# Metabolic differences in gait adaptation to a hip vs. ankle exoskeleton

Kennedy G. Kerr[1], Hansol X. Ryu[2], Dongho Park[2,3], Amro Alshareef[2,3], Hangyeol Song[2], Aaron J. Young[2,3], Gregory S. Sawicki[2,3]

[1]Wallace H. Coulter Department of Biomedical Engineering, Emory University and the Georgia Institute of Technology, Atlanta, GA
[2]Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA
[2]Institute for Robotics and Intelligent Machines, Georgia Institute of Technology, Atlanta, GA

PoWeR Lab — Physiology of Wearable Robotics · Emory University · Georgia Tech

## Exoskeleton adaptation reflects nervous system adaptation to a novel environment

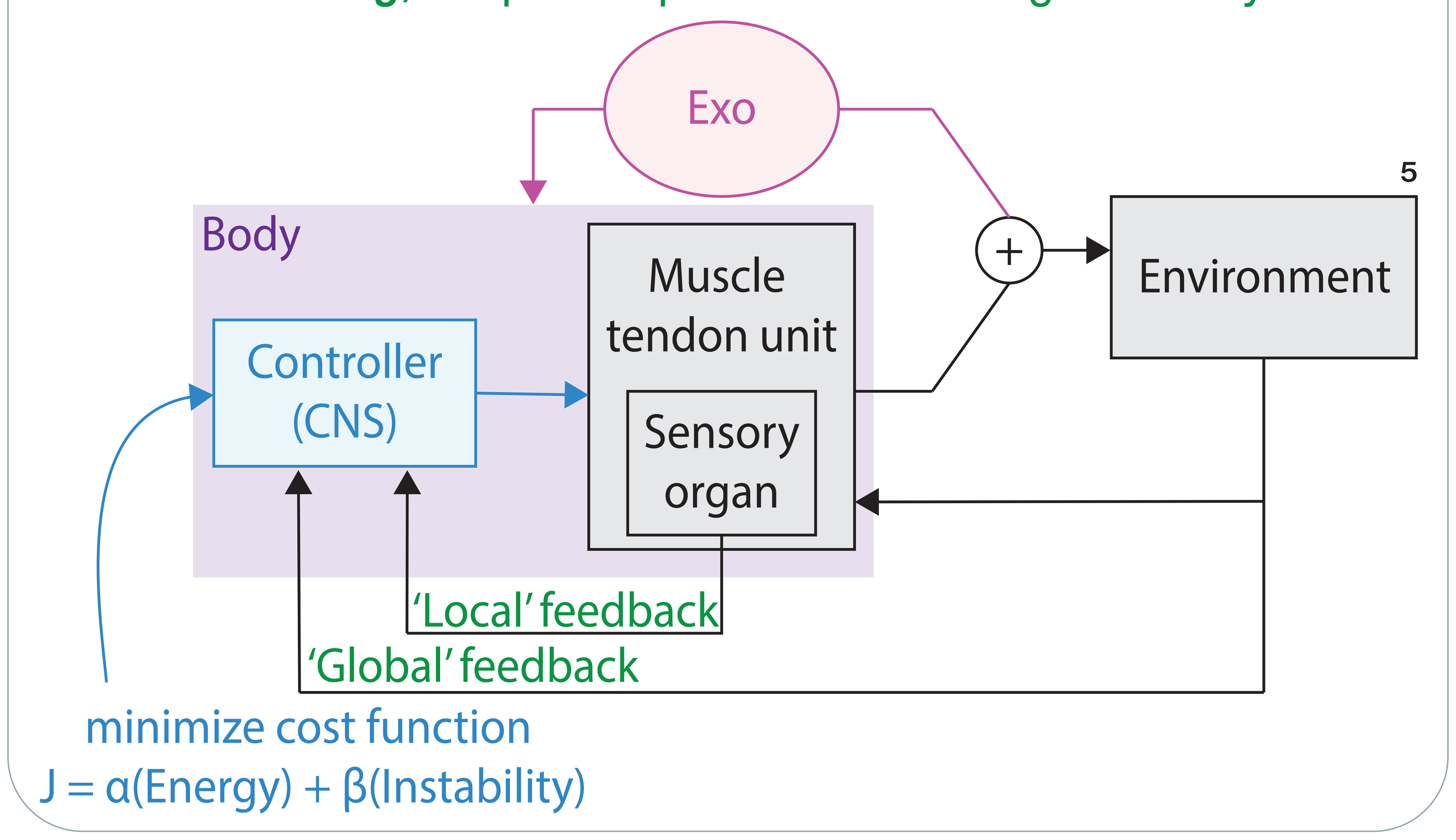
- Exoskeletons can probe gait adaptation at a single joint.[1,2,3]
- Metabolic cost reduction is a measure of gait adaptation[4] and a common goal of exoskeleton use.
- Effects of joint anatomy and individual differences on exoskeleton adaptation are unclear.

