

Immediate Effects of Dermatome Electrical Stimulation on Task-Oriented Movement in Patients With Chronic Hemiplegia

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Abstract

This study tested the hypothesis that performing task-oriented activities while receiving dermatome electrical stimulation would induce significant improvement in hand functions. Ten chronic stroke patients were recruited. The subjects were able to understand verbal commands, and the spasticity of wrist and hand flexors was between grades 1 to 2 on the Modified Ashworth Scale (MAS). Three functional tasks were given to perform: to attach and detach velcro pegs, to move cones, and the Box and Block Test as a task. All tasks were randomly performed with and without dermatome electrical stimulation. The surface electrodes for electrical stimulation were attached over the C8 dermatome and the intensity was adjusted to a level just below the threshold for a visible muscle contraction. An accelerometer was worn on the dorsal wrist of the subjects while performing cones task for analysis of the movement velocity. The results of all three tasks, and the accelerometer data showed that task-oriented movements combined with dermatome electrical stimulation produced a significant immediate improvement in hand functions ($p < 0.05$).

1. INTRODUCTION

Cerebrovascular accidents (CVAs) have long been a worldwide leading cause of motor disabilities; a flexor synergy typically develops in an upper extremity during recovery [1]. The spastic flexor muscles and abnormal reflexes resulting from upper motor neuron lesion are closely related to the motor dysfunction in hemiplegic patients [2]. The results of previous clinical studies that investigated the effects of low intensity transcutaneous TENS in patients showed decreased spasticity, reduced magnitude of stretch reflexes, and decreased EMG co-contraction ratio in central nervous

system [3], [4]. The recent study by Lee [5] proved the positive effects of dermatome electrical stimulation of finger flexor's dermatome (C8) in chronic hemiplegic patients; resulting in decreased spasticity and shortened delay in finger extensor contraction onset and offset. Bajd et al. [6] proposed the dermatome stimulation combined with treadmill walking as a modality for gait training in incomplete SCI persons and proved it to be efficient in diminishing the extensor tone of the paralyzed limb, thus resulting in improved flexion of the leg during swing phase. Based on these findings, this study was conducted to determine whether the dermatome stimulation combined with functional tasks that are particular to hand grasp and release could be used as a modality for functional task training in chronic hemiplegic patients. The specific objective of this study was to investigate the immediate effect difference between task-oriented movements with and without dermatome stimulation, applied concurrently while performing the given tasks.

2. METHODS

2.1. Subjects

Ten hemorrhagic or non-hemorrhagic stroke patients (four males) were recruited for this study. The mean age of the stroke patients was 55.0 (SD 4.94) years, the mean duration since the onset was 3.0 (SD 0.86) years, and they were right-side dominant before the stroke. All of the recruited patients met the selection criteria: a score of at least 24 out of 30 on the Korean Mini-Mental State Examination (K-MMSE) (Kang et al. 1997), spasticity of paretic finger flexors measured with Modified Ashworth Scale (MAS) greater than or equal to G1, Manual Muscle Testing (MMT) score of paretic finger flexors greater than or equal to poor, Bruunstrom stage higher or equal to stage 2, no history of relapse stroke, not suffering

from any musculoskeletal or peripheral nervous disease, and duration of longer than 12 months since stroke onset.

2.2. Apparatus

Subjects underwent the intervention once a week for three weeks. The experimental devices used as functional tasks in this study were as follows: Box and Block for opposition, lateral pinch grip, or grasping; velcro pegboard for relatively strong volar grip and pulling; and cones for mild volar grip and releasing. These three given tasks were performed concurrently with and without dermatomal electrical stimulation in a random sequence, with 1 to 2-minute rests in between each trial.

2.3. Intervention

Box and Block test [7] was used both as an assessment tool and a given functional task for the hand. It is provided with 2.54 cm-square wooden blocks and a wooden box with a division in the middle. The task was to grasp blocks with the paretic hand, to transport over the division of the box to the other side, and to release it as many and as fast as possible for 1 minute.

As the second task, a total of 26 cones were moved from one side to the other for one minute. Two cones that were 56 cm apart from each other were fixed on a wooden board. Subjects were told to stack just one cone at a time, over onto the fixed cones, in order to keep the movement range on the y-axis (lifting level) the same. An accelerometer was worn on the subjects' dorsal wrist for analysis of the movement velocity while performing this task; at both the times with and without stimulation.

