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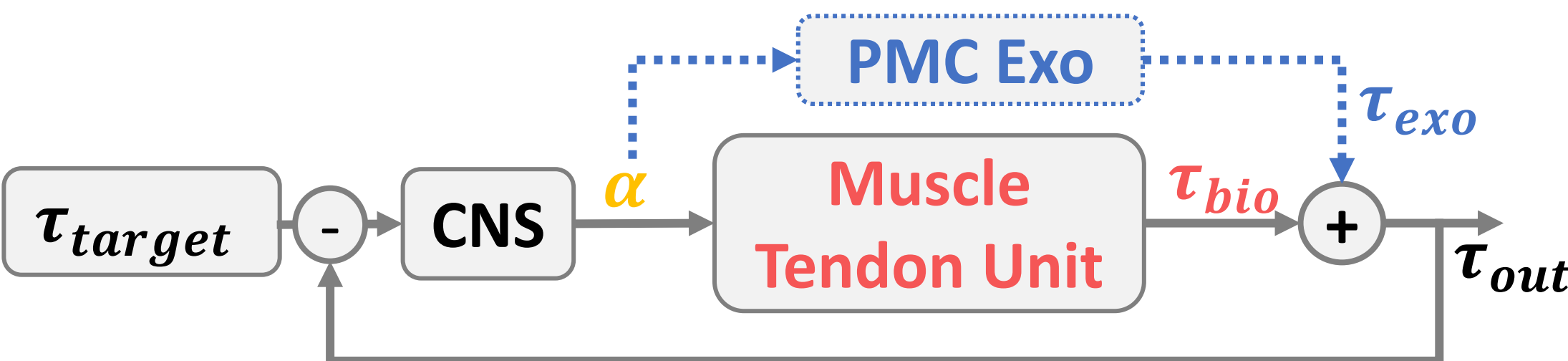
Motivation

- How do exoskeletons affect sensorimotor control of movement?
- Exos act in parallel to a joint, affecting sensorimotor control loops that govern human movement [1].
- This may have unintended impacts on overall agility and stability [2].
- Recent work has begun to quantify human force responsiveness [3] and effects of neuromotor regulation on joint impedance [4].

