Case Report

FES cycling reduces spastic muscle tone in a patient with multiple sclerosis

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Abstract. We report on a multiple sclerosis patient who received functional electrical stimulation to reduce spastic muscle tone of the lower limbs. Stimulation by means of surface electrodes applied to the thigh muscles induced cycling leg movements. Spastic muscle tone was measured clinically using the modified Ashworth scale and semiautomatically by pendulum testing of spasticity. This was done before and directly after stimulation. The patient was able to endure the stimulation for ca. 30 minutes; there was a significant reduction of spasticity after each stimulation session. We conclude, that this type of stimulation could be another potential treatment modality for multiple sclerosis patients, especially those with a high score in the expanded disability Status scale.

Keywords: Multiple sclerosis, functional electrical stimulation, spasticity, case report

1. Introduction

Functional electrical nerve stimulation (FES) is widely used to induce limb movements (i.e., for cycling, standing or walking) in the spinal cord injured (SCI) [5,9,10], but also in stroke patients [3,4,6]. Another effect of FES is the reduction of spastic muscle tone [9]. Few studies present data on electrical stimulation for reducing spasticity in patients with multiple sclerosis (MS) [11,12], and none have used FES.

A limiting factor of FES is the probable induction of uncomfortable or painful sensations when the electricity increases and reaches intensities useful for movement. This is especially the case in patients with residual perception (i.e., incomplete SCI, stroke, or MS). In this case study we report on a patient with multiple sclerosis who was able to tolerate FES for the induction of cycling leg movements and experienced a reduction of spastic muscle tone.

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2. Case report

A 46-year-old man with multiple sclerosis for more than 20 years took part in these pilot experiments. His MS episodes were initially completely remitting, but they took a secondary progressive course 10 years ago. The patient's current clinical state was characterized by tetraparesis mainly of the lower limbs and the left side. With a score of 7.5 on the expanded disability Status scale (EDSS), he was unable to walk and used a wheelchair for most distances, including those in his home. He was able to stand up only with support. The degrees of muscle force were 1–2/5 in the distal and 4–5/5 in the proximal muscle groups of the lower limbs. His arms showed degrees of around 4/5. Force impairment was also mainly on the left side, and all other fine motor activity was strongly limited. At the time of the study he was taking no medication for MS or spasticity, and no MS episode had occurred.

Spastic muscle tone was evaluated using the modified Ashworth scale (MAS) [2] and semiautomated pendulum testing of spasticity (PT) [1]. The MAS was done while the investigator moved the examined limb passively. This was done by two investigators indepen-

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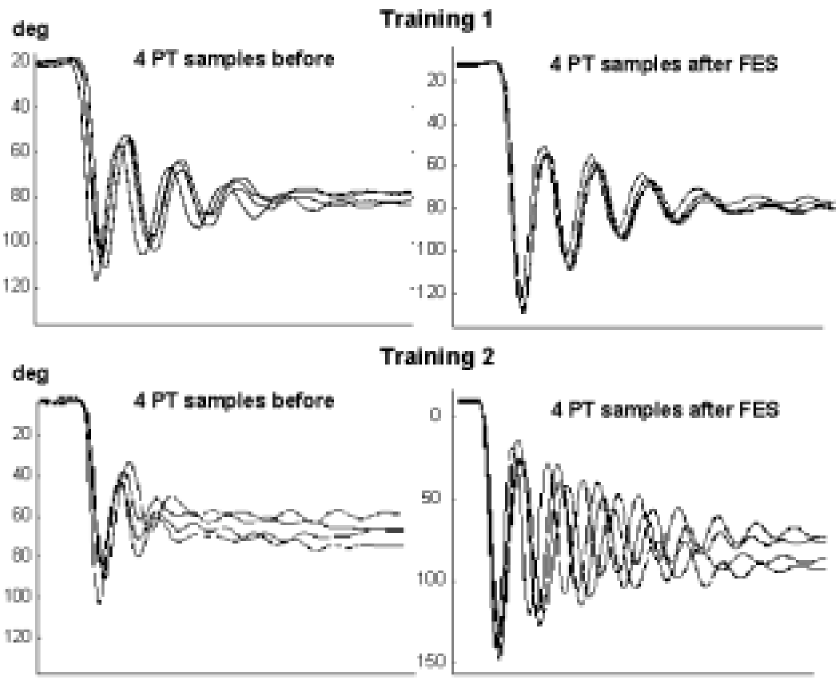

