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MetroHealth Medical Center

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Abstract Submission Form

Poster Title: **Computational Stability and Sensitivity Analysis for Effort-Dependent Contralaterally-Controlled Functional Electrical Stimulation for Post-Stroke Hemiplegia**

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Location of Laboratory: **SM2-009 UP Extremity Treat/VR, OBC**

Category: **Physical Medicine and Rehabilitation**

Voluntary effort combined with functional electrical stimulation (FES) can improve post-stroke motor recovery, but current FES devices provide assistance even if rehabilitation participants are not actively trying to move their affected hand, allowing stimulation to completely take over the task. This phenomenon, known as "slacking", was first observed in robotic rehabilitation and resulted in reduced therapeutic efficacy. However, there is no FES modality that delivers movement assistance "as-needed" depending on participant effort despite the decades-long suspicion that slacking might reduce the efficacy of FES therapy. In this study, an effort-dependent contralaterally-controlled FES (CCFES) controller was proposed to prevent slacking during repetitive task practice by assisting only when the rehabilitation participant's volitional effort is detected. Electromyography (EMG) based effort estimation is required for this modality yet is a challenging task when the stimulation is simultaneously applied to the same muscle where voluntary effort is being estimated. This is because stimulation artifacts and stimulation response (M-Waves) obscure the voluntary EMG. It is not known if the current state of EMG-based effort estimation methods will be able to provide sensitivity and stability required for task practice. An system that is overly sensitive to participant behavior or electronic equipment variability could cause inconsistent stimulation or effort estimation and an unstable system might even lead to unintended oscillatory movements that makes it difficult for the participant to perform rehabilitation tasks. Therefore, the current work conducted computational stability, sensitivity, and performance analysis of a simulated effort-dependent CCFES modality. The performance and stability of three different methods for removing M-waves (Gram-Schmidt filter, comb filter, and blanking filter) were evaluated and compared using tracking error, signal-to-noise ratio, and linear regression R-squared. These methods were tested using simulated clinical cases (representing mild, moderate, and severe hand impairment) and sensitivity analyses with varying clinically-relevant parameters. The results showed that stability was consistent across different hand opening parameters, EMG conditions, and hypothetical M-Wave filtering quality, with percent changes in stability margins being less than 2.2%. Sensitivity analyses also indicated that the GS filter provided around 4 times better target tracking for simulated post-stroke hand movement under optimal conditions, while the comb and blanking filters had consistent responses across a wide range of parameters related to post-stroke hand impairment.