Original Article

Effects of Compelled Weight Shift on Balance Ability in Patients with Stroke

Sung Min Son

Department of Physical Therapy, College of Health Science, Cheongju University, Cheongju, Korea

Purpose: This study aimed to investigate the effects of compelled weight shift in paretic lower limb training on balance ability in patients with stroke.
Methods: Thirty-six individuals with hemiparesis, who were randomly assigned to a 10CWST (10 mm constrained –weight shift training) group, a 5CWST (5 mm constrained-weight shift training) group, and a control group participated in this study. Compelled weight shift training was performed in 3 sets of 5 min with a rest period of 1 min between sets. Both the 5CWST and 10CWST groups performed 5 times per week for 4 weeks. Static (mediolateral and anteroposterior sway velocities) and dynamic balance (mediolateral and anteroposterior distances) was assessed using the Good Balance system.
Results: Significant differences were found in the M-L and A-P sway velocities, and the M-L sway distance. The M-L and A-P sway velocities, and M-L sway distance showed significantly large group effects (p < 0.05), time effects (p < 0.05), and group-by-time interaction (p < 0.05). The post hoc analyses indicated that, following intervention, the 10CWST group showed more significant changes in the M-L and A-P sway velocities, and the M-L sway distance than the control group.
Conclusion: These results suggest that the use of compelled weight shift in paretic lower limb training may be an effective method to improve balance ability in patients with stroke.

Keywords: Compelled weight shift, Stroke, Balance

INTRODUCTION

Impaired postural control is a major problem for many patients with a stroke, as postural instability greatly restricts activities of daily life and gait.[1,2] The distribution of weight between the legs is an important aspect of balance control post-stroke.[3] Typically, patients with stroke have difficulty maintaining a weight shift to their paretic side, and there is greater postural sway when loading the paretic compared to the non-paretic leg during quiet standing.[4] Favoring the non-paretic limb can reduce reliance on the more impaired limb for balance control.[3] Weight-bearing asymmetry is often used as a measure of impairment in balance control, and restoring symmetry in weight-bearing is traditionally considered an important goal of rehabilitation.[1,5]

Without rehabilitation patients with stroke is inclined to stop us-ing the affected side due to paretic limb after being discouraged by the difficulty. Consequently, the cortical area representing the paretic limb is dramatically reduced.[6,7] By constraining the unaffected limb and forcing the patient to use the affected limb, previous study may help patients recover the use of their paretic limb.[8] This type of therapy has been named constrained-induced movement therapy (CIMT) and it usually be required the patient to wear a mitt or a sling on the paretic upper-limb in order to restrict its use.[9] However, the development of effective lower limbs constraints has proven challenging.

Several studies have examined CIMT by locking the knee joint of the non-affected lower-limb.[10] However, constraint of the lower limbs be disturbed to the patient's mobility and makes maintaining postural control even more difficult. Furthermore, coordination across of both lower-limb is essential to postural control, in contrast

to the upper-limbs are generally much more independent. Another method to improve weight symmetry is to apply a shoe lift to the non-paretic limb in individuals with hemiparesis. Applying a lift under the non-paretic limb provides a compelled shift of the body weight onto the paretic limb, as recently described.[8,11] This technique helps patients overcome the learned disuse mechanism by forcing them to use the paretic lower limb. The aim of the present study was to investigate whether the use of compelled weight shift in paretic lower limb training for 4 weeks could enhance balance ability in patients with stroke.

METHODS

1. Subject

Thirty-six individuals with hemiparesis participated after discharge from an inpatient rehabilitation unit. Each patient was randomly assigned to either a 10 mm constrained -weight shift training (10 CWST) (n = 12), 5 mm constrained-weight shift training (5 CWST) (n = 12), or control group (n = 12).

