NEURAL CONTROL OF FDI MOTOR UNITS DURING ISOLATED AND SYNERGISTIC CONTRACTIONS

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Summary

Understanding the neural and biomechanical control of motor units (MUs) is crucial for elucidating muscle coordination and force production. We investigated the activity in the first dorsal interosseous (FDI) MUs tracked across *isolated finger flexion* and *pinch* tasks. The greater variability in interspike intervals (ISI) in *pinch* after increased and decreased excitatory drive may suggest a greater effect of sustained MU activation in synergistic tasks. These findings highlight the complexity and adaptability of motor control strategies in different tasks, which may contribute to our understanding of MU behavior and its modulation by task-specific demands.

Introduction

Recent studies have highlighted the role of intrinsic motoneuron properties in shaping MU behavior. For instance, it has been demonstrated that dendritic persistent inward currents (PICs) in motoneurons can significantly influence torque control by amplifying and prolonging synaptic inputs [1,2]. Interestingly, when superimposing excitatory and inhibitory input over an isometric contraction, PIC-induced prolongation may degrade the precision of motor output [2]. Previous studies focused on individual muscles as primary effectors, but it remains unclear if similar behavior occurs in muscles acting both in isolated and synergistic tasks. We examined how PIC-induced prolongation could affect motor control during *isolated finger flexion* and *pinch* movements, bridging the gap in understanding neuromechanical control of FDI MUs tracked across both tasks.

Methods

Nine healthy adults (3 females) were seated with their right arm and wrist fixed. High-density surface electromyograms (HDsEMG) were recorded from the FDI muscle as participants performed an isometric force-matching task under two conditions: *finger flexion* (isolated) and *pinch* (synergistic). They specifically followed a force profile termed *sombrero* (Figure 1A) [2]. HDsEMG were decomposed into MU spike trains [3] and MUs were tracked across conditions. We calculated MUs' mean discharge rate (MDR), DR variability during plateau 1 and 2, and MU recruitment and derecruitment thresholds. We also quantified the force steadiness during both plateaus by the CoV of force. Analyses were performed with openhdemg library.

Results and Discussion

MU MDR decreased from plateau 1 to 2 in *pinch* task (P<0.001), but not in the *isolated* task (P=0.051) (Figure 1B). CoV-ISI increased in plateau 2 compared to plateau 1 in *pinch* (P=0.003), with no significant difference in *isolated* task (P=0.29) (Figure 1C). CoV force was significantly higher in *pinch* than *isolated* task, likely due to the increased variability during plateau 2 (P = 0.04) (Figure 1D).

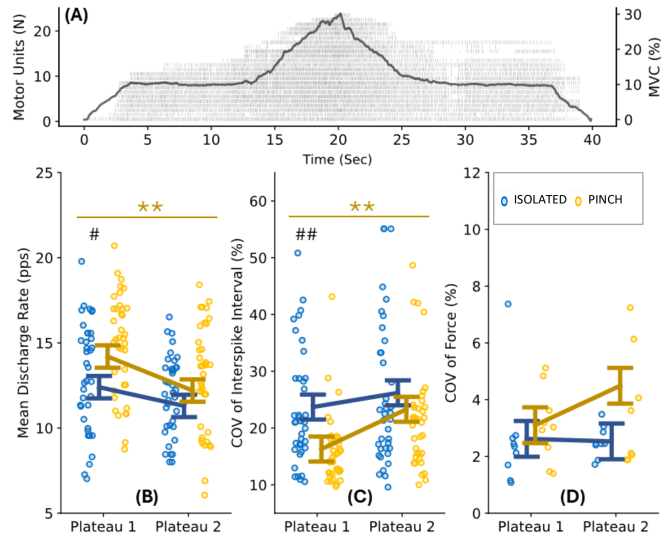

Figure 1: A) Sombrero profile: 10-s at 10% MVC (plateau 1 and 2) and a linear increase and decrease to 30% MVC at 3% MVC/s. B and C) Discharge characteristics of matched MUs, and D) force variability in *isolated* and *pinch* before and after the increase and decrease of excitatory drive (p<0.05).

After an increase and decrease of excitatory drive over a superimposed pattern, the second sustained force exhibited greater variability in DR during *pinch* but not *isolated finger flexion*. These results might indicate a greater effect of prolonged PIC-induced MU activation in *pinch*. These findings are consistent with previous studies that highlight the complexity and adaptability of motor control strategies in different tasks [1,2].

Conclusions

The increased DR variability in *pinch* compared to *isolated finger flexion* task suggests that distinct neural strategies are employed in these complex force-tracking profiles.

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References

[1] Goodlich BI et al. (2024). Antagonism of 5-HT2 receptors attenuates self-sustained firing of human motor units. *The Journal of Physiology*, **602**: 1759-1774.
[2] Beauchamp JA et al. (2023). Intrinsic properties of spinal motoneurons degrade ankle torque control in humans. *BioRxiv*, 2023.10.23.563670.
[3] Negro F et al. (2016). Multi-channel intramuscular and surface EMG decomposition by convolutive blind source separation. *Journal of Neural Engineering*, **13**: 026027.