Lastly, a total of 25, a diameter of 2 cm, and a height of 10 cm wooden cylinder-shaped pegs were detached, released, and then re-attached onto the velcro board for 1 minute; moving as many and as fast as possible

2.4. Stimulation Protocols

FATA Vu (Hammtek Korea, Inc. Rev 1.0) was used for dermatomal stimulation with the aim to decrease the flexor tone of the wrist and hand flexors. Two surface electrodes of 2 cm in diameter were placed over the C8 dermatome, one on the proximal and one on the distal area of medial forearm, which is the cutaneous area of wrist and hand flexors innervated corresponding to the spinal segments. Schematic representation of the electrode positions is shown in Figure 1. A stimulation

frequency of 100 Hz, a pulse width of 250 μ s, and a biphasic rectangular waveform were used. The intensity of the electrical stimulation was below the threshold of causing any muscle contraction.

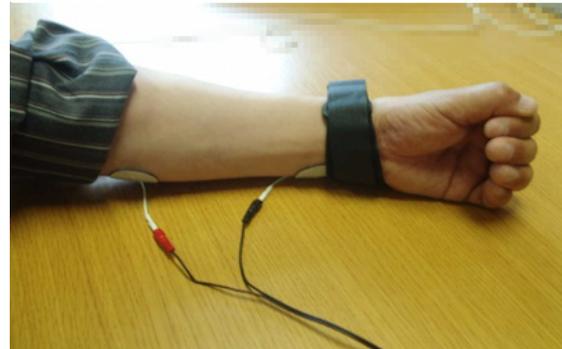


Figure 1 – Placement of stimulator electrodes and accelerometer.

2.5. Outcome Measures

The performances of three given functional tasks were compared between with and without concurrent dermatomal stimulation. The accelerometer data were collected with a physiologic data acquisition system (MP150, Biopac Systems, Goleta, CA). Velocity was calculated by Matlab program in which the acceleration data (x, y, z values) were integrated by time, and the equation $v = (\chi \times 56m) / 60 \text{ sec}$ was used for calculation ($v = d/t$). Microsoft Excel program was used to calculate the mean of delta t, the time spent to move one cone.

2.6. Statistical Analysis

SPSS (version 12.0) was used for the nonparametric Wilcoxon matched-paired signed-ranks test. The significance level was set at $p < 0.05$.

3. RESULTS

Subjects showed significant immediate improvements in all three functional tasks when they were combined with concurrent dermatomal electrical stimulation ($p < 0.05$). The mean number of moved blocks in Box and Block task were 17.57 (without stimulation) and 18.72 (with stimulation). In cones task, the means were 15.77 (without stimulation) and 17.48 (with stimulation). The mean number of detached pegs were 17.94 (without) and 18.95 (with) (Figure 2). The mean of velocity were

0.17 (without stimulation) and 0.18 (with stimulation) (Figure 3).

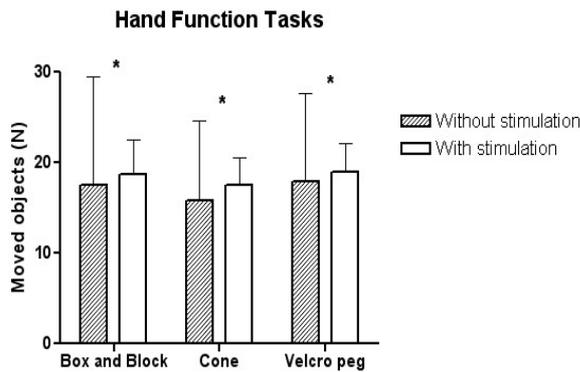


Figure 2 – Number of moved objects in three tasks (Box and Block, cones, velcro pegs); comparison of with and without concurrent dermatomal stimulation.

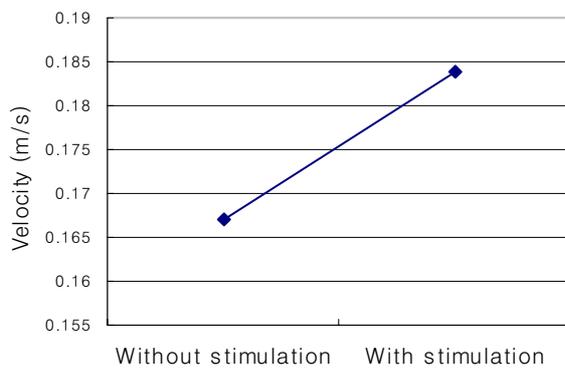


Figure 3 – Comparison of movement velocity recorded while performing cones task with and without dermatomal stimulation.

4. DISCUSSION AND CONCLUSIONS

The stimulation of the C8 dermatome proved to be efficient in improving hand function in chronic hemiplegic patients, especially when combined with task-oriented movements. All subjects included in this study were more than a year poststroke, at which time no spontaneous recovery was expected. Therefore, the quantitative results represent genuine improvements in hemiplegic hand function resulting from the task-oriented movements combined with concurrent dermatome stimulation. Electrical stimulation of the dermatomes, described in this study, is one other possible access to the spinal neural circuitry from the periphery that could provide positive effects in improving hand functions of chronic hemiplegia.

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