Effects of Functional Electrical Stimulation Combined with Task-Oriented Movements for Hemiplegic Hand Function

Chung YJ [1,2], Lee YH [1], Kim Y [2]

[1] Wonju College of Medicine, Department of Rehabilitation Medicine, Republic of Korea
[2] Department of Rehabilitation Therapy, The Graduate School, Yonsei University, Republic of Korea

nobility3004@hotmail.com

Abstract

This study examined whether functional electrical stimulation (FES)-assisted task-oriented training approach could improve hand function in two subjects with stroke.
Test measurement included Box and Block test, detaching velcro pegboard, moving the cone from one side to the other, and median frequency of extensor digitorum muscles during cones task – all as many as possible in 1 minute. Two pretest, one posttest measurements occurred. Training consisted of 20 sessions of cones task during the 30 minute with FES. A FES stimulator was used to assist hand opening. Data were analyzed by visual inspection and by statistical analysis that examined whether posttest measurements exceeded the mean of the two pretess by at least two standard deviations on at least two consecutive posttest measurements. Posttest results showed that the hand function improved statistically in Box and Block test, detaching velcro pegboard task, and moving the cone task. Median frequency of extensor digitorum muscle showed increased statistically after training. We concluded that FES-assisted task-oriented training approach produced training effects in hand function and muscle recruitment.

1. INTRODUCTION

Hemiplegia is one of the most common forms of impairments in adults. Many studies addressed the efficacy of the Functional electrical stimulation (FES)-assisted training in the recovery of hand function in patients with neurological disabilities such as tetraplegics [1]. It has been reported that many patients who use FES on a regular basis experience significant carry-over in function that persists although patients did not use devices [2]. Popovic et al. study also reported better recovery of hand function in the group that performed the FES-assisted task-oriented training, compared with that of the non-FES group [3]. The purpose of this study was to examine effects of a FES-assisted task-oriented training on motor function of the hemiplegic hand.

2. METHODS

2.1. Subjects

A 37-year old female patient who had right hemiplegia for the 23 months post-stroke. The stroke lesion was locate at the left intracerebral hemisphere hemorrhage. Her cognition was assessed with the Mini-Mental State Examination (MMSE)[4] on which she scored 30 out of 30. The strength of the extensor muscles of the fingers of her affected hand was trace in Manual Muscle Testing (MMT).
A 52-year old male patient who developed left hemiplegia characterized by intracerbral hemorrhage 9 months ago. He showed MMSE score of 28 out of a total of 30. The strength of the extensor muscles of the fingers of his affected hand was poor in MMT.

2.2. Intervention

Subjects were administered their respective therapies for 4 weeks, 5 days per week, one session per day, and 30 min per session. Electrical stimulation was applied to extensor digitorum and activated by a hand switch (Figure 1). By pressing a switch, the patients commanded hand opening. Once the neuroprosthesis applies to artificially generated muscle movement required to perform grasping and releasing tasks of moving cone from one side to the other The FES intervention was highly customized so that releasing was optimized throughout the task. The participant was asked to repeat the same hand task 150~200 times during a 30 minute treatment session.

2.3. Stimulation Parameters

Stimulation parameters that were used in these trials were 1) asymmetric biphasic, currentregulated electrical pulses; 2) pulse amplitude from 20 ~ 25 mA(typical values 23 mA); 3) pulse width 250 μs and pulse frequency 40 Hz.

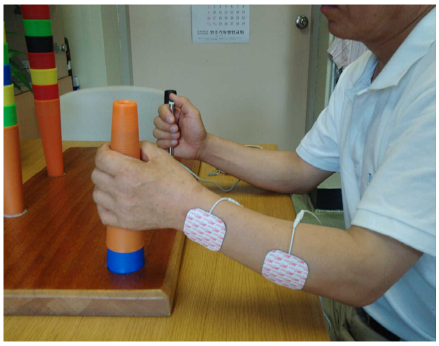

Figure 1 – Electrode arrangement; extensor digitorum for release of grasp.

2.4. Outcome Measures

Subjects completed the first pretest, which was followed by the 2nd pretest after two weeks, the 4-week training and a posttest. The following tasks were tested: Box and Block test, detaching velcro pegboard, moving the cone from one side to the other. The number of objects moved were counted for assessment. Median frequency of the finger extensor muscles during the moving the cone task was analyzed by fast fourier transformation (FFT) using the Matlab6.5(Math Works Inc.MA.USA) application. Subjects were asked to perform the same task three times in a row, and the results were averaged.

2.5. Statistical Analysis

We examined for a training effect using the two-standard-deviation (two-SD) band method [5]. We calculated the mean and standard deviation for the two pretest measurements of Box and Block test, number of velcro peg and cone, and median frequency of extensor digitorum m. We defined a significant training effect as any change in magnitude of these parameters that exceeded a two-SD band from the pretests mean and occurred on at least two consecutive posttest measurements.

3. RESULTS

Subjects showed significant improvements in all posttreatment measurements. However the results comparing the assessment in pretest 1 and pretest 2 were not statistically significant. The mean value (±SD) of the two Box and Block pretests were 9.50 (±0.87) in subject 1, and 17.33 (±1.44) in subject 2 (Figure 2). The mean of posttest exceeded the means of two pretests in both subjects: 11.33 (±0.58); 21.00 (±2.65). Thus, a statistically significant change was achieved.

