Functional electrical stimulation optimized in patients with hemiparesis due to cerebrovascular disease

Simone Hitomi Oshiro[1], Carolina Lemes de Oliveira[1], Amanda Carolina da Silva Bim[1], Gisele Saraiva Reis de Oliveira[2], Marcelo Riberto[3]

ABSTRACT

Functional Electrical Stimulation (FES) is one of the techniques used on patients with motor sequelae such as hemiparesis after a stroke (CVA). Recent studies show positive results for the use of FES in the increase of isometric muscular strength for wrist extensors and reduction of tonus for patients with active extension of upper wrist at 20° before the intervention. **Objective:** As for the amplitude of movement and reduction of tonus in patients with 10° and 20° of active extension of the wrist, no significant gains were observed. **Method:** This study evaluated the efficiency of optimized functional electrical stimulation (O-FES) for two weeks on the manual dexterity and range of movement (ROM) of three individuals showing hemiparesis due to a stroke. **Results:** All the patients improved in one or more items of the evaluation (manual dexterity and ROM). **Conclusion:** We can conclude that the application of stimulation according to this new parameter showed benefits with a short time of stimulation on those patients with only a hint of finger movement.

Keywords: electric stimulation, paresis, stroke/rehabilitation

[1] Occupational therapist taking an Advanced Training Course at the Instituto de Reabilitação Lucy Montoro do Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto (Lucy Montoro Rehabilitation Institute at the Clinics Hospital - College of Medicine - Ribeirão Preto).
[2] Occupational therapist, Lucy Montoro Rehabilitation Institute at the Clinics Hospital - College of Medicine - Ribeirão Preto.
[3] Professor at the Department of Biomechanics, Medicine, and Rehabilitation of the Locomotor System at the College of Medicine - Ribeirão Preto - University of São Paulo.

Mailing address:
FMRP USP, Departamento de Biomecânica, Medicina e Reabilitação do Aparelho Locomotor
Avenida Bandeirantes, 3900, Monte Alegre
CEP 14048-900
Ribeirão Preto - SP

Received on July 6, 2012.
Accepted on August 6, 2012.

DOI: 10.5935/0104-7795.20120010

INTRODUCTION

A stroke is defined as a lesion in the brain, characterized by an interruption of blood flow caused by an embolus, thrombus, or blood extravasation in a specific area of the brain, with consequent neurological dysfunctions.[1] Hemiparesis is one of the motor impairments caused by a stroke, with alteration of the tonus, disruption of active movement, and spasticity.[1] Among the main clinical characteristics of the upper limb are the flexor pattern, adduction and internal rotation of the shoulder, elbow flexion, forearm pronation, and wrist and finger flexion.[2]

In the therapeutic rehabilitation arsenal for individuals with stroke sequelae, functional electrical stimulation (FES) has stood out recently. Functional Electrical Stimulation consists of an electrical current that provokes action potentials in the motor nerve,[3] and may cause strengthening, decrease in spasticity (by reciprocal inhibition), and muscular relaxation, depending on the frequency used and on other parameters (pulse width, time on/off, and area stimulated).

The clinical use of FES has not yet become popular due to the heterogeneity of the studies and to the lack of knowledge about its effects and the appropriate parameters of stimulation.[3] The parameters normally used in producing scientific articles are: frequency of 20 to 100 hz, amplitude of 14 to 60 mA, and pulse width of 200 to 300 μs.[3] For muscle strength and muscle tone, there is strong evidence of positive effects, emphasizing that, for the effect of diminishing tone, this is limited to patients with active wrist extension greater than 20° before intervention.As for the range of active movement (ROM) and in the group of patients with active extension between 10° and 20°, there were no significant gains.[3] The duration of the interventions varies on average from 10 to 15 sessions.[4]

The term FES optimized (FES-O) refers to the clinical observations made by the authors of this article about its evolution being faster and more progressive when compared to other electrical stimulation protocols, and for it being based on muscular physiology studies.

OBJECTIVE

This study seeks to evaluate the efficacy of optimized functional electrical stimulation (FES-O) on manual dexterity and on ROM in 3 individuals with hemiparetic sequelae caused by stroke.

METHOD

Research subjects

The subjects of the research were recruited at the Rehabilitation Center (CER) at the Clinics Hospital, Ribeirão Preto Unit (HCRP) from the University of São Paulo. This is a case study with three clinically stable individuals with hemiparesis caused by stroke. The first patient is a female, 42 years old, whose stroke occurred 7 months earlier. The second patient is a male, 52 years old, whose stroke occurred a month and a half previous. The third patient is also male, 29 years old, whose stroke occurred 2 months earlier. All three patients understood the procedures of the study and were not under any other kind of therapy for the upper limbs until the end of the study.

This study, as well as the Free and Informed Consent form were approved by the Ethics Research Committee, in accordance with the HCRP Process n. 15616/2011, and the subjects or those responsible for them signed the Free and Informed Consent Form.

