TOWARDS ENHANCING GAIT SYMMETRY AND METABOLIC COSTS FOR AMPUTEE GAITS WITH A POWERED TRANSFEMORAL PROSTHESES

MECHANICAL ENGINEERING
TEXAS A&M UNIVERSITY

HUMAN REHABILITATION (HUR) GROUP

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INTRODUCTION

Background

- Approximately 185,000 new amputations are operated each year in the U.S., and one of every five amputees have transfemoral amputations [1].

Problem Statement

- Transfemoral amputees have increased asymmetries and energy expenditure during walking [2],[3].

Device Design

- Brushless DC motors for both the ankle and the knee joints
- Utilizes: Inertial measurement unit on intact leg (IMU) and force sensors on foot of AMPRO II
- Height: 380mm
- Mass: 4.6kg

Control Features

- Knee
  - Human Inspired Control [4]
    - Attempts to create optimal walking trajectory based on parameters of user.
    - Uses feedback from intact leg to estimate step progression.
- Ankle
  - Flat Foot
    - Foot remains flat during walking.

Objectives

- To conduct a performance evaluation of AMPRO II and assess if improvements need to be made by studying.
  - Energy Expenditure
  - Kinematic Symmetry
  - Kinetic Symmetry
- Compare to Microprocessor knee.

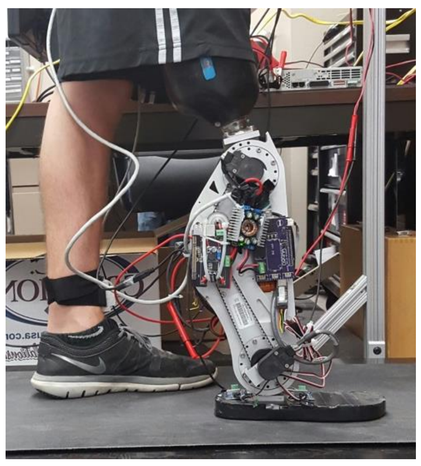
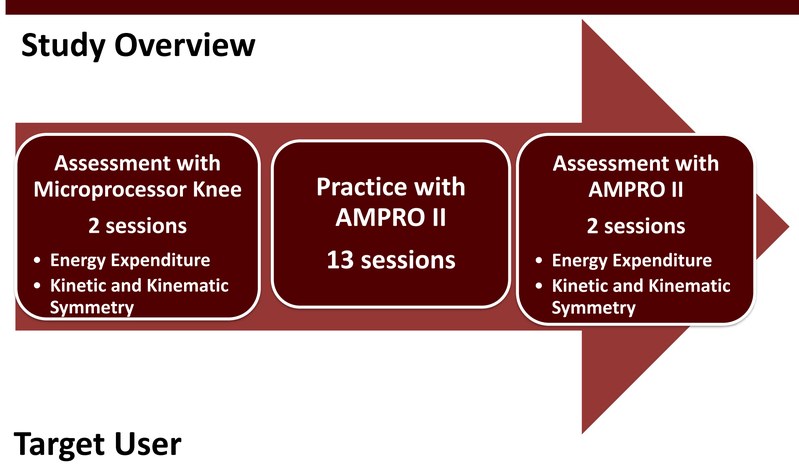


Fig. 1 Target user wearing AMPRO II.

METHODS

Study Overview



Target User

- Recruited one male transfemoral amputee.
  - Age: 21
  - Weight: 120lbs (without prosthesis)
  - Current Device: Genium microprocessor controlled knee and low profile Triton foot
  - Cause of Amputation: Cancer

Energy Expenditure

- VO2 Max test
  - Measures oxygen uptake over time.
- Walked at self-selected walking speed for 5 minutes.

Motion Capture and Force Plate Collection

- Qualisys motion capture system
  - Markers placed on joint centers of rotation, heel, tip of toe, and shoulder
- Bertec force platform
  - 6 walking trials total
  - 3 left foot force plate strike
  - 3 right foot force plate strike
- Used to measure joint angles (kinematic data).
- Used with Inverse dynamics to estimate joint moments (kinetic data).

Symmetry Index (SI)

- SI is used to measure symmetry for ground reaction forces, joint angles, joint moments

$$SI = \frac{|X_I - X_P|}{0.5(X_I + X_P)} \times 100$$

RESULTS AND DISCUSSION

Ground Reaction Force (GRF)

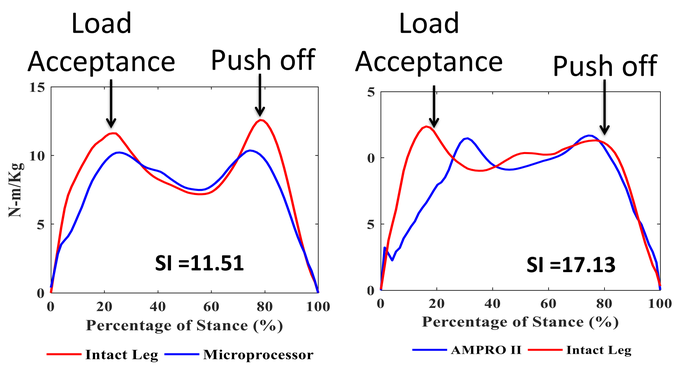


Fig. 2 GRF while using microprocessor knee | **Fig. 3 GRF while using AMPRO II**

	Max GRF (N/kg) Difference
Microprocessor	1.91
AMPRO II	0.6

- Overall GRF is more symmetric using the microprocessor knee.
- GRF is more symmetric at the end of stance using AMPRO II due to assistance of powered knee.
- Max GRF is closer while using AMPRO II.

