ORIGINAL ARTICLE

Functional electrical stimulation in upper extremity recovery of hemiparetic patients after stroke

Antonio Vinicius Soares[1], Leila Poluceno[2], Caroline da Rosa Cremonini[2], Priscila Baracho Ponsoni[3], Susana Cristina Domenech[4], Noé Gomes Borges Júnior[4]

ABSTRACT

The rehabilitation of the upper limb of hemiparetic patients by stroke is a major challenge. Among the various therapeutic resources used, functional electrical stimulation (FES) has been a popular avenue explored in treatment programs for these patients. **Objective:** To evaluate the effects of FES on wrist and finger extensors in a specific task (ST). **Methods:** We conducted a pre-experimental study (pre and post-tests) with eight chronic patients with a mean age of 63.4 years (± 6.1). The evaluation parameters were for manual mobility by the hand movement scale (EMM), grip strength by dynamometry (Din), dexterity of the upper limb by the box and blocks test (CB) and the 9-pin and holes test (9PB), spasticity by the modified Ashworth scale (MAS), and functional independence by the Barthel index (BI). The ST chosen was performing the movement of reaching and grasping plastic bottles of different sizes with the affected upper limb in different combinations of positions for a total maximum of 54 repetitions per session. FES was used to assist the hand in grabbing and holding the object during the ST. There was a mean of 20 sessions with attendance twice a week. **Results:** The results showed improvement in all parameters, the difference was statistically significant in all the tests, except for Din. **Conclusion:** In this sample, FES in the proposed ST resulted in improved performance in the upper limb function of patients undergoing treatment.

Keywords: electric stimulation, motor skills, paresis, rehabilitation, stroke

[1] Physiotherapist, Master in Sciences of Human Movement, Researcher from the Neuro-rehabilitation Research Center - NUPEN.
[2] Physiotherapist.
[3] Physiotherapist, Specialist in Neurological Rehabilitation.
[4] Professor, Center for Health Sciences and Sports - CEFID/UDESC.

Mailing address:
NUPEN - Núcleo de Pesquisas em Neuroreabilitação (FGG/ACE)
Antonio Vinicius Soares
Rua São José, 490, Anita Garibaldi
CEP 89202-010
Joinville - SC
E-mail: a.vini@ig.com.br
Study developed at NUPEN - Neuro-rehabilitation Research Center/Course at the Guilherme Guimbala School of Physiotherapy at the Santa Catarina Teaching Association- FGG/ACE.

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INTRODUCTION

Stroke (CVA) is a cerebrovascular disease characterized by a brain injury stemming from permanently compromised local blood flow, causing various deficits, and it is one of the most disabling health conditions in the world, even leading to death.[1-3] In 2001, stroke was statistically the leading cause of death in Brazil.[4]

A stroke can be caused by hypertension and age, the main risk factors,[5] resulting in paresis or paralysis of the side opposite to the injury,[6,7] and manifested in muscle weakness, spasticity, and atypical motor patterns, disabling its victims or hampering the functionality of the upper limb.[8,9]

Recovering movement and function of the upper limb is a concern for individuals who have suffered paresis after a stroke.[10-12] Among survivors, 80% of the victims suffer from acute paresis of the upper limb after a stroke, and only a third of them recover full function.[10]

Improvement in the function of the paretic upper limb has been reported recently in people with chronic stroke, following an intervention that compels the less impaired upper limb and intensifies practices in the impaired upper limb.[13,14] From this perspective, repetitive movements induced by electrical stimulation may be important for motor relearning, through mechanisms that include somatosensory cortex stimulation by increasing sensory feedback, thus increasing proprioceptive stimulation as a result of muscular activation.[5,15]

Functional electrical stimulation (FES) can be an appropriate intervention to enable the active practice of a hemiparetic patient.[16] Segmented functional practice is the key to improving strength, so associating FES with specific functional tasks could be a good therapeutic strategy.[13] Recovering the capacity to perform functional tasks is one of the main goals of rehabilitation for patients with motor deficits.[17]

OBJECTIVE

Since recovering the usage of the upper limbs of chronic hemiparetic patients is a rehabilitation challenge, the objective of this study was to investigate the effects of FES on a specific task of the affected upper limb.

