Neural Prosthesis to Assist People with Muscle Weakness

Martin L. Tanaka[1], Reza Farsad Asadi[1], Paul Yanik[1], Dave Hudson[2]
[1] *School of Engineering and Technology, Western Carolina University, Cullowhee, North Carolina, USA*
[2] *Department of Physical Therapy, Western Carolina University, Cullowhee, North Carolina, USA*

Introduction

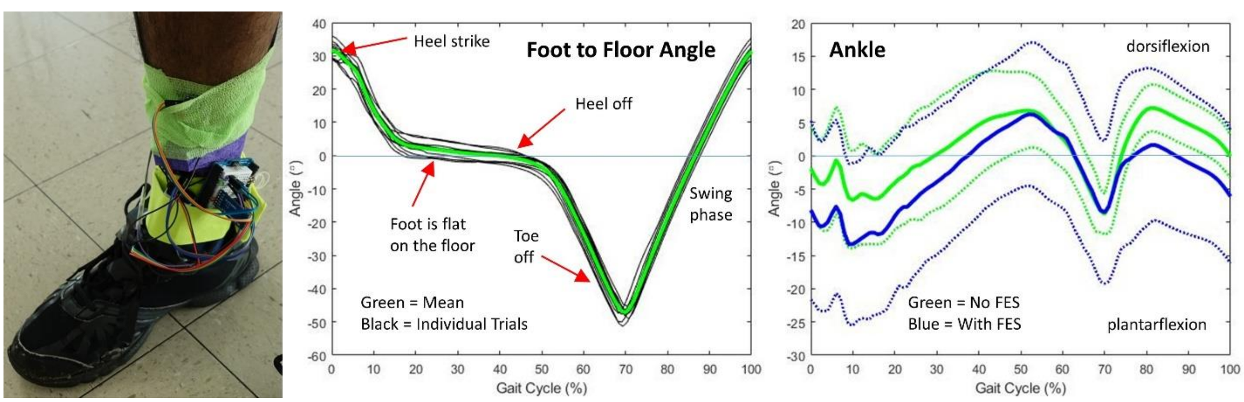
The latest generation of prosthesis include intelligent artificial controllers that enhance the performance of the prosthetic. Although these sophisticated systems enhance performance, they can be costly. However, recent technological advances have led to the emergence of low cost inertial measurement units (IMU) and microcontrollers (μC) suitable for integrations into intelligent prostheses. This research describes the design, development and testing of a neural prosthesis to assist with muscle weakness caused by stroke, spinal cord injury, or other conditions that compromise neuromuscular function. The overarching goal is to develop a device that can detect the state within the gait cycle and deliver a properly timed electric impulse capable of improving muscle force and function.

Methods

A neural prosthesis was developed using IMUs, foot pressure sensors, a microcontroller, a wireless transmitter, and an electrical stimulator. Each IMUs contained a 3-axis gyroscope, 3-axis accelerometer, and onboard motion processor. IMUs attached to the foot and shank captured angle data with respect to an inertial reference frame. Foot pressure sensors provided additional data. The microcontroller processed all sensor data and transmitted this wirelessly to a nearby computer. In later versions of the device, the controller will use these data to determine the state within the gait cycle and control timing of the electrical stimulator. The current version of the neural prosthesis uses a manually controlled electrical stimulator. Electrical pads placed across the gastrocnemius induce a muscular contraction that increase plantarflexion to augment the push power needed for swinging the limb forward. Human subject testing was conducted to evaluate device performance.

Results

The addition of artificial muscular stimulation had a noticeable effect on gait. Electrical stimulation causes the toe to push down (plantarflexion) during push off and it remains slightly down during the swing phase and at heel strike. Stimulation increased trial-to-trial variability, but did not destabilize gait enough to cause an inability to walk.



Discussion

Data obtained from the IMUs and foot pressure sensors were able to capture gait cycle parameters in real time. Access to real time sensor data is necessary for closed loop control. Although motion capture systems that utilize cameras are more accurate, these data are not available to real time controllers within the device. The finding that artificial electrical stimulation did not result in excessive gait destabilization is encouraging that later versions of this device will be able to improve gait for people with muscle weakness.

Acknowledgements

Provost Internal Funding Support Grant from Western Carolina University supported this research.

References

1. Meng, L., et al., (2017). *Proc IMechE Part H: Journal of Engineering in Medicine*, 231(4) p315-325.
2. Roche, A, et al., (2009). *Physical Therapy Reviews*, 14(2) p63-80.