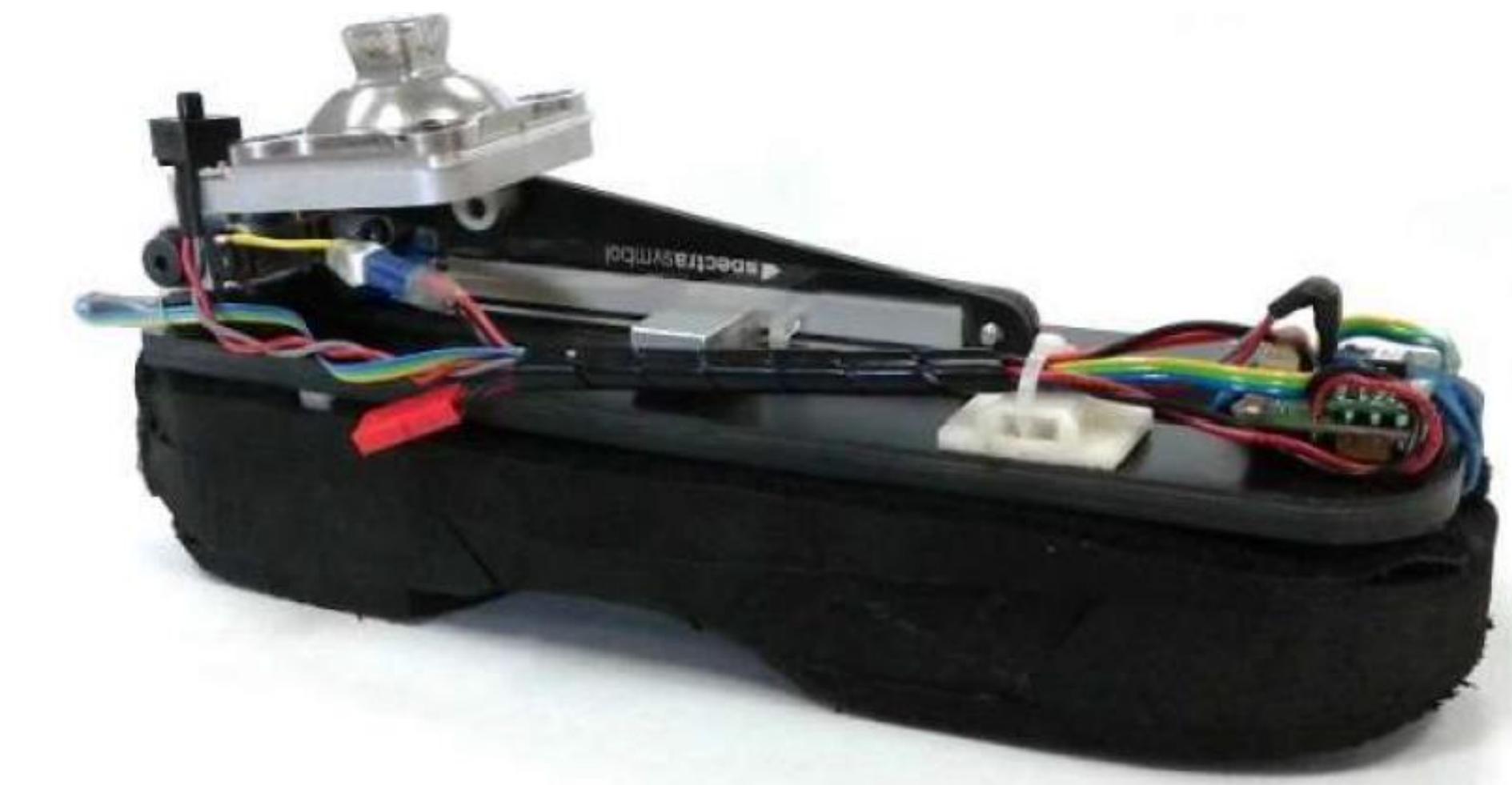


# Variable Stiffness Foot provides Users with Adjustment of Knee and Ankle Mechanics



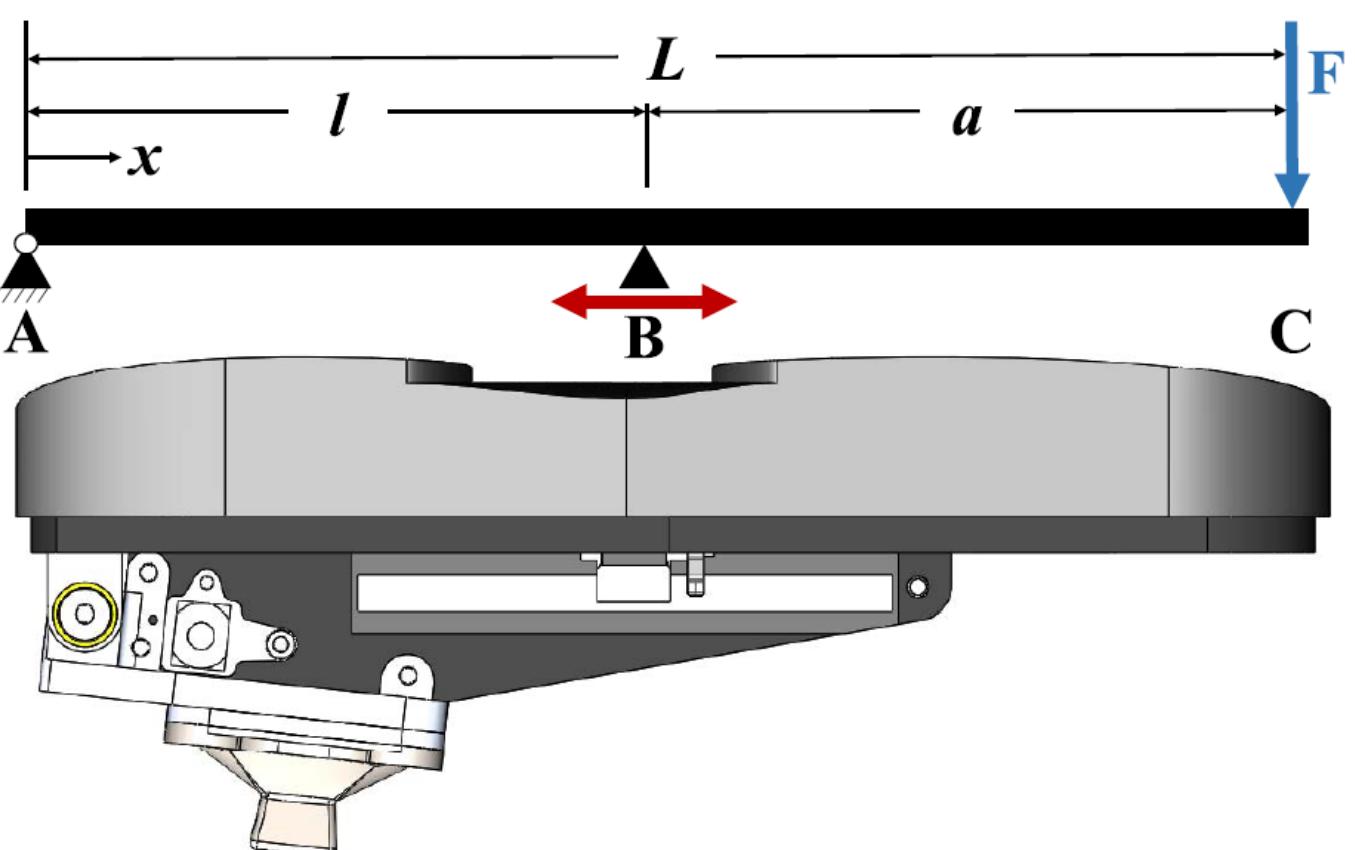
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## Introduction

### Variable Stiffness Foot (VSF)

- Low Power
- Lightweight
- Adaptable



### Hypotheses for mechanics using stiffer foot:

#### Angle:

- Decreasing peak ankle dorsiflexion
- Increasing peak stance phase knee extension angles

