



# Effects of Upper Limb Loss and Prosthesis Use on Standing Balance



NORTHWESTERN UNIVERSITY

<sup>1,2,3</sup> Matthew J Major, <sup>1</sup> Tara Shirvaikar, <sup>2</sup> Rebecca Stine, and <sup>1,2</sup> Steven A Gard

<sup>1</sup> Northwestern University, Chicago, IL; <sup>2</sup> Jesse Brown VA Medical Center, Chicago, IL; <sup>3</sup> Edward Hines Jr VA Hospital, Chicago, IL  
email: matthew-major@northwestern.edu, web: http://www.nupoc.northwestern.edu/

## Introduction

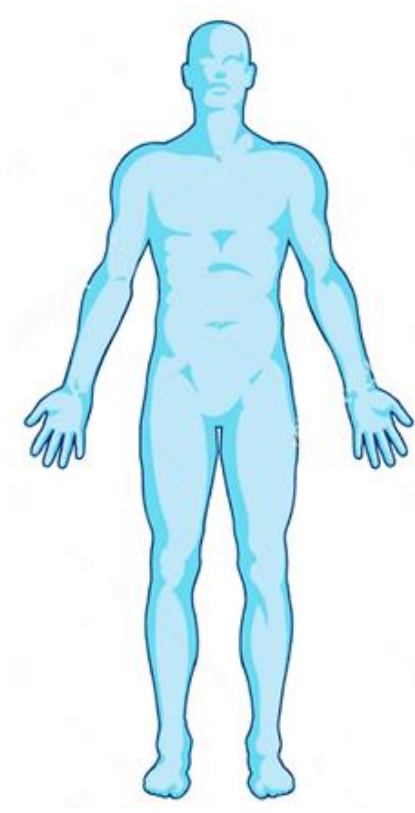
- Whole-body internal models influence the motor behavior required for controlling posture, with arms contributing to standing balance (Imaizumi 2016, Shafeie 2012).
- Nearly half of persons with upper limb (UL) loss fall at least once per year, with fall likelihood increasing by 6 times for those who use a prosthesis (Major 2017).
- Wearing an UL prosthesis may help center the body axis while standing, but evidence suggests it may also be perceived as a postural disturbance (Imaizumi 2016).

**Aim:** Evaluate the acute effects of UL loss and wearing an UL prosthesis, particularly matching the mass of both upper limbs, on standing balance.

- H1:** Presence of UL loss will cause an increase in postural sway.
- H2:** Wearing an UL prosthesis will improve bilateral weight symmetry.
- H3:** Wearing an UL prosthesis will cause an increase in postural sway.

