

Effect of gait training with constrained-induced movement therapy (CIMT) on the balance of stroke patients

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Abstract. [Purpose] The purpose of the present study was to examine the effect of intensive gait training using a constrained induced movement therapy (CIMT) technique applied to the non-paretic upper extremity on the balance ability of stroke patients. [Subjects and Methods] Twenty stroke patients were randomly assigned to an experimental group or a control group. The experimental group received gait training with CIMT for 30 minutes per session, three sessions per week for four weeks, and the control group received gait training alone. [Results] The experimental group showed improvements in dynamic balance and the degree of improvement in this group was greater than that observed in the control group. Furthermore, the experimental group showed improvements in movement distances to the paretic side. On the other hand, the control group showed no significant improvements in balance indices after the intervention. [Conclusion] Gait training of stroke patients using CIMT techniques should be regarded as a treatment that can improve the balance of stroke patients.

Key words: Constrained-induced movement therapy, Gait training, Balance

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INTRODUCTION

Arm swing during walking plays a role in maintaining body balance by inducing rotation of the upper extremity in the opposite direction to the direction of pelvic rotation¹⁾. Stroke patients show arm swing asymmetry which is considered to be due to their low walking velocity and the asymmetric movements of the paretic and non-paretic sides due to an incorrect stance^{2, 3)}. Reduction or limitation of arm swing due to paralysis excessively increases non-paretic side arm swing leading to reductions in paretic side stride length, stride frequency, and walking velocity. It also limits thoracic rotation and alters normal movements of the extremities and the trunk, thereby adversely affecting balance control while walking⁴⁻⁶⁾.

Constrained-induced movement therapy (CIMT) is a training method that encourages the use of the paretic upper extremity by suppressing excessive use of the non-paretic upper extremity, and has been reported to be effective at not only enhancing the paretic upper extremity functions of hemiplegia patients, but also at enhancing coordination between the upper and lower extremities⁷⁻⁹⁾.

The majority of training courses that utilize CIMT techniques are based on functional training in sitting positions rather than walking, and the major dependent variables used to determine the training effects of CIMT have been associated with movements of the upper extremity during gait^{6, 9, 10)}. In fact, no study has investigated whether gait training that directly induces paretic side arm swing by fixing the non-paretic upper extremity during walking improves the balance ability of stroke patients. Therefore, the present study was conducted to examine the effects of intensive gait training combined with CIMT techniques, to induce paretic side arm swing, on the balance abilities of hemiplegia patients.

SUBJECTS AND METHODS

Subjects inclusion criteria were: stroke onset of at least three months before the study commencement, a Korean Mini-Mental State Examination (MMSE-K) score of ≥ 24 points, and the ability to walk independently outdoors for at least 30 minutes without an ambulatory aid. The study exclusion criteria were: a limitation in movement of the non-paretic upper extremity, a visual field defect, problems with the vestibular organ, or an orthopedic medical history of the upper or lower extremity. From among a total of 151 subjects considered, 20 subjects were selected following the above-mentioned inclusion and exclusion criteria. Before participating in the experiment, all subjects were provided with a comprehensive explanation of the study purpose and method and they voluntarily agreed to participate. The

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experiment was approved by the Institutional Bioethics Committee of Daejeon University.

The experimental group received ground gait training, after fixing the non-paretic upper extremity so that it could not move, for 30 minutes per session, three sessions per week for 4 weeks in addition to central nervous system developmental treatment for 60 minutes per session, five times per week, over the same 4 weeks. The control group received general ground gait training, without fixation of the non-paretic upper extremity, as well as central nervous system developmental treatment for the same number of sessions and duration as those received by the experimental group.

To fix the non-paretic upper extremity, the midpoint between the shoulder joint, and the elbow joint, and the midpoint between the elbow joint and the wrist were fixed to the trunk using Velcro straps to prevent the non-paretic upper extremity from moving. All subjects in the two groups performed gait training by walking back and forth on a 10 m straight indoor walking path on an even floor a set number of times at speeds which were determined based on subject comfort. Subjects were instructed to swing the paretic upper extremity to the greatest extent they could. Rest time was allowed whenever a subject complained of fatigue after which gait training was re-started. Therapists assisted subjects as required.

To measure balance ability, dynamic balance was measured using a Biorescue (RM INGENIERIE, Rodez, France). Subjects were instructed to spread their feet to approximately 30° and keep their eyes looking forward in an upright standing position. Before taking measurements, subjects were shown a video of the measuring method and were given a demonstration. The Trunk Impairment Scale (TIS) is used to measure the degree of damage to the trunk and to assess trunk coordination and balance in the sitting position. The TIS is subdivided into static sitting balance, dynamic sitting balance, and coordination. Higher scores indicate less trunk damage¹¹⁾. The maximum limit of stability (LOS) is defined as the distance moved by the center of gravity in the standing position when body weight is moved maximally to the paretic and non-paretic sides using ankle strategies without losing balance. Measurements were taken three times and the results were averaged¹²⁾.