#### Moments:

- Increasing peak plantarflexor ankle
- Decreasing peak knee flexor moment

#### Energy:

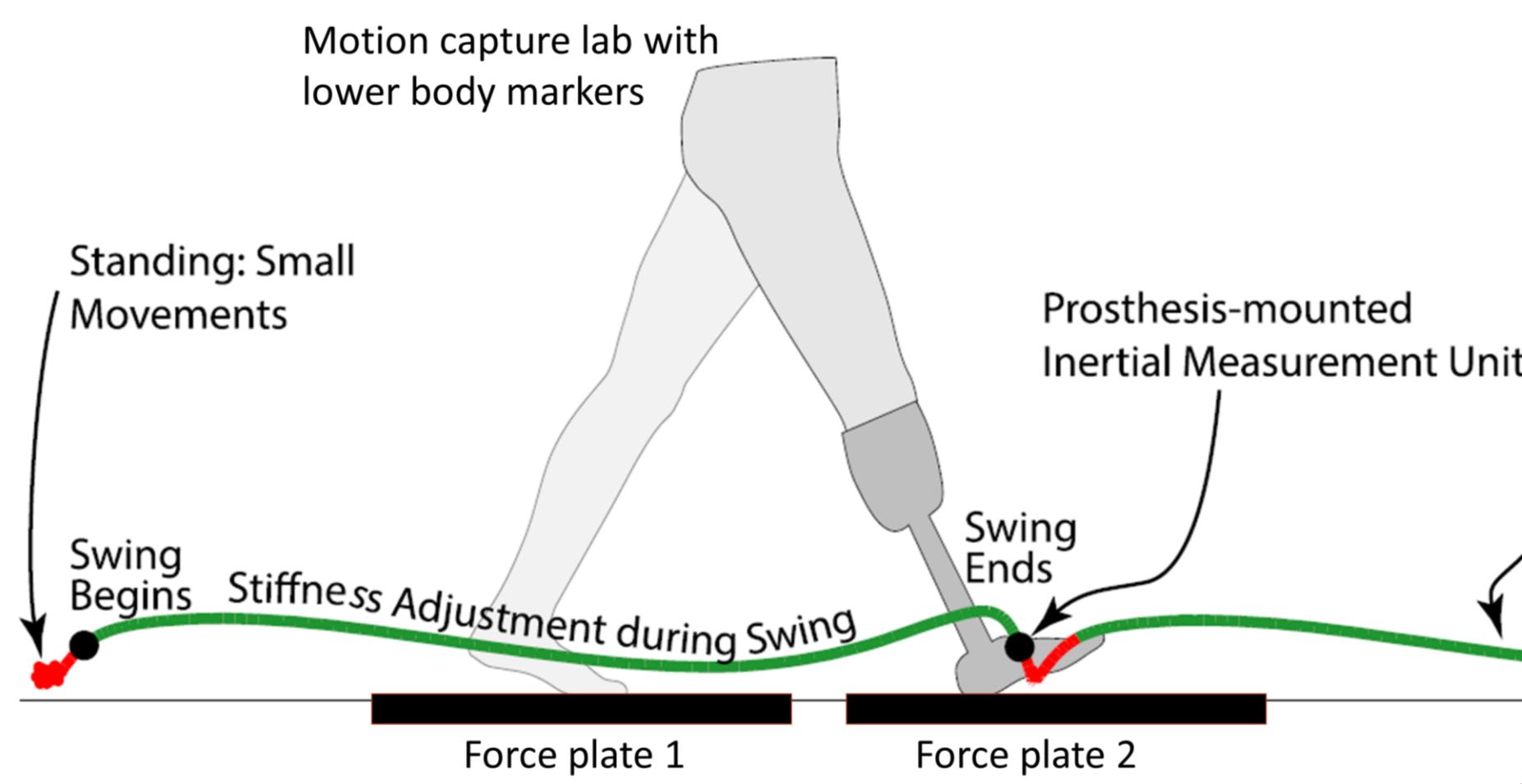