## Methods

### Participants



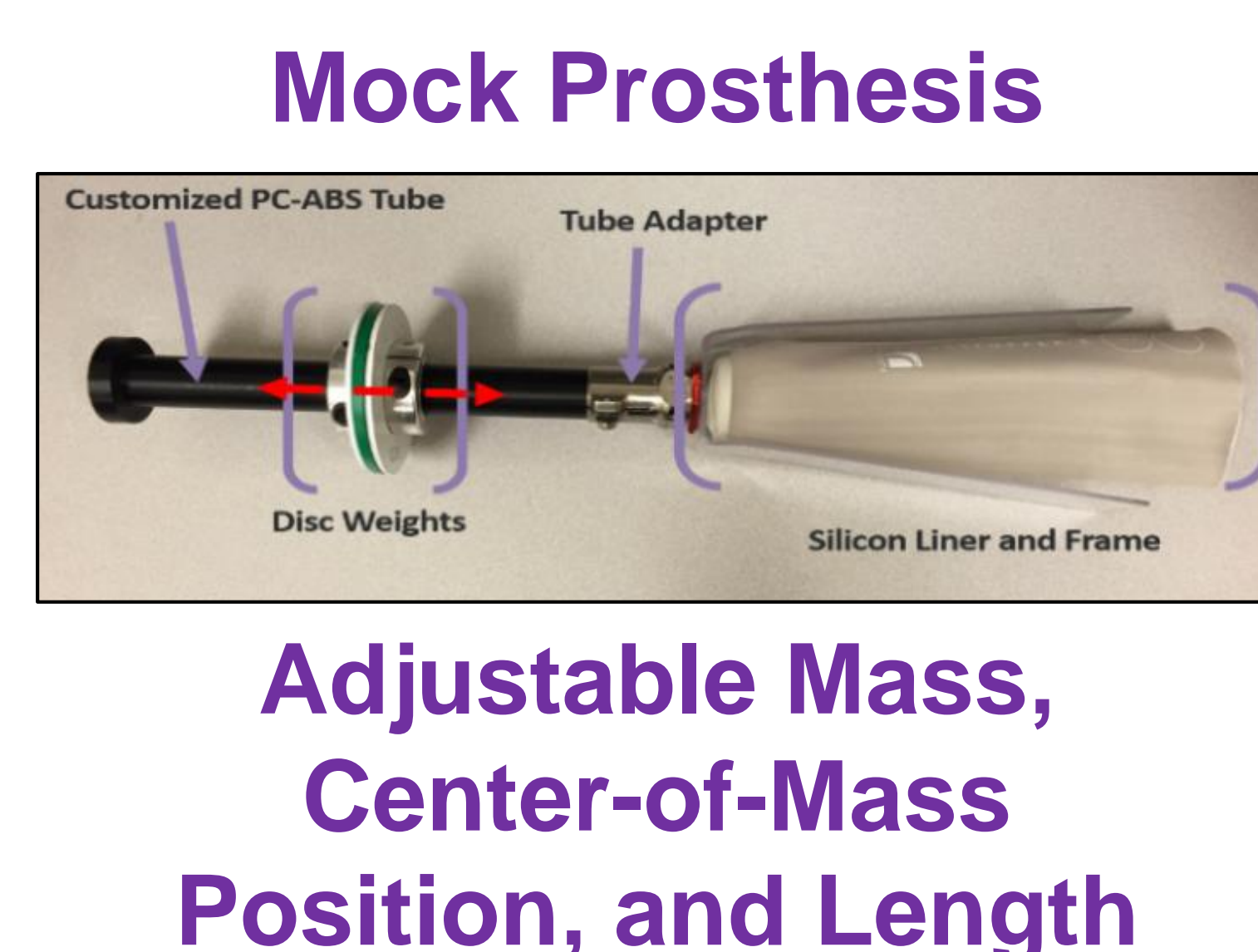
11 Able-Bodied  
(35±14 yrs,  
174.7±8.2 cm,  
78.9±13.4 kg)

