**Simulations Capture Relationship between Upper Limb Posture and Thumb-Tip Force**

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**Introduction:** Wrist and forearm posture are important when analyzing hand function because changes in posture are known to influence to what extent muscles can generate force. Given that muscle forces cannot be directly measured, computer simulations are often utilized to analyze these forces. However, simulations of hand function are often run at a neutral posture with the forearm neither pronated nor supinated and the wrist neither flexed nor extended. This is problematic for computationally evaluating functional tasks, such as lateral pinch, where posture is known to change based on the environment in which the task is completed. In this study, we aim to evaluate how wrist and forearm posture influence thumb-tip force during lateral pinch and understand to what extent our simulated results align with experimental literature.

**Materials and Methods:** A musculoskeletal model of the forearm, wrist, and thumb was created by combining a previously developed thumb model [1] and a validated upper limb model [2] in OpenSim (v. 3.3). This model importantly included 180˚ pronation/supination at the forearm and 140˚ flexion/extension at the wrist. To examine the effects of forearm and wrist posture on lateral pinch, forward dynamic simulations were executed across combinations of 5 forearm postures (-90˚ supination to 90˚ pronation in increments of 45˚) and 5 wrist postures (-60˚ extension to 60˚ flexion in increments of 30˚). The input to each simulation was the set of muscle activations to generate a lateral pinch force. The output was force vectors describing external pinch force at each posture. For each posture (23 postures total), the maximum thumb-tip force magnitude was calculated and compared to reported experimental values that measured mean pinch force while adjusting both wrist and forearm posture [3,4].

**Results and Discussion:** In comparison to extended and neutral wrist postures, our simulations demonstrated decreased pinch force magnitude during wrist flexion. This decreased force with wrist flexion was present across all forearm postures and is exemplified by the 80% difference in pinch force between peak wrist extension and flexion with the forearm held at 45˚ pronation (Fig. 1). The validity of this result is supported by the literature, which demonstrates up to a 40% decrease in pinch force between a neutral and flexed wrist posture [3,4]. Our simulations also demonstrate that when compared to pronated postures, neutral and supinated postures on average result in 20% larger pinch strengths. This result is supported by experimental literature reporting the greatest pinch force in a neutral forearm posture [5].

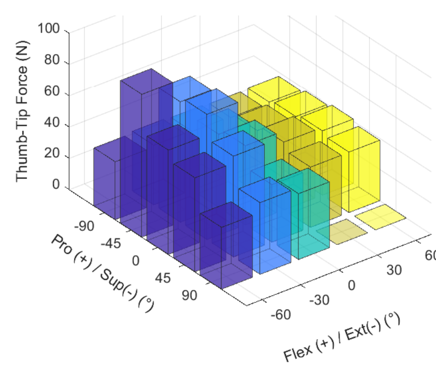


**Figure 1**: Magnitude of force generated at each posture during lateral pinch. No data collected for (90, 30) and (90, 60).

**Conclusions:** Through our simulations, we demonstrate our model's ability to generate physiologically reasonable data by comparing simulated thumb-tip force to experimental results from the literature. Future work should involve varying muscle activations across postures. This would allow simulations to better reflect the physiological changes in muscle activations that occur as posture changes and enable more accurate simulation of postural changes that occur during daily life.

**References:** [1] Nichols, et al. (2017) *J Biomech.* 58:97–104. [2] Saul, et al. (2015) *Comput Methods Biomech Biomed Eng*. 18:1445-58. [3] Imrhan S.N. (1991) *Appl Ergon*. 22(6):379-384. [4] Halpern, et al. (1996) *J Hum Ergol*. 25(2):115-130.