J. Phys. Ther. Sci.
27: 2625–2627, 2015

Original Article

Effects of foot position of the nonparetic side during sit-to-stand training on postural balance in patients with stroke

Jintae Han, PT, PhD[1)*], Youngmi Kim, PT, PhD[2)], Kyung Kim, PT, PhD[3)]

[1)] *Department of Physical Therapy, College of Science, Kyungsung University: 309 Suyeong-ro, Nam-gu, Busan 608-736, Republic of Korea*
[2)] *Department of Rehabilitation Science, Graduate school, Daegu University, Republic of Korea*
[3)] *Department of Physical Therapy, College of Rehabilitation Science, Daegu University, Republic of Korea*

Abstract. [Purpose] We aimed to investigate postural balance after sit-to-stand (STS) training with different nonparetic foot positions in stroke patients. [Subjects] Thirty-six subjects who experienced a stroke (21 males, 15 females) participated and were divided into the symmetric foot position (SYMM), asymmetric foot position (ASYM), and step foot (STEP) groups. [Methods] Each group performed repetitive sit-to-stand training 5 times a week for 6 weeks. The timed up-and-go test (TUG), functional reach test (FRT), and F-mat system correcting the anterior/posterior (A-P) and medial/lateral (M-L) distance of the center of pressure (COP) were used to measure the static and dynamic postural balance pre- and postintervention. ANCOVA was used to analyze differences among groups, and preintervention variables were used as covariates. [Results] The TUG, FRT, and A-P and M-L distance of the COP in the ASYM and STEP groups were significantly decreased after intervention compared with the SYMM group. All parameters in the STEP group were lower than those in the ASYM group, without a significant difference. [Conclusion] The asymmetric foot position during STS is a good intervention to improve the static and dynamic postural balance in stroke patients. Especially, using a step to change the foot position is effective in improving STS performance.

Key words: Foot position, Sit-to-stand, Postural balance

(This article was submitted Apr. 13, 2015, and was accepted May 18, 2015)

INTRODUCTION

Sit-to-stand (STS) movement is a common daily activity that consists in a person rising from a chair[1)]; however, the ability to accomplish STS is diminished after a stroke[2)]. In previous studies, patients who experienced a stroke were shown to perform STS with a longer duration[3)], due to the modification of both the anterior-posterior (A-P) and medial-lateral (M-L) displacement of the center of mass (COP)[4)], and due to an asymmetric weight-bearing pattern[5, 6)].

Patients with stroke have a compromised ability to use their paretic limb during the transfer from sitting to standing[7, 8)]. They often become acclimated to compensatory strategies and bear less weight on their paretic lower limb[9, 10)]; however, their predominant use of the nonparetic lower limb during STS transfer results in an asymmetric pattern[11, 12)]. Recently, studies involving trunk restriction for reach and grasp[13)], foot positioning during STS[14, 15)], and lifting the nonparetic foot during quiet standing[16)] have shown that patients with stroke can achieve a better performance with their paretic limb.

The asymmetric weight-bearing pattern in patients with stroke can be improved by altering the foot position of the nonparetic limb during STS[11)]. Also, patients with acute stroke who support their nonparetic lower limb on a 10-cm-high step during STS tasks can improve the weight-bearing rate of their paretic limb by about 20% when compared with the symmetric foot position[17)].

However, few studies have described the effect of the nonparetic foot position during STS in patients with stroke. Therefore, the purpose of this study is to investigate postural balance after STS training with different nonparetic foot positions in such a population.

SUBJECTS AND METHODS

Thirty-six subjects (21 males, 15 females) with stroke participated in this study. The subjects were divided into three groups according to the nonparetic foot position: (i) symmetric foot position group (SYMM, n = 10), with both feet placed side by side at 10° dorsiflexion; (ii) asymmetric foot position group (ASYM, n = 13), with the nonparetic

*Corresponding author. Jintae Han (E-mail: jthan2001@ks.ac.kr)

foot dorsiflexed at 10° and placed backward at a distance corresponding to 50% of the subject's foot length; and (iii) step foot position group (STEP, n = 13), with the nonparetic foot placed on a step and the paretic foot placed at ground level and both feet with 10° dorsiflexion. The size of the step was 40 × 20 cm (length × width), and the height of the step was adjustable from 50 to 20 cm, allowing it to be adapted to each subject by normalization to 25% of the knee height[5].

The participants completed a survey, and those with either cognitive impairments or cerebellar involvement were excluded from the study. Before participation in this study, all subjects signed an informed consent document that was approved by the Institute Research Board of Kyungsung University.

Each group carried out repetitive STS training 5 times a week for a total of 6 weeks. The timed up-and-go (TUG) test was used to measure the dynamic balance ability. The TUG test measures the time that a person takes to rise from a chair, walk 3 m, turn around, walk back to the chair, and sit down.[18] A functional reach test (FRT) was used to measure the functional balance before and after the interventions. The FRT measures the distance between the length of the arm and the maximal forward reach in the standing position while the person maintains a fixed base of support[19]. An F-Mat (Tekscan Inc., Boston, MA, USA) was used to compare the A-P and M-L distance of the COP at pre- and postintervention[20]. The COP distance was measured for 5 s while each subject maintained the static balance position. All variables were measured at pre- and postintervention.

