Capability After Limb Loss: the challenges of measuring and mastering movement with an artificial limb
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A biofeedback gait re-training system for trans-femoral amputees

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1. Introduction

Following discharge amputees do not always receive regular reviews by physiotherapists, and may adopt a variety of habitual gait patterns that can lead to back pain. The increase in transverse rotation of the pelvis in trans-femoral amputees, as produced by circumduction, is a contributing factor to lower back pain (Morgenroth *et al.,* 2010). Real-time biofeedback of kinematic data to amputees may help address inappropriate habitual gait patterns. Recently there has been renewed interest in the application of biofeedback for gait re-education (Lunenburger *et al.* 2007). Such feedback could also help therapists convey information to patients regarding kinematic alterations during hands-on physiotherapy in a rehabilitation gym.

2. Aims

This paper summarises the development of a real-time biofeedback training system to assist in the reduction of habitual circumduction and abduction gait patterns seen in trans-femoral amputees.

3. Biofeedback Training System

The system (Figure 1) uses a passive infra-red motion capture system (ProReflex, Qualysis, Sweden) to track lower limb kinematics whilst the amputee walks on a treadmill. Software was written using LabVIEW (National Instruments, UK) to calculate and compare the hip joint angles against a reference data set in real-time. The extent of gait deviation is determined from the combined coronal and sagittal hip joint angles and guides the delivery of an electro-tactile stimulus around the surface of the stump.

A multi-channel stimulator was developed which produces an electro-tactile sensation through an array of eight annular skin surface electrodes. Each electrode pair contains an active conductor surrounded by a single reference. The conductors were etched from a flexible polyimide printed circuit. A hydrogel formed a self-adhesive skin-electrode interface. Further details of the training system can be found in Webb (2013).

The stimulator provides control of the waveform pulse-width, frequency and amplitude. To determine which parameters produce a comfortable sensation on the thigh surface, under different neuromuscular conditions, the sensory thresholds and stimulus discrimination abilities of thirteen non-amputees and four trans-femoral amputees were investigated. Subjects were recruited from the University of Surrey and Queen Mary's Hospital (Roehampton) respectively. The four amputees then went on to test the usability of the training system. The studies received favourable consideration from the NRES London-Surrey Borders and University of Surrey Research Ethics Committees.

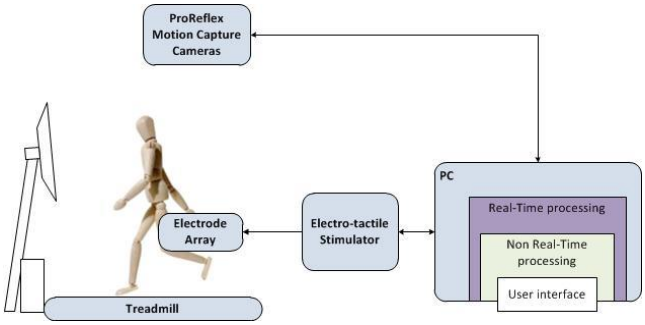

Figure 1 Biofeedback Training System Overview

4. Results

Sensation threshold levels and the ability to discriminate stimuli were found to be comparable between the amputee and non-amputee groups. The amputees reported positively on the use of the system. They were able to perceive and understand the feedback stimuli, relate the information to their movement, and in some cases make positive changes to their gait.

5. Discussion

This work has the potential to become integrated into prosthetic components, and can be adapted for use with a broader range of patient groups with upper and lower limb movement disorders. The analysis software has the potential to be further developed to provide real-time interpretation of gait patterns.

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References

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