Supraspinatus Produces Highest Muscle Force as Glenohumeral Joint Force Increase with Speed

Dominique Barnes and Jennifer A. Nichols, PhD

University of Florida, Gainesville, FL | J. Crayton Pruitt Family Department of Biomedical Engineering | Department of Mechanical and Aerospace Engineering

Introduction

Shoulder injuries are among the leading cause of time lost from training and competition among female volleyball players.[1]

Task speed may affect muscle and joint forces in the shoulder and contribute to injuries.

The **objective** was to use a simulated shoulder model[2] (Fig.1)

(1) To determine how speed can affect the joint forces at the glenohumeral joint

(2) Identify which rotator cuff muscles are dominant during various shoulder movements: flexion, abduction, shrug

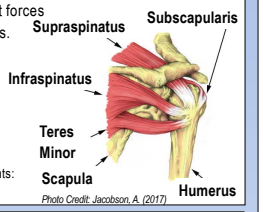
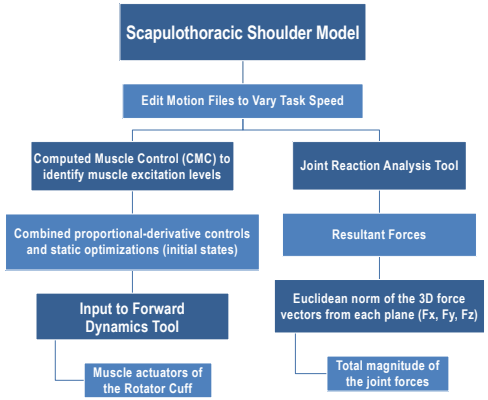


Photo Credit: Jacobson, A. (2017)

Methods



- The Scapulothoracic Shoulder Model[2] was used (Fig.1) to simulate shoulder movement.
- Three tasks (flexion, abduction, and shrug) at two task speeds (slow, fast) were simulated.
- Analyses examined joint and muscle forces:
  - The Joint Reaction Analysis tool was used to calculate the joint forces in the glenohumeral joint.
  - The CMC tool in combination with Forward Dynamics tool was used to calculate forces of muscle actuators.

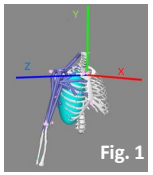
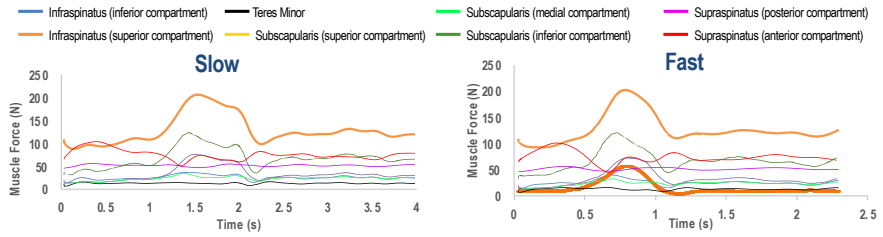


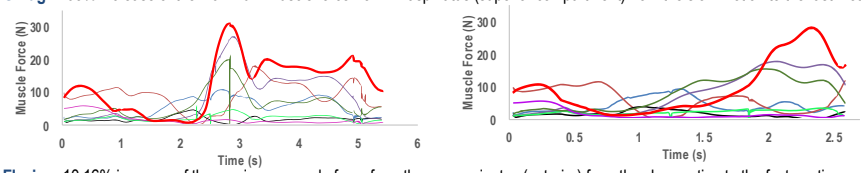
Fig. 1

Results: Muscle Actuators of the Rotator Cuff

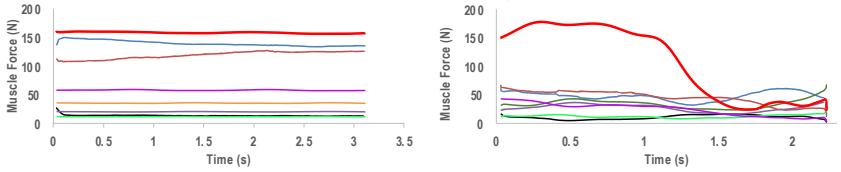
The force generated by each rotator cuff muscle varied based on task and speed.



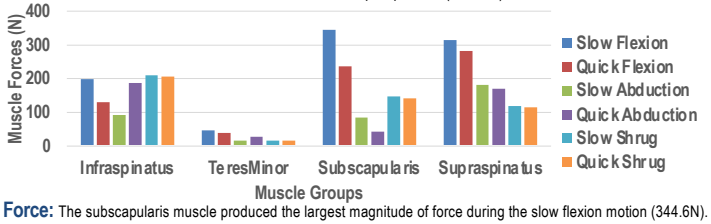
Shrug: 1.93% increase of the maximum muscle force from infraspinatus (superior compartment) from the slow motion to the fast motion.



Flexion: 10.16% increase of the maximum muscle force from the supraspinatus (anterior) from the slow motion to the fast motion.

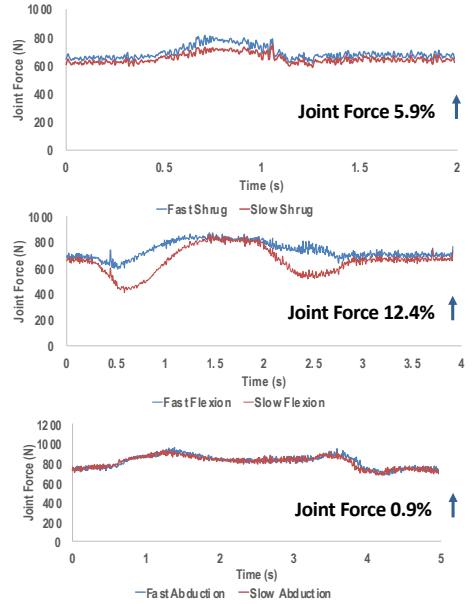


Abduction: 10.79% increase of the maximum muscle force from the supraspinatus (anterior) from the slow to the fast motion



Total Muscle Force: The subscapularis muscle produced the largest magnitude of force during the slow flexion motion (344.6N). The supraspinatus muscle was dominant during the quick flexion and abduction motions, and the infraspinatus was dominant during shrugging motions.

Results: Glenohumeral Joint Force



Joint reaction forces were largest for the abduction task (bottom), compared to the shrug (top) and flexion (middle).

Conclusion

- The simulations indicate an increase in speed results in increased glenohumeral joint forces and muscle forces.
- Increasing the speeds of motions may lead to instability of the shoulder; however, the rotator cuff muscles can stabilize the glenohumeral joint.
- Further study is needed specifically on a simulated volleyball swing to determine how the muscles forces of the rotator cuff contribute to the stabilization of the glenohumeral joint during sports performance.

References: [1] Reeser et al. (2006) Br J Sports Med. 40(7):594-600 [2] Seth et al. (2019) Front. Neurorobot. 13:90

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