Descriptive statistics were used to represent the general characteristics of the subjects. ANCOVA was used to analyze the differences among groups, and each preintervention variable was used as a covariate. The SPSS software (version 21.0; SPSS, Chicago, IL, USA) was used for statistical analyses. A value of $p < 0.05$ was considered statistically significant.

RESULTS

The characteristics of the subjects are shown in Table 1. The TUG measurement of the ASYM and STEP groups was significantly decreased after STS training compared with the SYMM group ($p < 0.05$). The TUG measurement of the STEP group was lower than that of the ASYM group; however, no significant difference was found between them ($p > 0.05$) (Table 2). The FRT measurement of the ASYM and STEP groups was significantly increased after STS training compared with the SYMM group ($p < 0.05$). The FRT measurement of the STEP group was higher than that of the ASYM group; however, no significant difference was found between them ($p > 0.05$) (Table 2).

The A-P distance of the COP in the ASYM and STEP groups was significantly decreased after STS training compared with the SYMM group ($p < 0.05$). The A-P distance of the COP in the STEP group was shorter than that of the ASYM group; however, no significant difference was found between these groups ($p > 0.05$) (Table 2). The M-L distance of the COP in the ASYM and STEP groups was significantly decreased after STS training compared with the SYMM group ($p < 0.05$). The M-L distance of the COP in the STEP

Table 1. Subjects' characteristics (mean ± SD)

Variable	Group		
	SYMM (n = 10)	ASYM (n = 13)	STEP (n = 13)
Age (years)	61.20 ± 12.73	64.23 ± 7.35	55.92 ± 9.23
Time since stroke (months)	37.40 ± 20.53	27.85 ± 17.00	24.00 ± 13.11
Type (ischemic/hemorrhagic)	3/7	8/5	7/6
Side (L/R)	3/7	8/5	11/2
Sex (M/F)	5/5	7/6	8/5
Height (cm)	161.80 ± 8.49	162.92 ± 8.89	166.00 ± 8.46
Weight (kg)	61.50 ± 14.33	60.23 ± 10.70	62.15 ± 8.65

SD: standard deviation, SYMM: symmetric foot position, ASYM: asymmetric foot position, STEP: step foot position

Table 2. Comparisons of TUG, FRT, and distance of COP between pre- and postintervention (mean ± SD)

Variable	Group		
	SYMM	ASYM	STEP
TUG (s)	21.79 ± 13.15	19.47 ± 4.90*	17.11 ± 7.72†
FRT (cm)	18.50 ± 3.06	22.38 ± 4.91*	23.79 ± 3.95†
A/P distance of COP (cm)	6.11 ± 1.20	4.57 ± 1.18*	4.35 ± 0.73†
M/L distance of COP (cm)	6.06 ± 1.33	4.86 ± 1.09*	3.95 ± 0.85†

TUG: timed up-and-go test, FRT: functional reach test, A/P: anterior/posterior, M/L: medial/lateral, COP: center of pressure. *$p < 0.05$ significantly different between SYMM and ASYM, †$p < 0.05$ significantly different between SYMM and STEP

group was shorter than that of the ASYM group; however, no significant difference was found between them ($p > 0.05$) (Table 2).

DISCUSSION

After a stroke, a person's ability to perform STS movement is reduced. Recent studies about STS tasks in patients with hemiparesis have been conducted usually to investigate the asymmetric foot position[14, 21].

In this study, we examined the effect of the asymmetric and step foot positions during STS training on the postural balance of patients with stroke. Patients with stroke who underwent repetitive STS training with the asymmetric foot position and step foot position improved their static and dynamic postural balance in comparison with those with the symmetric foot position. Particularly, STS training with the step foot position was better than the other foot positions.

These results are similar to those of Brunt et al.[11], who reported that manipulating the foot placement of the unaffected limb may be a beneficial strategy in STS tasks for patients with hemiplegia, and to those of Rocha et al.[6], who suggested that using a step is a relevant therapeutic intervention to lessen the asymmetric loading during rising to stand. The predominant use of the nonparetic lower limb during the STS transfer results in an asymmetric behavior that may lead to learned nonuse[12, 13].

The results of this study show that using the step foot position during repetitive STS training is effective in improving the static and dynamic postural balance in patients with hemiplegia. Moreover, these results are also similar to those of a previous study that reported that the STEP condition can benefit the balance training of patients with hemiparesis[6]. Therefore, it is likely that the asymmetry of weight bearing by using a step during STS training could spontaneously help load the affected limb in such a population.

In conclusion, the asymmetric foot position during STS is a good intervention to improve the static and dynamic postural balance in patients with hemiparesis. Especially, using a step to change the foot position is also effective in improving the ability to perform STS.

