Comparing Two Motion Capture Marker Sets for Measuring Thumb Kinematics

Taylor Hilton and Jennifer A. Nichols Ph.D.
University of Florida, Gainesville, FL

Introduction: Motion capture, which records human movement by measuring the position of passive reflective markers, is widely used to study hand biomechanics [1, 2]. However, a standardized marker set has not yet emerged for studying the thumb. Measuring thumb kinematics is challenging due to the small size of its bone segments and complexity of motions enabled by its multi-degree-of-freedom joints. In this study, we examine differences in joint angles measured using two common marker sets for measuring thumb kinematics.

Materials and Methods: One healthy female (age 21, height 160 cm, 54.4 kg) participated in this IRB-approved study. During testing, 12 reflective markers were secured to the participant's thumb: 3 on the distal phalanx, 3 on the proximal phalanx, and 6 on the first metacarpal. A 12-camera motion capture system recorded thumb movement as the participant completed two range of motion tasks (abduction-adduction and flexion-extension) and two functional tasks (lateral and opposition pinch). Importantly, all tasks were completed with all markers. During post-processing, the markers were subdivided into two separate marker sets. The first marker set, termed the complex set, included all 12 markers (Fig. 1A) and is similar to that used by [3]. The second marker set, termed the simple set, included 1 marker on the distal and proximal phalanxes and 3 markers on the first metacarpal (Fig. 1A, red circles). For each marker set and task, joint angles were calculated using inverse kinematic simulations in OpenSim v. 3.3. The inputs to these simulations were an anthropometrically scaled model of the thumb [4] and the measured marker trajectories. The outputs were joint angles versus time. Joint angles were compared by calculating the average percent error and maximum difference across each task.

Results and Discussion: Regardless of task, the joint angles measured across the carpometacarpal (CMC), metacarpophalangeal (MP), and interphalangeal (IP) joints of the thumb were substantially different when using the complex versus simple marker sets. For example, the smallest average percent error between marker sets was 3.5% and occurred at the CMC joint during the flexion-extension task (Fig. 1B), while the largest was 7657% and occurred at the MP joint during the abduction-adduction task (Fig. 1C). The latter result corresponds to a difference between 0.2 and -12.2 degrees in the complex and simple marker sets, respectively. The MP joint result is an example of two consistent findings. First, the largest differences between joint angles measured by each marker set occurred during the range of motion tasks. Second, differences in measured joint angles were more apparent at the MP and IP joints than the CMC joint.

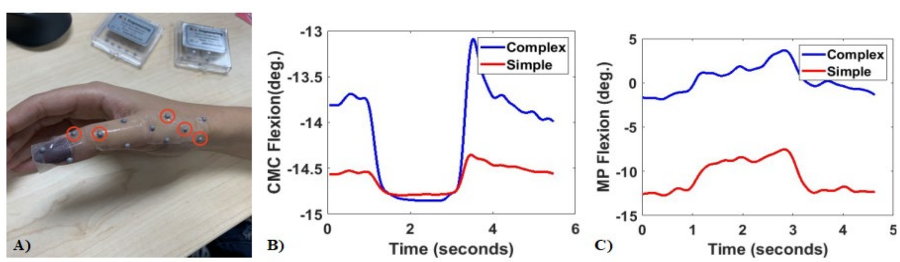

Figure 1. (A) The complex (all markers) and simple (red circles) marker sets were recorded simultaneously. (B) CMC flexion-extension angles during the flexion-extension task and (C) MP flexion-extension angles during the abduction-adduction task are shown for the complex (blue) and simple (red) marker sets.

Conclusion: This study highlights the importance of marker set selection when analyzing thumb kinematics because calculated joint angles are affected by the marker set used. Due to our unique study design, in which the two marker sets were recorded simultaneously, we can fully attribute differences in joint angle measurements to differences in marker set. Future work will aim to determine when each marker set should (or should not) be used. For example, the presented results suggest both marker sets are appropriate for examining the functional tasks, but not the range of motion tasks. Additional data recording more trials in a range of subjects is needed to understand the generalizability of the presented results and assess the ground truth accuracy of the calculated joint angles.

Acknowledgements: Funding was provided by NIH NCATS KL2 TROO1429.

References: [1] Alexanderson et al. (2016) *9th Intl Conf Motion in Games.* pp. 7-13. [2] Buczek et al. (2011) *J Biomech.* 44(9): 1805-1809. [3] Leitkam et al. (2014) *J Biomech Eng.* 136(2): 21-22. [4] Nichols et al. (2017) *J Biomech.* 58: 97-104.