11 Persons with Unilateral  
UL Loss (8 Transradial /  
3 Transhumeral, 50±18 yrs,  
175.1±7.4 cm, 79.6±22.6 kg)

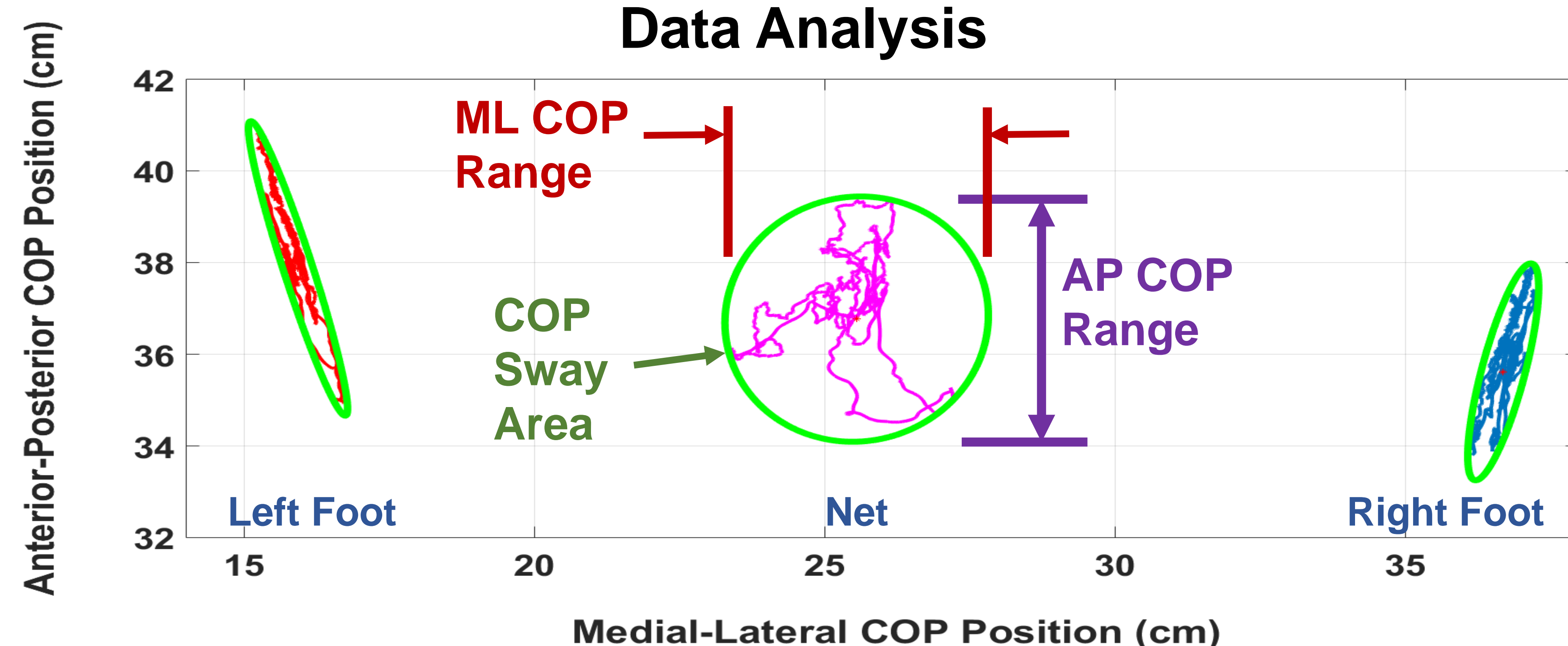


### Protocol

- 30 Seconds × 3 Trials
- Focusing on a Target
- Force Plate-Tracked COP
- UL Loss Conditions:
  - No Prosthesis
  - Customary Prosthesis
  - Mock Prosthesis