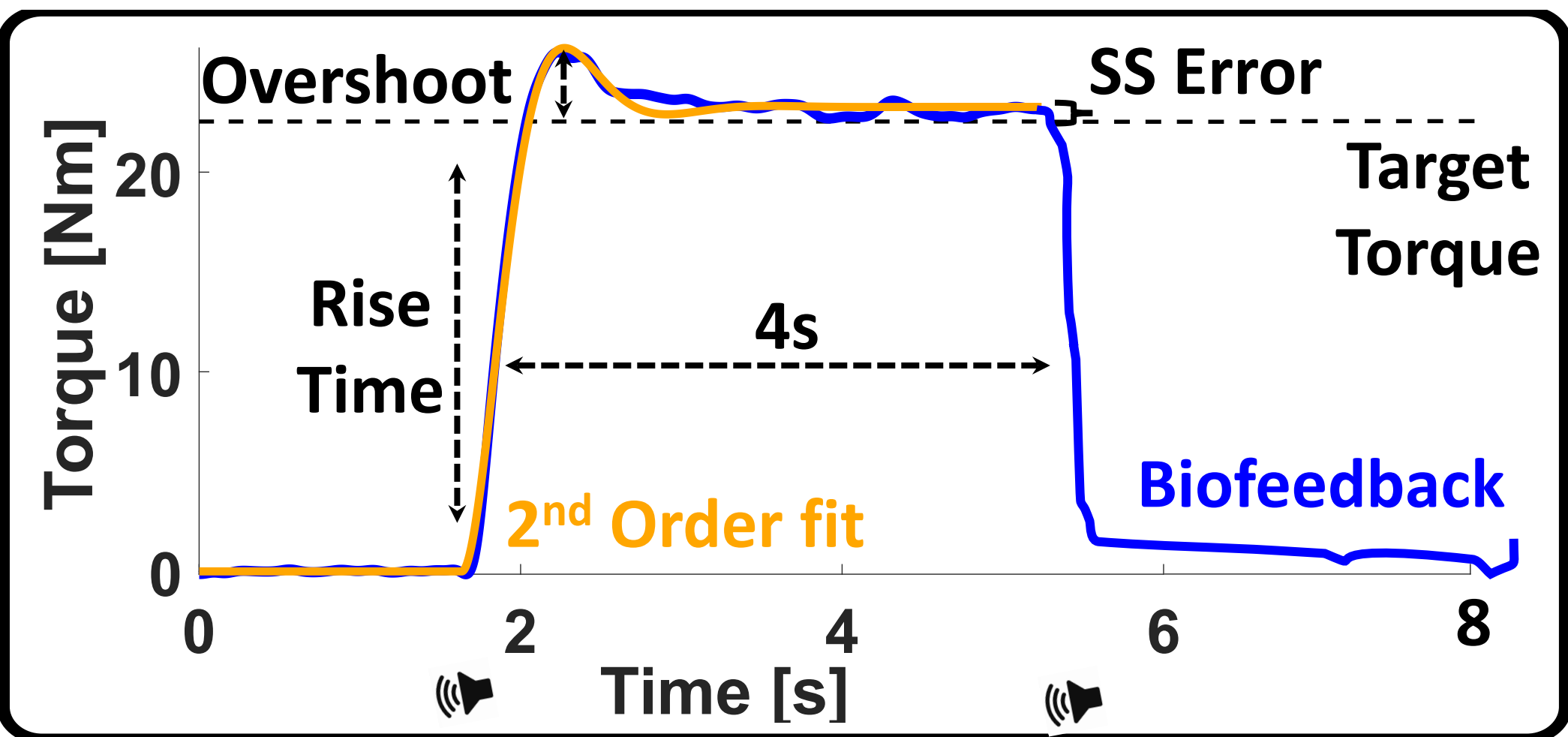
Hypothesis

- H1. Human +Exo system will be more responsive with **PMC** than **NA**
H2. Human + Exo system will be less accurate with **PMC** than **NA**

Methods



- **Exo: Proportional Myoelectric (PMC)** via Soleus EMG and **No Assistance (NA)**
- **Target Torques: 20%, 40% and 60% of MVC**
- **3 Repetitions** of the full condition set

