Sensory Amplification By Cutaneous Electrical Stimulation For Retraining Proprioception

Paul Taylor, Jane Burridge

Department of Medical Physics and Biomedical Engineering, Salisbury, District Hospital, Salisbury, Wiltshire, SP2 8BJ.

5th IPBM Clinical FES Meeting, Salisbury, March 1997

Introduction

A patient (right side hemiplegic following CVA) presented at our clinic for electrical stimulation to improve his hand function. In fact his motor function was not greatly impaired, his main disability being in lack of proprioception. If a digit was touched while he was blind folded, he was unable to correctly identify the area that was touched although he was aware that he had been touched. Earlier work (1) had shown that electrical stimulation of the hand and wrist muscles could lead to an improvement in two point discrimination. By experimentation it was found that after repeated stimulation of the thumb and index finger pulps, the subject could better identify the areas when they were tested immediately after training. This paper describes the development of apparatus for the technique and initial results with one subject.

Materials and methods

The apparatus evolved through several stages. Initial experimentation was made using the University of Surrey Compustim 10B stimulator. Two FSRs (Force Sensitive Resistors) were placed either side of a block of high destiny foam, about 3cm thick.. Self adhesive active electrodes were placed on the pulp of the index finger and thumb. The stimulator was set up to give an output when a FSR was pressed. One channel stimulated at 10 Hz while the second stimulated at 40 Hz. The output level was set at comfortable level for the user giving sensation but no muscle contraction. With each FSR labelled as "finger or thumb" The subject was asked to repeatedly grasp and release the foam block. Initial results were encouraging but the system was limited by two factors. Firstly the equipment could only be used as training device and not for picking up other objects. Secondly it was hard to set the stimulator to respond to very small changes in the FSR, typical of light grip, without the FSRs drifting out of the range of operation.

The first problem could be solved by mounting the FSRs on the back of the electrodes. In order to keep the assembly as thin as possible electrodes were made from a flexible PCB. This also enabled both active and indifferent to be mounted on the pulp. Electrode gel was used as a conductive mediun. Tape was required to hold he electrode / sensor

assembly in place. The second problem was solved by using a tracking comparitor input (2) for the FSR which avoided the problem of drift while enabling high sensitivity. This necessitated the construction of a second stimulator. These design modifications enabled orthotic use of the device for activities of daily living. However the use of wet conductive gel was not liked by the user as the electrodes tended to slip and was messy. This lead to a return to the use of self adhesive electrodes. Two Pals Plus 1 1/4 " electrodes were cut in half, close to the line of the central conductor. The two halves were then placed close together on the pulp to provide the active and indifferent. In order to maintain the separation later assemblies had a non conductive spacer between the electrodes. As the subject found it was necessary to wear gloves to protect the electrodes and sensors the FSR was mounted on the inside of a thin riding glove. However this was rejected by the user as it restricted him to clean activities. The FSRs were again mounted on the back of the electrodes leaving the user to chose his own gloves for activities such as gardening or washing up.

Subject

Male, aged 64 years, 3 years post CVA, right side hemiplegic

Assessments

Three assessments were made.

The Jebson test: A standardised hand function test consisting of 6 tasks (card turning, picking up small objects, simulated feeding, stacking draught pieces, picking up empty tins, picking up 500gm full tins). The time to complete each task is recorded.

Rolyon nine hole peg test: Nine pegs are picked up from a dish and inserted into holes in the Rolyon board. The times to insert all nine pegs and then place them back in the dish are recorded.

Sensation discrimination: Discrimination was tested by moving a single blunt metal pin across the pulp of either the 1st finger or the thumb. With the subject blindfolded, they were asked to identify whether it was the thumb or finger that was touched. If the subject did not respond a score of 0 was recorded. For the correct answer 1 was scored while the wrong answer scored -1. The test was repeated ten times and the scores added for a total score, the maximum score being 10, the minimum score -10.

The subject used the device daily at home, Assessments were made prior to treatment and at 1, 4 and 6 weeks. Sensation tests were performed with and without stimulation

Results

Jebson test

week	card turning	small objects	simulated feed	stacking dr'ts	empty tins	full tins
-10	11.2s	36.6s	21.8s	18.0s	14.3s	9.5s
6	9.9s	29.3s	20.1s	60s	19.5s	10.3s

Rolyon nine hole peg test

	hemi hand	hemi hand	non-hemi hand
week	time in (s)	total time (s)	total time (s)
-1	372	399	24
0	280	371	25
1	410	429	25
4	223	237	26
6	217	235	25

Sensation discrimination

	hemi						non-	hemi
	pre stm		with stm		post stm		no stm	
week	thumb	index	thumb	index	thumb	index	thumb	index
-10	1	0					10	10
-1	1	-1					10	10
0	-2	1	6	3	2	0	10	10
1	4	3	7	7	-1	4	10	10
4	6	4	5	6	8	7	10	10
6	0	8	10	10	6	6	10	10

It was noted after about 1 month of use of the device that the user required a significant reduction in stimulation amplitude from about 60 mA to 15 mA. The lower current amplitude is typical of that found comfortable by individuals with unimpaired sensation. The subject reported that he was much more aware of his hand. He was able to carry a bag and believed his balance to be improved. For example, he was now able to carry a bucket while walking over his rockery with less fear of falling. He felt that use of the system gave him improved awareness for several hours after use.

The results suggest that there was a training effect due to the electrical stimulation both in sensory and motor function. The Jebson test may not be representative as the subject's tone was raised due to his anxiousness to perform well on the test.

References

1. Taylor PN, Burridge JH, Hagan SA, Swain IDS. Electrical stimulation exercises to improve hand function and sensation following chronic stroke. Pro. 5th Vienna International Workshop on Functional Electrostimulation 1995 ISBN 3-900928-03-7 pp359-3

2. Taylor PN, Burridge JH. Multipurpose Two Channel Stimulator For Gait Correction Proceedings of the IPEMB FES Meeting, Salisbury March 1997