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A prosthesis to train the proprioceptive capabilities of the residual limb of military personnel recovering from lower limb amputation

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14. ABSTRACT Learning to walk following lower limb amputation takes many months owing largely to the fact that new amputees cannot perceive when the prosthetic foot is in contact with the ground. To overcome this limitation, we have developed a system that detects foot pressures and relays this information to the residual limb. To data, a prototype sensor/stimulator system was been developed and we are preparing for human subjects tests.					
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Introduction

One of the major obstacles amputees must overcome during post-operative rehabilitation is learning to maintain balance. Over time, amputees learn to substitute tactile feedback discerned from pressures imparted on the residual limb by the prosthetic socket to control balance [1], but during the post-operative period the lack of afferent feedback from the ankle and foot poses challenge. To compensate for the lack of afferent feedback, amputees look down at the prosthesis to sense body position [1, 2] and continue to do so for up to eight months post-surgery [1]. Visual dependence is problematic since it may cause amputees to miss obstacles that need to be avoided. Furthermore, the visual feedback is not as effective as somatosensory feedback. As such, falls are frequent [3] which can cause injury to the surgical site, further delaying the rehabilitation process [4] and increasing costs.

In an effort to improve post-operative gait training for lower limb amputees, we have developed a vibrotactile sensory feedback system (Fig 1). This system uses sensors placed on the prosthetic foot to measure loading, process this information, and output it to vibrotactile stimulators that communicate both the level and location of the load. It is our hope that by including this capability in a prosthesis, we may be able to help new amputees learn to walk in a more timely manner.

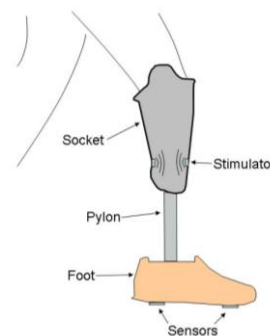


Fig 1: Supplementary Feedback System

Body

The research proposed for this project included three specific aims: 1) Design and fabricate a vibrotactile sensory feedback system, 2) Investigate appropriate body sites for sensory feedback, and 3) Investigate the ability of the system to help amputees modulate body position in response to sensory feedback.

To date, we have developed a multi-channel sensory feedback device. The device uses an external power supply and is controlled by an Atmel microprocessor. Inputs are taken from Tekscan Flexiforce sensors which output a voltage proportional to the pressure present in the sensors. The sensor output is processed by the microprocessor, and then the appropriate voltage is released to the vibrating stimulator. Vibration amplitude is proportional to sensor pressure.

We had secured IRB approval to begin recruiting for this study, but we moved our office and the IRB has instructed us to submit a modification to our protocol with our new address. This modification is now pending and once approved we will recruit the lower limb amputee subjects and complete the study.

Key Research Accomplishments

- Completion of multi-input sensory feedback device.

Reportable Outcomes

A pending provisional patent application reported in the last report was tabled for budgetary reasons. The application will be written and filed prior to public disclosure of patentable mechanisms in the design.

Conclusion

We have developed a new prototype sensory feedback device. Data collection is pending.

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