FES-Assisted Exercise Therapy in the Sub-Acute Phase of Stroke Recovery.

Kowalczewski J [1], Gritsenko V[1], Ashworth N [1,2], Prochazka A [1]

[1] Centre for Neuroscience University of Alberta
[2] Glenrose Rehabilitation Hospital

Email : arthur.prochazka@ualberta.ca

Abstract

A surface stimulator combined with an instrumented workstation comprised of tasks of daily life was used to rehabilitate the upper extremity of patients with severe hemiplegia. 20 sub-acute patients (no more than 3 months post stroke) took part in this double blind randomised clinical trial. Ten patients in the experimental group underwent daily 1 hour training sessions on the workstation with functional electrical stimulation for a duration of 4 weeks. The control group of 10 patients received 15 minutes of daily sub threshold stimulation and one training session per week on the workstation. The workstation was used for task-specific training as well as kinematic data recording. Outcome measures of hand function included the Wolf Motor Function Test (WMFT), the Upper extremity Fugl-Myer Test (FMT), the Motor Activity Log (MAL), and the kinematic scores derived from the workstation. The results indicate a significant improvement in hand function for the treatment group over the control group in some but not all of the outcome measures.

1. INTRODUCTION

The therapeutic use of functional electrical stimulation (FES) of the hand was pioneered in the 1970s. The method provides increased arm function by generating hand opening and a functional grasp via electrical stimulation. The functional grasp allows patient to perform numerous tasks previously not possible. Although many new tasks could be attempted, the focus of this study was to rehabilitate and increase the quality of life after stroke, hence the patients used objects that represented daily activities. These objects where instrumented and located on a custom-built workstation. Unlike traditional therapy the workstation provides a means to gather quantitative data on the performance of each task in each session. Previous FES-assisted exercise studies have reported functional improvements during the acute stage of recovery [1, 2], as well as in the chronic stroke population [3]. This study evaluates the effectiveness of an instrumented workstation to deliver FES-assisted exercise to sub-acute stroke subjects in a rehabilitation hospital setting.

2. METHODS

2.1 System

The surface stimulator used in this study was a modified Impact Cuff [4] with the electrodes positioned on the forearm in order to activate finger extensors. This stimulation setup provided sufficient hand opening in patients to perform the required tasks. The workstation tasks included pulling a weighted handle, rotating a door handle and a door knob, placing objects on shelves, unscrewing a lid from a jar, and gripping a spring-loaded caliper. These objects where instrumented with potentiometers, except for the jar and shelves which both contained proximity sensors. The sensors allowed us to record time and amplitude for each of the tasks performed.

2.2. Subjects

20 subjects from a local rehabilitation hospital with stroke-induced hemiplegia participated in this study. The subjects were block-randomized into control and treatment groups, 10 subjects in each group. Patients participating had had a stroke no more than 3 months prior to the beginning of the study and were unable voluntarily to grasp and release any three objects on the workstation. A score of >16 on Folstein's Mini-mental test, as well as tolerance of the level of FES needed for hand opening where also required.

2.3. Intervention

Subjects in the treatment group received supplementary 1 hour exercise sessions every

workday for 3-4 weeks (15-20 sessions) in addition to their regular therapy. Each session consisted of the subject manipulating 3 objects on the workstation using his or her affected hand. The exercise focused on reaching, grasping, manipulating (pulling, rotating, etc.) and releasing the object. If the subject was unable to reach for the tasks a sling was used to assist in the movements. Subjects in the control group received sham treatment consisting of weak (sub-motor threshold) electrical stimulation of the forearm muscles for 15 minutes, 4 days a week. On the fifth day the control subjects attended exercise sessions so that their performance on the workstation could be monitored and compared to that of the treatment group.

