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Case Report

Effect of functional electrical stimulation on the proprioception, motor function of the paretic upper limb, and patient quality of life: A case report

Carlos Bustamante PT, MSc *, Francisco Brevis PT, BSc, Sebastián Canales PT, BSc, Sebastián Millón PT, BSc, Rodrigo Pascual PT, PhD

Escuela de Kinesiología, Facultad de Ciencias, Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile

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ABSTRACT

Functional electrical stimulation (FES) has shown to improve motor function of the affected side in stroke patients; however, the effects of FES on proprioception, the functional recovery of the paretic upper limb, and the patient quality of life (QoL) are not clear. The aim of the current case report was to determine whether FES can improve joint position sense and the scores on measurements of upper limb function and a QoL survey. The participant was assessed before and after 10 consecutive intervention sessions; in addition, the patient performed the training tasks in the workstation assisted by the FES device. Improvements in angles and time only in the affected wrist and enhancement in the Action Research Arm Test scores for both upper limbs were found after FES intervention. In addition, the patient's health-related QoL measurements improved. FES could ameliorate the proprioceptive deficit and the activity limitations of a stroke survivor.

Oxford Level of Evidence: 3b; individual case control study.

Introduction

According to many reports, stroke is a worldwide health care problem, and the global burden of the disease continues to increase.[1] In most countries, cerebrovascular disease is one of the main causes of acquired adult disability.[2] Notably, this phenomenon has also been observed in developing countries; for example, in Chile, an annual incidence of 97.4 strokes per 100,000 inhabitants, causing 9% of the total number of deaths in the country, has been reported.[3] Clinical studies have shown that stroke survivors frequently present diminished motor function in the affected upper limb together with sensory deficits in the paretic hand.[4-6] Indeed, more than 40% of stroke patients exhibit proprioceptive deficits,[7] which most likely help increase the limitations of mobility and independence in activities of daily living.[8]

By contrast, many studies have shown that the use of functional electrical stimulation (FES) improves the motor function of the affected upper limb in stroke patients, yielding beneficial effects such as increased muscle strength and range of motion or a decrease in spasticity.[9-11] In particular, clinical studies have demonstrated that FES treatment together with upper limb training may be a beneficial intervention in rehabilitating reaching and grasping during the acute stroke phase.[12] The underlying mechanisms remain elusive, but it has been proposed that the sensorimotor afferents may facilitate changes in motor control, possibly through activity-dependent plasticity.[13,14] Moreover, Smith et al[15] have reported that repetitive electrical stimulation of the fingers of the affected hand is associated with improvements in sensory discrimination and motor task performance in a group of chronic stroke subjects. Although most studies have focused on motor impairment of the affected limb,[16] there is limited knowledge regarding whether FES may improve the proprioceptive deficits in chronic stroke patients and whether this putative improvement is associated with an enhancement in hand function. Finally, although it is well known that many patients with chronic stroke have an impaired quality of life (QoL), little is known about whether FES therapy could play a positive role on this relevant parameter.[17] Therefore, the aims of the present study were to determine whether FES induces beneficial changes in proprioception, hand function, and patient's health-related QoL measurements.

Conflict of interest: All named authors hereby declare that they have no conflicts of interest to disclose.

* Corresponding author. Avenida Universidad 330, Curauma, Valparaíso 2373223, Chile. Tel.: +56 32 2274075; fax: +56 32 2274395.
E-mail address: carlos.bustamante@ucv.cl (C. Bustamante).

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Experimental procedures

The current investigation was a case report.

The inclusion criteria were as follows: diagnosis of stroke from more than 6 months and up to 2 years of injury; level of spasticity in the affected upper limb less than 4 (Modified Ashworth Scale); completion of the rehabilitation to the affected upper limb; able to provide informed consent and age older than 18 years. The exclusion criteria were as follows: pregnant; a metal implant in the affected upper limb, and current participation in any study involving physical rehabilitation of the affected upper limb.

Patient description

The patient was a 46-year-old right-handed female. She suffered a stroke 11 months before she was enrolled in this study. The stroke resulted in chronic right hemiparesis due to a left cerebral hemorrhage. Eight months before the FES treatment, she had received standard rehabilitation services including inpatient and outpatient physical (10 sessions) and occupational (4 sessions) therapy during the acute phase of her illness. At the time of study enrollment, the participant's medication included paracetamol (1000 mg daily) to ameliorate right shoulder pain. Notably, in the present study, the participant did not show abnormal muscle tone at the first or last assessment sessions. The subject was invited to voluntarily participate in the study. Before the initial assessment, she signed an informed consent, and all her questions or doubts about the study and the FES protocol were clarified. This research was approved by the local Bioethical Committee of the Pontificia Universidad de Valparaíso. All the experimental procedures used here were noninvasive and posed no hazard to the patient's health.