The χ^2 and independent t tests were used to verify group homogeneity. Wilcoxon's signed rank test was used to compare results before and after the intervention, and the Mann-Whitney U test was used to compare the experimental and control groups with respect to differences in values before and after intervention. Statistical significance was accepted for p values < 0.05.

RESULTS

The general characteristics of the subjects in the experimental and control groups are shown in Table 1. Group homogeneity testing failed to reveal any significant differences between the groups' general characteristics other than age. Out of the 20 subjects, one subject in the experimental group and one in the control group dropped out before post-testing due to a deteriorating condition or discharge from hospital. Accordingly, the analysis was conducted using the data of the 9 subjects remaining in each group. Table 2 summarizes the balance abilities of the two groups before and after intervention. The experimental group showed an improvement of 28.6% in dynamic balance as determined by the TIS, and of 34.3% in movement distances of the paretic side as determined by the LOS, and the changes in dynamic balance were significantly larger in the experimental group than in the control group, which showed no significant improvements in balance ability after gait training.

Table 1. Baseline characteristics of the subjects (n = 20)

Characteristics	Experimental group	Control group
Sex (male/female)	6/4	7/3
Affected side (right/left)	3/7	6/4
Age (years)*	57.6±3.7	51.9±6.1
Height (cm)	164.8±8.2	166.2±8.0
Weight (kg)	64.6±12.4	69.21±16.5
Onset (month)	24.1±10.7	30.8±11.0

Values are expressed as frequency or mean (SD)

*Significant difference between two groups, p<0.05

Table 2. Comparison of balance changes in the experimental and control groups

	Experimental group (n=9)		Control group (n=9)	
	Pre-test	Post-test	Pre-test	Post-test
TIS				
Static	7.0 (6.0–7.0)	7.0 (7.0–7.0)	6.0 (4.0–6.5)	6.0 (6.0–7.0)
Dynamic ^a	7.0 (5.0–8.0)	9.0 (8.0–9.5)*	7.0 (5.5–9.0)	8.0 (5.5–8.5)
Coordination	4.0 (2.0–4.0)	4.0 (3.0–4.5)	4.0 (2.5–4.5)	3.0 (2.0–4.5)
LOS				
TAS (cm)	3.2 (1.6–5.6)	4.3 (3.7–7.3)*	3.6 (2.7–4.5)	4.0 (3.3–4.9)
TUS (cm)	2.9 (1.3–5.9)	5.2 (3.0–7.5)	3.7 (2.5–6.4)	4.3 (3.5–5.8)

Values are expressed as median (25–75% percentile). TIS: trunk impairment scale; LOS: limit of stability, TAS: to affected side; TUS: to unaffected side.

*Significant difference from pre-test, p<0.05. ^aSignificant difference in changes between the two groups, p<0.05

DISCUSSION

The present study was undertaken to examine the effect of intensive gait training using a constrained induced movement therapy (CIMT) technique for the non-paretic upper extremity on the balance ability of stroke patients.

According to our results, gait training conducted with CIMT improved the dynamic balance of hemiplegic stroke patients by 28.6% after training, indicating improved trunk stability, and movement distances to the paretic side in the standing position increased by 34.3%. Furthermore, the improvements were larger in the experimental group than in the control group. Stephenson et al.¹³⁾ reported that gait training of stroke patients with the non-paretic upper extremity fixed to treadmill handrails was effective at inducing paretic side arm swing and that training improved upper trunk stabilization, results which are in agreement with our findings.

In the present study, the experimental group showed increases in movement distance to the paretic side. We consider this was due to fixation of the non-paretic upper extremity, which would have increased the pendulum movement of the paretic upper extremity and conscious attempts to swing the paretic side arm⁹⁾.

Homogeneity testing of the two groups revealed significant differences in the groups' ages. However, our results indicate that the experimental group achieved greater benefits from gait training with CIMT despite having a higher average age. Therefore, we consider the age difference was not a confounding factor for the results.

The major limitation of the present study was the small number of study subjects, which makes it difficult to generalize our results in the context of proposing an intervention for improving the balance of stroke patients. However, the results of the present study are meaningful, because it is the first study to investigate the effects of upper extremity CIMT techniques combined with gait training on the balance ability of stroke patients. Therefore, we suggest that additional studies should be conducted to investigate the levels

of upper extremity function and training effects according to movements of the paretic upper extremity to confirm our findings. Despite the limitations of our study, in our opinion, the method presented in the present study could be applied as a gait training method to improve the balance of stroke patients.

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