Identifying the Optimal Damping Coefficient for a Passive Prosthetic Knee

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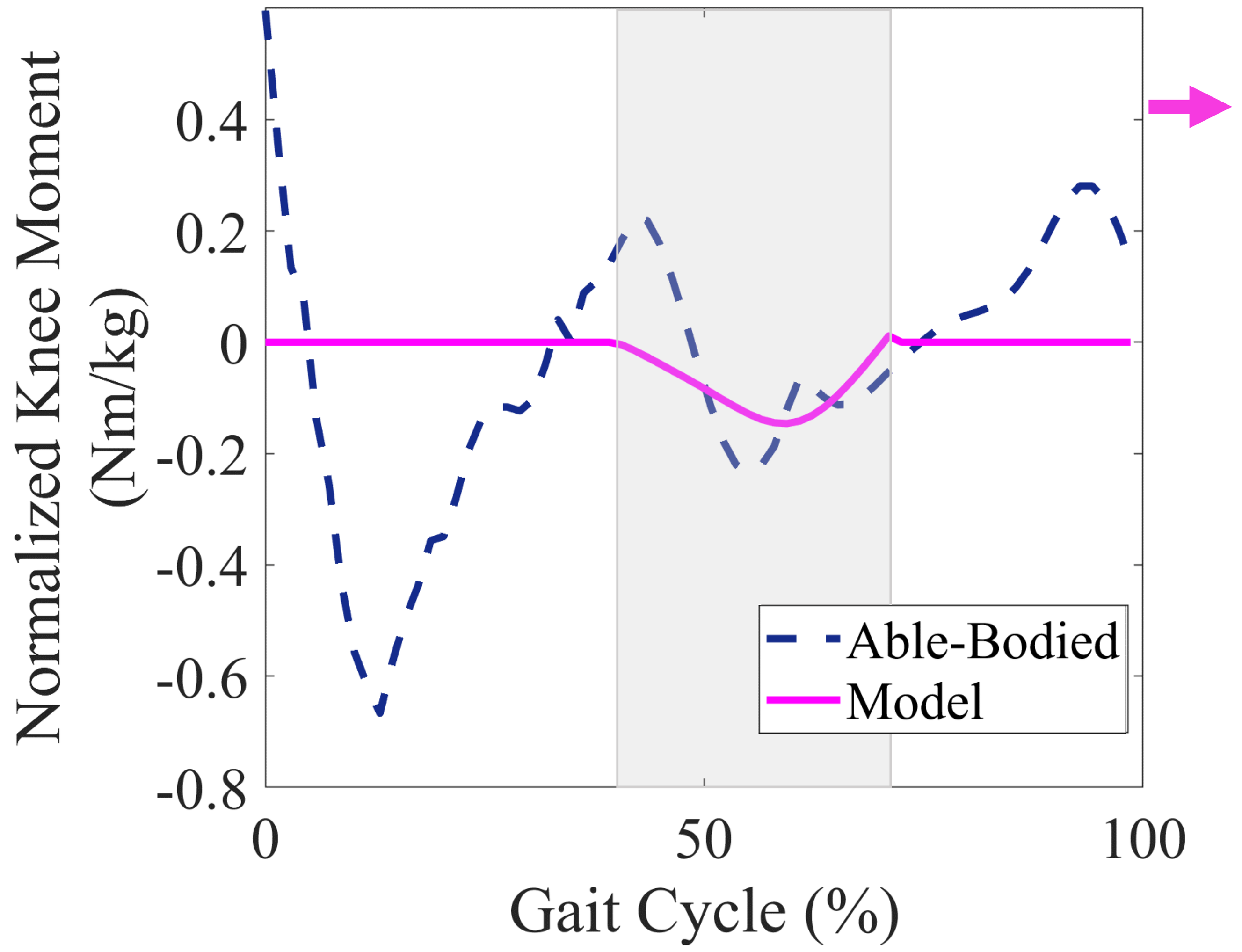
Motivation

- Need for low-cost, high-performance knee prostheses in India that promotes able-bodied walking pattern [1,2]
- Affordable designs enables stability, but results in uneven, intermittent walking pattern
- Fluid-based dampers can make walking smoother
- Damping coefficient must be tuned to prevent hyper-flexion in early swing while still allowing adequate knee flexion for toe clearance

