Dynamometric evaluation of NMES treatment on patients with tetraplegia

Ferreira VMV[1], Varoto R[2], Beinotti F[1], Cliquet Jr. A[1,2]

[1] State University of Campinas (UNICAMP), Campinas, Brazil

[2] University of São Paulo (USP), São Carlos, Brazil

Abstract

Persons with tetraplegia present severe loss of muscle control and strength. This study aim to evaluate through dynamometry the efficacy of NMES treatment on the upper limb. Seven individuals with complete chronic spinal cord injury at cervical level participated in the study. NMES treatment consists of strengthening and functional training periods. An 8-channel stimulator with monophasic square voltage output with frequency at 25 Hz was used with surface electrodes placed at the upper limb. Dynamometric data were performed for the right elbow flexors and extensors with an interval of two years. Patients presented strength improvement for the elbow flexors, but no statistical difference was observed for the elbow extensors. More studies are necessary to conclude if NMES treatment improves strength on paralyzed muscles in chronic tetraplegia.

***Keywords**: tetraplegia, dynamometry, strength, neuromuscular electrical stimulation.*

Introduction

After a spinal cord injury (SCI) of cervical level the individual present several disabilities due to the loss of motor control and strength deficits, resulting in limitations to perform functional activities, such as to grasp an object.

The neuromuscular electrical stimulation (NMES) is used in rehabilitation to improve the muscular tonus and to induce plasticity, throughout other applications. [1]

Dynamometry is used in SCI to analyze the strength and has been shown to be more sensitive than other tests, as manual muscle testing. [2, 3]

The aim of this study is to evaluate through dynamometry the efficacy of NMES treatment on the upper limb.

Material and Methods

Participants

Seven individuals (six males and one female) with complete chronic spinal cord injury at cervical level were recruited from University Hospital and voluntarily participated in this study (Table 1). The inclusion criteria were SCI following traumatic lesion, at least two years of SCI, motor level between C4-C8 and age over 18 years. The exclusion criteria were: previous neurological or degenerative disease, cognitive impairments, upper limbs skin lesions, tendon transfer surgery and inability to remain seated on a wheelchair. This work was approved by the local ethics committee.

Table 1. Clinical characteristics of the subjects (n=7)

	Patients							Mean	SD
	A	B	C	D	E	F	G		
Age[(a)]	25	33	38	28	45	32	42	34.7	7.3
Body mass[(b)]	80	78	64	62	64	63	51	66	10
Height[(c)]	1.83	1.72	1.72	1.7	1.77	1.77	1.6	1.73	0.1
BMI[(d)]	24	26	22	21	20	20	20	21.9	2.4
Injury time[(a)]	3	13	8	4	10	9	21	9.7	6
Motor level[(e)]	C5	C7	C5	C4	C6	C6	C8	-	-

[(a)] years; [(b)] kg; [(c)] m; [(d)] body mass index (kg/m^2); [(e)] ASIA right motor level

NMES treatment

An 8 channel stimulator controlled by computer was used with adhesive surface electrodes placed on the upper limb. The stimulator generates a monophasic square voltage output with frequency at 25 Hz and maximum pulse width fixed at 300 µs. The amplitude was adjusted to ensure motor contraction for each muscle.

The treatment with NMES is performed once a week, during 20min, and consists of two periods: strengthening and functional training. The number of sessions varies between each patient.

For the functional training the patient should grasp and move an object with the hand, and then place it on a task-table. The exercise is done bilaterally and alternating both arms. On the strengthening period the patient is instructed to open and close the hand

following the stimulation, but without moving the object (Figure 1).

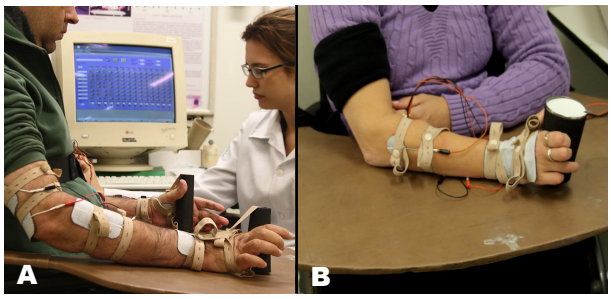

Figure 1 – Patient performing NMES during strengthening (A) and functional training (B).

For the opening/reaching phase the following muscles were stimulated (2s): triceps brachii, extensor carpi ulnaris, extensor digitorum communis and lumbricalis. The patients A, C, D and E also stimulated the anterior deltoid.

On the closing/grasp phase the flexor digitorum and opponens pollicis were stimulated (2s). The patients C and D also stimulated the biceps brachii.

Dynamometry

The strength of the right elbow extensors and flexors were assessed with an electronic DFS-100 dynamometer (Shimpo Instruments, Itasca, IL, USA) adapted to measure maximal isometric force (Figure 2). The participant was instructed to perform a maximal contraction for 5 seconds with a rest period of 10s (n=9). The mean value was used as the dynamometric data. Only the right arm was tested.