2.4. Assessment

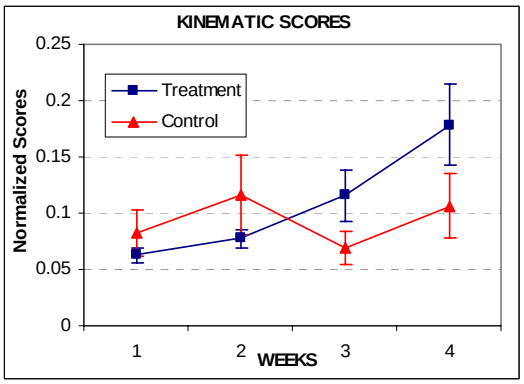
Two types of clinical measures where used to gauge improvement in upper extremity function; kinematic scores derived from sensor readings on the workstation and clinical tests performed and scored by a therapist blinded to the treatment. Except for the shelf placement task, kinematic scores were obtained for each task by dividing the maximal displacement by the time taken. This score was then normalized to that of a group of 4 healthy individuals.

Clinical measures included the upper extremity portion of the Fugl-Meyer test (FMT) [5] in order to assess the active range of motion, and The Wolf Motor Function test (WMFT) [6] to measure motor impairment. Other Clinical measures included the Functional Independence Measure (FIM) [7] routinely administered to inpatients in the rehabilitation hospital. FIM scores obtained close to the start and end dates of our trial were used. In order to estimate the involvement of the hemiplegic hand in activities of daily life the Motor Activity Log (MAL) was used. The FMT, WMFT and MAL where administer pre-treatment, post-treatement and at 3 and 6 month follow ups.

3. RESULTS

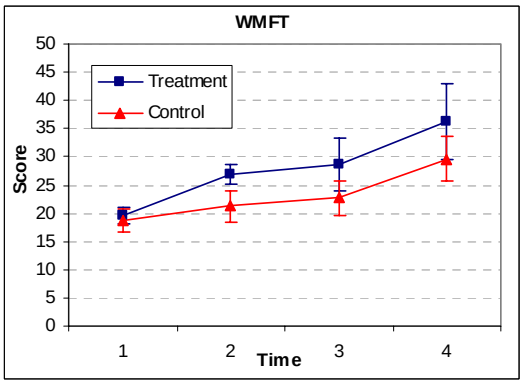
3.1. Combined kinematic scores:

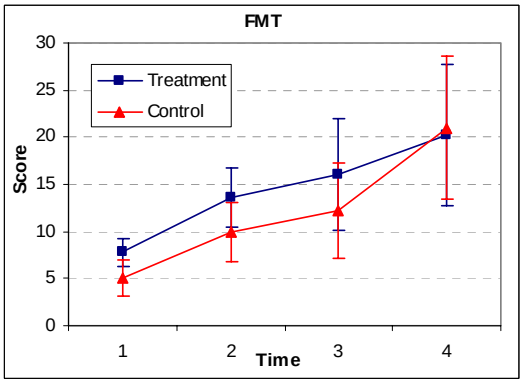
The means of the normalized individual task scores (combined, normalized kinematic scores) were significantly better in the treatment group than those of the control group after the 4 weeks of therapy (Fig. 1). This suggests an improvement in hand function and increased ability to perform tasks of daily living. We cannot exclude the possibility of a learning effect in the kinematic scores.



3.2. Clinical scores

Significant improvement in the WMFT was observed in the experimental group, providing evidence for an increase in hand function beyond that due to specific learning of the workstation tasks. A trend was also noted in the FMT but significance was not reached within the 4 week period of the trial. The improvements in the WMFT did not stay statistically significant through the follow-up periods. This is most likely due to the difference in therapies received by each patient following discharge from the rehabilitation hospital.





4. DISCUSSION AND CONCLUSIONS

The results of this double blind study indicate that conventional therapy supplemented with FES even for a short period of time can provide a significant improvement to hand function in the sub-acute phase of stroke recovery. This study offers evidence in support of FES-assisted rehabilitation as a complement to traditional rehabilitation.

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