Sensitivity of Mechanical Outcomes to Various Stiffnesses of Variable Stiffness Foot

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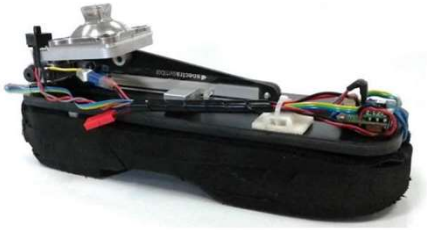
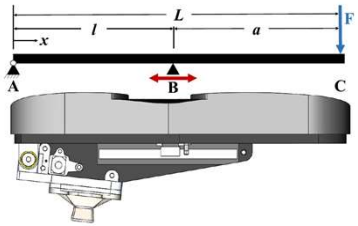


Introduction

Variable Stiffness Foot (VSF)

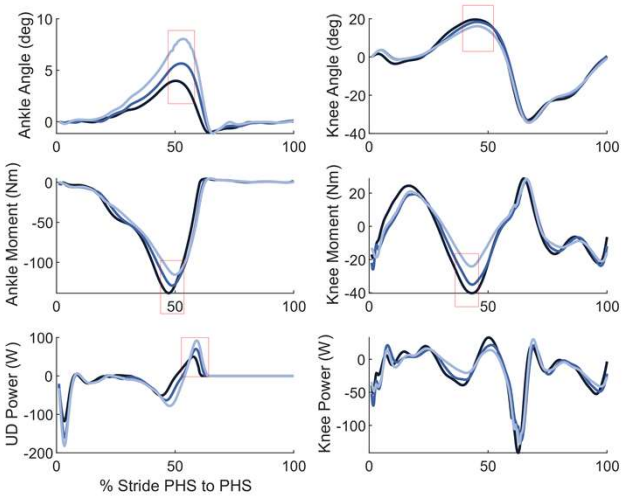
• Low Power• Lightweight
• Adaptable stiffness



Hypotheses for mechanical effects with stiffer foot:

- Decreased peak ankle dorsiflexion, increased plantarflexor moment, and decreased push off energy return
- Increased stance phase knee extension angle and decreased flexor moment

Representative mechanical outcomes

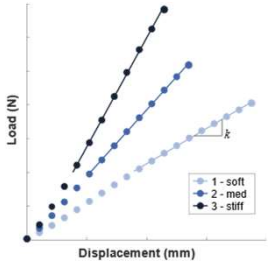


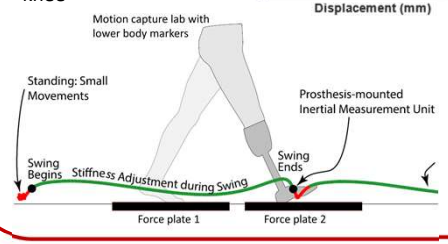
Main results

- Metrics shown on left from representative subject. PHS is prosthetic heel strike. Positive is dorsiflexion for ankle and extension for knee.
- Stiffer VSF has smaller excursion of dorsiflexion and less plantarflexor moment
- It also has more peak UD power during toe off which correlates with more push off energy. UD Power is the Unified Deformable body that specifies the power flow through the prosthesis.
- More extended knee angle is associated with increased flexor knee moment and ankle plantarflexor moment
- No distinctive features of Knee Power

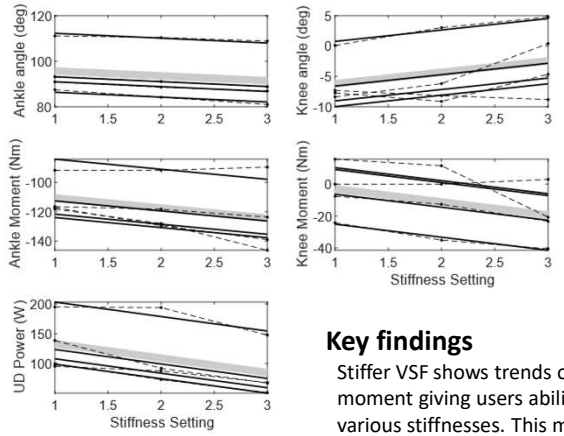
Method

- N=4 with transtibial amputation
- Three different stiffness for 3 walking trials each at 1.1 m/s
- Calculated outcomes of angle, moment, and power for ankle and knee





Summative results



Discussion

- General linear trends with increasing stiffness:
  - Decreased peak plantarflexion ankle angle,
  - More negative (plantarflexion) peak ankle moment
  - Decreased UD power
  - Increased knee extension angle
  - Decreased knee flexor moment
- Data analysis for 2-4 other subjects and appropriate statistics need to be completed

Key findings

Stiffer VSF shows trends of increased knee extension, knee moment, and ankle moment giving users ability to modulate various mechanical outcomes based on various stiffnesses. This modulation will hopefully aid in their gait across level and sloped surfaces, and stairs.

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Biomechatronics, Assistive Devices, Gait Engineering, & Rehabilitation

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REFERNCES:
[1] Glanzer et. al, IEEE TNSRE 26.12, 2351- 2359, 2018.
[2] Adamczyk et al, IEEE TNSRE, 23, 776-785, 2015.
[3] Torburn et al. Clinical Orthopaedics, 303 185-192, 1994
[4] Hansen et al. Gait & posture 32.2 181-184, 2010