Evaluation of the Mechanical Function of a Novel Lower-Limb Biarticular Prosthesis

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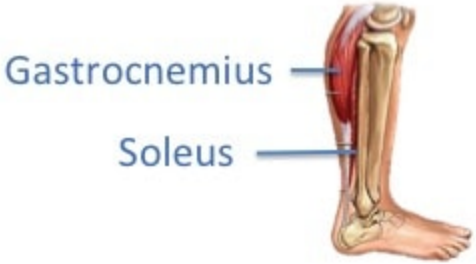
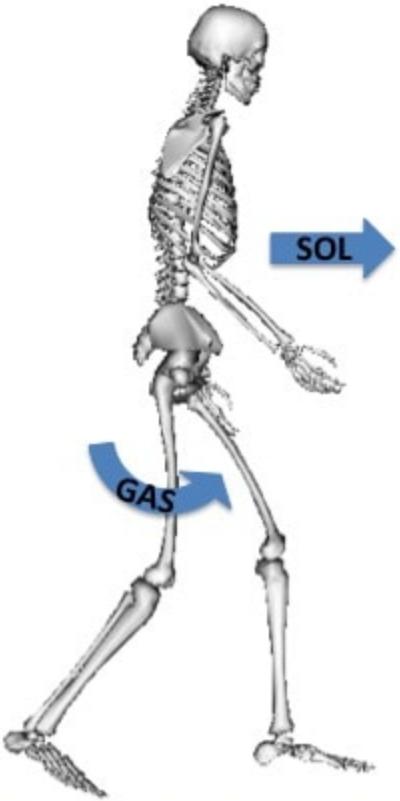
Introduction





- Gastronemius (GAS): accelerates leg into swing in late stance phase [1]
- Soleus (SOL): accelerates trunk forward [1]
- Other muscles compensate for lack of biarticular GAS function [2]

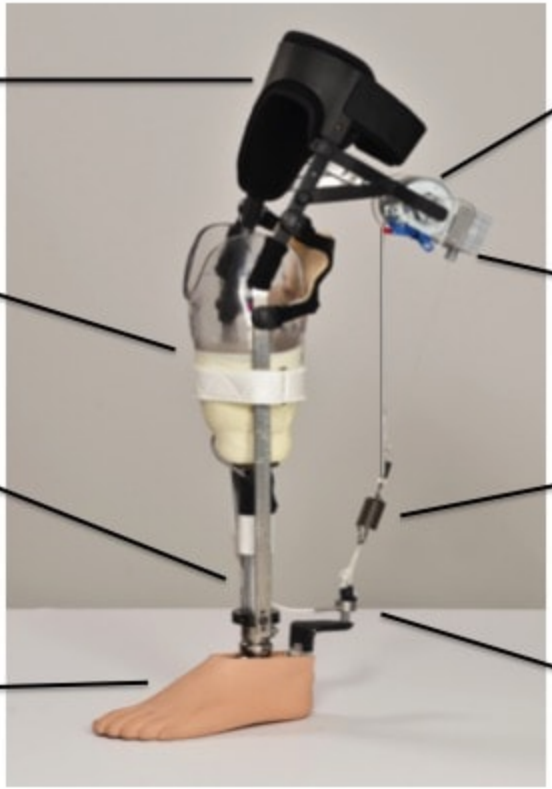
1. Neptune RR, et al. *J Biomech*, **34**, 1387-1398, 2001.
2. Zmitrewicz RJ, et al. *J Biomech*, **40**, 1824-1831, 2007.

Overall Research Goals

- Develop biarticular clutched spring prosthesis that replicates functional role of GAS
  - Supply ankle power at toe-off
  - Reduce compensatory muscle forces
  - Reduce metabolic cost of amputee walking

http://www.360oandp.com/video/categories/8/misc-prosthetics.aspx

Mechanical Design



BP Spring Control

Clutch On

Pylon strain gauge detects heel strike

Ratcheted clutch engages

Spring produces force after length minimizes

Clutch disengages when Forces < threshold

Specific Aims

1. Evaluate the mechanical function of the Biarticular Prosthesis (BP)

2. Analyze the energetic effects of the BP on amputee gait

Methods

Walking trials:

