J. Phys. Ther. Sci. 30: 697–699, 2018

The Journal of Physical Therapy Science

Original Article

The effect of chest expansion exercise with TENS on gait ability and trunk control in chronic stroke patients

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Abstract. [Purpose] The purpose of this study was to investigate the effect of chest expansion exercise with transcutaneous electrical nerve stimulation (TENS) on gait ability and trunk control of patient with stroke. [Subjects and Methods] The subjects were divided into 7 in the chest expansion exercise with TENS group (experimental group) and 7 in the chest expansion exercise with placebo TENS (control group). The gait ability and trunk contol were measured using Six-Minute Walk Test, Tinetti gait index and Trunk impairment scale (TIS). [Results] Both the experimental group and the control group showed significant improvement in the Six-Minute Walk Test, Tinetti gait index, and TIS total score. The dynamic sitting balance and coordination of TIS showed significant improvement only in the experimental group. In comparison between the two groups, the experimental group showed a more significant improvement in Tinetti gait index and TIS total score than the control group. [Conclusion] This study showed that chest expansion exercise with TENS was an effective method for improving gait ability and trunk control in chronic stroke patients.

Key words: Chest expansion exercise, Ttranscutaneous electrical nerve stimulation, Stroke

(This article was submitted Jan. 15, 2018, and was accepted Feb. 19, 2018)

INTRODUCTION

Following stroke, patients with hemiplegia show weakness in their trunk muscles[1, 2)]. Consequently, it is necessary to develop an intervention method that can selectively activate these muscles and improve their ability to regulate the body and gait ability.

Transcutaneous electrical nerve stimulation (TENS) provides sensory cues by stimulating below the threshold of motor nerves[3, 4)]. The activity of respiratory muscles is significantly correlated with trunk control[5)], and the performance ability of the trunk is closely related to gait[6)].

The intervention involved in the present study is characterized by the combination and application of TENS with the one-sided chest expansion exercise.

The purpose of this study was to identify an effective interventional method for the rehabilitation of stroke patients by identifying the effects of TENS on trunk control and gait ability in stroke patients when applied simultaneously with chest expansion exercise.

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Table 1. Changes of outcome measurements on two intervention groups

Categories		Experimental group (n=7)	Control group (n=7)
Six-Minute Walk Test (meter)	Before	142.6 ± 50.4	132.0 ± 66.1
	After	159.0 ± 55.4*	149.9 ± 66.6*
Tinetti gait index (point)	Before	5.7 ± 1.6	5.2 ± 2.0
	After	8.1 ± 1.5*‡	6.1 ± 2.1*
Trunk impairment scale total score	Before	9.7 ± 2.6	11.4 ± 3.4
	After	14.0 ± 2.8*‡	13.1 ± 3.5*
Static siting balance score	Before	5.5 ± 0.9	5.4 ± 1.2
	After	6.4 ± 0.5	5.8 ± 0.9
Dynamic siting balance score	Before	2.8 ± 2.1	4.0 ± 2.3
	After	4.7 ± 2.4*	4.86 ± 2.5
Coordination score	Before	1.2 ± 0.7	2.0 ± 0.0
	After	2.8 ± 0.9*	2.4 ± 0.5

Valures are means ± SD.
*Significant difference between before and after the chest expansion exercise in each group ($p<0.05$).
‡Significant difference between the experimental group and control group ($p<0.05$).

SUBJECTS AND METHODS

This study involved 14 stroke in-patients at A Hospital. The inclusion criteria were as follows: diagnosed with stroke 6 months ago, no congenital deformity in the chest, a score of 24 points in the Korean Mini-Mental State Examination (K-MMSE), no serious abnormality in the pin prick test, ability to walk 20 m independently without aids, ability to hold a standing posture for 30 seconds or more, and the absence of skin disease. Before starting the study, we explained the purpose, process, and risk factors of this study, and obtained written consent from each participant. The general characteristics of the experimental group were as follows: age, 62.00 ± 10.36 years; weight, 72.00 ± 5.20 kg; time since stroke, 11.86 ± 3.02 months; K-MMSE, 26.14 ± 1.21; gender, 6 male and 1 female, The general characteristics of the control group were: age, 66.71 ± 5.02 years; weight, 69.71 ± 7.78 kg; time since stroke, 12.43 ± 2.99 months; K-MMSE, 26.29 ± 1.25; gender: 5 male and 2 female. This study was conducted according to the Declaration of Helsinki and was approved by the Institutional Review Board of Yongin University.

