J. Phys. Ther. Sci.
26: 1689–1691, 2014

Original Article

Effect of Unstable Surface Training on Walking Ability in Stroke Patients

Dae-Hyouk Bang, PT, MSc[1)], Won-Seob Shin, PT, PhD[1, 2)], Hyeon-Jeong Noh, PT, MSc[1)], Myung-Soo Song, PT, PhD[3)]*

[1)] *Department of Physical Therapy, Graduate School of Daejeon University, Republic of Korea*
[2)] *Department of Physical Therapy, College of Natural Science, Daejeon University, Republic of Korea*
[3)] *Department of Physical Therapy, Wonkwang Health Science University: 514 Sinyong-dong, Iksan-si, Jeollabuk-do 570-750, Republic of Korea*

Abstract. [Purpose] The purpose of this study was to determine the effects of unstable surface training (UST) on walking ability in chronic stroke patients. [Subjects] The subjects were 12 stroke patients who were randomly divided into experimental (n_1=6) and control (n_2=6) groups. [Methods] The Subjects in both groups performed treadmill training for 30 minutes. The Subjects in the experimental group also performed UST after treadmill training, with the UST being performed for 10 minutes, five times per week, for four weeks. All subjects were evaluated with a 10-meter walk test, Timed Up and Go test and 6-minute walk test. The pared t-test was performed to test the significant differences between before and after the intervention. The independent t-test was conducted to test the significant differences between groups. [Results] Following the intervention, the experimental group showed significant differences in the Timed Up and Go test and 6-minute walk test. [Conclusion] The results of the study suggest that UST is an effective method for improvement of walking ability in chronic stroke patients.
Key words: Stroke, Unstable surface training, Walking ability

(This article was submitted Mar. 24, 2014, and was accepted May 6, 2014)

INTRODUCTION

Walking ability is an important element for independent living in stroke patients[1)]. Various studies have been conducted to improve the walking ability in stroke, as recovery of walking ability is a rehabilitation goal for most stroke patients[2)].

Treadmill training was suggested to be an effective method for improving the walking ability in stroke in a systematic review[3)]. Olney et al. demonstrated that treadmill training is a type of forced use and that it also could improve both quality and quantity aspects of walking[4)].

Balance ability is an important factor for independent walking in stroke patients[5, 6)]. For stable and functional walking, increasing the balance ability is a prior to other capacity[7)]. Numerous interventions have been devised to improve balance, such as unstable surface training (UST)[8)], balance training[9)], and virtual reality programs[10)]. UST in particular has been proven to improve the strength, proprioception, and balance ability of the lower extremity[8)]. Some authors have reported that UST increased the weight bearing ratio by more in the affected lower limb in stroke patients[7, 8)]. UST has also been shown to positively influence muscle activation and improvement of balance ability[8)].

However, most of the studies that have been conducted to date have only evaluated the effects of UST on balance ability. Little is known about the effects of UST on lower extremity function, especially walking performance for independent living in stroke patients. Therefore, the purpose of this study was to investigate whether UST influences walking ability during treadmill training in stroke patients.

We hypothesize that a UST and with treadmill training group will show greater improvements in the 10-meter walk test, Timed Up and Go test, and 6-minute walk test compared with a control group performing treadmill training alone.

SUBJECTS AND METHODS

The subjects were 12 poststroke individuals admitted to a rehabilitation hospital in the Republic of Korea. They were randomized into two groups by a physical therapist not involved in the study: the experimental group also performed UST after treadmill training, with the UST being performed for 10 minutes; the control group performed treadmill training only. The inclusion criteria were (1) history and clinical presentation (hemiparesis) of stroke (first hemorrhage or infarction), (2) more than 1 year post event, (3) gait speed over 0.5 m/s, enough to exercise on a treadmill, (4) not training in any interventions related to gait concurrently from other institutions, (5) independent gait possible over 10 m, and (6) sufficient cognition to participate in the training, that is, a:

*Corresponding author. Myung-Soo Song (E-mail: 9298ms@hanmail.net)

Mini-Mental State Exam (MMSE)[11] score of 21 or higher. The exclusion criteria were (1) any comorbidity or disability other than stroke that precluded gait training and (2) any uncontrolled health conditions for which training is contraindicated. Participation in the study was voluntary, and the subjects fully understood the contents of this study. Written informed consent, after providing an explanation of the study purpose and the experimental method and processes, was obtained from all patients. The study was approved by the Daejeon University institutional review board.

A 10-m walk test (10-MWT) was performed by walking 10 m to measure the gait speed[12]. The walkway was 14 m long, including a 2-m section for acceleration and a 2-m section for deceleration, and it has been used in other studies. The participants were asked to walk as fast and as safely as they could. Gait speed was measured with a stop watch. The participants were asked to walk 3 times, and the average round-trip time was recorded.

The Timed Up and Go Test (TUG) was used as a dynamic balance test[13]. This test records the time taken to rise from a chair (height: 50 cm), walk 3 m, turn around a marker, walk back to the chair, and sit down. The participants were asked to walk 3 times, and the average round-trip time was recorded.

