Assessing gait quality for the development of a human-in-the-loop tuning algorithm for robotic ankle prostheses

Kinsey Herrin, MSPO, C/LPO, FAAOP[1], Sam Kwak[1], Audra Davidson[1], Young-Hui Chang, PhD[1]

Xiangrong Shen, PhD[2], Edward Sazonov, PhD[2]

[1]Georgia Institute of Technology, Atlanta, GA

[2]University of Alabama, Tuscaloosa, AL

## Powered robotic prostheses can improve gait, but are time-consuming for clinicians to tune

- There are **more than 1.6 million people living with limb loss**, which is expected to more than double by 2050[1]
- Powered **robotic prostheses may improve metabolic cost, joint loading, and overall mobility**[2]
- **Tuning powered prostheses is time consuming** for clinicians and **based on subjective, observational metrics**

## "Good gait" is hard to define and quantify

- There are many ways to measure gait, making it **difficult to determine when gait is "good" or "bad"**
- Recent studies have attempted to combine biomechanical measures (joint angles, kinetics, etc.) to create indices of gait quality, but it is **unclear what measure is most sensitive to changes in gait**

This project aims to use **gait quality metrics** to develop an algorithm that will **automatically tune robotic prostheses** using a trunk motion sensor
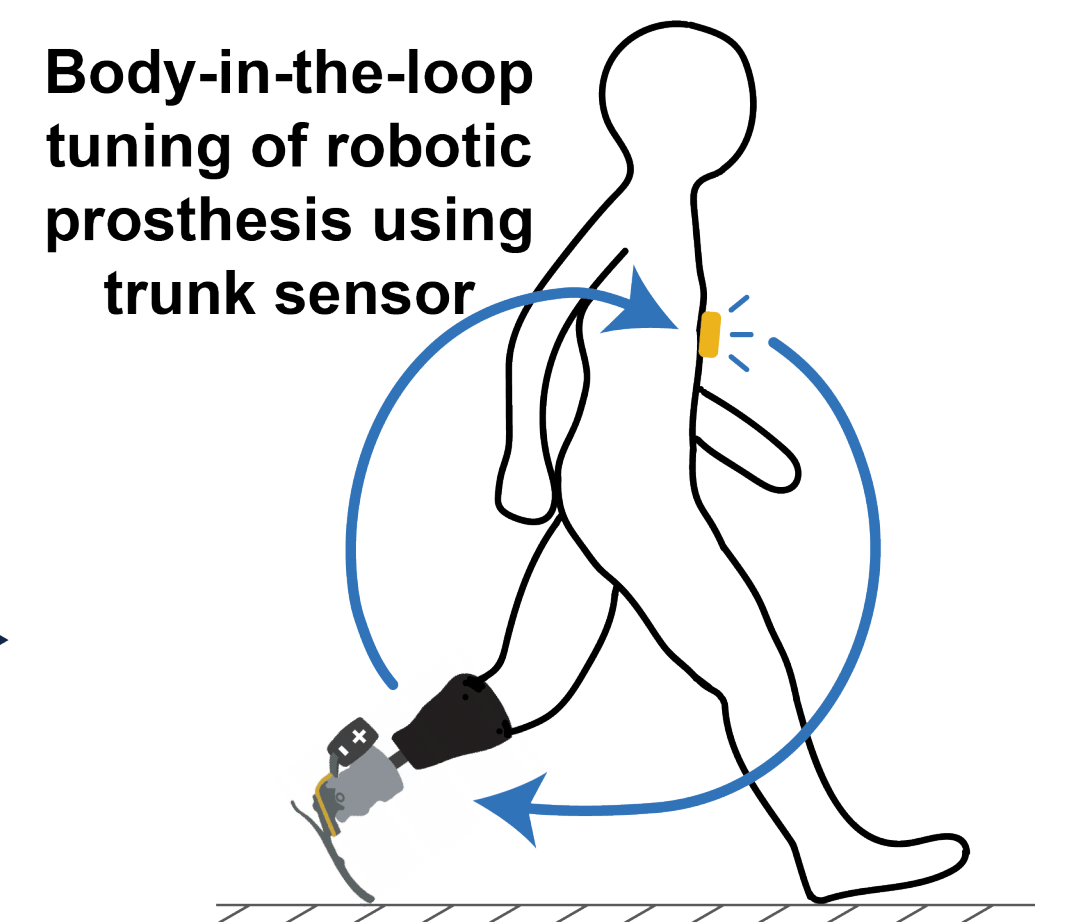
1. Quantify gait quality