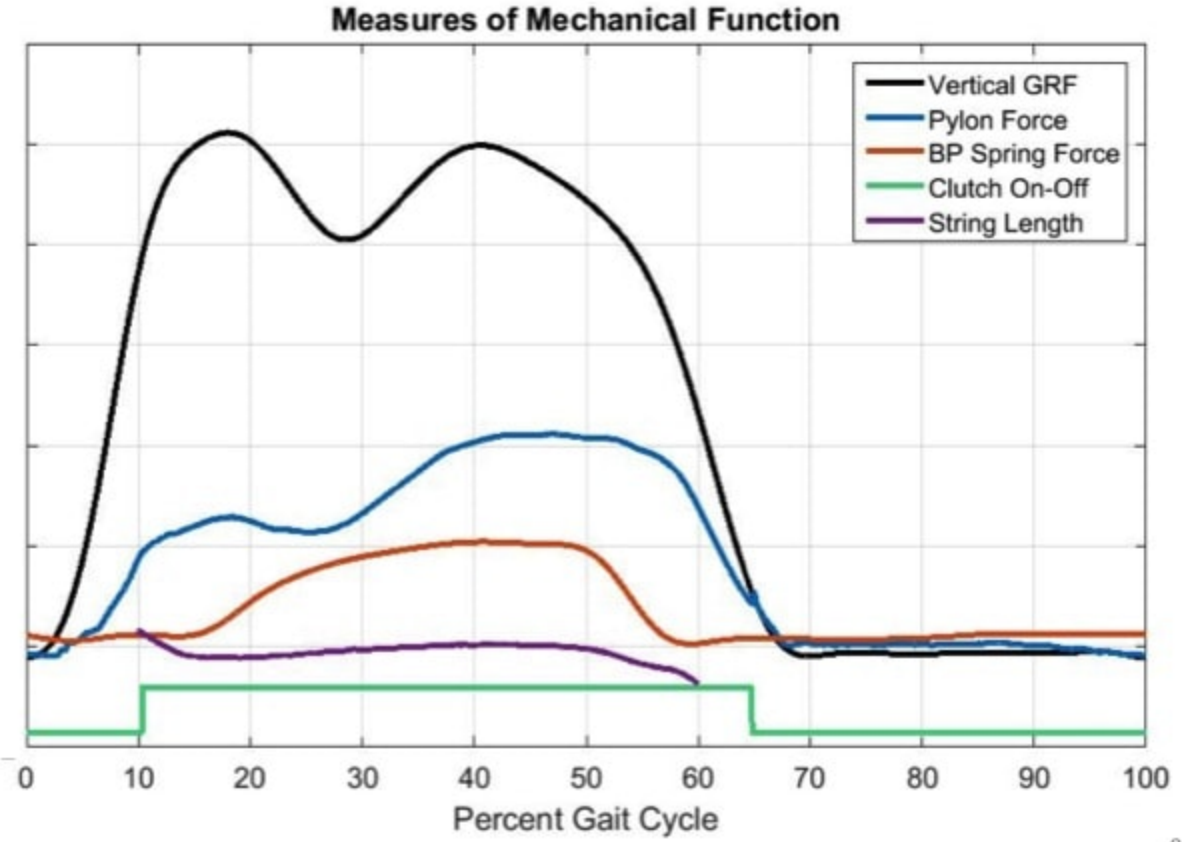
1. Prescribed Prosthesis
2. Unrecorded acclimation with unpowered BP
3. BP with increasing spring stiffness
   - 1.85 N/mm
   - 3.7 N/mm
   - 10 N/mm
4. Unpowered BP