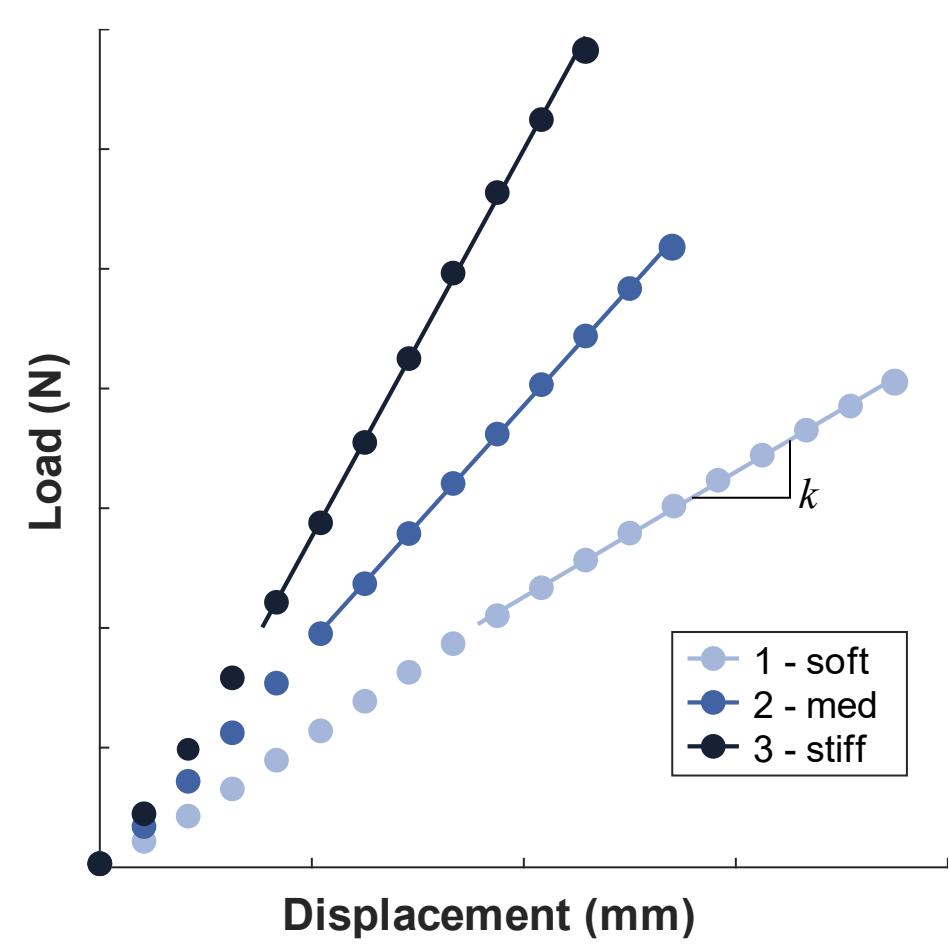
- Decreasing peak unified deformable (UD) power
- Increasing UD energy storage (excluding heel collision)
- Decreasing UD energy return