Fig. 1. Each graph represents four swing tests of the PT recorded for the left leg during two training sessions. It can be seen that the starting position differs depending on spasticity. The leg can be stretched more after the training and with reduced spastic tone.

dently. An extensive description of the pendulum testing is given elsewhere [1,7]. In short, an electrical goniometer was applied to the knee joint of the examined side, so that the movements of the free-swinging lower leg against the thigh could be recorded. These data were stored in a personal computer for offline analysis (Fig. 1). The so-called relaxation index and the peak velocity – measured during the first leg flexion from an extended position – were used to measure spastic muscle tone before and after FES. For each leg and each testing session ten PT trials were recorded. These were then averaged and analyzed using the t-test for dependent samples.

A commercial electrical stimulator type microstim 8 (Krauth + Timmermann®, Germany: biphasic rectangular impulses, 10 to 500 μsec width, frequencies from 0.1 to 50 Hz) was used to induce a functional cycling movement training of the lower limbs. Reusable surface electrodes were applied (5 $\times$ 9 cm rectangular shaped, Krauth + Timmermann®, Germany) on the target muscles including a total of three muscle groups in each leg (gluteal group, quadriceps, and femoral biceps on both sides) [10]. A customized computer program, also described elsewhere [10], was used to synchronize the FES and muscle stimulation to induce cycling movements. The patient sat on a chair, which was fastened to an ergometer at which the training and experiments were done.

The patient tolerated the electricity relatively well and became used to it, so that it could be increased during the training (starting with 30 mA up to 90 mA). It was possible to stimulate his legs for at least 30 minutes, allowing for short breaks of 3–5 minutes.

3. Results

The graphs of Fig. 1 show four samples of the PT. In each graph the swing curves of four PT are shown for a total of two training sessions. The curve starts when the leg is in a nearly stretched position (around 10–20 deg) and swings until the resting position (around 80 deg) is reached. After FES the curve seems to be more sinusoidal and shows additional swings. It is also evident that after FES the leg starts in a more stretched position (20 deg vs. 15 deg) and reaches a larger swing range (95 deg vs. 130 deg).

Parallel to these changes in the figure the peak velocity reached during the first flexion swing phase during the PT was also measured. This and the relaxation in-

Table 1
A comparison of data before and after FES indicated that significant reductions occurred in the relaxation index as well as the peak velocity

	FES training 1				FES training 2			
Leg	Right		Left		Right		Left	
FES session	Before	After	Before	After	Before	After	Before	After
MAS	2	1	2–3	1	2	1	3	1
Relaxation index	1.12	1.2*	0.89	1.02**	1.02	1.14*	0.89	1.03**
Mean (standard dev.)	(0.05)	(0.01)	(0.04)	(0.05)	(0.07)	(0.05)	(0.08)	(0.06)
Peak velocity (deg/s)	487	498*	381	434**	464	558**	388	557**
Mean (standard dev.)	(33.1)	(14.9)	(33.7)	(22.1)	(28.4)	(15.3)	(12.9)	(29.3)

$^{*}p < 0.01$ and $^{**}p < 0.001$.

dex were significantly improved after both training sessions ($p < 0.01$ and $p < 0.001$), indicating that spastic muscle tone was reduced in both legs (Table 1).

4. Discussion

A patient with MS who tolerated FES very well showed a visible (swing curves) and measurable (peak velocity and relaxation index) reduction of spastic muscle tone directly after FES. Since the patient came only once in two weeks for the training and then also only for the period of testing before the training, and after testing, we could not record a further course of reduction of spasticity. However, the patient reported experiencing the reduced muscle tone for several hours after training.

With each training session the patient tolerated the uncomfortable sensations induced with increasing electricity (from 30 mA up to 90 mA) and became used to FES. In addition to the reduction of spasticity, as described here, FES also has other benefits, as known from its use in spinal cord injured [8] or stroke patients [3]. We think that this case study presents another possible use of FES also for patients with MS and a higher EDSS score. It would be a positive additional physical therapy tool and can improve the mobility of such patients. However, a further systematic investigation in MS patients, also concerning the question of force development with FES training would be necessary. This would also allow speculation about the underlying mechanisms.

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