Amputee Model

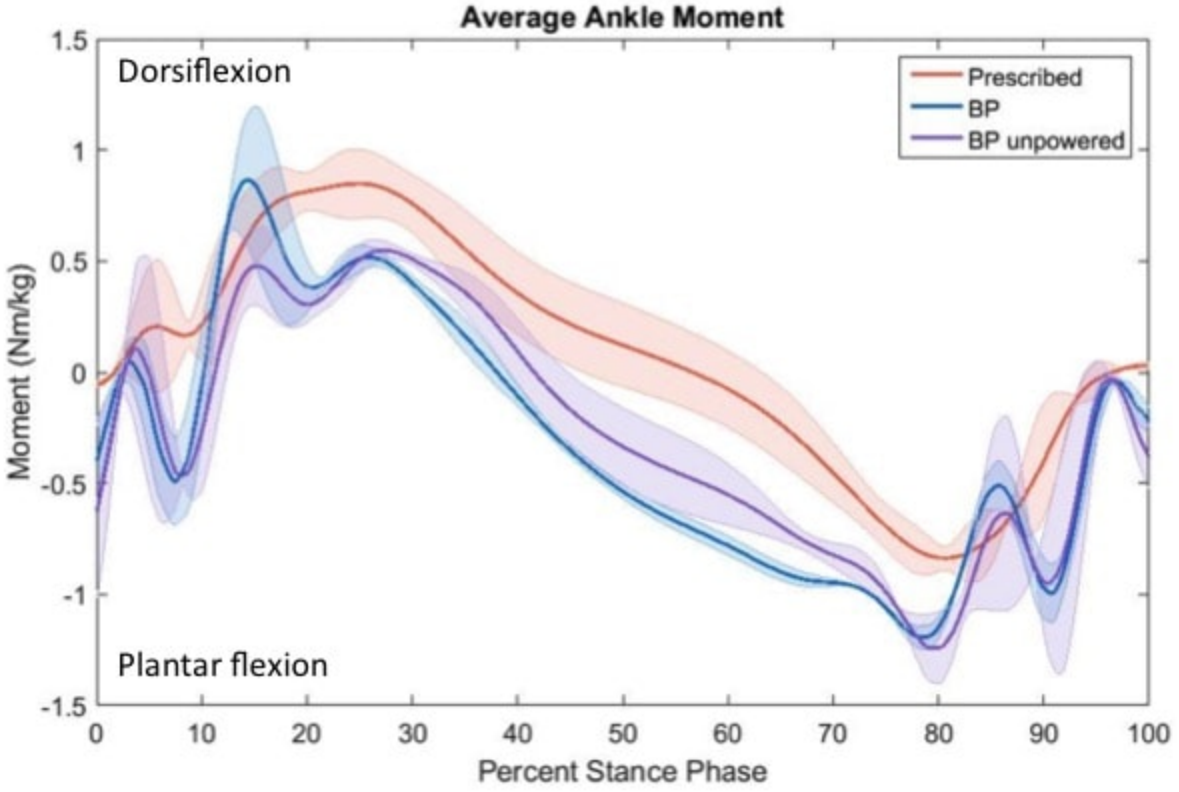
- 80 muscles
- 19 degrees of freedom in lower body
- Residual limb and prosthesis mass properties derived from literature [4,5]
- Pin joint created in same relative position as intact ankle to replicate flexion in prosthesis

