Evaluation the use of neuromuscular electrical stimulation in spinal cord injured subjects: pendulum spasticity test

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Abstract

Spasticity is usually present in spinal cord injuries- above level T-12. Paraplegics and tetraplegics that have some degree of spasticity were assessed before and after the application of neuromuscular electrical stimulation. The PST consists of accelerometers and flexible electrogoniometers optical fiber. The data showed a decrease in spasticity after neuromuscular electrical stimulation (NMES), with features such as an increase in the variation between maximum and minimum peaks, the amplitude of the curves and relaxation index. Furthermore, data from the Modified Ashworth Scale after neuromuscular electrical stimulation also presented a reduction in values.

Keywords: *spinal cord injuries, spasticity, neuromuscular electrical stimulation, pendulum test*

Introduction

Spinal cord injury, depending on the degree of damage, usually causes a neurological disorder. [1]. The motor impairment that occurs most often that is characterized by upper motor neuron lesions causing an increased stretch reflex, muscle tone changes, and especially an increased resistance to passive movement, among others [2, 3]. Spasticity can be measured by the pendulum test which has been proved to be a good indicator [4]. A much used technique is the pendulum test of Wartenberg that consists of measuring spasticity and rigidity through the passive motion of the knee joint [5]. Recently, good results were seen during NMES (neuromuscular electrical stimulation) therapy. The objective was to determine if neuromuscular electrical stimulation applied to the spinal cord injured patients improves the intensity of spasticity.

Material and Methods

Subjects

Sixteen male subjects with SCI (10 Tetraplegic and 6 Paraplegic), with level of lesion C4-T4 and age 33.5 $\pm$ 10.3 years, participated in this study. Written informed consent was obtained from all subjects. All volunteers are outpatients of Clinical Hospital - UNICAMP. All subjects had their quadriceps muscle and fibular nerve being stimulated for 20 and 15 minutes respectively. A 4-channel electrical stimulator delivered a signal of 25Hz with monophasic rectangular pulses with 300μs of duration and a maximum intensity of 200V (1kΩ load). The assessment was done before and after the NMES.

Experiment protocol

The spinal cord injured subjects were kept in a semi-sittin position during the experiment. The Ashworth scale was assessed in patients beforehand. After that, the pendulum test was performed through the device, which was named PST (Pendulum Spasticity Test), designed and built especially for pendulum test as shown in figure 1 [6]. Before and after the NMES the test was performed 3 times. The equipment was composed with two types of sensors: the accelerometer and electrogoniometer. The accelerometer consists of transducers of quartz crystals that were sensitive to the piezoelectric effect caused by muscle tremors. The electrogoniometer measures the angular displacement. It is a device consisting of flexible optical fiber. The observed attenuation allows it related to the measured angular displacement. The electrogoniometer devices are applied to the patient data collection. The angular displacements and voltages, which are sent to a microcontroller are converted from analog signals to digital.

Fig.1: Equipment PST.

Results

The graphics in figure 2 and 3 show the results of collecting data for one patient with spinal cord injury. Measurements were done before and after stimulation

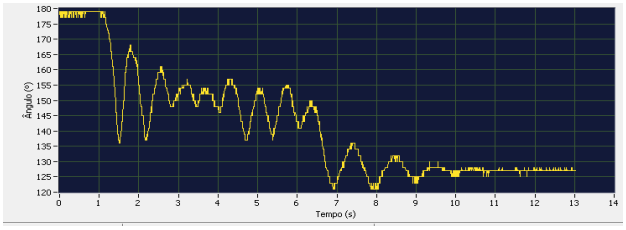

Fig.2: Data collected before NMES

In Figure 2, the patient's leg describes a disorganized oscillating movement that is released under the action of gravity. There is no muscle control and a constant frequency of oscillation. The beginning of the movement is marked by an angular position that is generally smaller.

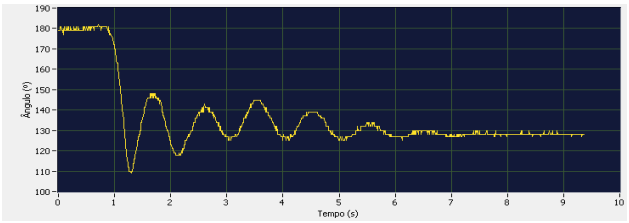

Fig.3: Data collected after NMES.