The 6-minute walk test (6MWT) was used as an endurance test[14]. The participants were asked to walk as fast as they could for 6 minutes. Walking capacity was monitored using a standardized protocol. Distance walked (m) was measured by the assessor. The test was performed in a 100-m-long corridor.

Twelve people fulfilled the criteria and voluntarily agreed to participate in this study. The participants were randomly assigned into an experimental group (n_1 = 6) or control group (n_2 = 6). The intervention comprised 4 weeks of inpatient treatment. Participants in the experimental group performed the UST using the method of Verhagen et al. The participants in the experimental group used a balance mat (Aeromat, Ironcompany, Rancho Cucamonga, CA, USA). The UST program consisted of (1) forward reaching in a sitting position on the balance mat (10 times), (2) maintaining a standing position on the balance mat (30 seconds), (3) squatting exercise on the balance mat (10 times), (4) marching in place on the balance mat (30 seconds), (5) lifting the heels of a foot on the balance mat (30 seconds), and (6) forward reaching in a standing position on the balance mat (10 times). Both groups performed one session (30 minutes) a day (5 days/week) of treadmill training. The groups were randomized to the treadmill exercises and performed 30 minutes of supported walking exercise. The treadmill was equipped with hand railings and included a sensor that would stop the treadmill if there were any problems with balance or safety. The treadmill exercise was conducted with the treadmill in a flat position. The speed was set to the lowest stage and increased within the first minute to the working stage. The working load was increased to a stage that the participants felt comfortable with. After the treadmill exercise, the participants finished the training with deep breathing and simple stretching.

All the collected data were analyzed using SPSS 18.0. Descriptive and analytical statics are presented. Independent t-tests were used to compare differences between group means, and paired t-tests were used to compare within-group means. Data are presented as the mean and standard deviation (SD). Differences between categorical variables were analyzed using the χ^2-test. Statistical significance was set at $p<0.05$.

Table 1. General characteristics of the subjects

	Experimental group (n_1=6)	Control group (n_2=6)
Gender		
Male/female	4/2	3/3
Paretic side		
Right/left	3/3	2/4
Age (years)	61.1±4.8[a]	58.5±3.4
Weight (kg)	65.4±5.1	60.4±8.2
Height (cm)	164.7±5.8	163.7±5.2
Duration (months)	15.4±2.1	16.7±2.8

[a]Mean±SD

RESULTS

All patients completed the intervention and assessments. There were no significant differences in gender, paretic side, age, weight, height and duration since onset between the groups (Table 1). Differences in walking ability are presented in Table 2. After the intervention, both groups showed significant differences compared with before the intervention in the 10-MWT, TUG, and 6MWT ($p<0.05$). There were significant differences in the TUG and 6MWT between groups ($p<0.05$). However, there were no significant differences in the 10-MWT between groups after the intervention ($p>0.05$).

DISCUSSION

In chronic stroke patients, improvement of walking ability has been considered an important element for promoting social interaction and for improving quality of life through participation in social activities and activities of daily living[15]. This study was conducted to evaluate the effects of UST in improving walking ability. The results of this study were as follows: (1) Both groups showed significant differences in the 10-MWT, TUG and 6-MWT results after treadmill training. (2) The experimental group showed a significant difference from the control group for the TUG and 6-MWT results. Treadmill exercise effectively improved the performance in both groups, and the additional effects of UST suggest that it would be an efficacious method in rehabilitation.

A previous study showed that UST increased muscle endurance and postural control compared with training on a typical surface[16]. These results were similar to our results, as we found significant differences in the TUG and 6-MWT. Shin et al.[17] suggested that improvement of balance could affect walking ability. On the basis of that TUG was used

Table 2. Descriptive measurements

	Experimental group (n_1=6)		Control group (n_2=6)	
	Pretest	Posttest	Pretest	Posttest
10MWT (m/s)	0.68±0.04[a]	0.97±0.10*	0.72±0.07	0.94±0.14*
TUG (s)	16.81±1.02	11.16±1.46*+	16.56±1.01	13.91±1.19*
6MWT (m)	226.41±24.05	278.94±18.30*+	206.09±12.48	254.23±14.54*

[a]Means ±SD
*Significant difference within group. +Significant difference between groups.
CI, confidence interval; TUG, Timed Up and Go test; 10MWT, 10-meter walking test; 6MWT, 6-minute walk test distance.
The pretest was performed before the intervention, and the posttest was performed after 4 weeks.
The significant level was set at p<0.05 for differences between the groups

as a dynamic balance test[13)], it was suggested that the UST would improve balance ability[18)]. Our study is in agreement with the above results. Irion reported that UST improved dynamic balance compared with training on a stable surface[19)]. In our study, the experimental group showed better improvement in the TUG than the control group (p<0.05). These results support the previous study. In the current study, the 6-MWT was used to evaluate improvements in endurance during walking. For independent living, stroke patients have to be able to walk more than 300 m. In our study, the participants were unable to walk 300 m in the pretest. In the posttest, the experimental group showed significant improvements compared with the control group in the 6-MWT (p<0.05). However, the participants in both group were still unable to walk 300 m in the 6-MWT. Although UST resulted in significant differences in dynamic balance and walking endurance between the groups, walking speed was not significantly different. We think that these results seemed to indicate improved dynamic balance and endurance. UST with treadmill training is a useful intervention for improving dynamic balance and walking endurance.