### Question: Does adaptation differ between joints?

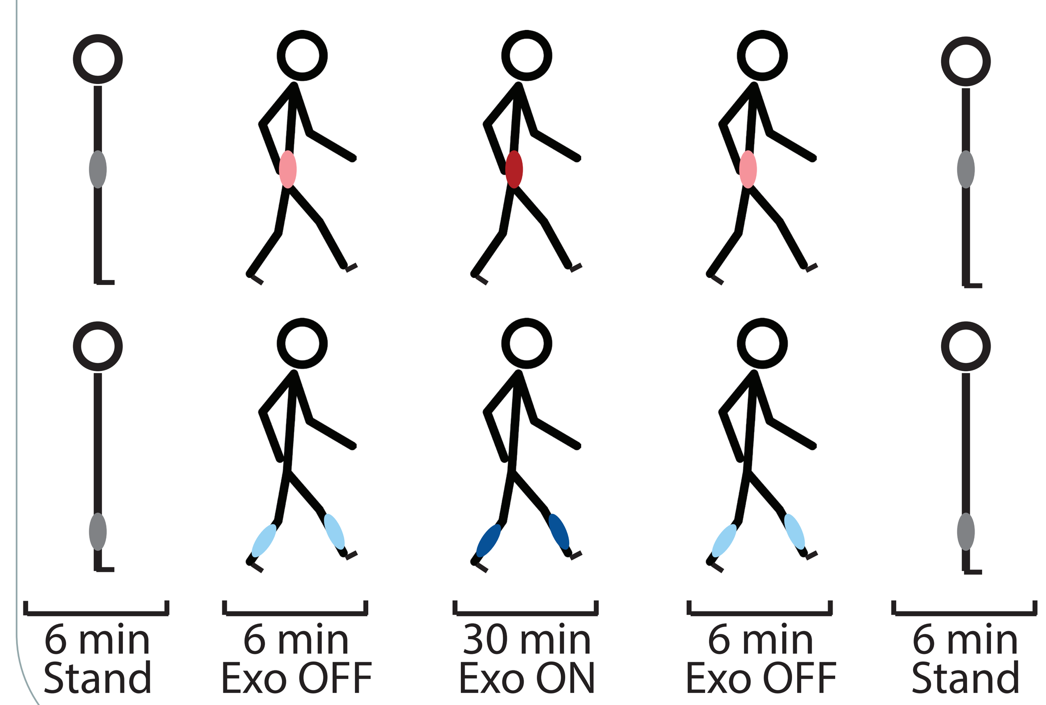
Hypothesis: Adaptation to an exoskeleton at a *proximal* joint occurs faster than at a *distal* joint.

Local: Joints with a ***compliant tendon*** (ankle), sensory input is attenuated, J is difficult to approximate.

Global: Perturbations at a distal joint (ankle) are more ***destabilizing***, adaptation prioririzes reducing instability.