### Data Analysis



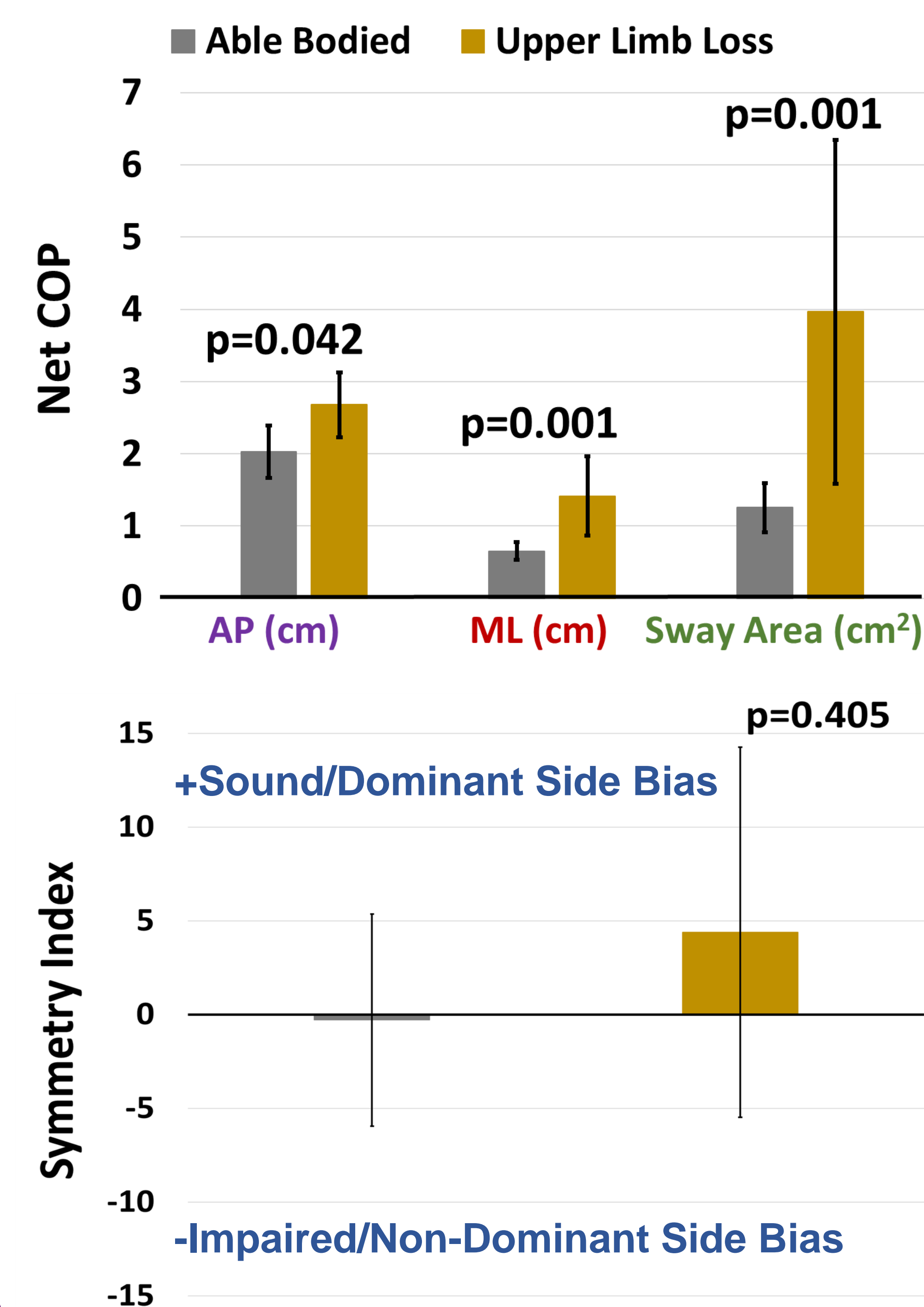
$$\text{Symmetry Index} \left( \frac{N}{N} \right) = \frac{\text{Sound, Dominant Load} - \text{Impaired, Non-Dominant Load}}{0.5 \times (\text{Sound, Dominant Load} + \text{Impaired, Non-Dominant Load})}$$

