Differential Sensitivity of Manipulation and Grasp Forces to Task Requirements

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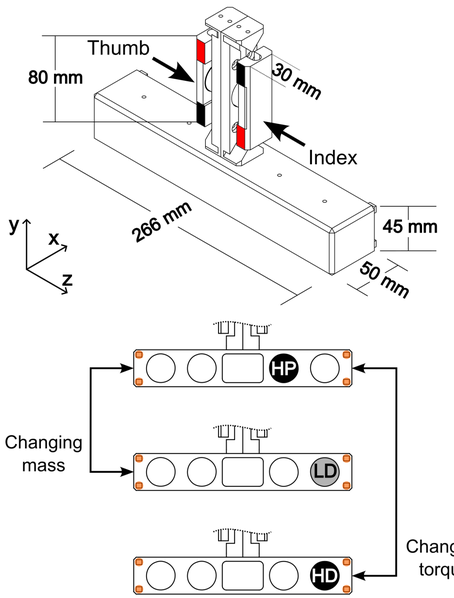
BACKGROUND

Successful dexterous manipulation requires *simultaneous* prevention of object slip and object pose control.[3] However, how humans coordinate digit forces to attain these two goals is not well understood. This gap is due to (1) the use of tasks devoid of dexterity requirements and/or (2) the use of analytical techniques that cannot isolate the dual role of digit forces. **Research question:** Can grasp and manipulation forces be independently modulated by changing mass and torque, respectively?

INSTRUMENTATION

- **Task:** Grasp with thumb and index fingertip (precision grip), lift and hold an inverted T-shaped object while preventing it from slipping and tilting.



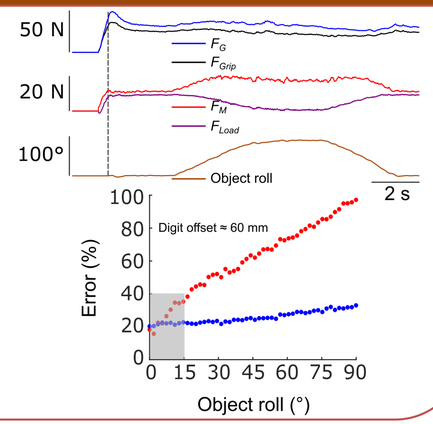
METHODS

Grasp Force (F_G)

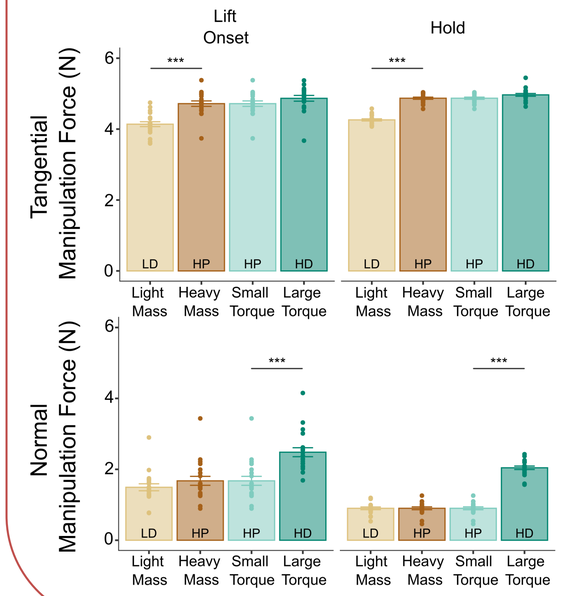
$$\vec{F}_G = G_0 G_0^T \begin{bmatrix} \vec{F}_C^{TH} & \vec{F}_C^{IN} \end{bmatrix}^T$$

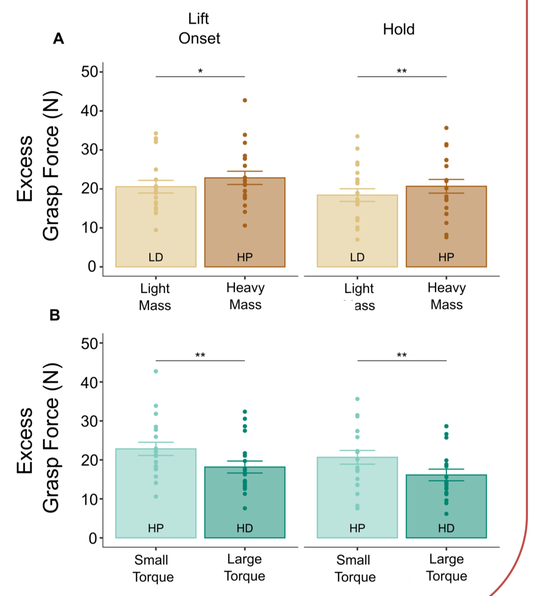
Manipulation Force (F_M)

$$\vec{F}_M = \begin{bmatrix} \vec{F}_C^{TH} & \vec{F}_C^{IN} \end{bmatrix}^T - \vec{F}_G$$

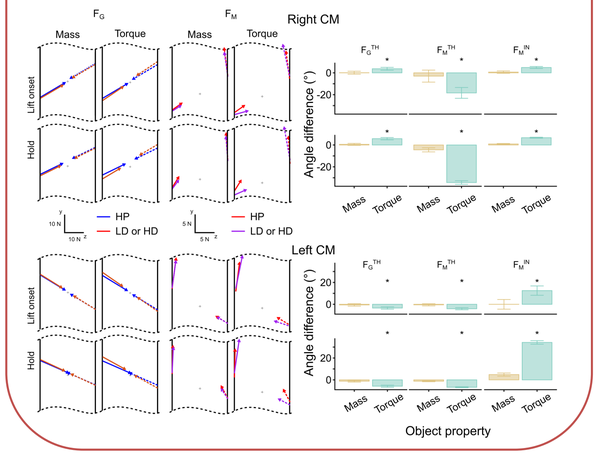


RESULTS





RESULTS



CONCLUSIONS

The distinct sensitivity of F_G and F_M likely underscores differences in their:

- Functional role: Object slip prevention (F_G) vs. object pose control (F_M normal component).
- Sensorimotor mechanisms: Feedforward (F_G) vs. feedback (F_M).[3]
- Tactile afferent inputs: Encoding of digit force vector direction.

REFERENCES

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[3] Wu, Y.-H and Santello, M. (2023). *Sci Rep* 13(1), 12037.
[4] Murray, R. M. 1994. A Mathematical Introduction to Robotic Manipulation (1st ed.). CRC Press.

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