The inclusion criteria were as follows: hemiparesis due to cerebrovascular accident, and the ability to stand independently without an assistive device, such as a cane or a walker. Exclusion criteria were as follows: visual or vestibular deficits (such as hemianopia, neglect, and pusher syndrome), inability to understand the informed consent form because of impaired cognitive function (a score less than 24 on the mini mental state examination-Korean), a history of lower extremity orthopedic problem, or a neurological condition other than stroke. Each subject gave written consent to the experimental procedure, which was approved by the institutional review board of the local ethics committee.

2. Procedure and balance ability measurement

To achieve the compelled body weight shift, the participants in the 5 CWST and 10 CWST groups were provided with 5-mm or 10-mm shoe lifts fabricated from a medium hardness foam material made of ethylene vinyl acetate for placement beneath the unaffected lower extremity. Compelled weight shift training was performed in 3 sets of 5 minutes with a rest period of 1 minute between sets. Both the 5 CWST and 10 CWST groups performed the training 5 times per week for 4 weeks. The participants in the control group maintained routine activities and performed ergometer exercises for the muscle strength training of the lower limb for 15 minutes. In addition, the participants in all 3 groups received conservative physical therapy for 30 minutes per day, 5 days per week, for a period of 4 weeks.

Static and dynamic balance was assessed using the Good Balance system (Metitur Oy, Jyvaskyla, Finland), which consists of a portable equilateral triangular force platform (800 mm × 800 mm × 800 mm) with strain gauge transducers connected to a 3-channel DC amplifier and a 12-byte analogue-to digital (A/D) converter connected to a computer. Amplified analogue signals were digitized with a sampling frequency of fs = 50 Hz and input to the computer through a serial port. All filtering and data processing were carried out in digital form using Good Balance software. To measure the mediolateral and anteroposterior sway velocities of static balance, the participants stood on the force plate with their lower limbs spread at shoulder width and then looked at a number on a monitor for 30 seconds. In order to measure postural sway, the subjects were asked to stand barefoot quietly in a comfortable upright position on the force plate while looking straight ahead. For the measurement of the mediolateral and anteroposterior distances of dynamic balance, the participants were instructed to shift their weight toward the target when one of the peripheral targets was presented randomly, and then to shift back to the central target. At the beginning of each trial, the examiner checked that the subject was standing symmetrically on both legs and did not lean backwards or forwards. The subject was instructed to reach the targets as quickly and accurately as possible, and to avoid unnecessary and uneconomic movements. After demonstrating the static and dynamic balance tests, the subjects were allowed to practice once with a preliminary test once before the measurements were taken. Each subject performed the actual tests 3 times.

3. Statistical analysis

All data were analyzed through separate univariate 3 × 2 ANOVA analyses with repeated measures. When interactions were detected, a post hoc analysis with Bonferroni adjustment was employed. Data was analyzed with the SPSS version 18.0 (SPSS Korea DataSolution, Chicago, IL, USA) and a significance level of 0.05 was chosen for all analyses.

RESULTS

Table 1 presents the demographic information of the 3 groups. No significant differences were observed among them in terms of sex, age, height, weight, paretic side, and time since stroke onset (p > 0.05). Table 2 indicates the pre-test and post-test measurements of static (mediolateral and anteroposterior sway velocities) and dynamic balance (mediolateral and anteroposterior distances) for each group. Two-way ANOVA with repeated measures revealed a significant difference in the M-L and A-P sway velocities, and the M-L sway distance between the 3 groups. The M-L and A-P sway velocities and M-L sway distance showed significant of group effects (p < 0.05), time effects (p < 0.05), and group-by-time interaction (p < 0.05). The post hoc analyses indicated that, following intervention, the 10CWST group showed more significant changes in the M-L and A-P sway velocities, and M-L sway distance than the control group. However, no significant difference in the A-P sway distance was observed between the 3 groups.

DISCUSSION

In the current study, we investigated the effect of compelled weight shift training in paretic lower limb training on the balance ability of patients with stroke. The 10CWST group showed significant improvements in the A-P and M-L sway velocities and M-L sway distance. These results suggest that the inclusion of compelled weight shift in paretic lower limb training may be an effective method to improve balance ability in patients with stroke.