In figure 3 and 4 after stimulation shows a decrease in the spasticity intensity, where a greater variation between maximum and minimum peaks of the curve and more harmonic curves.

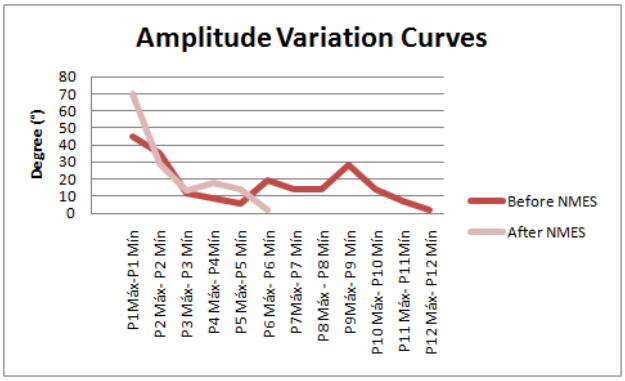

Fig.5: Variation between minimum and maximum peak

Table 2 shows the data before and after stimulation the patients in the test pendulum. Besides the pendulum test, assessment scales for spasticity were conducted.

Table 2:Results from patients with PST

Mesuare	Before NMES	**After NMES**
Plat Amp(°)	45 ± 8.97	50.18 ± 11.55
F1 Amp(°)	83,93 ± 31.43	104,43 ± 31.68
E1 Amp(°)	75.81 ± 31.81	92.81 ± 33.01
RI	1.84 ± 0.55	2.11 ± 0.54
ERI	1.65 ± 0.58	1.88 ± 0.62
Scale Ashworth:	(n)	(n)
3	3	1
1+	3	0
2	2	1
1	6	4
0	2	10

Means ± SD
Abbreviations: plateau amplitude, Plat Amp; amplitude Initial flexion, F1Amp; extension initial amplitude, E1Amp; relaxation index extension, ERI; relaxation index, RI [7].

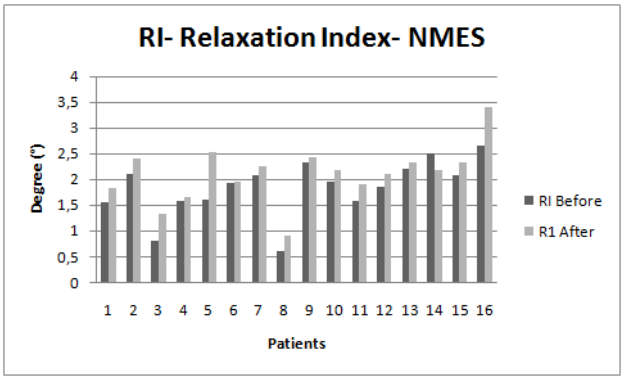

Fig 5. Relaxation index

Discussion

The assessment of muscle tone becomes difficult if used only a subjective interpretation based on passive movements. Thus pendulum test was used to assess the tone of the quadriceps muscles. Moreover, the scarcity of methods for assessment of spasticity, the pendulum test, being a simple and reliable measure of normal and abnormal joint movements, has become an effective method of clinical assessment of spasticity. Data of figures 2 and 3 show clearly that after neuromuscular electrical stimulation in spinal cord injuries a decrease in spasticity occur, as the minimum peak data are smaller due to a relaxation of muscles. And in figure 4, which show the graph of the variation between maximum and minimum peaks after neuromuscular electrical stimulation, the variation increases, i.e., the curves show a greater intensity, which indicates that there is relaxation of the muscles, causing a decrease in spasticity. Robinson [8] conducted a survey to assess the initial effects and long-term electrical stimulation in patients with hemiplegic and little was reported about the long-term effects on spinal cord injured patients with spasticity. Table 2, show some data of sixteen patients evaluated before and after neuromuscular electrical stimulation. In figure 5 shows the relaxation index. Relaxation values collected before and after neuromuscular electrical stimulation show an increase, helping to reduce the severity of spasticity.

Conclusion

The data show that neuromuscular electrical stimulation may result in improvement in spasticity, thereby improving the quality of life of patients with spinal cord injury.

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