## Metabolic cost tracks adaptation to each device during a single trial



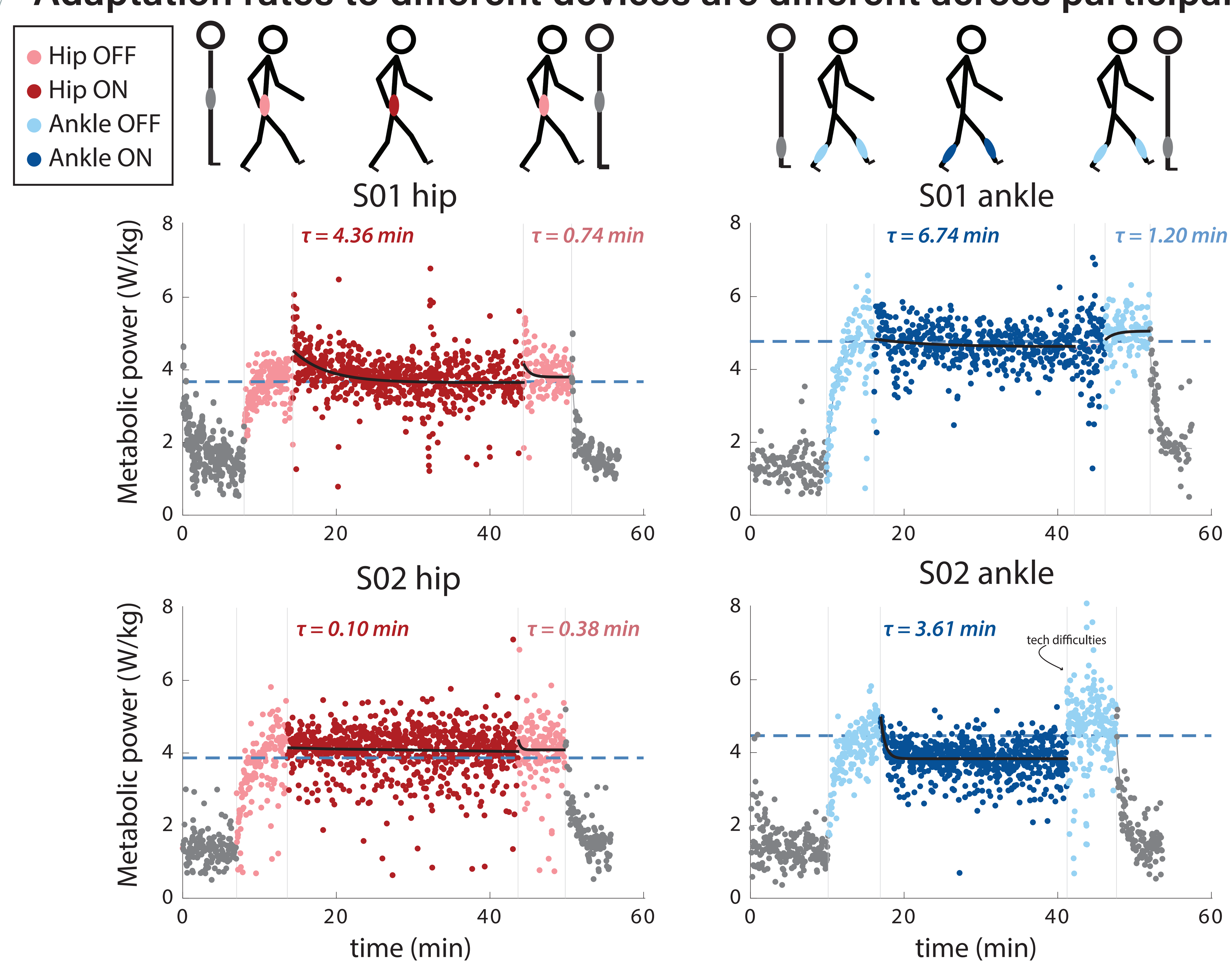

N = 2 able bodied young adults

- Treadmill walking at 1.25ms
- Metabolic cost using indirect calorimetry
- Pseudo-random trial order