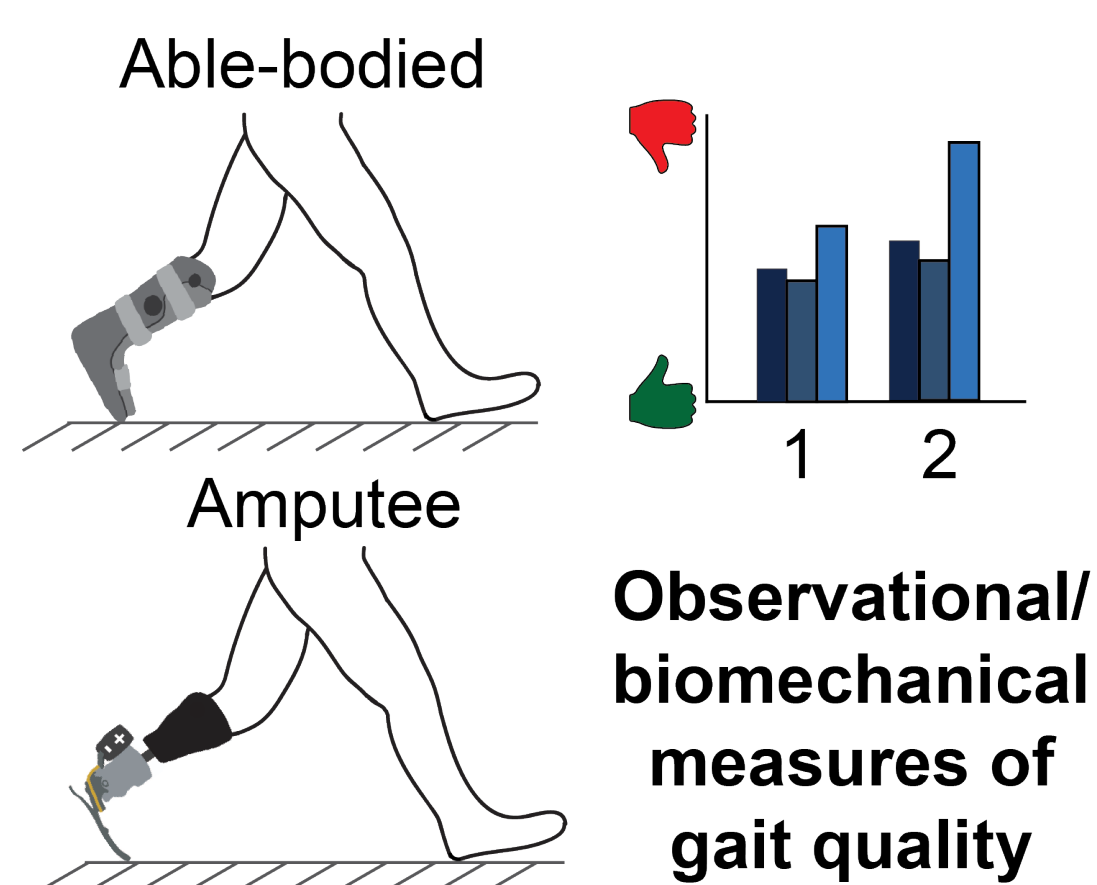
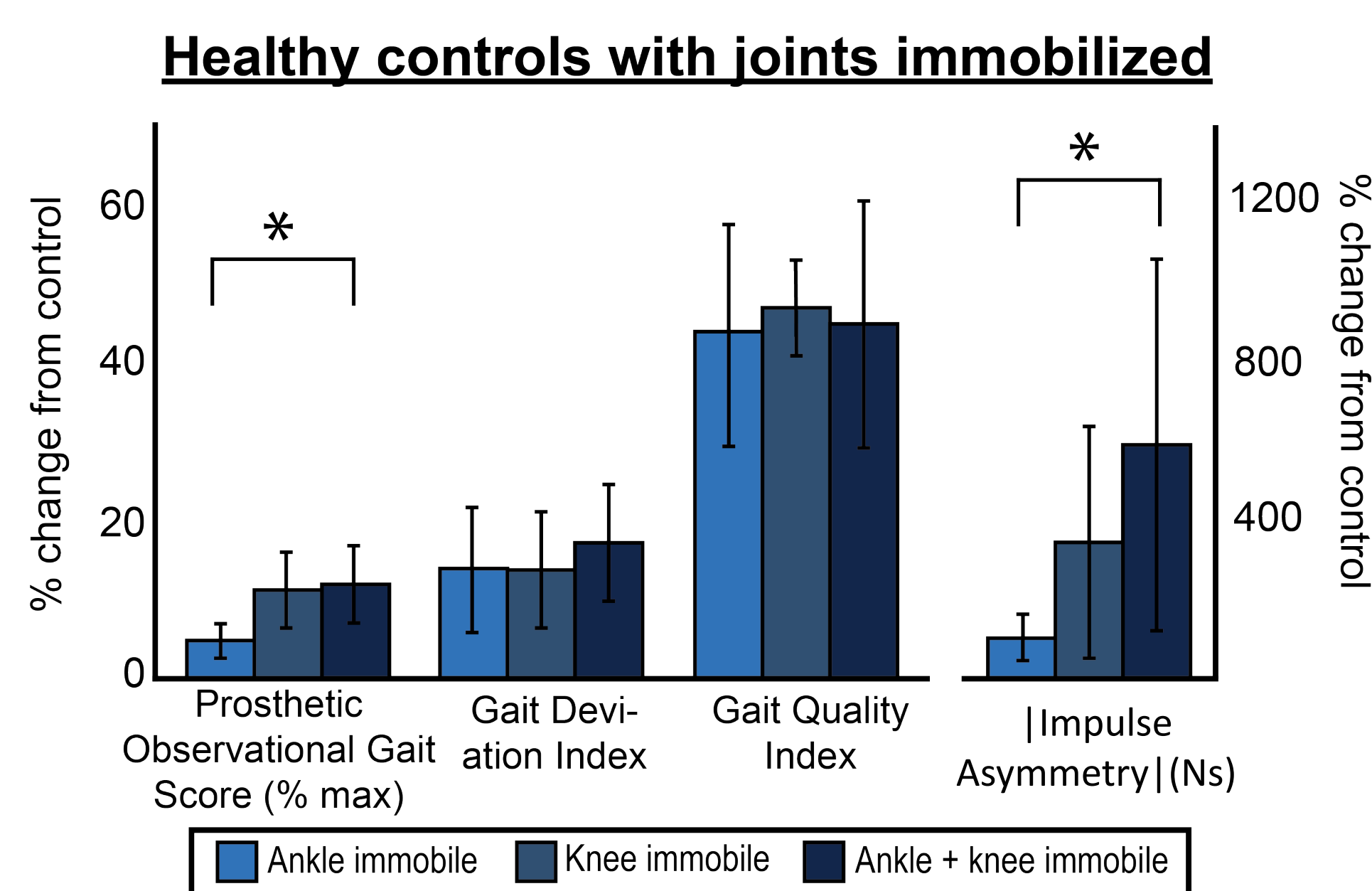### 2. Gait quality metrics to inform algorithm and trunk sensor development
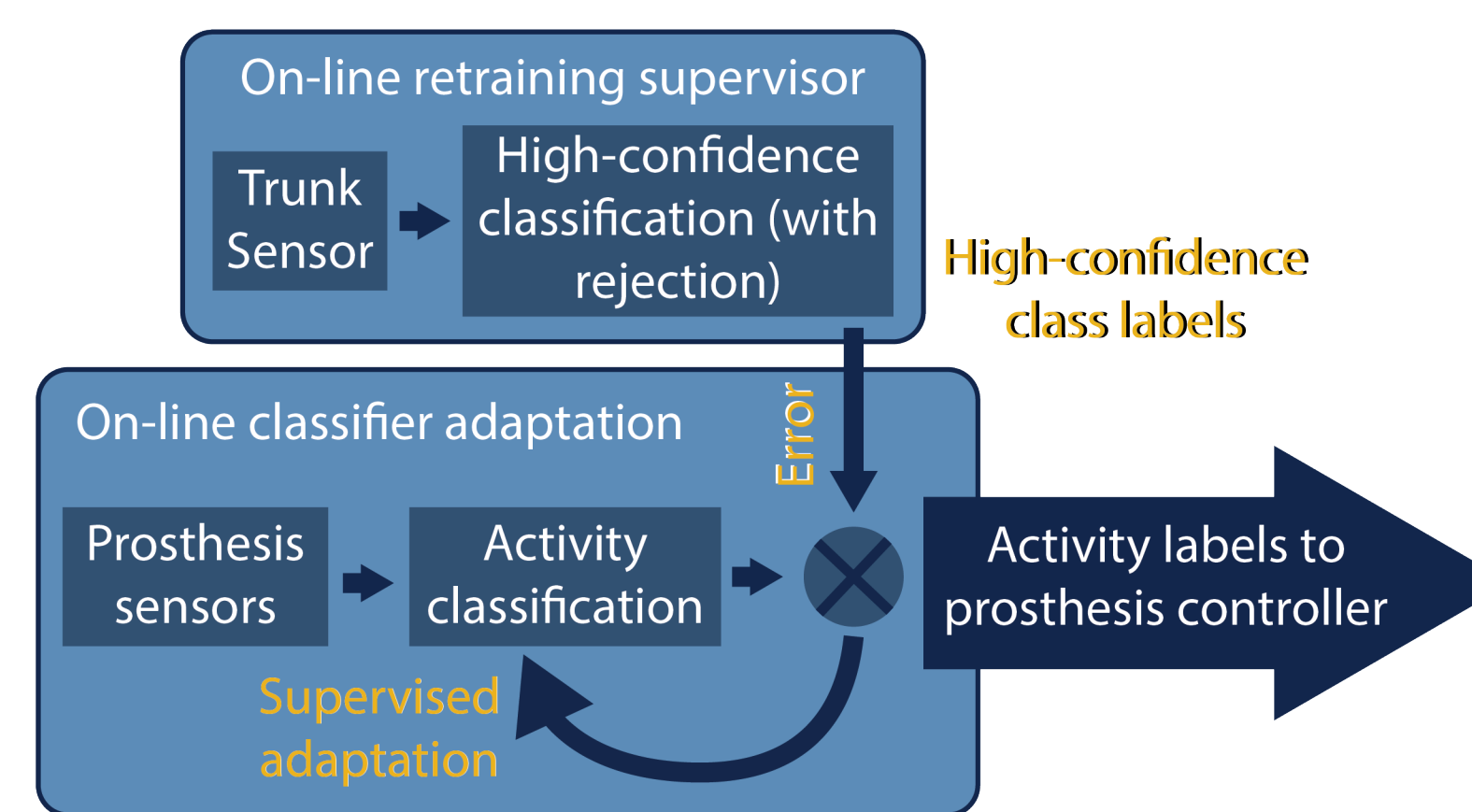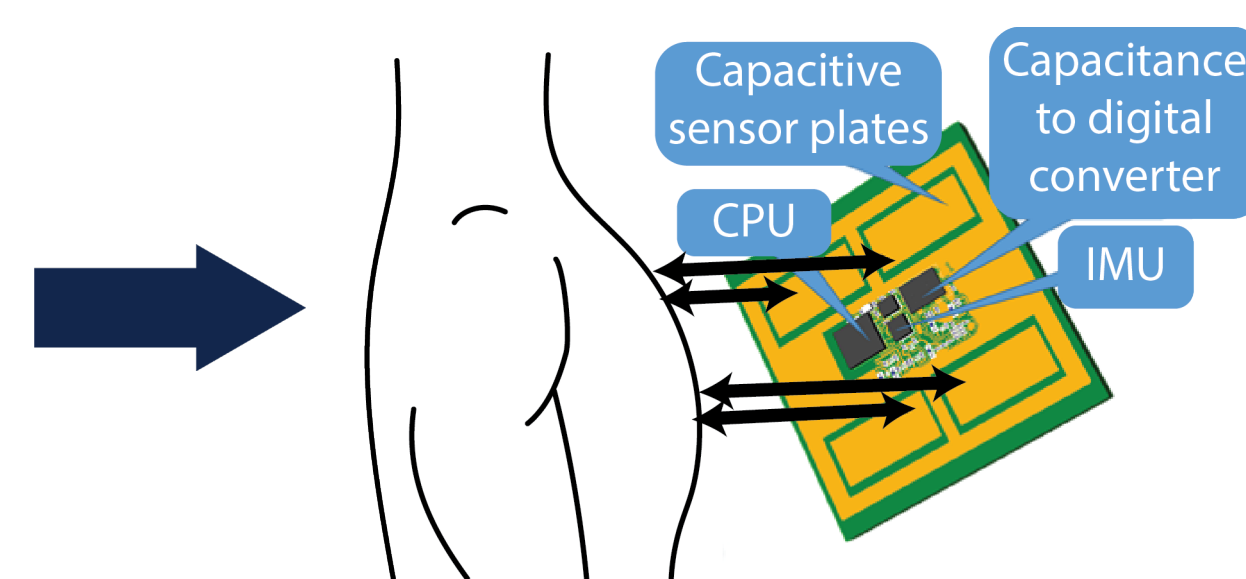
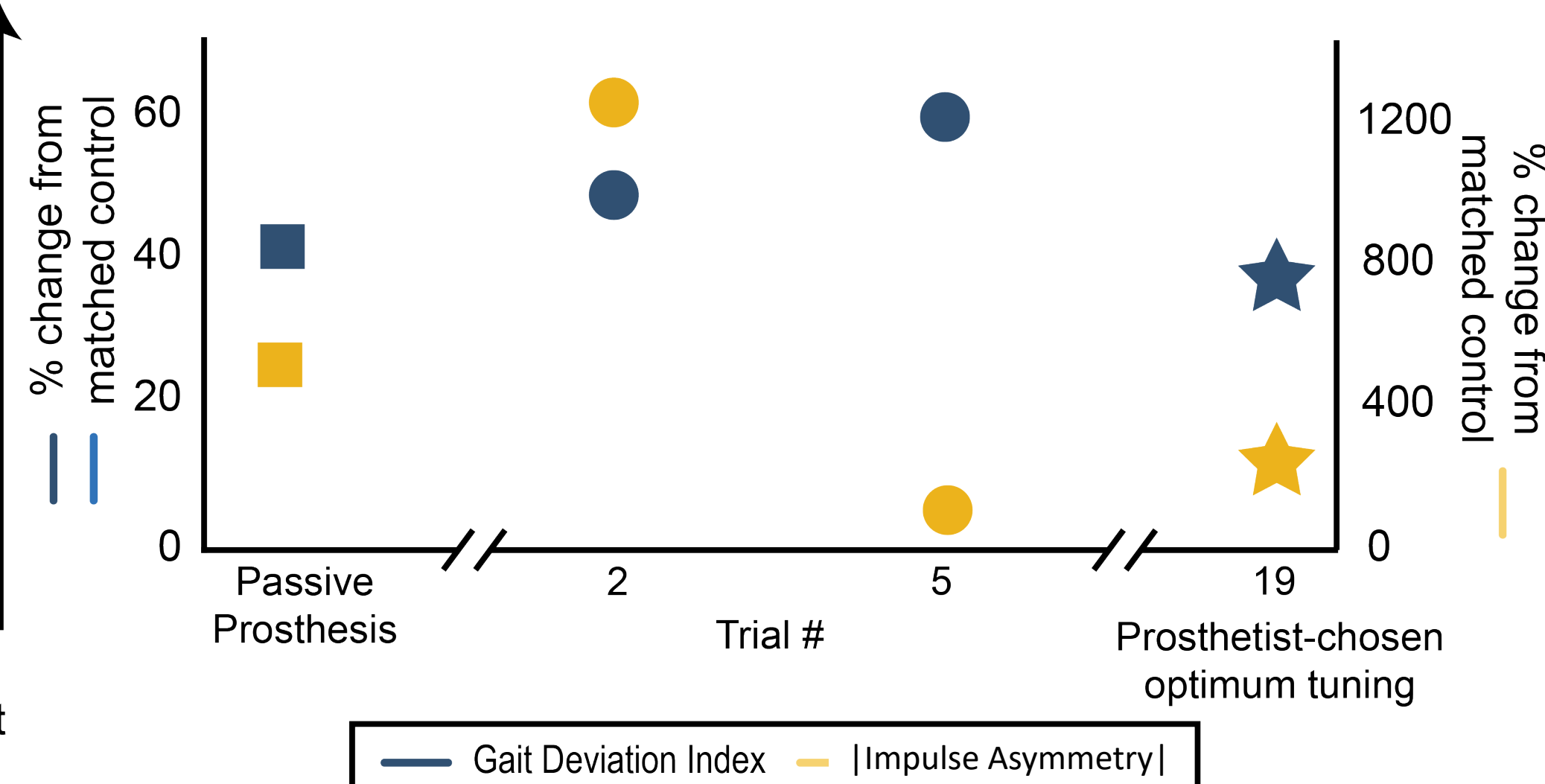### 3. Automatically tune prosthesis to optimize gait quality

