

Functional Electrical Stimulation to Correct Foot Drop in Stroke Rehabilitation

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ABSTRACT

Stroke is one of leading cause of long-term disability throughout the world. Functional electrical stimulation (FES) is a technique that uses low levels of electrical currents to activate nerves innervating extremities affected by paralysis resulting from cerebral stroke, spinal cord injury (SCI), or similar conditions. Therapeutically, FES is primarily used to restore motor functions in people with disabilities. In this work, a programmable and portable dual-channel multipattern transcutaneous FES system was developed using embedded technology, and tested to correct foot-drop in stroke patients. Microcontroller was used to generate different types of stimulus envelopes (the tibialis anterior (TA) electromyography (EMG) pattern, trapezoidal, packets and continuous rectangular), for versatile applications in clinical rehabilitation. It is provided with bi-phasic, constant-current stimulus at the output. In the preliminary trial, the novel TA EMG envelope stimulus was found to be more effective compared to the rectangular envelope for foot drop correction. The foot pressure sensor based FES system, and an “intelligent” EMG-controlled closed-loop FES system for controlling stimulus intensity in real time, by getting feedback from the patient’s affected leg has been developed and tested.

The effects of FES of the TA muscle combined with conventional rehabilitation program to correct foot drop in stroke patients has been evaluated. Fifty-one consecutive patients with foot drop due to stroke were alternatively assigned to the FES group (n=27) or to the control group (n=24). All subjects participated in a conventional stroke rehabilitation program for 1 hr per day, 5 days per week, for 12-weeks. The FES group also received 20-30 minutes of electrical stimulation to TA muscle of the paretic limb during swing phase of gait. The outcome measures were gait characteristics, effort of walking, dorsiflexor strength, voluntary ankle dorsiflexion, lower-extremity motor functions, calf spasticity, and quality-of-life. The study showed a mean increase in walking speed of 26.5% and decrease in plantarflexor spasticity of 38.3% in FES group, and changes of 11.6% and 21.2% respectively, in control group. The FES group had better improvement in above mentioned parameters than control group. The comparison between-groups of percentage changes was significant at post-treatment assessment ($P<0.05$). It has also been found that an early intervention of FES is more effective in stroke rehabilitation.

Keywords: Stroke; Disability; Stimulation; Programmable; Foot drop; Gait; Spasticity.

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