METHOD

The study was approved by the Committee for Ethics in Research with Human Beings from the *Associação Educacional Luterana Bom Jesus/IELUSC (Lutheran Education Association)* (Nº. 056/2010). The patients, or the person responsible, received a formal invitation and signed the Free and Informed Consent Form.

The population studied was hemiparetic stroke patients attended at the *Associação dos Deficientes Físicos de Joinville (ADEJ) - Joinville Association for the Physically Disabled.* The sample consisted of eight chronic patients who were independent and capable to perform reaching movements with the affected upper limb.

The inclusion criterion was Stroke-induced Hemiparesis, and the exclusion criteria were: sensory and/or mixed aphasia, visual and/or auditory deficit, other associated neurological diseases, important cognitive alterations, or alterations or injuries to the skin where the FES was to be applied.

Two professionals not involved with the treatment program made all the evaluations before and after the tests.

Initially, general data was collected from the patient's history chart. To evaluate the manual motricity, the Hand Movement Scale (HMS)[18] was used with a score of 1 to 6, where the patient was instructed to perform some finger movements, and those were classified by the scale. The best performance gives a score of 6. Hand grip strength was evaluated using the Takei Dynamometer GRIP-D® TAKEI - Scientific Instruments - Japan.[19-21]

Two dexterity tests were applied to the upper limb. The first test was the Box and Blocks Test (B&B):[22] a box with 150 wooden blocks, where the patient picks up one block at a time and quickly puts it in another box compartment. It lasts one minute and was applied to both upper limbs. The other was the 9-Hole Peg Test (9-HPT),[22,23] where the patient is instructed to remove and place the pegs with one hand, without help from the other hand, except to hold the base of the object. This test has to be done rapidly and by both upper limbs. The performance in this test is recorded in seconds.

The evaluation of the Upper Limb Spasticity (elbow, wrist, and finger flexors) was applied following the Modified Ashworth Scale (MAS),[24,25] with a score of 0 to 5.

The independence in daily life activities was evaluated by the Barthel Index (BI).[26-28] The BI evaluates the individual's autonomy for self care, and its maximum value is 100, with the cut point between 60 and 65; when less than 60 it represents greater dependence.

The treatment program consisted of 20 minutes of conventional physical therapy (classic kinesiotherapy) and 30 minutes of FES protocol in the extensor muscles of the wrist and fingers during a functional task (Figure 1). During the reach and grasp objects task (plastic bottles) the patient's electrical stimulation was manual, facilitating the opening of the hand and preparing it for the grasping of the objects. Bottles of one half, one and a half, and two liters were used, each containing half a liter of water. The patient should take the bottle, lift it, and place it back in the same place. These sessions occurred twice a week for ten weeks, thus totaling 20 sessions. The bottles were placed on a table of standard height (about 77cm), at a distance that allowed the shoulder to flex and the elbow to completely extend. They were positioned at 45° abduction from the shoulder in the contralateral plane, in front of the sagittal plane, and at 45° of adduction from the shoulder in the ipsilateral plane. Six series of three repetitions for each bottle were done, totaling 54 repetitions.

A neuromuscular stimulator such as the FESVIF 995 dual® Quark - two channel asymmetrical bipolar current; pulse width: 250 µs; frequency: 80 Hz; sustainment: 5 seconds; rest: turned off. A pair of self-adhesive electrodes was used, positioned on the wrist and finger extensor muscle group. The electrical stimulation was initiated and finalized manually.

The data collected was analyzed by the GraphPad Prism 4® software through descriptive statistics, determining the averages and standard deviations. The *Student t* test was applied to verify whether the performance indices (percent variation) between the pre - and post-test averages had any statistical significance ($p < 0.05$).

