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ABSTRACT

Brain-computer interface (BCI) controlled functional electrical stimulation (FES) represents a promising integration of technologies aimed at enhancing the quality of life for individuals with disabilities resulting from spinal cord injuries (SCI). This study evaluates the efficacy and feasibility of a BCI-FES system in both healthy subjects and SCI patients to restore voluntary motor control and promote neuroplasticity.

The study was divided into two primary phases. The first phase involved training and testing with twenty healthy participants to calibrate the BCI system and refine the FES protocols. Participants engaged in a series of tasks that involved imagining or attempting specific limb movements while their brain activity was recorded via EEG. The BCI system was designed to detect these intent-driven neural patterns and trigger corresponding FES to induce the desired limb movement.

In the second phase, ten patients with varying degrees of SCI were enrolled to assess the therapeutic potential of the BCI-FES system. Participants underwent a six-week intervention where they used the BCI to control FES-assisted movements. Key outcomes measured included the accuracy of BCI decoding, the functional improvement in limb movements as quantified by the Fugl-Meyer Assessment (FMA) and changes in muscle strength.

This study underscores the potential of BCI-FES systems in rehabilitation and the restoration of function. By providing real-time feedback and enabling active participation of patients in their recovery, such technologies not only enhance motor recovery but also facilitate cortical reorganization. Future research should focus on long-term usage and integration of BCI-FES systems in everyday life activities, exploring adaptive algorithms that can cope with the day-to-day variations in EEG signals and refining the system for better individual customization.

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