The Trunk Impairment Scale (Korean version) was used to evaluate trunk balance and coordination ability in a sitting posture. The higher the score, the better the trunk balance and coordination ability.

The Tinetti-Gait Scale (Korean version) was used to evaluate gait ability.

The six-minute walk test was performed to evaluate gait endurance. This evaluation was carried out by marking a 20-meter-long footpath on the floor and asking the participants to walk on it repeatedly for 6 minutes. The distance (m) in which the participants moved for 6 minutes was recorded and used as a data point.

All participants performed 30 minutes of general exercise therapy, including mat exercise and gait exercise. The intervention period was 4 weeks, 5 times a week. For the chest expansion exercise, 3–5 ribs or 7–9 ribs on the non-paretic side were manually contacted and a quick stretch was applied at the end of the exhalation. When the chest became swollen on the non-paretic side during inhalation, resistance in the opposite direction was provided by the therapist's hand[7].

For certain parts of this study, TENS (Novastim CU-FS1, CU Medical Systems, Korea) was applied. TENS (frequency: 0–100 Hz; pulse width: 20–700 μs) provided a stimulus that the participants could easily feel, and the level of stimulation was increased until just prior to muscle contraction. To each participant, a pair of electrodes was attached to the latissimus dorsi muscle and the external oblique muscle[4]. The intervention time was 30 min and TENS was applied simultaneously with the chest expansion exercise.

Statistical analysis and treatment were performed using SPSS 20.0 (Windows version). Differences between the experimental and control groups were analyzed with the Mann-Whitney U test. Wilcoxon's signed-ranks test was also used to compare differences in variations between the two groups. Tests were considered to be statistically significant when $p<0.05$.

RESULTS

Both the experimental group and the control group showed a significant improvement in six-minute walk test, Tinetti Gait Index, and TIS Total score ($p<0.05$), but only the experimental group showed a significant improvement in dynamic sitting balance and coordination among the TIS subscales ($p<0.05$). When comparing effects between the two groups, the

experimental group showed more significant improvement than the control group in both the Tinetti Gait Index and the TIS Total Score ($p<0.01$) (Table 1).

DISCUSSION

Data showed that the experimental group and the control group showed significant improvement in TIS, Tinetti Gait Index, and the six-minute walk test after intervention. However, only the experimental group showed significant improvement in dynamic sitting balance, coordination among the TIS subscales, and a more significant increase in the Tinetti Gait Index and TIS total score, as compared to the control group.

TENS attached to the external oblique muscle and the latissimus dorsi muscle, the latissimus dorsi muscle showed more significant improvement in TIS than placebo TENS did in task-related trunk training[4].

The six-minute walk test, which was used to test gait endurance in this study, is known to be more affected by ankle or leg function than by cardiovascular loads or aerobic thresholds[8]. Therefore, gait training among general exercise treatment programs, which was applied equally to both groups, influenced the six-minute walk test result in stroke patients; consequently, there was no significant difference between the two groups with this respect.

A previous study of stroke patients showed that a reduction in trunk control ability and Tinetti Gait Index was related to the total TIS score of each specific item[6]. Therefore, our present experimental group showed a significant increase in dynamic sitting balance score and coordination score of the TIS, and thus demonstrated better results in the Tinetti-Gait Score and TIS total score than the control group.

The chest expansion exercise used in the present study is an intervention method used to help chest movement and contraction of the diaphragm[9]. It is considered that an increase in chest mediolateral and anterioposterior diameters, inspiratory muscle contraction[10] causes a subsequent increase in intra-abdominal pressure, which is effective in improving trunk stability and gait ability. The application of TENS in the present study helped the paretic sensory input to stimulate the paretic trunk muscles, thereby further increasing trunk control[3].

This study is of significance in that it not only confirmed improvement in trunk control after TENS intervention but also identified gait ability as a factor to consider for trunk stability.

However, there are some limitations associated with the present study that should be considered when interpreting our results. First, the study only involved a small number of subjects. Second, evaluation items were judged by the therapist or just checked the time and distance. In future studies, it is expected that there will be more a meaningful difference if evaluations are applied to a greater number of participants by using additional tests that can quantitatively identify a wider range of temporal and spatial variables associated gait and trunk stability.

Conflict of interest

None.

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