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

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**OBJECTIVE:** To evaluate how wrist and forearm posture affect thumb-tip force during lateral pinch and compare simulated results with experimental literature in order to inform a model capable of predicting postures that require excessive strength inputs.

**Methods**

**Model Creation**

- A musculoskeletal model of the forearm, wrist, and thumb was created in OpenSim [v 3.3].
- This model importantly included 180° pronation/supination at the forearm and 140° flexion/extension at the wrist.

**Simulations**

- Simulations combined 5 forearm postures (45˚–90˚) and 5 wrist postures (90˚–0˚ flexion in increments of 30˚).
- Simulations demonstrated how wrist and forearm posture affect thumb-tip force during lateral pinch and compare simulated results with experimental literature in order to inform a model capable of predicting which postures result in suboptimal force generation.

**Analysis**

- Maximum thumb-tip force magnitudes were plotted to examine the relationship between force and posture (Fig. 1). Simulations demonstrated lower pinch force magnitude during wrist flexion in forearm postures in the range of -45˚ to 45˚.
- This result is exemplified by the 80% difference in pinch force between peak wrist extension and flexion at forearm 45˚ pronation.
- Validity of this result is supported by literature, which demonstrates up to a 40% decrease in pinch force between a neutral and flexed wrist posture [3,4].
- Simulations demonstrated neutral and supinated wrist postures resulted in up to 20% larger pinch strengths on average compared to pronated postures.
- This result is supported by experimental literature reporting the greatest pinch force in a neutral forearm posture [4].

**External pinch force vectors for all postures**

**Comparison**

- Through our simulations, we demonstrate our model’s ability to generate physiologically reasonable force data. This is an important step toward creating a model capable of predicting which postures result in suboptimal force generation.
- Our model indicates that changing wrist posture results in lower force generation. This greater force generating requirement relative to a neutral wrist posture is consistent with the literature [3,4].
- Future work will involve varying muscle activations across postures to further improve the model’s predictive power.

**Results & Discussion**

- Comparing trends across postures between simulated and experimental results was another important part of the analysis (Fig. 2).
- Simulations demonstrated a decrease in pinch force from neutral wrist posture to complete wrist flexion at a neutral forearm posture.
- The validity of this result is supported by literature, which demonstrates a similar decrease in force generation and assets that flexion results in decreased pinch force [3,4].
- Simulations demonstrated that an extended wrist resulted in lower pinch force compared to force generated in the neutral wrist posture at a forearm posture of 90˚.
- This result is supported by experimental data reporting that the greatest pinch force occurs at a neutral wrist posture [4].
- Data showing force generated during lateral pinch with a flexed wrist at a forearm posture of 90˚ was not collected due to inability to run simulations at these postures.

**References**