Functional electrical stimulation effect on upper limb tremor

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Abstract. We report on the preliminary results of the functional electrical stimulation (FES) suppression of upper limb tremor in 3 neurological patients (diagnosis: essential tremor, Parkinson’s disease, paraneoplastic cerebellar syndrome). Patients exhibited combinations of rest, postural and kinetic tremor. The following upper limb muscles were stimulated: flexor radialis carpi, extensor radialis carpi, biceps and triceps. The range of intensities of stimulation was 8-36 mAmp. A clear reduction was found in the patient with essential tremor who was refractory to conventional medications. FES might represent a viable therapy in selected patients.

Keywords: tremor, FES, accelerometry, Crest Factor.

1. Introduction

Tremor is a rhythmic shaking of a body part [Deuschl et al., 1998] defined as a rapid back-and-forth movement [McAuley and Marsden, 2000]. It causes functional disability and social inconvenience, disturbing daily life activities [Louis et al., 1995]. The Tremor Project (http://www.iai.csic.es/tremor) aims to use FES for management of upper limb tremor in a framework of a brain-computer interface (BCI) distinguishing voluntary commands from tremor. Indeed, FES might represent a novel therapy to manage neurological tremor [Manto et al., 2009]. The technique is based on electrical stimulation of muscles [Prochazka et al., 1992; Javidan et al., 1992; Zhang and Ang, 2007]. The Clinical Neurophysiological Functional Tremor Evaluation Scale (CNF-TES) is a specifically-designed and detailed composite scale which compares clinical, neurophysiological and functional results. The scale is characterized by good correlations between the neurophysiological parameters and clinical data such as the grade of tremor and the mechanical counter test [Grimaldi and Manto, 2010a]. We selected a core of items from the CNF-TES to evaluate the tremor suppression effect of FES. Preliminary trials showed a very positive effect on a ET patient [Grimaldi and Manto, 2010b].

2. Material and Methods

2.1. Patients and experimental set-up

We evaluated 3 patients affected by essential tremor (ET), Parkinson’s disease (PD) and paraneoplastic cerebellar syndrome. The patients presented, respectively, postural and kinetic tremor, rest and postural tremor, kinetic tremor. The maximum grade of tremor intensity at the more affected arm was 4/4, 3/4, 3/4. Patients were comfortably seated and equipped with: (a) FES electrodes fixed on flexor radialis carpi, extensor radialis carpi, biceps and triceps (patched on the more affected side); (b) triaxial accelerometers (Biopac, USA) affixed on the index finger (3rd phalanx), wrist, elbow (about 2 cm below the olecraneum), arm (about 2 cm below the acromion). Patients performed the following 6 tasks: rest, postural (arms outstretched), finger to finger, index-on-the-nose, mechanical counter. Each task was executed in 2 conditions: “stimulation off” and “stimulation on”. Each condition was repeated three times.

2.2. Pattern of stimulation

The pattern of stimulation was cocontraction: the current is delivered on the 4 muscles following a defined schema (1 sec ramp increasing- 20 secs plateau- 1 sec ramp decreasing). Frequency of stimulation was 30Hz and pulse width 100μsec. The intensity was defined on the basis of patient comfort and muscle reaction. ET patient received on the FRC muscle 20mAmp, ERC 16mAmp, Biceps 18mAmp, Triceps 36mAmp; PD patient: 26mAmp, 18mAmp, 8mAmp, 27mAmp; Cerebellar patient: 18mAmp, 17mAmp, 11mAmp, 23mAmp.
2.3. Analysis

We analyzed tremor clinically (6 tasks, see 2.1) and using the FFT analysis of the accelerometer affixed on the index by extracting the following parameters: PSD max, Frequency max, integral sub-band 2-40Hz and 2-15Hz, Crest factor (CF= PSD max divided integral sub-bands). Indexes of variability (VI) were computed. Moreover, the comfort of patients was evaluated with the Happy Face Pain Rating Scale, the 11-Point Box Scale and the QDSA modified.

3. Results

3.1. Clinical evaluation

ET patient revealed a good response to FES with a decrease of the grade of tremor from 4/4 to 2/4 in the finger-to-finger task (VI= 1.6). On the contrary, FES induced no clinical effect or even a slight worsening of the grade of tremor in the PD patient and in the cerebellar patient. Nevertheless, these 2 patients showed a trend of slight improvement in the mechanical counter task when FES is delivered (the mean scores of 3 trials in the FES off and FES on conditions were, respectively: 8 and 9 – best trial 8 and 12- for the cerebellar patient; 26 and 27 – best trial 25 and 30- for the PD patient).

3.2. FFT analysis

The CF values (of the 2-13Hz sub-band) during different tasks in FES off and FES on conditions are reported in Table 1. FFT analysis for the finger-to-finger task in the ET patient and for the index-to-nose task in the cerebellar patient confirmed the clinical findings as well as the analysis of the rest condition in the PD patient. On the contrary the analysis of the postural task in the PD patient revealed a decreased PSD when the current is delivered.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Task</th>
<th>CF - FES off</th>
<th>CF - FES on</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET patient</td>
<td>Finger-to-finger</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>PD patient</td>
<td>Rest</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Postural</td>
<td>1.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Cerebellar patient</td>
<td>Index-to-nose</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>

3.3. Evaluation of patient comfort

The patients reported the following ranges of score: during the stimulation off condition: 0-3 for the Happy Face Rating scale and 0-2 for the 11-Point Box scale; during the stimulation on: 1-3 and 1-4, respectively. The discomfort was mainly described as tingling or paresthesias of moderate intensity.

4. Discussion

We present the preliminary results of the FES effect on upper limb tremor. The procedure is well tolerated. Positive effect is evident in our ET patient both neurophysiologically and clinically. In the postural task, PD patient showed a positive response that was not detected by the clinical evaluation, thus confirming the higher sensibility of the FTT analysis when changes in the tremor intensity are slight. CNF-TES and combinations of its sub-items are effective in the evaluation of tremor.

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References