Kinematic Symmetry

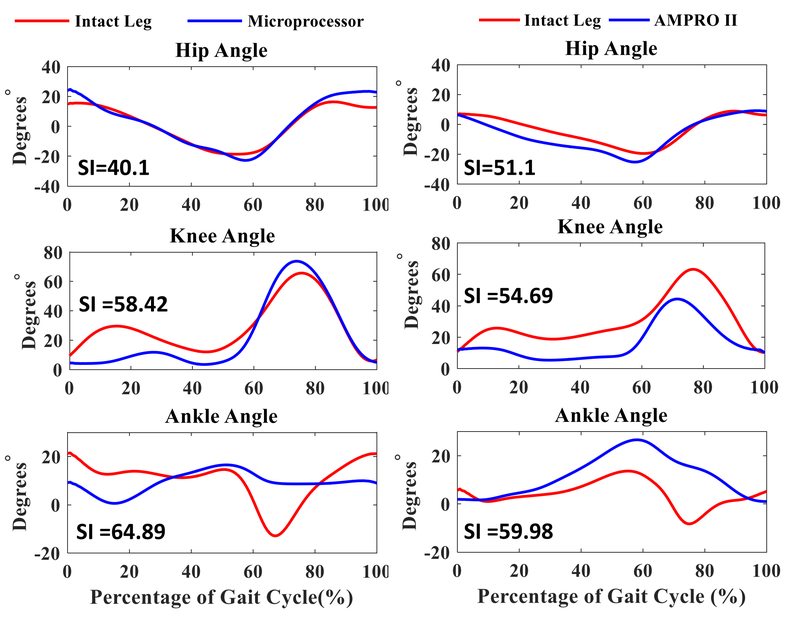


Fig. 4 Hip, knee, and ankle angles using microprocessor knee | **Fig. 5 Hip, knee, and ankle angles using AMPRO II**

- Lower hip SI while using microprocessor
- Lower knee flexion of intact leg while using microprocessor knee
- Knee angle compensation while using AMPRO II leads to abnormal gait.
- More symmetric angle while using AMPRO II due to allowed flexion angle about ankle.

Kinetic Symmetry

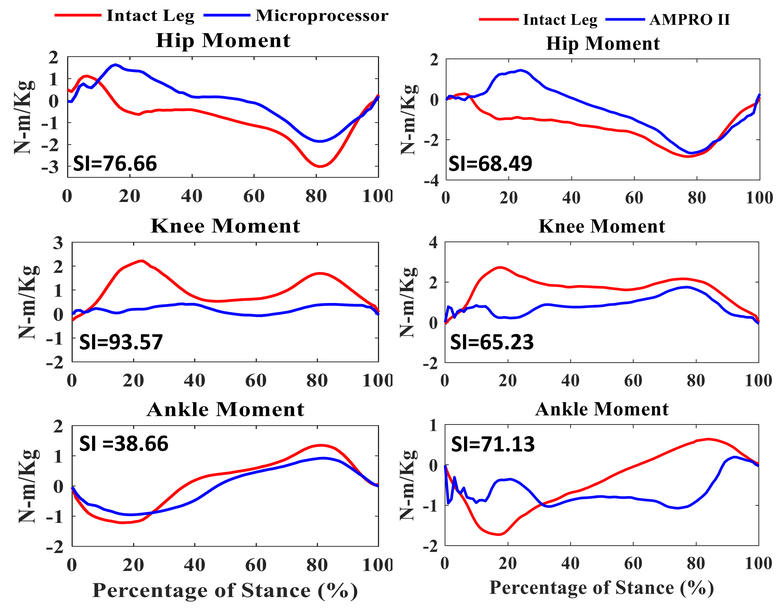


Fig. 6 Hip, knee, and ankle moments using microprocessor knee | **Fig. 7 Hip, knee, and ankle moments using AMPRO II**

- Hip and knee SI moment smaller while using AMPRO II.
  - Moments more symmetric at end of stance sue to assistance from powered knee.
- Ankle moment very asymmetric due to low shock absorption and flat foot control

Energy Expenditure

- Self selected speed: 1.3 miles per hour
- VO2 Max with AMPRO II
  - 17.2 ml/kg/min
- VO2 Max with Microprocessor
  - 14.2 ml/kg/min

CONCLUSIONS

- AMPRO II has more benefits at the end of stance for kinetics.
- Flat foot walking is not beneficial during stance.
- Compliance from spring led to a more symmetric ankle moment.
- Weight led to
  - Decreased self selected gait speed
  - Decreased step length
  - Increased Energy expenditure

Future Work

- Multi-contact walking (Active plantar and dorsiflexion)
- Include shock absorption
  - Springs, padding, shoe
- Weight reduction
- Increase range of motion for prosthetic knee point
- Change training (longer duration)
- Adjustable height

References

[1] Program, T. L., & America, A. C. (2015).
[2]A. S. Göktepe, B. Cakir, B. Yilmaz and K. Yazicioglu, Prosthetics and Orthotics International, p. 31–36, 2010.
[3] Gailey, R, Rehabilitation Research & Development, (2008).
[4] A. D. Ames. Robot Motion and Control 2011, Springer London:89-116, 2012.

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