The assessments were performed with an interval of two years.

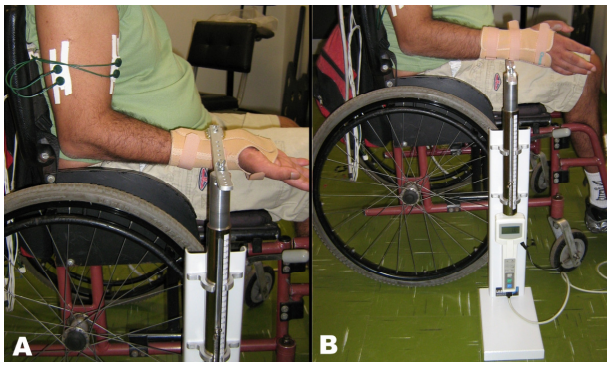

Figure 2 – Dynamometric assessment for the elbow flexors (A) and extensors (B).

The Wilcoxon signed-rank was performed for statistical analyses. The significance was fixed at 0.05.

Results

The patient E did not performed the final dynamometric assessment for the right elbow flexors.

Figure 3 shows the dynamometric data for each patient at initial and final evaluations. The patients presented improvement on the right elbow flexors strength (p=0.04).

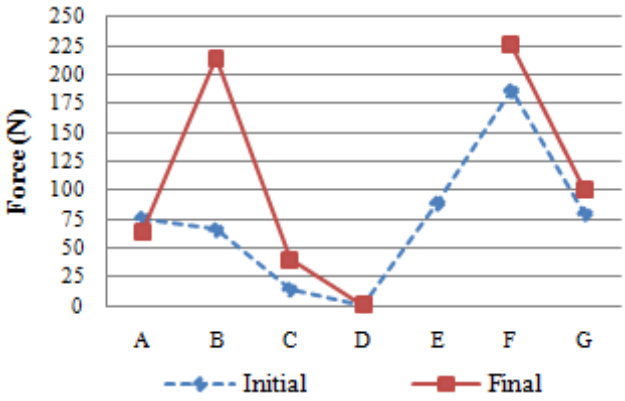

Figure 3 – Dynamometric data for the right elbow flexors.

For the right elbow extensors the dynamometric data is shown in Figure 4. No statistical difference was seen between the initial and final evaluations, although the patients B and G presented an improvement on strength.

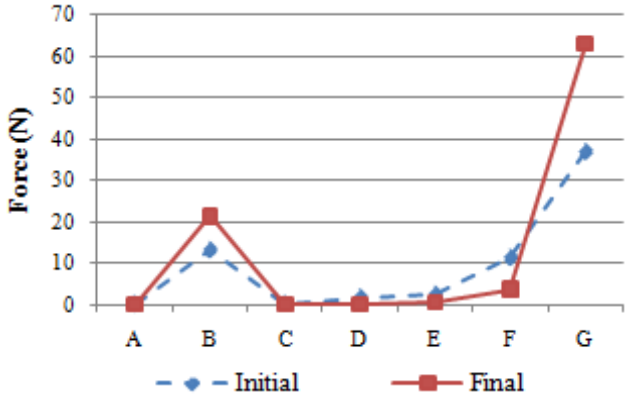

Figure 4 – Dynamometric data for the right elbow extensors.

Discussion

Of the six patients that performed both evaluations for the right elbow flexors, two stimulated the biceps brachii (C and D). Despite this, the patients presented improvement on strength. It is important to note that only the patient D do not have motor control of the biceps brachii. This improvement may have occurred due to the functional training or other factors, as conventional exercise.

All patients were stimulated on the triceps brachii, but only the patients with C7 and C8 motor levels presented improvements. This can be explained by the fact that the proposed functional training may not properly activate the triceps brachii [4].

These results show that in chronic tetraplegia is more likely to occur improvement of strength in muscles that have some level of motor control by the patient.

Conclusions

It is necessary more studies to conclude if NMES treatment improves strength in muscles with paralysis in chronic tetraplegia.

References

[1] Hamid S, Hayek R. Role of electrical stimulation for rehabilitation and regeneration after spinal cord injury: an overview. *Eur Spine J* 2007; 17:1256-69.

[2] Sisto SA, Dyson-Hudson T. Dynamometry testing in spinal cord injury. *J Rehabil Res Dev* 2007;44: 123-136.

[3] Noreau L, Vachon J. Comparison of three methods to assess muscular strength in individuals with spinal cord injury. *Spinal Cord* 1998;36: 716-723.

[4] Hoffman G, Laffont I, Hanneton S, Roby-Brami A. How to extend the elbow with a weak or paralyzed triceps: control of arm kinematics for aiming in C6-C7 quadriplegic patients. *Neuroscience* 2006;139: 749-765.

Acknowledgements

We thank the support by grants from the São Paulo Research Foundation (FAPESP).

Author's Address

Vanessa Maria de Vargas Ferreira
State University of Campinas
vavargas@fcm.unicamp.br