#### Force:

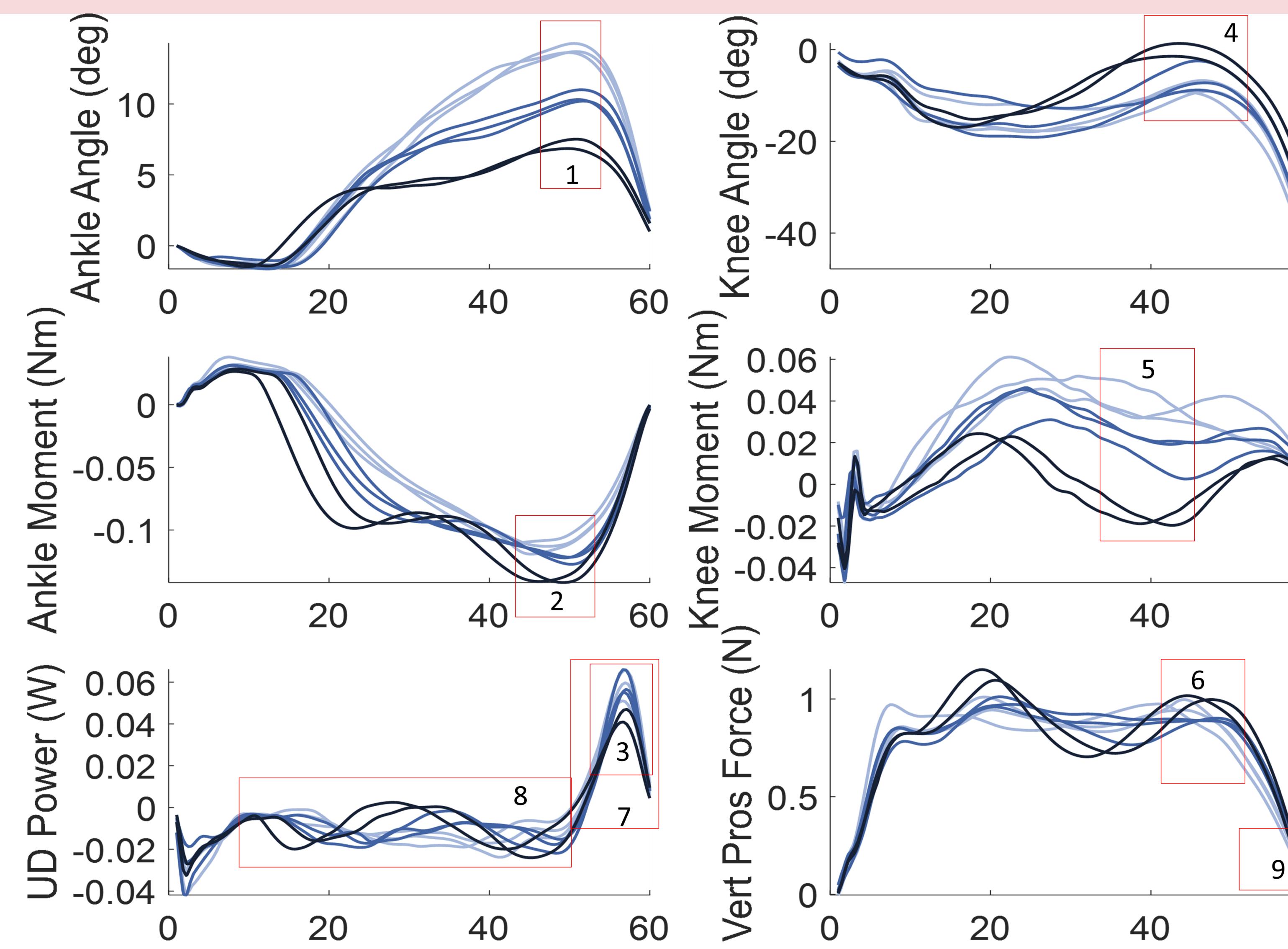
- Increasing off-loading rate of vertical ground reaction force (vGRF)
- Increasing second peak of vGRF

## Method

- N=7 with transtibial amputation
- Three different stiffness for 3 walking trials each at 1.1 m/s
- Mixed linear effect for ankle and knee angles, moments, and UD power, energy storage and return for the non-dimensionalized data