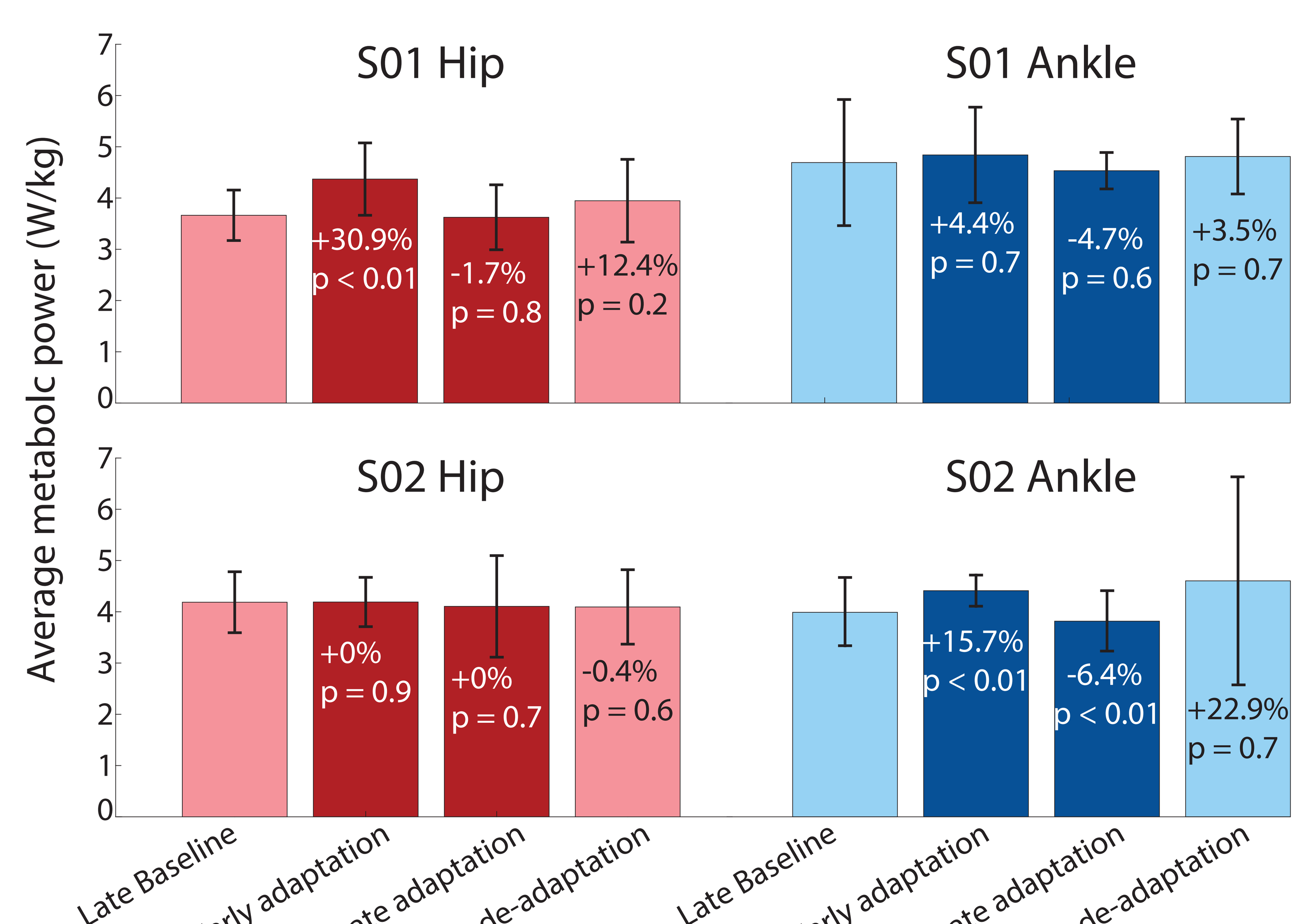
Hip = 10% biological hip flexion[6]

Ankle = 10-15% biological ankle plantarflexion[7]