GOAL: Able-bodied peak knee flexion during swing

Methods: identifying optimal damping coefficient for a rotary damper



$$B_{damper} = 0.0238 \frac{Nm}{kg \frac{rad}{s}}$$

Scale by 49% based on swing phase asymmetry

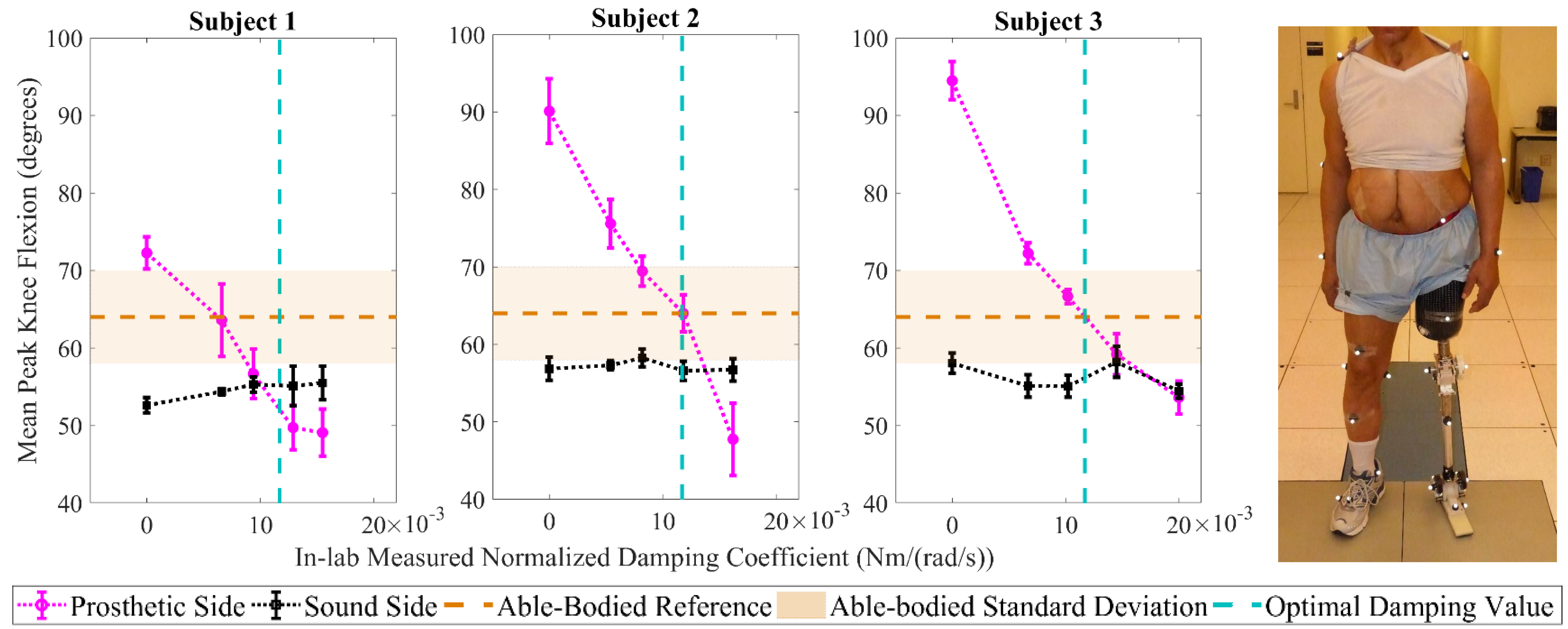
$$B_{damper}^{optimal} = 0.0117 \frac{Nm}{kg \frac{rad}{s}}$$

- Compute optimal damping coefficient for a rotary hydraulic damper that could best replicate the target able-bodied knee moment [3] during terminal stance for target knee angular velocity [4, 5]
- Optimal damping coefficient is invariant with walking speed [6]
- Based on amputee's asymmetrical gait, prosthetic knee flexing faster than that of the sound side during swing, the optimal damping coefficient is scaled by 49% [7]

Experimental Study: testing dampers with varying damping coefficients

Three subjects walked on level ground with:

- Single-axis passive prosthesis prototype [8]
- Shear-based rotary hydraulic dampers of different damping coefficients in increasing order [9]



Results: optimal damping condition resulted in symmetric peak knee flexion

- Increasing damping decreases the peak knee flexion angle during swing
- No damping condition results in hyperflexion during swing phase
- Optimal damping coefficient allows for close to able-bodied kinematics or symmetry with sound leg

Ongoing Work

- Update optimal damping model with able-bodied data collected at Northwestern University
- Optimizing prosthetic knee components for stance phase and swing extension
- Design a foot for the knee using the Lower Leg Trajectory Error (see Victor Prost's poster)

Acknowledgements

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References

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