## Results and Discussion



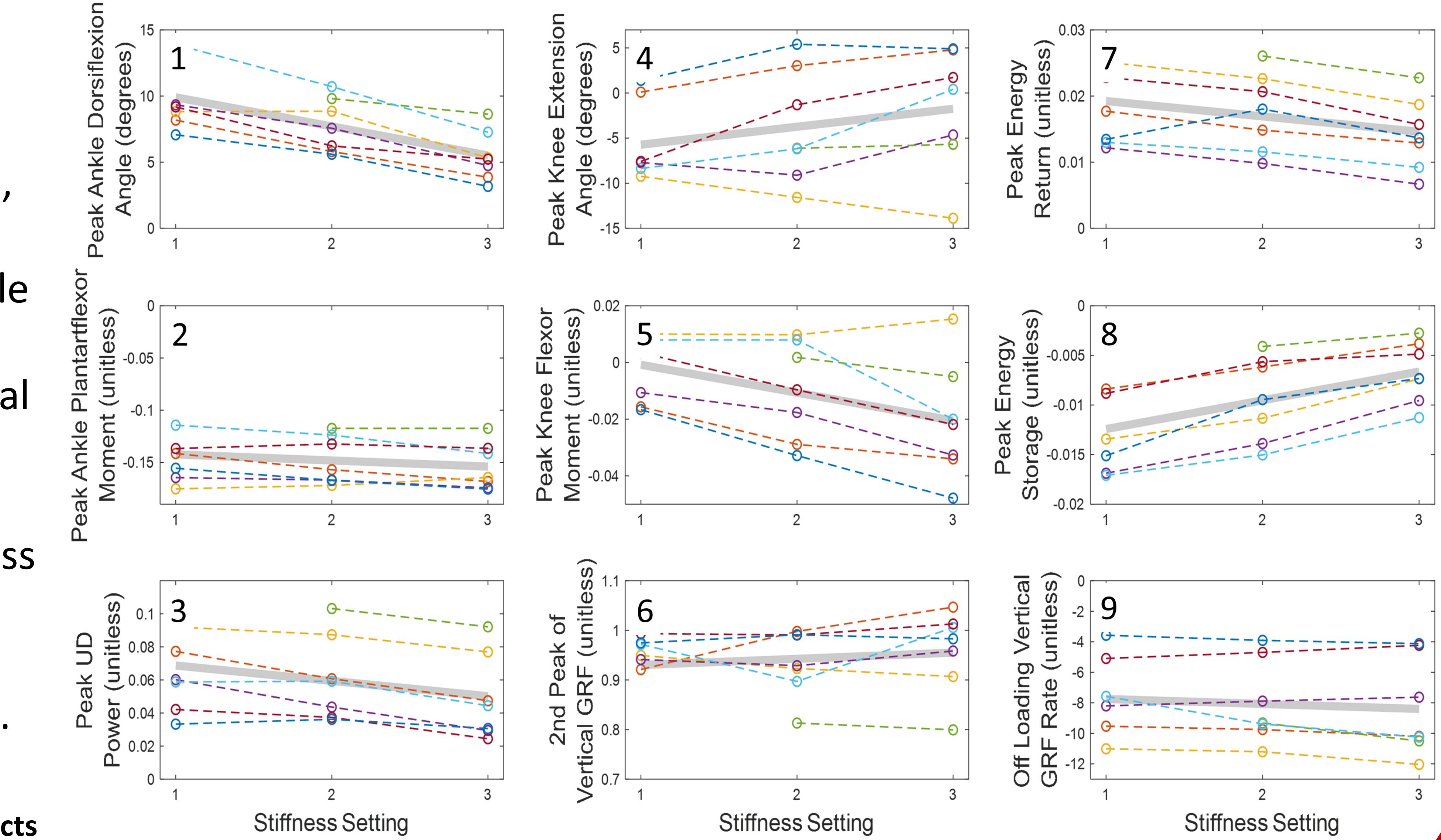
### Example Data from representative subject

Ankle and knee angles and moment, Unified Deformable (UD) power, and vertical prosthetic force of prosthetic side of representative subject from three steps per stiffness (non-dimensionalized and normalized to 0-60% of entire stride). Positive is dorsiflexion for ankle and extension for knee.

## Results

General mixed linear effects trends with increased stiffness:

- Decreased peak ankle dorsiflexion\*\* and increased peak knee extension angles\*\* in late stance
  - Increased peak plantarflexor ankle\*\* and decreased peak knee flexor moments\*\* before the peak joint angles
  - Decreased peak UD power for push off\*\*\*, decreased energy storage in foot rollover\*\*\*, and decreased energy return\*\* in late stance
  - Increased off-loading rate \*\*\* and increased second peak\*\* of vertical ground reaction force in late stance
- Strong(\*\*), moderate (\*\*), and weak (\*) trends relate to  $r^2>0.95$ ,  $0.85< r^2<0.95$ , and  $r^2<0.85$ , respectively. All p-values were below 0.0001.



### Summative Results from all subjects

Mixed linear effect trends for ankle and knee angles, moments, and UD power, energy storage and return for the non-dimensionalized data. The grey bar represents the mixed linear effects fit of all subjects for the given metric. Plantarflexion/flexor (ankle) and flexion/flexor (knee) are in the negative direction.

### REFERENCES:

- [1] Glanzer et. al, IEEE TNSRE 26.12, 2351- 2359, 2018.
- [2] Adamczyk et al, IEEE TNSRE, 23, 776-785, 2015.
- [3] Raschke et al, Journal of Biomechanics 48, 146-152, 2015