Design of Robotic Hand based intervention with Brain Stimulation Applications for Post-stroke Neuro-Rehabilitation

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ABSTRACT
Robots have the potential to help provide exercise therapy in a repeatable and reproducible manner for stroke survivors. To facilitate rehabilitation of the wrist and fingers, an electromechanical exoskeleton was developed that simultaneously moves the wrist and metacarpophalangeal joints. A Computer Aided Design model of the mechanical linkage was made, simulated for Factor of Safety and fatigue life, 3D printed and assembled. The device was designed for ease of manufacturing and maintenance, crucial considerations for countries with limited resources. Active participation of the user is ensured by implementation of electromyographic control and visual feedback of performance. Muscle activity requirements, movement parameters, range of motion, and speed can all be customized to meet the needs of the user. Twenty-three stroke survivors, ranging from the subacute to chronic phases of recovery (mean 10.6 months poststroke), successfully participated in a randomized controlled study with two groups- Robotic therapy (n=12) and Control group (n=11). In robotic therapy group, participants completed 20 sessions, each lasting 45 minutes and dose matched physiotherapy was given to patients in control group. Overall, in robotic therapy group, patients exhibited statistically significant changes (p <0.05) in clinical outcome measures than control group following the treatments, with the FuglMeyer Stroke Assessment score for the upper extremity, Barthel Index, active range of wrist motion and Modified Ashworth Scale. Cortical excitability, amplitude of Motor Evoked Potential and Resting Motor Threshold, was observed to be increased post-therapy in robotic therapy group than control group (p < 0.05). Thus, this device shows promise for improving rehabilitation outcomes, especially for patients in countries with limited resources. The device has been synchronized with brain stimulation for evoking activity-dependent stimulation. Hardware has been developed and protocol has been optimized with Transcranial Magnetic Stimulation and has been tested on four patients completing 20 sessions with promising results. Index Terms— Electromyogram, Exoskeleton, Fugl-Meyer Assessment, Rehabilitation, Stroke, Cortical Excitability, Brain Stimulation, Motor Evoked Potential