REFERENCES

1) Riley PO, Schenkman ML, Mann RW, et al.: Mechanics of a constrained chair-rise. J Biomech, 1991, 24: 77–85. [Medline] [CrossRef]
2) Roy G, Nadeau S, Gravel D, et al.: The effect of foot position and chair height on the asymmetry of vertical forces during sit-to-stand and stand-to-sit tasks in individuals with hemiparesis. Clin Biomech (Bristol, Avon), 2006, 21: 585–593. [Medline] [CrossRef]
3) Malouin F, Richards CL, Doyon J, et al.: Training mobility tasks after stroke with combined mental and physical practice: a feasibility study. Neurorehabil Neural Repair, 2004, 18: 66–75. [Medline] [CrossRef]
4) Chou SW, Wong AM, Leong CP, et al.: Postural control during sit-to stand and gait in stroke patients. Am J Phys Med Rehabil, 2003, 82: 42–47. [Medline] [CrossRef]
5) Eng JJ, Chu KS: Reliability and comparison of weight-bearing ability during standing tasks for individuals with chronic stroke. Arch Phys Med Rehabil, 2002, 83: 1138–1144. [Medline] [CrossRef]
6) Rocha AS, Knabben RJ, Michaelsen SM: Non-paretic lower limb constraint with a step decreases the asymmetry of vertical forces during sit-to-stand at two seat heights in subjects with hemiparesis. Gait Posture, 2010, 32: 457–463. [Medline] [CrossRef]
7) Lomaglio MJ, Eng JJ: Muscle strength and weight-bearing symmetry relate to sit-to-stand performance in individuals with stroke. Gait Posture, 2005, 22: 126–131. [Medline] [CrossRef]
8) Galli M, Cimolin V, Crivellini M, et al.: Quantitative analysis of sit to stand movement: experimental set-up definition and application to healthy and hemiplegic adults. Gait Posture, 2008, 28: 80–85. [Medline] [CrossRef]
9) Britton E, Harris N, Turton A: An exploratory randomized controlled trial of assisted practice for improving sit-to-stand in stroke patients in the hospital setting. Clin Rehabil, 2008, 22: 458–468. [Medline] [CrossRef]
10) Perry SB, Marchetti GF, Wagner S, et al.: Predicting caregiver assistance required for sit-to-stand following rehabilitation for acute stroke. J Neurol Phys Ther, 2006, 30: 2–11. [Medline] [CrossRef]
11) Brunt D, Greenberg B, Wankadia S, et al.: The effect of foot placement on sit to stand in healthy young subjects and patients with hemiplegia. Arch Phys Med Rehabil, 2002, 83: 924–929. [Medline] [CrossRef]
12) Taub E, Uswatte G, Mark VW, et al.: The learned nonuse phenomenon: implications for rehabilitation. Eura Medicophys, 2006, 42: 241–256. [Medline]
13) Michaelsen SM, Dannenbaum R, Levin MF: Task-specific training with trunk restraint on arm recovery in stroke: randomized control trial. Stroke, 2006, 37: 186–192. [Medline] [CrossRef]
14) Duclos C, Nadeau S, Lecours J: Lateral trunk displacement and stability during sit-to-stand transfer in relation to foot placement in patients with hemiparesis. Neurorehabil Neural Repair, 2008, 22: 715–722. [Medline] [CrossRef]
15) Lecours J, Nadeau S, Gravel D, et al.: Interactions between foot placement, trunk frontal position, weight-bearing and knee moment asymmetry at seat-off during rising from a chair in healthy controls and persons with hemiparesis. J Rehabil Med, 2008, 40: 200–207. [Medline] [CrossRef]
16) Aruin AS, Hanke T, Chaudhuri G, et al.: Compelled weightbearing in persons with hemiparesis following stroke: the effect of a lift insert and goal-directed balance exercise. J Rehabil Res Dev, 2000, 37: 65–72. [Medline]
17) Laufer Y, Dickstein R, Resnik S, et al.: Weight-bearing shifts of hemiparetic and healthy adults upon stepping on stairs of various heights. Clin Rehabil, 2000, 14: 125–129. [Medline] [CrossRef]
18) Ng SS, Hui-Chan CW: The timed up & go test: its reliability and association with lower-limb impairments and locomotor capacities in people with chronic stroke. Arch Phys Med Rehabil, 2005, 86: 1641–1647. [Medline] [CrossRef]
19) Jonsson E, Henriksson M, Hirschfeld H: Does the functional reach test reflect stability limits in elderly people? J Rehabil Med, 2003, 35: 26–30. [Medline] [CrossRef]
20) Han JT, Koo HM, Jung JM, et al.: Differences in plantar foot pressure and COP between flat and normal feet during walking. J Phys Ther Sci, 2011, 23: 683–685. [CrossRef]
21) Camargos AC, Rodrigues-de-Paula-Goulart F, Teixeira-Salmela LF: The effects of foot position on the performance of the sit-to-stand movement with chronic stroke subjects. Arch Phys Med Rehabil, 2009, 90: 314–319. [Medline] [CrossRef]