Intervention

Three individuals were recruited, either through the waiting list or who were already being treated, who had hemiparesis due to stroke. For the patients already under treatment, it was asked that their therapists did not impose any type of exercise for the upper limbs during the period of the study. All the recruited patients accepted to be part of the study, and to go to the Rehabilitation Center three times a week, for two weeks.

The protocol consisted of stimulating the extensor muscles of the fingers, wrist, and triceps for 45 minutes, 3 times a week, on non-consecutive days to avoid fatigue, for 2 weeks, completing a total of 6 sessions. Active exercises to extend the fingers, wrist, and elbow were mixed with the electrical stimulation, without provoking synergic movements or finger flexion. The 4 channel Neurodyn II device was used, made by Ibramed (Chart 1).

Evaluations

The evaluations were made before the beginning of the therapeutic intervention and immediately after the end of the study. They consisted of:

Manual dexterity: the box and blocks test (BBT) was used to evaluate unilateral manual dexterity. The task is to take 150 blocks placed on the same side as the limb being tested and, one by one, put them on the other side for 60 seconds. The test can be used due to its validation and reliability having been established in 1994, in which the difference between the afflicted upper limb and the non-afflicted one was statistically significant.[5] The quantifications were made with both upper limbs, but we will only show the side afflicted by stroke in this study.

Range of movement (ROM): active goniometry of fingers and wrist made with a manual universal[6] goniometer following the positioning of the joints in flexion and extension.

RESULTS

Patient 1

Right-handed female, 42 years old, completed elementary school, had developed a hemorrhagic stroke with right hemibody impairment seven months before the beginning of the study. She did not show any cognitive impairment, and had received physiotherapeutic treatment only in the lower limbs.

At the initial evaluation she presented heightened flexor tone, showing only a small movement. She was using a positioning orthosis on her hand, wrist, and fingers mainly for night use and intermittently during the day. She was independent in her daily life activities and cared for her newborn son with both hands, using the RUL as a support. The intermittent use of the RUL increased the flexor pattern.

At the end of the treatment, an improvement of the MCP extension was observed, not by active movement, but by decrease in the flexor tone (Table 1).

Patient 2

Right-handed male, 52 years old, completed elementary school, had developed ischemic stroke with right hemibody impairment a month and a half before the beginning of the study. He did not show any cognitive impairment, and was not receiving any other treatments.

At the initial evaluation he showed little mobility of fingers and wrist, and edema was observed in his right hand.

After the FES-O protocol, there were gains in the goniometry of finger flexion and extension and in the box and blocks test. The right hand edema diminished, but did not disappear completely. The patient complained about the discomfort in his wrist, and residential retrograde massage was requested (Table 2).

Chart 1. Electrical stimulation parameters for strengthening with the FES-O

	FES Strengthening
Frequency	20 hz
Pulse width	500 us
Time On/Off	6s/6s
Time Up/Down	1s
Eletrodes	In the motor area of the extensor muscles of the fingers and wrist and in the motor area of the triceps muscles. Self-adhesive electrodes were used
Intensity	Increase the intensity to the limit of the patient, without provoking any movement contrary to the muscle being stimulated

Table 1. Quantitative evaluation of patient 1 before and after the application of FES-O

Variable		Before FES-O	After FES-O	Gain
Box and blocks		0	0	0
Goniometry of active MCP flexion	1st finger	60°	45°	-15°
	2nd finger	88°	90°	2°
	3rd finger	90°	90°	0°
	4th finger	90°	90°	0°
	5th finger	64°	90°	26°
Goniometry of active MCP extension	1st finger	-53°	-40°	13°
	2nd finger	-80°	-40°	40°
	3rd finger	-85°	-40°	45°
	4th finger	-85°	-40°	45°
	5th finger	-60°	-40°	20°

Patient 3

Right-handed male, 29 years old, completed high school, had developed ischemic stroke with right hemibody impairment 2 months before the beginning of this intervention. He did not show any cognitive impairment, and was receiving treatment only in the lower limbs.

At the initial evaluation, the patient showed little mobility in the fingers of his right hand, without maintaining the ROM reached and fatiguing easily. His muscle tone was slightly elevated during the extension of fingers and wrist. Despite the lack of finger mobility, the patient was able to have the ulnar grip strength to pass 9 blocks from the right to the left side of the box.

After the electrical stimulation, the patient mentioned improvement in the mobility of fingers and wrist and he has been able to use the RUL in his daily activities (Table 3).

DISCUSSION

Clinical studies suggest that after a stroke, the motor recovery of the paretic limb must be treated with the active and repetitive use of the limb, however, many acute patients show a significant degree of paresis that limit active mobilization strategies during rehabilitation. Thus, many rehabilitation services choose to teach compensating strategies for the practice of daily activities instead of restoring the motor control as the first treatment.[8] The present study demonstrated that the use of the FES-O protocol resulted in 3 patients with a dramatic increase in one of more evaluation items (manual dexterity and active movement in the flexion and extension of fingers).