## Adaptation rates to different devices are different across participants



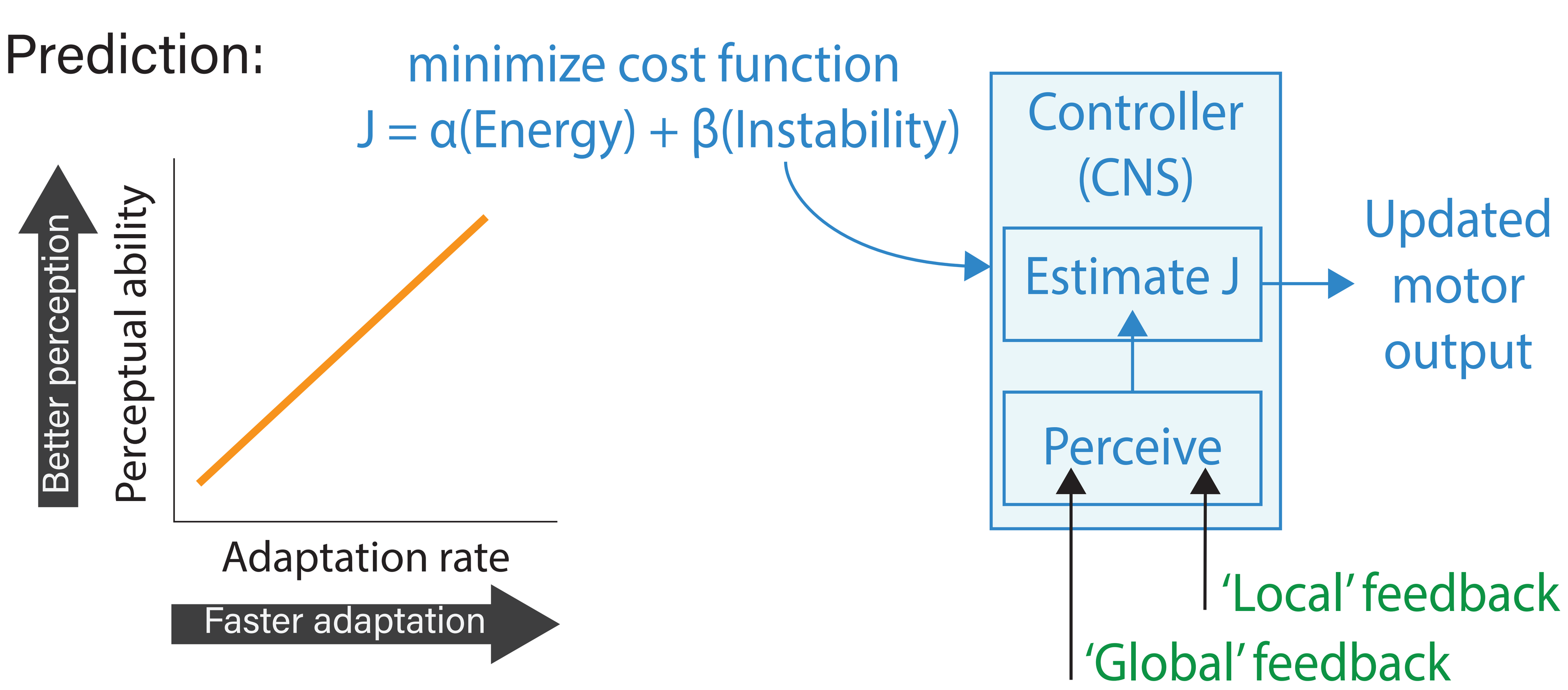

Compared to baseline walking, trends in metabolic cost during adaptation and de-adaptation are opposite across participants.




## Next Steps

- Future work will implement comparable control across devices.
- Individual differences in gait adaptation may be related to whole body motion perception[8,9] and sensorimotor integration.[10]

Prediction:




- Understanding mechanisms of exoskeleton adaptation may allow for more personalized and efficient device selection.

## References

[1] Poggensee and Collins 2021, [2] Sawicki and Ferris 2008, [3] Franks et al. 2021, [4] Finley et al. 2013, [5] Seethapathi et al. 2024, [6] Molinaro et al. 2024, [7] Zhang et al. 2017, [8] Hoogkamer et al. 2015, [9] Sombric et al. 2019, [10] Jacobsen and Ferris 2023

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contact: kgkerr@gatech.edu