The plotted data of pegboard task also showed a trend toward improvement after training (Figure 3). The mean number of moved pegs in the two pretest measurements in subject 1 and subject 2 were 8.83 (±1.08) and 17.17 (±0.79), relatively. The posttest means exceeded the two pretests means in both subjects: 12.67 (±2.52); 26.67 (±1.53). Thus a statistically significant change was achieved.

The means (±SD) in cones task of the two pretest measurements in subject 1 and subject 2 were 12.5 (±0.58) and 14.67 (±1.61), relatively (Figure 4). The posttest means exceeded the two pretests means in both subjects: 15.67 (±0.58); 21.00 (±2.00). Thus a statistically significant change was achieved.

The plotted means for median frequency showed a trend toward improvement following training (Figure 5). The mean median frequency of the two pretest measurements in subject 1 and subject 2 were 14.16 (±3.66) and 14.47 (±5.70), relatively. Thus a statistically significant change was achieved.

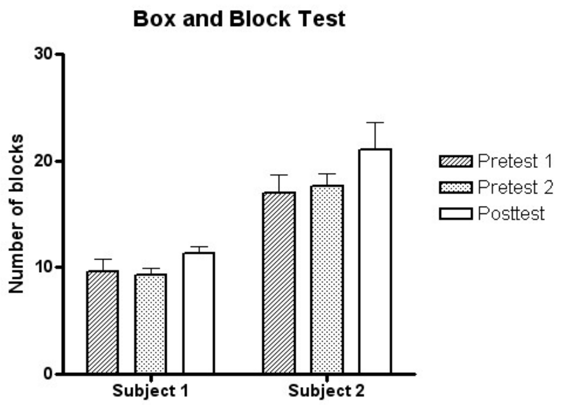

Figure 2 – Number of moved blocks in Box and Block test at pretests(1,2) and posttest.

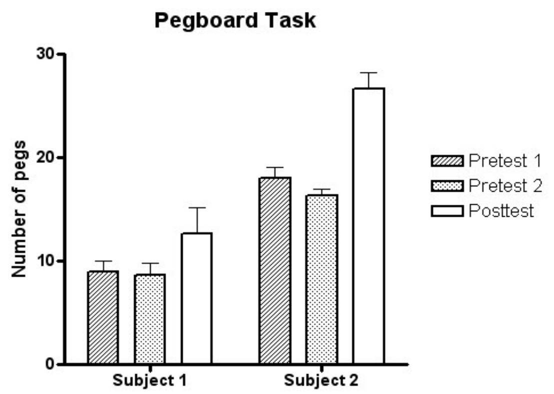

Figure 3 – Number of moved pegs in pegboard task at pretests(1,2) and posttest.

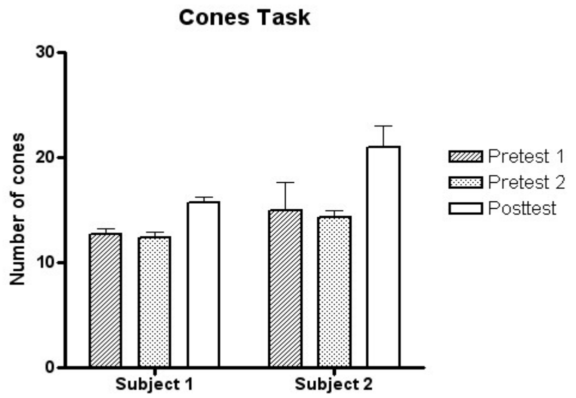

Figure 4 – Number of moved cones in cone task at pretests(1,2) and posttest.

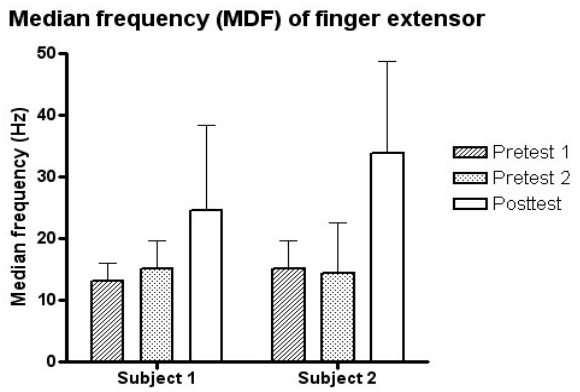

Figure 5 – Median frequency of extensor digitorum m. at pretests(1,2) and posttest.

4. DISCUSSION AND CONCLUSIONS

The use of electrical stimulation combined task oriented training has been shown to produce therapeutic effects: increased hand function and muscle recruitment. Although the mechanisms underlying the effects of the FES-assisted training are still controversial, it seems clear that a repetitive motor training of grasping and releasing functions using FES is effective to improve manual dexterity.

This study therefore suggests diversity of meaningful tasks combined with FES may play an important role in retraining releasing hand function. This study also demonstrated the possibility that a FES-assisted task-oriented training is used to optimize rehabilitation treatment when the necessary equipment and therapeutic service are available.

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