Outcome measures

All measurements were performed during the pretreatment and posttreatment testings.

Proprioceptive assessment

Various methods of assessing proprioceptive sense have been used in clinical research. In the present study, we chose to measure the angular measurements to test joint position sense because they have been used broadly by researchers to assess proprioception.[18] Although the validity and reliability of the arm matching test has been minimally researched, the magnitude of the end-position errors has been thought to be a good indicator of acuity in motion and position sense. Moreover, to determine indirectly if the patient had improved accuracy in matching the position of the 2 homologous limbs, we decided to measure the time needed to complete the task. In summary, we chose the aforementioned measures because in addition to the fact that they do not require complex instrumentation and they result in quantitative measurements, the instructions provided to the patient are very simple, and its performance does not require much time. Due to a lack of standardized testing protocols for clinics, we based the evaluation procedure of the present study on previous research conducted by Li and Wu,[18] which applied the use of a simple motion analysis system to measure joint position sense in the contralateral matching method. The subject was evaluated while she lay on a mat (supine), with the hips and knees flexed and the eyes closed. The examiner supported the weight of the paretic upper limb and held the elbow and wrist on their medial and lateral surfaces; then, the examiner held the shoulder in flexion and abduction, elbow in flexion, forearm in supination, and wrist in extension (Fig. 1). The examiner asked the patient to move and position the unaffected limb in the same position as the other. The patient was required to inform the examiner when she perceived her upper limb to be in the same position as her paretic extremity. Three different joint angles of the paretic upper limb were assessed: shoulder, elbow, and wrist. The assessment was recorded by a video camera that recorded images in the frontal plane. Consequently, a video graphic analysis was performed. Two variables were measured: (1) the joint angles measured by the Kinovea (v. 0.8.15; Copyright 2006–2011, Joan Charmant & Contrib, http://www.kinovea.org/) software and (2) the time required by the patient to achieve the required position.

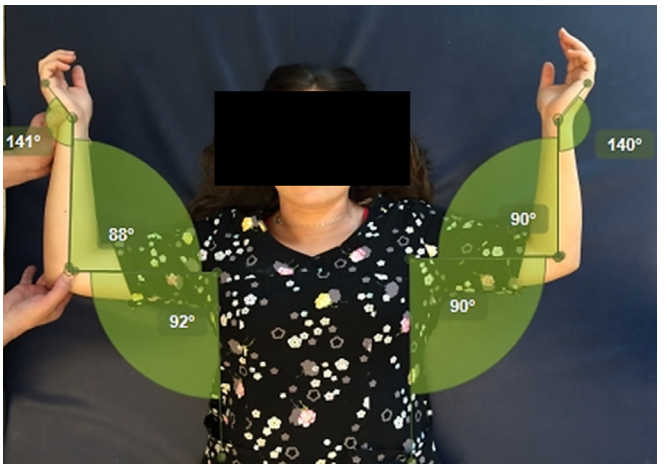

Fig. 1. Joint position measurement technique.

To determine changes in functional limitation of the upper limb, we administered the Action Research Arm Test

This instrument has been widely used to measure motor function of the upper limb in stroke survivors, and it has been validated in the Chilean population. As the aim of the present study was to determine not only changes in impairment-level measures, the Action Research Arm Test (ARAT) is a very useful tool because, to our knowledge, it reflects measurements at the activity domain level. In addition, the ARAT was chosen because it has been used as the gold standard for the comparison of other upper limb measures; moreover, the reliability, validity, and responsiveness of the ARAT[19] have been investigated and reported to meet the recommended criteria. A study performed by Van der Lee et al[19] confirms the high intrarater and interrater reliability of the ARAT in a population of chronic stroke survivors with a moderate residual loss of upper limb function. Briefly, this test consists of 19 items, which are divided into 4 categories: (1) grasp, (2) grip, (3) pinch, and (4) gross movement. Items are graded on a 4-point ordinal scale (0 = cannot perform the test; 3 = performs test normally), for a total possible score of 57. The assessment included the use of a portable workstation, located on a table with various objects, such as spheres, wooden blocks, and vessels. The patient performed several activities in the sitting position after receiving verbal instructions and a demonstration by the examiner. The activities were performed by the patient using first her contralateral upper limb (unaffected) and then her paretic upper limb. A videotaped record of the functional assessment for further analysis and an assignment of scores for each test were performed.

QoL assessment

In the present study, we chose version 2 of 36-Item Short Form Health Survey (SF-36, version 2) survey to incorporate measures of health-related quality of life that focused not only on stroke-related deficits or impairments. In fact, the SF-36, version 2, is a very useful