In this study, the compelled weight shift group showed significant improvement in the M-L and A-P sway velocities and M-L sway distance. The reeducation of patients on how to attain a symmetrical stance is important for improving balance control and is widely implemented in rehabilitation.[12,13] Compelled weight shift using shoe lifts on the non-paretic lower limb provides a more equal distribution of forces generated through both the paretic and non-paretic lower extremities.[8,14] With the use of the shoe lifts, a shift in the center of gravity from the paretic lower limb to the midline and a subsequent increase in stability has been observed.[8,15] Similarly, a previous study showed that lifts in the shoe of the non-paretic limb provided a more equal distribution of forces generated through both lower extremities and a shift of latency and strength response scores toward the normal range.[14] In addition, modified CIMT rehabilitation improved participant's performance in COP tracking and stance symmetry. One of the goals of CIMT is to encourage stroke survivors to engage of their paretic limb. Without correction, functional limitations on one side of the body can cause stroke survivors to use their non-paretic side more frequently, leading to further physical deteriorations on the paretic side. Thus, our results suggest that increased weight bearing of the affected side due to 10 mm shoe lift on the non-affected side can be facilitated load receptor feedback to the central nervous system, and this can improve the balance ability of stroke patients.

Table 1. Baseline characteristics of each group

Variable	10 CWST group	5 CWST group	Control group
Gender (male/female)	10/2	10/2	10/2
Age (year)	57.17±10.67	55.67±10.72	54.83±10.95
Paretic side (right/left)	5/7	6/6	6/6
Time since Stroke onset (month)	14.42±6.10	14.08±6.27	14.67±6.92
Height (cm)	167.92±5.28	167.00±6.78	165.42±6.23
Weight (kg)	62.00±7.03	62.33±8.80	60.50±7.63

Values are presented as mean±SD.
10 CWST: 10 mm constrained -weight shift training, 5 CWST: 5 mm constrained -weight shift training.

Table 2. Comparisons of mean static and dynamic balance parameters of the 3 groups

		10 CWST group		5 CWST group		Control group	
		Pre	Post	Pre	Post	Pre	Post
SB (cm/s)	MLSV	6.56±1.96	4.48±1.31*†	6.70±1.92	5.23±1.94*	6.53±2.86	6.21±2.89
	APSV	9.15±2.04	5.28±2.14*†‡	8.89±2.55	7.43±2.47*	8.67±2.60	8.38±2.79
DB (mm)	MLD	1,150.69±569.84	807.92±407.73*†	1,214.97±554.41	1,059.56±509.61*	1,192.34±563.75	1,144.53±464.32
	APD	1,317.38±491.54	1,026.98±363.65*	1,311.48±450.37	1,237.8±326.48	1,322.41±457.01	1,279.91±374.11

Values are presented as mean±SD.
SB: static balance, DB: dynamic balance, MLSV: mediolateral sway velocity, APSV: anteroposterior sway velocity, MLD: mediolateral distance, APD: anteroposterior distance.
*significant difference between pre- and post-test (p < 0.05)
†significant difference compared with the control group (p < 0.05)
‡signifincat difference between the 5CWST and 10CWST group (p < 0.05)

The use of shoe lifts will surely provide an opportunity to use the paretic lower limb and help to facilitate more symmetrical weight-bearing. Therefore, the compelled weight shift involving shoe lifts may be an effective method to enhance balance ability in patients with stroke. However, the results of this study should be interpreted with consideration of potential limitations. Our results cannot be generalized due to the small sample size. Moreover, there is a need for clinical trials to verify the long-term effects of compelled weight shift in patients with various degrees of symptom severity. A future study that includes an evaluation of the long-term effects of compelled weight bearing on improvement of locomotion patterns in patients with unilateral hemiparesis is warranted.

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