### General Linear Model

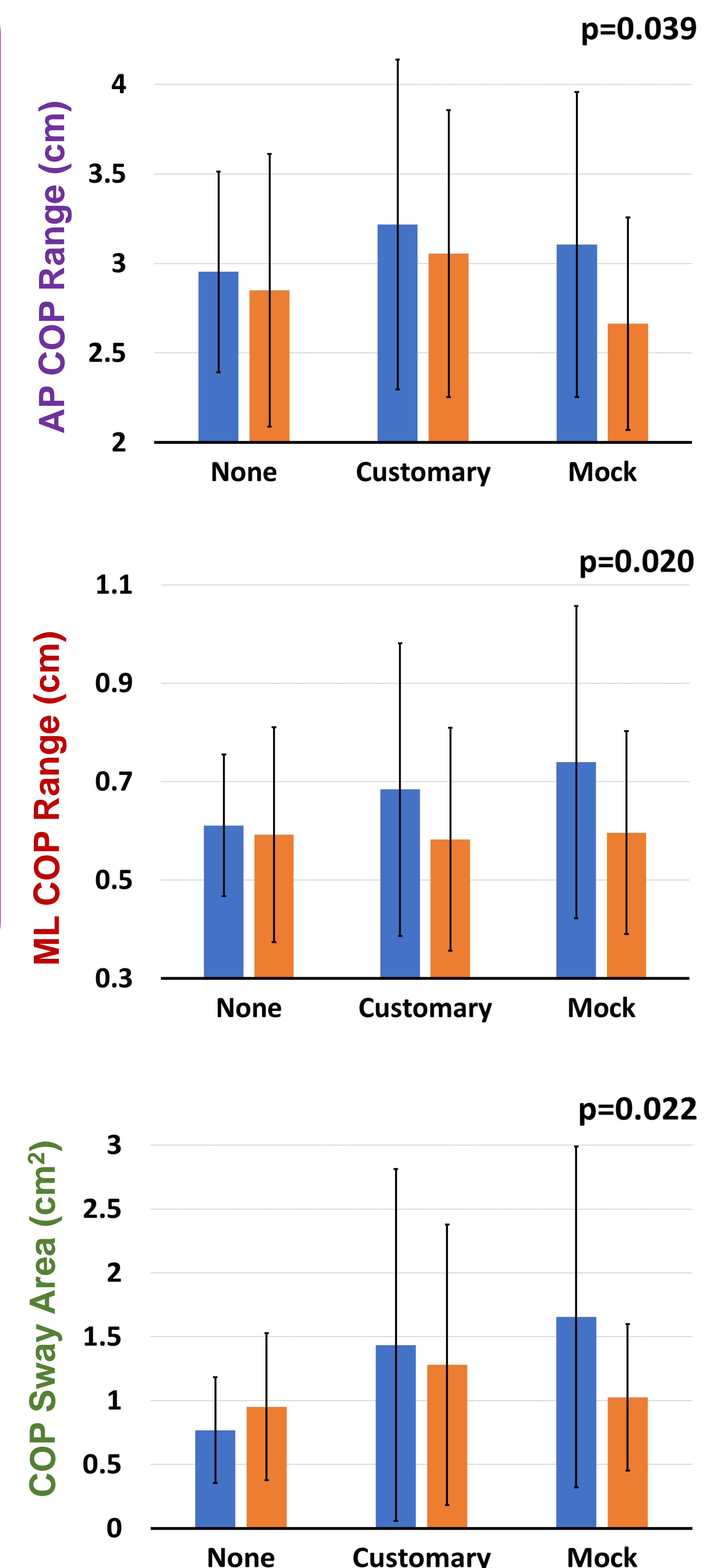
Persons with UL Loss: Side x Condition x Group (Fallers, Non-Fallers)  
Able-Bodied vs. UL Loss: Group  
Covariates: stance width, body mass index ( $\alpha=0.05$ )

## Results

### Able-Bodied vs. Upper Limb Loss



Sound Impaired



## Discussion

- H1 supported:** Persons with UL loss not wearing a prosthesis displayed greater COP sway than able-bodied controls, with no significant difference in weight symmetry.
- H2 supported:** Wearing a prosthesis improved weight symmetry with greatest symmetry when prosthetic limb mass is matched to the sound limb.
- H3 supported:** Wearing a prosthesis appears to cause an acute increase in COP sway, but no difference between limb side or fallers versus non-fallers.
- UL loss may increase postural demands, while wearing a prosthesis may disturb standing balance, but the link to fall risk warrants further exploration (Pizzigalli 2016).

## References

Imaizumi S, et al. *Conscious Cogn*, 45, 2016. Pizzigalli L, et al. *J B Mov Ther*, 20, 2016.  
Major MJ. *16th ISPO World Congress*, 2017. Shafeie M, et al. *IEEE EMBS*, 2012.

## Acknowledgements

We thank John Brinkmann, CPO, for helping design the mock prosthesis and Suzanne McConn for data collection assistance. Work was supported in part by the NU Undergraduate Research Assistant Program and the US Dept. of VA (#1121RX001388 and 1K2RX001322).