RESULTS

Eight chronically hemiparetic patients, aged between 56 and 72 years, with age average of 63.4 ± 6.1 years, with time of injury between 14 and 120 months, and with average of 48.3 ± 33.1 months were submitted to the treatment. The study group was composed of 5 males (62.5%) and 3 females (37.5%). From the sample, 75% of the patients had right hemiparesis and 25% had left hemiparesis. All the patients were right-handed.

Table 1 shows the performance indices by the pre - and post-test percentage differences, as well as the significance levels of these alterations.

The patients showed statistically significant improvement in the tests: HMS (28.2%), B&B (32%), 9-HPT (15.4%), and MAS (41.7%).

Observe the placement of the FES electrodes for the extensor muscles of wrist and fingers

Figure 1. Initial position for the execution of the specific reach and grasp task of the bottles

Table 1. Index of performance in the tests

Tests	Before	After	PI
HMS	3.9	5.0	28.2%*
DYN	16.8	19.2	14.3%*
B&B	20.3	26.8	32.0%*
9-HPT	137.4	116.3	15.4%*
MAS	1.2	0.7	41.7%*
BI	83.1	86.3	3.9%

* $p < 0.05$; HMS: Hand Movement Scale (1-6); DYN: Grip Dynamometer (kgf); B&B: Box and Blocks (number of blocks in one minute); 9-HPT: 9-Hole Peg Test (remove and replace in less time, seconds); MAS: Modified Ashworth Scale (0-5); BI: Barthel Index (0-100); PI:erformance Index (%)

However, although the patients improved their performances in the dynamometry (14.3%) and also in the Barthel Index (3.9%), these differences were not statistically significant.

DISCUSSION

By the results obtained, all the patients were benefitted by the treatment, showing improvement in most requirements evaluated when compared to the initial evaluation values.

The first parameter evaluated was the Hand Movement Scale (HMS), where all the patients showed significant improvement. This test has a predictive value and in general is related to the functional performance of these patients' upper limbs. Katrak et al.,[18] after observing the hand recovery of post-stroke hemiparetic patients, developed the Hand Movement Scale, which quantifies the movements of fingers and thumbs.[29]

In the 9-Hole Peg Test and Box and Blocks Test, there was significant improvement in the performance of the patients submitted to the training. Arantes et al.,[22] while systematically reviewing FES in the wrist muscle extensors also found good results with this technique. It is important to use these upper limb dexterity tests, for they are quick, simple, and give an estimation of the functionality of the upper limb.[8,23]

Despite the study sample having slight spasticity initially, a significant reduction could be seen through the Modified Ashworth Scale. Although some studies have demonstrated the effects of electrical stimulation reducing spasticity,[8] some others did not compare their findings with other therapeutic interventions.[13,30,31]

The Barthel Index is frequently used to evaluate the functional independence of neurological patients.[15,31] In this study there was a small percentage variation and it did not show any statistical significance. One needs to remember that this instrument reflects the degree of independence of the subject, and even if there is behavioral adaptation, it is not necessarily accompanied by any specific recovery of the deficit.[26-28]

As for the dynamometry, all the patients showed improvement in muscular strength, despite this result not being statistically significant. This may be explained by the reduced number of patients. Other authors[6,13] have already demonstrated benefits in gained strength for hemiparetic patients.

CONCLUSION

The recovery of the upper limb for post-stroke hemiparetic patients in the chronic phase is a great challenge for rehabilitation professionals. It is important that new treatment strategies be tested with the objective of exploring the possible residual potentials in these patients.

In this study, where the patients were submitted to a training program with FES in a functional task with the upper limb, the results were positive and encouraging. However, these findings must be observed with caution, for the study parameters and the small sample size limited any possibility of generalizing. Thus, for future studies we suggest enlarging the sample, working with other tasks according to the individual's demand, and also to work with uni- and bi-manual tasks.

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