There is a plateau of spontaneous recovery or even under therapeutic stimulation after the first 6 months of stroke-induced hemiplegia. However, more than 85% of these patients show residual deficits in the upper limb on the impaired side.[9] Most studies are made with patients who had a stroke at least 1 year before, that is, after the subacute phase, with strong spasticity, deformities, and almost no motor response from the antagonistic muscles, such as the fingers, wrist, and elbow extensors. For this reason we decided to make this small study with patients within the period of 1 year after the stroke.

The FES-O action mechanism involves the strengthening of the muscle groups directly stimulated, but it is important to point out that the electrical stimulation also consists of a strong sensory contribution that can activate latent afferent pathways, increasing awareness to the movement of the stimulated segment. The possibility of properly stimulating the afferent and efferent pathways in a phase in which it is believed the neuronal plasticity is higher may have a determining role in the installation of secondary deficiencies such as spasticity and the development of inadequate synergic patterns.

This case report is limited for there was no appropriate control of the interventions and for having been made with patients in the early phases of disability (2 patients less than 2 months after their stroke), which allows the argument that those gains could have been spontaneous. However, the perfect association of improvements in the motor performance with the period of stimulation allow us to affirm that this intervention may accelerate the gains that the patient would eventually develop in its natural evolution, but in accelerating this process, other gains relative to the period of dependence and to the time spent with reduced dexterity for instrumental activities could justify its application in the early phases of disability.

CONCLUSION

We can conclude that the application of this new optimized functional electrical stimulation parameter has been beneficial

Table 2. Quantitative evaluation of patient 2 before and after the application of FES-O

Variable		Before FES-O	After FES-O	Gain
Box and blocks		11	22	11
Goniometry of active MCP flexion	1st finger	25°	40°	15°
	2nd finger	40°	50°	10°
	3rd finger	40°	50°	10°
	4th finger	25°	50°	25°
	5th finger	20°	55°	35°
Goniometry of active MCP flexion	1st finger	-25°	-15°	10°
	2nd finger	-30°	-15°	15°
	3rd finger	-30°	-15°	15°
	4th finger	-30°	-10°	20°
	5th finger	-30°	-10°	20°

Table 3. Quantitative evaluation of patient 3 before and after the application of FES-O

Variable		Before FES-O	After FES-O	Gain
Box and blocks		9	28	19
Goniometry of active MCP flexion	1st finger	60°	50°	-10°
	2nd finger	78°	80°	2°
	3rd finger	82°	80°	-2°
	4th finger	92°	75°	-17°
	5th finger	95°	80°	-15°
Goniometry of active MCP flexion	1st finger	-60°	0°	60°
	2nd finger	-78°	-10°	68°
	3rd finger	-82°	-10°	72°
	4th finger	-92°	-10°	82°
	5th finger	-95°	-10°	85°

in the functional improvement of the upper limb in patients with hemiparesis after a stroke.

REFERENCES

1. PulaskiKH. Disfunção neurológica no adulto. In: Neistadt ME, Crepeau EB, Willard & Spackman: terapia ocupacional. 9 ed. Rio de Janeiro: Guanabara Koogan; 2002.p.616-93.
2. Awad EA, Dykstra D. Tratamento da espasticidade pela neurólise. In: Kottke FJ, Lehmann JF. Tratado de medicina física e reabilitação de Krusen. 4 ed. São Paulo: Manole;1994.p.1145-51.
3. Arantes NF, Vaz DV, Mancini MC, Pereira MSDC, Pinto FP, Pinto TPS. Efeitos da estimulação elétrica funcional nos músculos do punho e dedos em indivíduos hemiparéticos: uma revisão sistemática da literatura. Rev Bras Fisioter. 2007;11(6):419-27.
4. Reese NB. Testes de função muscular e sensorial. Rio de Janeiro: Guanabara Koogan;2000.
5. Cavaco NS, Alouche SR. Instrumentos de avaliação da função de membros superiores após acidente vascular encefálico: uma revisão sistemática. Fisioter Pesqui. 2010;17(2):178-83.
6. Marques AP. Manual de goniometria. 2 ed. São Paulo: Manole;2003.
7. Nicholas JA, Sapega A, Kraus H, Webb JN. Factors influencing manual muscle tests in physical therapy. J Bone Joint Surg Am. 1978;60(2):186-90.
8. Rezende FB, Borges HC, Monteiro VC, Masiero D, Chamlian TR. Efetividade da estimulação elétrica funcional no membro superior de hemiparéticos crônicos. Rev Neurocienc. 2009;17(1):72-8.
9. Chae J, Bethoux F, Bohine T, Dobos L, Davis T, Friedl A. Neuromuscular stimulation for upper extremity motor and functional recovery in acute hemiplegia. Stroke. 1998;29(5):975-9.