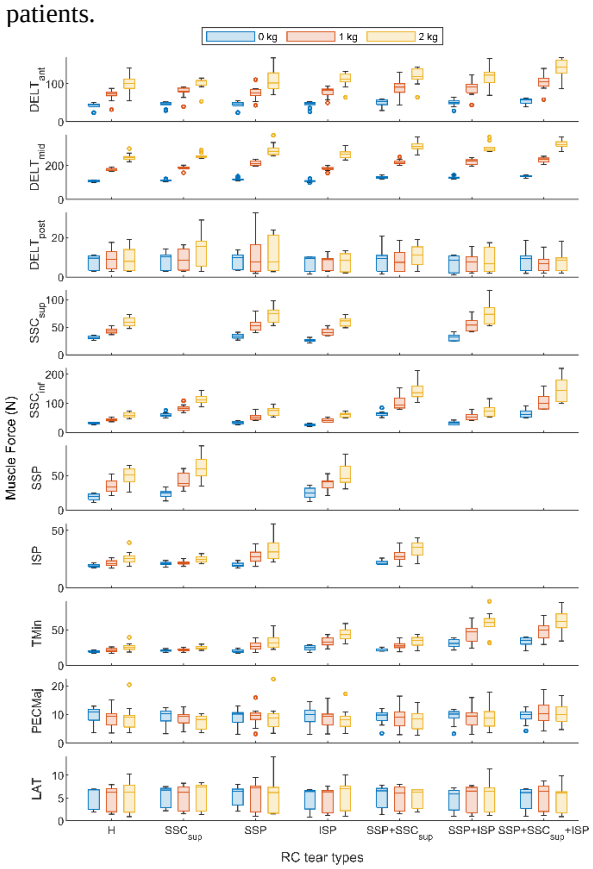

Figure 1: Boxplot of the muscle forces at 30° scaption grouped by RC tear type and weight-bearing loads (0kg, 1kg and 2kg). Legend: H – intact RC; $DELT_{ant}$ –anterior deltoid; $DELT_{mid}$–middle deltoid; $DELT_{post}$ posterior deltoid; SSP–supraspinatus; SSC_{sup}–superior subscapularis; SSC_{inf} –inferior subscapularis; ISP–infraspinatus; TMin–teres minor; PECMaj–pectoralis major; LAT–latissimus dorsi.

References

1. Nyffeler et al., J Bone Joint Surg Am, 88(4):800–5, 2006
2. Genter et al., at-automatiserungstechnik, 71(7):505:514, 2023

Acknowledgements

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