4. Silverman AK, Neptune RR. *J Biomech*, **45,** 2271-2278, 2012.
5. Smith JD, et al. *J Vis Exp,* **87**, 2014.

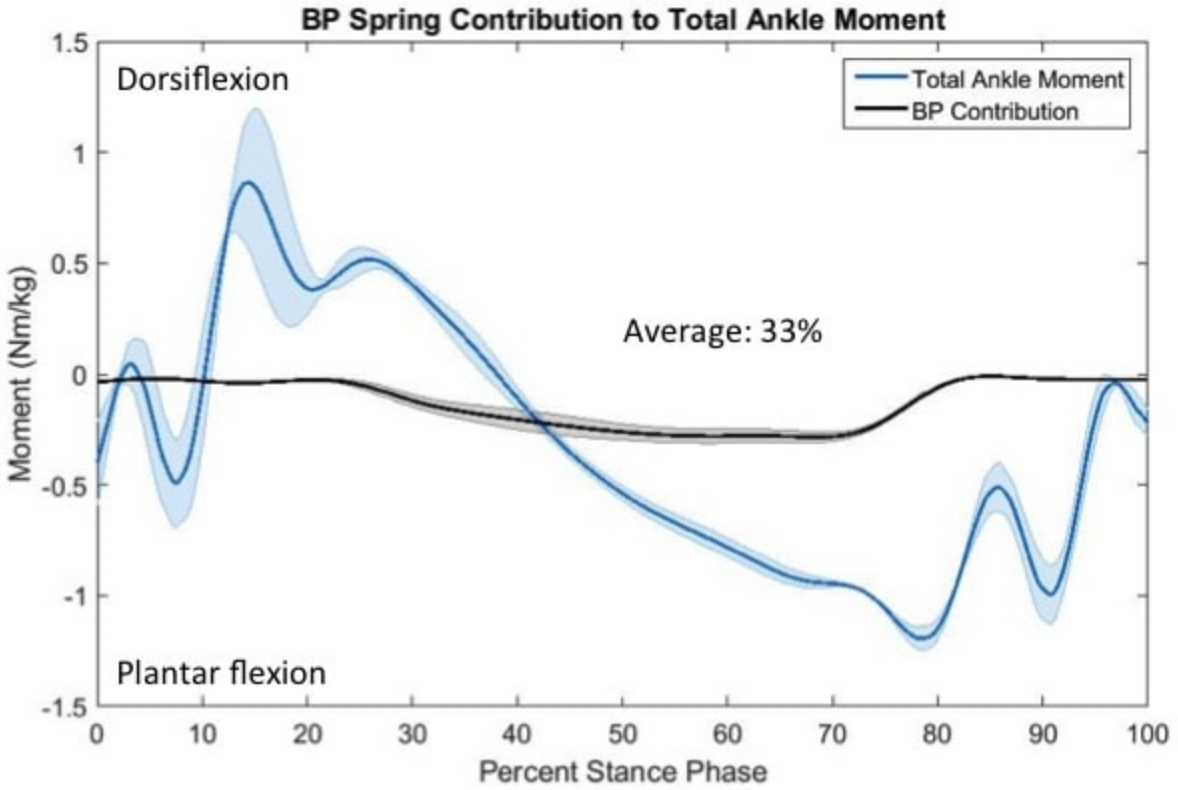
Results: Mechanical Test



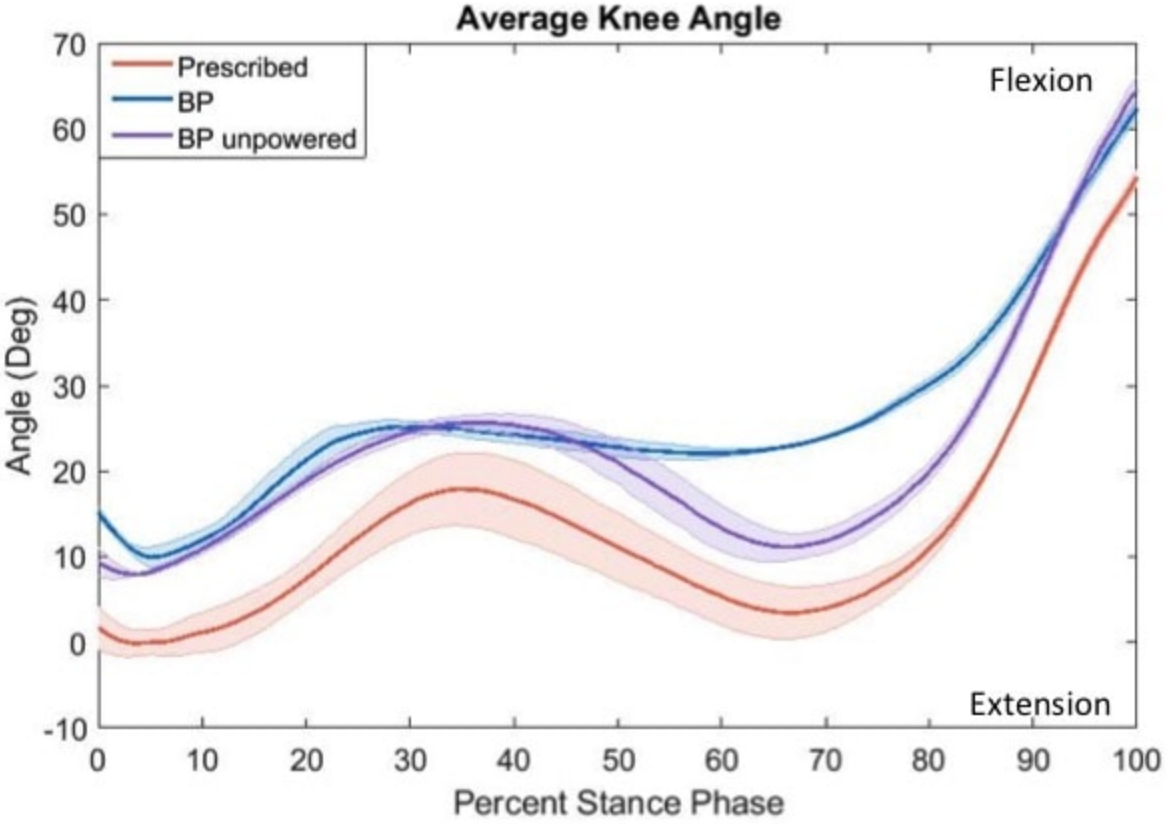
Results: Ankle Moment



Results: BP Ankle Moment



Results: Knee Kinematics



Discussion

- BP had appropriate mechanical function
  - Software, one-way clutch, pylon strain gauge, and thigh cuff worked in concert
- BP spring marginally increased ankle plantar flexion torque
  - Greater increase desired for future prototypes
- Spring stiffness affects peak knee extension in midstance

Future Work

- Repeat protocol with additional amputee subjects
- Look at BP effect on compensatory muscle forces

Acknowledgments

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