For scientific case study or technical/P&O treatment case

(Supply examples with special clinical case or special technical solution)

Summary*:

Sensory feedback based on residual muscle activity was implemented on top of a myoelectrically controlled active knee prosthesis. Gait symmetry, ease of use, and embodiment have been found to increase with sensory feedback. Positive effects were sustained and enhanced throughout the session.

Introduction/Basics*:

Current prosthetic devices lack intuitive and adaptive control. Voluntary muscle activation of the residual limb has the potential to directly control the prosthesis appropriately and adaptively in challenging environments [1]. With the use of surface electromyography (EMG) and sensory feedback, a non-invasive system has been designed that enables bidirectional communication between the user and the prosthesis. Myoelectrical prostheses pose initial challenges such as increased cognitive workload and muscle co-contractions [1]. The addition of sensory feedback seems promising in the mitigation of these challenges by accelerating learning and integrating the prosthesis with the user.

Methods/work process:

Two participants with a transfemoral amputation (TFA) participated in the experiment. The time since amputation was one year for the novice user, and 24 years for the experienced user. The participants were fitted with a custom-made liner and socket with built-in EMG electrodes and a powered knee prosthesis. An add-on vibrotactile feedback strap was mounted at the upper edge of the prosthetic socket. Sensory feedback was based on the user's EMG levels in the residual limb and was provided through seven vibrotactile motors. The experiment consisted of four trials of 2-minute level ground walking at a self-selected speed. The experiment started with a baseline measurement and was followed by three EMG trials with and without sensory feedback. Gait measurements were collected through built-in force plates and used for temporal gait symmetry calculations using the absolute symmetry index (ASI). After each trial, ease of use and acceptance were recorded with the NASA-TLX scale and the Prosthesis Embodiment Scale for Lower Limb Amputees, respectively. A Friedman test was performed first, and followed by a Wilcoxon signed-rank test with a Bonferroni correction when a significant difference was found. The statistical significance was set at $\alpha = 0.05$.

Implementation*:

Preliminary results indicated a sustained positive effect in ASI in both participants with the implementation of sensory feedback. A larger effect was found in the novice user when contrasted against the experienced user. No significant differences were found for embodiment and ease-of-use scores in the novice user. The only significant difference indicated that the experienced user had a lower acceptance with sensory feedback after the EMG controlled trial ($p = 0.007$). The following EMG controlled trial showed no significant difference with the other trials. The addition of sensory feedback showed a tendency to increase cognitive workload ($p = 0.04$). However, training with sensory feedback tended to have a positive sustained and continued effect on ease of use for the experienced user when comparing the EMG controlled trial before and after sensory feedback ($p = 0.03$).

Conclusion*:

The addition of sensory feedback tended towards positive effects on gait symmetry, acceptance, and ease of use in both an experienced and a novice user. An initial drop in ease of use and acceptance with sensory feedback was reverted during the same session. Positive training effects were sustained and continued throughout the session. These preliminary results show promising effects of the implementation of sensory feedback to improve myoelectric control and healthy prosthesis usage. The effects were most promising for recently amputated individuals, but also indicate potential for improvement for experienced prosthesis users. Further research exploring the generalisability and prolonged effects of sensory feedback usage will indicate the extent to which sensory feedback can be used for training purposes and the integration into everyday life.

Literature references:

[1] A. Fleming, N. Stafford, S. Huang, X. Hu, D. P. Ferris, and H. Huang, 'Myoelectric control of robotic lower limb prostheses: a review of electromyography interfaces, control paradigms, challenges and future directions', *J. Neural Eng.*, vol. 18, no. 4, Jul. 2021, doi: 10.1088/1741-2552/ac1176.

Please insert photos or tables as JPG, GIF, PNG here

***Mandatory!**