Gait quality assessment

- 5 healthy control subjects walked with various joint-immobilization conditions
- 1 patient w/ BK amputation walked w/ a prosthesis emulator[3]. Tuning parameter space was explored.
- Gait quality was assessed using an observational score (POGS)[4], indices of kinematic and kinetic deviations (GDI[5], GQI[6]), and kinetic data (impulse asymmetry)
- Data were compared to control values using RM ANOVA.
- * = significant difference at $\alpha=0.05$

Worse than control gait

Matches control gait

Worse than control gait

Matches control gait

Healthy controls with joints immobilized

Ankle immobile | Knee immobile | Ankle + knee immobile

Patient with below-knee amputation matched to control

Gait Deviation Index | |Impulse Asymmetry|

Scientific & Broader Impacts

This project will **aid clinicians, patients, and roboticists** in their **development of robotic assistive devices** by making the **tuning process quicker and more accurate**

This project has given our group the opportunity to participate in **outreach programs for over 50 underrepresented elementary and middle schoolers**, such as the *Programs for Enrichment and Accelerated Knowledge in STEAM* and *Hands On Future Tech*. We have led **activities about anatomy and physiology** and shown how those principles are **applied to the development of robotic assistive devices**.

References

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4. Hillman, et al. (2010). *Gait & Post., 32*(1), 39-45.
5. Schwartz, et al. (2008) *Gait & Post., 28*(3), 351-357.
6. Marks et al. (2018). *Sci Rep., 8*(1), 1-12.