COMPARING GLENOHUMERAL JOINT KINEMATICS USING MOTION CAPTURE AND TWO OPENSIM MODELS

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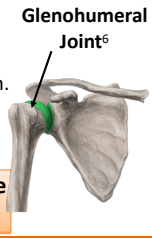
INTRODUCTION

- The shoulder is a complex joint system with a large range of motion.
- The muscles and soft tissues that surround the humerus and scapula make it difficult to accurately measure joint movements.
- Accurate kinematic models could improve assessment of joint motion.
- Several kinematic shoulder models exist, but it is unclear which one is the "right" one for a given study.

Objective: To evaluate whether two shoulder models provide equivalent interpretations of glenohumeral joint motion.



METHODS

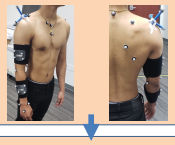
Data was recorded with a 12-camera motion capture system and transferred to Opensim 3.3[3] to test the MoBL-ARMS[4] and scapulothoracic[5] models. Inverse kinematics estimated plane of elevation, shoulder elevation, and shoulder rotation.

Data Collection

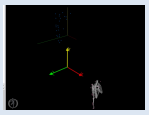
Subject Info
Biological Sex: Female
Age: 19 years
Height: 1.57 meters

Five trials of 3 movements:
- shoulder abduction
- shoulder flexion
- shoulder extension

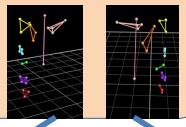
Define marker set[1,2]



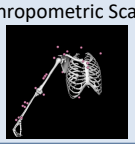
Coordinate Transformation



Vicon VST of Shoulder

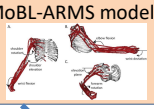


Anthropometric Scaling



Data Processing

MoBL-ARMS model[4]



Scapulothoracic model[5]

MoBL ARMS
- Glenohumeral joint has 3 DoF
- Prescribed scapular motion

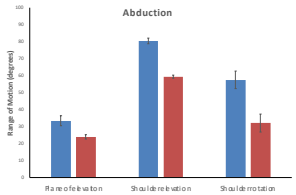
Inverse Kinematics

Scapulothoracic
- Glenohumeral joint has 3 DoF
- Unconstrained scapular motion

Plane of elevation | Shoulder elevation | Shoulder rotation

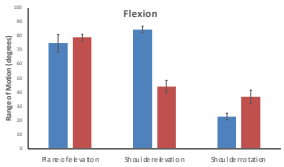
RESULTS & DISCUSSION

- **The joint angles output by the two models are not equivalent.**
  - For the extension task, the MoBL ARMS model averaged 88.5 degrees for plane of elevation angle while the scapulothoracic model averaged 43.9 degrees.
- **The glenohumeral joint demonstrate a larger and more variable range of motion in the MoBL-ARMS model than in the scapulothoracic model.**
  - The standard deviation was larger for MoBL-ARMS model than the scapulothoracic model.
- **Differences in scapular motion could explain the differences in the magnitude of range of motion.**
  - Shoulder elevation angles showed remarkable differences between models with 36.1 vs. 6.2 during extension, 84.9 vs. 44.2 during flexion, and 88.4 vs. 59.4 during abduction.



The error bars represent the std. dev. for each of the angles when using the respective model.

Range of motion was obtained by subtracting the minimum value from the maximum value of the trial.



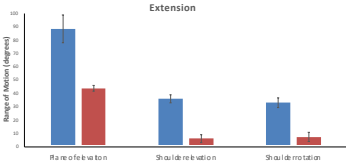


Figure 1. Range of motion calculated from inverse kinematics for each of the three tasks. Blue bars represent the *MoBL ARMS model.* Red bars represent the *scapulothoracic model.*

CONCLUSIONS

- This study highlights the importance of carefully selecting shoulder models when studying upper limb movement to obtain accurate data and reduce ambiguity about the "correct" measured movements.
- Future work includes collecting more data to evaluate to what extent the reported results hold across multiple subjects.

References

[1] Naaim et al. *J Biomech*. 2017 62: 102-109. [2] Wu et al. *J Biomech*. 2005 38(5): 981-992. [3] Delp et al. *IEEE Trans Biomed Eng* 54(11): 1940-1950. [4] Saul et al. *Comp. Method Biomech Eng*. 2015 18(13):14451458. [5] Seth et al. *PLOS ONE*. 2016 11(1): e0141028. [6] Koh,Y. Shoulder Joint Illustration, Library Kenhub GmbH, 2015

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