This study was conducted to evaluate the effect of UST in chronic stroke patients. The results of this study indicate that UST improved walking ability and suggest the applicability of UST for clinical rehabilitation. Improvement of walking ability in stroke patients increases the opportunities for independent living and social activities. In addition, it can be an effective approach to ensure continuous training after discharge. The UST protocol has a clinical advantage because it is simple and easy. In addition, UST is cost-effective because of the enhanced efficiency achieved by its use in combination with traditional methods. The limitations of this study include the relatively small groups and the absence of follow-up data. Therefore, the results must be interpreted with caution.

ACKNOWLEDGEMENT

This work was supported by the Wonkwang Health Science University Research Fund (2014).

REFERENCES

1) Bang DH, Shin WS, Kim SY, et al.: The effects of action observational training on walking ability in chronic stroke patients: a double-blind randomized controlled trial. Clin Rehabil, 2013, 27: 1118–1125. [Medline] [CrossRef]
2) Borel S, Schneider P, Newman CJ: Video analysis software increases the interrater reliability of video gait assessments in children with cerebral palsy. Gait Posture, 2011, 33: 727–729. [Medline] [CrossRef]
3) Ada L, Dean CM, Vargas J, et al.: Mechanically assisted walking with body weight support results in more independent walking than assisted overground walking in non-ambulatory patients early after stroke: a systematic review. J Physiother, 2010, 56: 153–161.
4) Olney SJ, Griffin MP, Monga TN, et al.: Work and power in gait of stroke patients. Arch Phys Med Rehabil, 1991, 72: 309–314. [Medline]
5) Lord SE, Rochester L: Measurement of community ambulation after stroke: current status and future developments. Stroke, 2005, 36: 1457–1461. [Medline] [CrossRef]
6) Lee KJ, Lee MM, Shin DC, et al.: The effects of a balance exercise program for enhancement of gait function on temporal and spatial gait parameters in young people with intellectual disabilities. J Phys Ther Sci, 2014, 26: 513–516. [Medline] [CrossRef]
7) Bayouk JF, Boucher JP, Leroux A: Balance training following stroke: effects of task-oriented exercises with and without altered sensory input. Int J Rehabil Res, 2006, 29: 51–59. [Medline] [CrossRef]
8) Verhagen E, Bobbert M, Inklaar M, et al.: The effect of a balance training programme on centre of pressure excursion in one-leg stance. Clin Biomech (Bristol, Avon), 2005, 20: 1094–1100. [Medline] [CrossRef]
9) Kawanabe K, Kawashima A, Sashimoto I, et al.: Effect of whole-body vibration exercise and muscle strengthening, balance, and walking exercises on walking ability in the elderly. Keio J Med, 2007, 56: 28–33. [Medline] [CrossRef]
10) Fong KN, Chow KY, Chan BC, et al.: Usability of a virtual reality environment simulating an automated teller machine for assessing and training persons with acquired brain injury. J Neuroeng Rehabil, 2010, 7: 19. [Medline] [CrossRef]
11) Cohen J: Statistical power analysis for the behavioral sciencies: Routledge; 1988.
12) van Loo MA, Moseley AM, Bosman JM, et al.: Test-re-test reliability of walking speed, step length and step width measurement after traumatic brain injury: a pilot study. Brain Inj, 2004, 18: 1041–1048. [Medline] [CrossRef]
13) Podsiadlo D, Richardson S: The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc, 1991, 39: 142–148. [Medline]
14) O'Keeffe ST, Lye M, Donnellan C, et al.: Reproducibility and responsiveness of quality of life assessment and six minute walk test in elderly heart failure patients. Heart, 1998, 80: 377–382. [Medline]
15) Lord SE, Rochester L, Weatherall M, et al.: The effect of environment and task on gait parameters after stroke: A randomized comparison of measurement conditions. Arch Phys Med Rehabil, 2006, 87: 967–973. [Medline] [CrossRef]
16) Dean N, Shuaib A: Transient ischaemic attacks: unstable, treatable, neglected. Lancet, 2007, 370: 1398–1400. [Medline] [CrossRef]
17) Shin WS, Lee SW, Lee YW, et al.: Effects of combined exercise training on balance of hemiplegic stroke patients. J Phys Ther Sci, 2011, 23: 639–643. [CrossRef]
18) Shumway-Cook A, Silver IF, LeMier M, et al.: Effectiveness of a community-based multifactorial intervention on falls and fall risk factors in community-living older adults: a randomized, controlled trial. J Gerontol A Biol Sci Med Sci, 2007, 62: 1420–1427. [Medline] [CrossRef]
19) Irion J: Use of the gym ball in rehabilitation of spinal dysfunction. Orthop