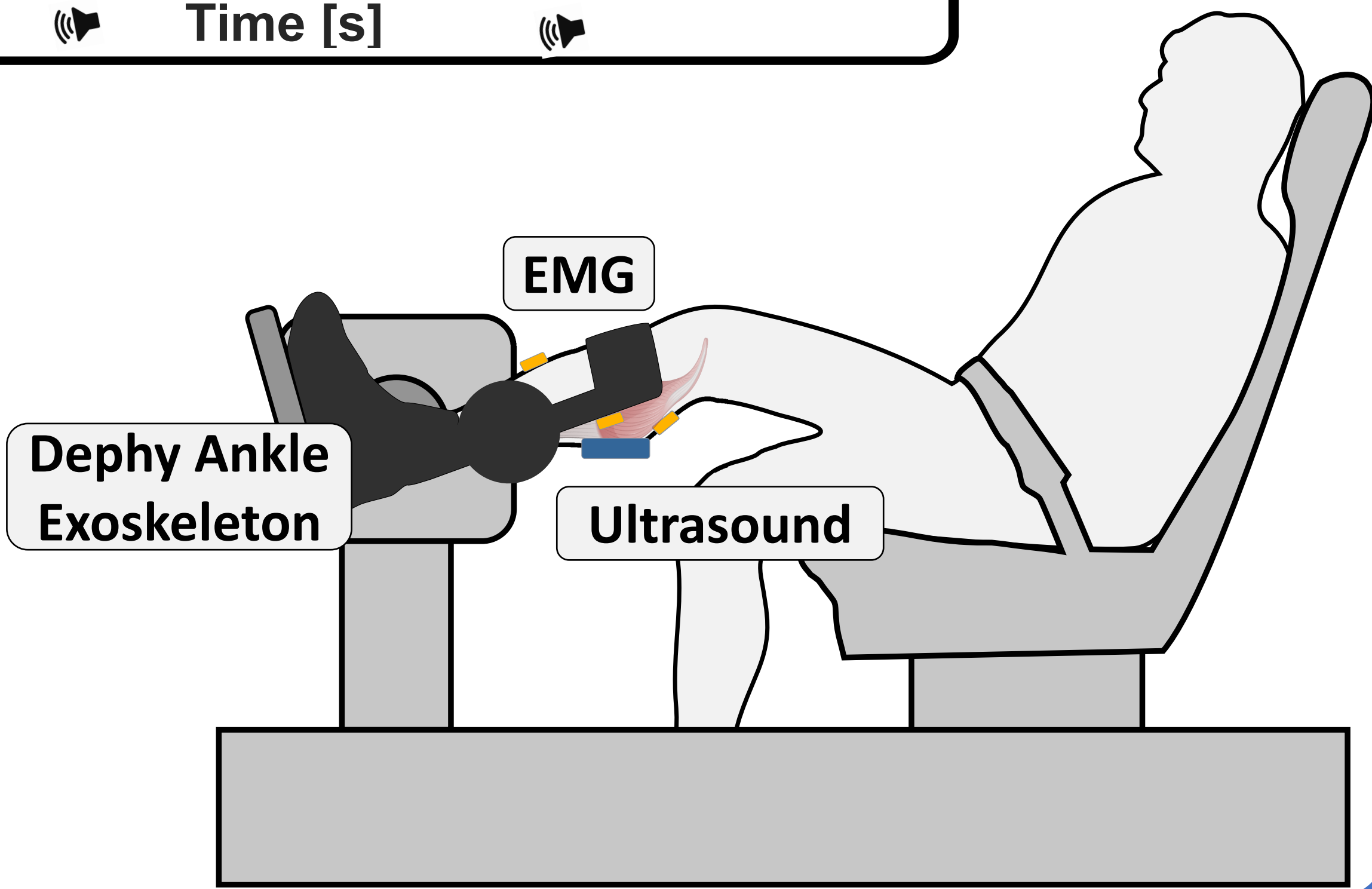


2nd Order model

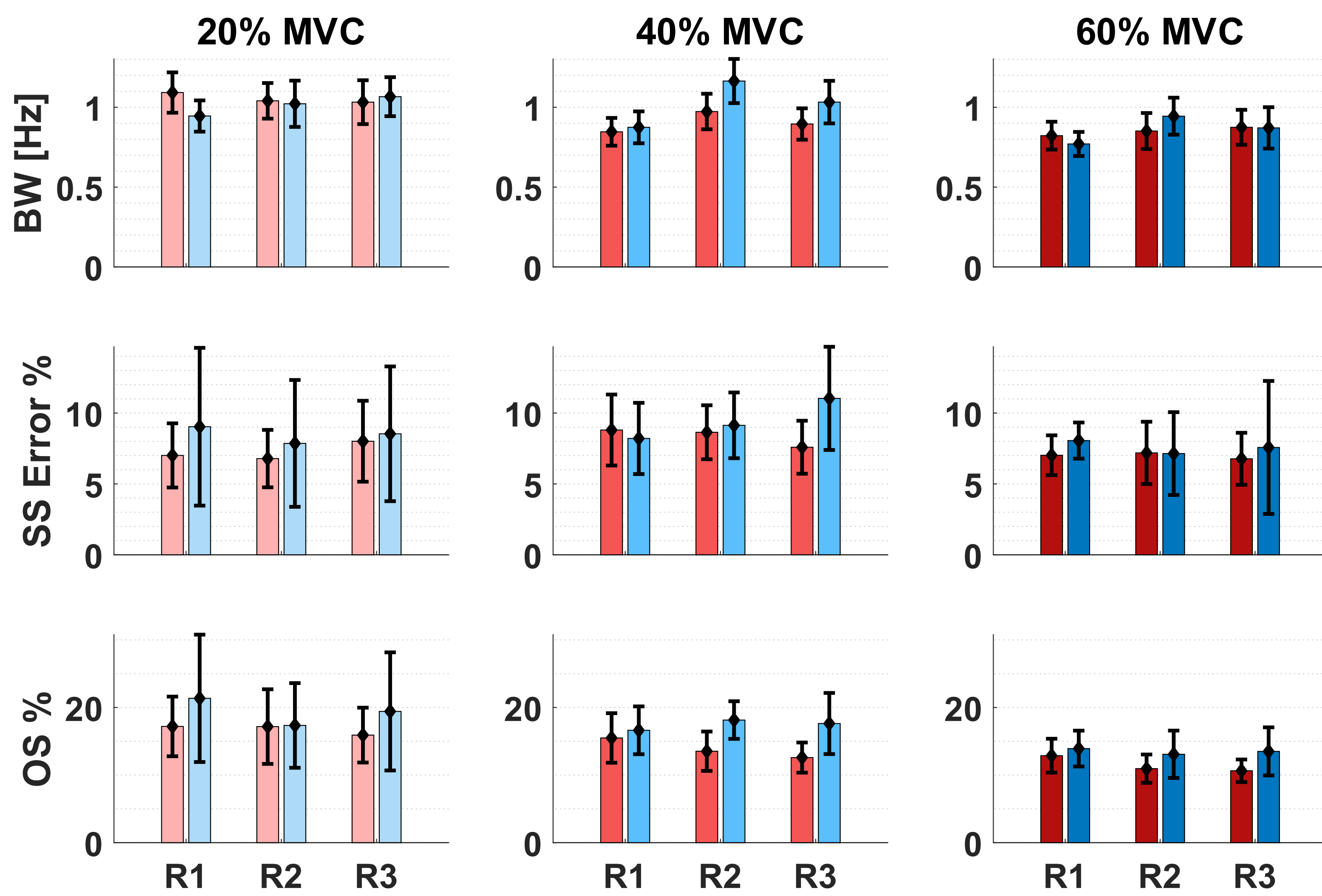
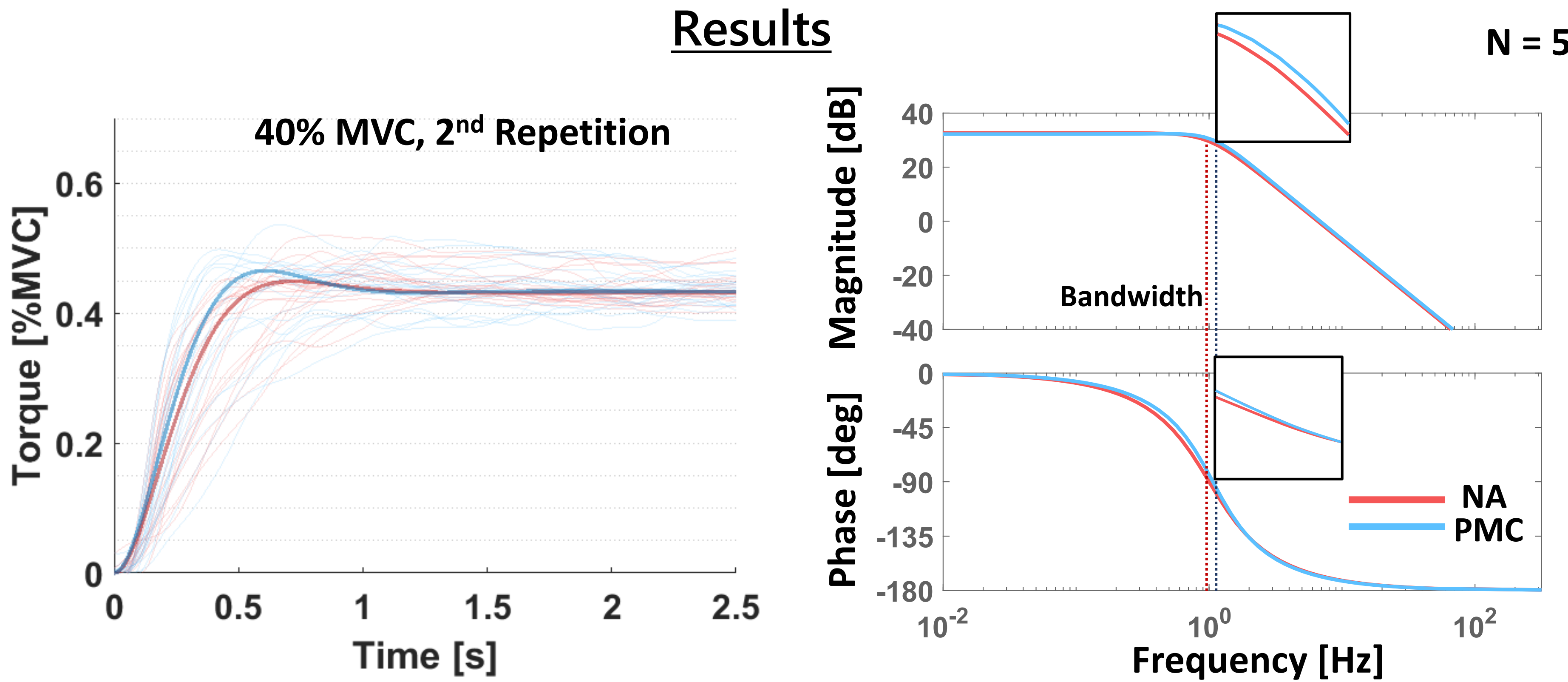
$$H(s) = \frac{K}{s^2 + 2\zeta\omega_n + \omega_n^2} e^{-\tau_d s}$$

Bandwidth = $f(\zeta, \omega_n)$

K – Steady State Gain
 ζ – Damping Ratio
 ω_n – Natural Frequency
 τ_d – Delay



Results



	Accuracy (H2)		Responsiveness (H1)
	SS Error	OS	BW
NA	✓	✓	
PMC			✓ (after adaptation)

Implications

- Exoskeletons will improve performance in tasks requiring fast responses (e.g. perturbations)
- Exoskeletons may worsen performance in tasks requiring high precision.
- Unclear of other control methods (non-PMC) will have similar outcomes

[1] Abram et al. (2022), Curr Biol 32; [2] Antonellis et al. (2018), Plos One 13;
[3] Kudzia et al. (2022), Sci Rep 12; [4] Wind et al. (2020) Sci Rep 10.