Scapula upward rotation is greater during concentric adduction than concentric abduction

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Summary

Our current understanding of healthy scapula motion has been limited to studies of the shoulder when it is generating an abduction torque. Here, we used biplanar videoradiography to compare scapula kinematics between concentric abduction and adduction. We observed more scapula upward rotation in adduction, indicating a potential load-specific mechanism where scapula motion facilitates glenohumeral joint stability.

Introduction

Our current understanding of healthy scapula motion is based mainly on observing the shoulder when it is generating an abduction torque against gravity. However, the shoulder can perform diverse tasks involving loads distinct from abduction. In particular, little attention has been given to how scapula motion contributes to concentric adduction despite its involvement in high-demand tasks like rock climbing and wheelchair transfers. Contrary to the deltoid's action during abduction, the shoulder adductors (e.g., latissimus dorsi) act as the prime movers during arm-lowering [1]. Investigating scapular kinematics during concentric adduction can provide new insights into understanding the mechanical demands that underlie healthy scapula motion.

Here, we used biplanar videoradiography to compare shoulder kinematics between concentric abduction and adduction. We predicted that although both tasks involve similar overall shoulder motion, they would be achieved through different combinations of glenohumeral and scapulothoracic kinematics since different muscles drive each task.

Methods

Ten healthy adults (5M/5F, age=24±2 yrs) performed two dynamic tasks: a press-up (concentric abduction) and a pull-down (concentric adduction). For each task, the participants bimanually held a carbon fibre rod while a tension load was applied from below (press-up) or above (pull-down). We used a controllable cable machine (*1080 Motion*) to set the tension to 7.5 kg for the press-up and 15 kg for the pull-down.

We measured kinematics of the dominant-sided scapula and humerus with biplanar videoradiography. We measured thorax motion with optical motion capture (*Qualisys*) synced and spatially registered to the biplanar videography system. We computed humerothoracic (HT), glenohumeral (GH), and scapulothoracic (ST) joint angles, and reported all joint angles as a function of HT abduction.

We tested for within-participant differences between the press-up and pull-down using paired t-tests with statistical parametric mapping (SPM) at a level of significance of 0.05.

Results and Discussion

The scapula was significantly more upwardly rotated in the pull-down (adduction) than in the press-up (abduction), with a mean difference of 5° across participants (Fig. 1). Greater ST upward rotation was complemented by less GH abduction to achieve the same HT abduction.

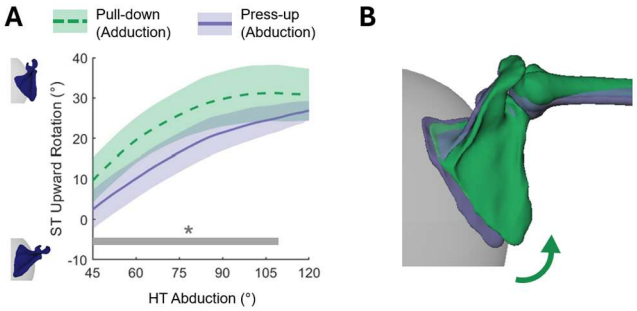

Figure 1: **(A)** ST upward rotation as a function of HT abduction. The grey line (*) indicates a suprathreshold cluster where upward rotation differed significantly between tasks. **(B)** The difference in scapula pose between the press-up (purple) and pull-down (green) at 90° HT abduction for one participant.

Our findings may indicate that the scapula facilitates joint stability in a load-specific manner by orienting the glenoid to be more aligned with the prime mover lines-of-action – effectively decreasing their ability to destabilize the GH joint [2]. In abduction, less upward rotation allows the deltoid line-of-action to act more compressively and less superiorly relative to the glenoid. In adduction, more upward rotation orients the glenoid normal more superiorly, allowing the adductor lines-of-action to act more compressively and less inferiorly relative to the glenoid. Future work involving electromyography and musculoskeletal modeling can further investigate this load-specific stabilizing mechanism.

Conclusions

We observed greater scapula upward rotation during adduction than abduction, indicating that upward rotation is not simply a function of overall HT abduction. Rather, scapula motion is load-specific and appears to move in a way that facilitates glenohumeral joint stability. This work informs our understanding of the mechanisms that underly healthy scapula motion, such that we can better identify and treat unhealthy motion (i.e. dyskinesis) [3].

References

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