J. Phys. Ther. Sci.
27: 833–835, 2015

Original Article

Effect of handrail use while performing treadmill walking on the gait of stroke patients

Kyung Woo Kang, MS, PT[1)], Na Kyung Lee, PhD, PT[1)], Sung Min Son, PhD, PT[2)], Jung Won Kwon, PhD, PT[1)], Kyoung Kim, PhD, PT[1)*]

[1)] *Department of Physical Therapy, College of Rehabilitation Science, Daegu University: 15 Jilyang, Gyeongsan-si, Kyeongbuk 712-714, Republic of Korea*
[2)] *Department of Physical Therapy, College of Health Science, Cheongju University, Republic of Korea*

Abstract. [Purpose] The purpose of this study was to investigate how the use of handrails during treadmill walking affects the gait parameters of stroke patients. [Subjects and Methods] The participants, 30 hemiplegic stroke patients, were randomly allocated to one of three groups: the NHG group (No Handrail group, n=10), the FHG group (Front handrail group, n=10), and BHG group (Bilateral Handrail group, n=10). All the subjects' performed treadmill walking for 30 min, five days a week, for a period of eight weeks. Gait parameters were evaluated using the RS-scan system. [Results] A statistically significant difference in the HM (heel-medial) area of plantar foot pressure was observed between BHG and NHG. Statistically significant difference in the HL (heel-lateral) area of plantar foot pressure was observed between BHG and NHG, and between FHG and NHG. A statistically significant difference in contact area of the rear foot was observed between BHG and NHG. [Conclusion] The results of this study show that holding handrails during treadmill training may enhance the improvement in the quality of patients' gait (plantar foot pressure, contact area of foot).
Key words: Treadmill training, Handrails, Stroke

(This article was submitted Sep. 2, 2014, and was accepted Oct. 26, 2014)

INTRODUCTION

Treadmills are widely used for gait training of stroke patients in clinical practice. The walking environment provided by a treadmill is similar to that of walking on the ground[1)]. While training on a treadmill, patients can usually place their hands on the handrails or use them for support. When walking on a treadmill, most stroke patients hold the handrails with the unaffected hand or both hands, which may be a strategy to correct or improve their body balance[2)]. Touching handrails lightly can decrease the physiologic stress of gait instability, and may facilitate balance control[3)].

A light touch by the fingertips of patients with sensory neuropathy of the peripheral nerves may partially mitigate the disturbance of their posture control function. Lackner et al.[4)] demonstrated the importance of a light touch by the fingertips. A light touch by the fingertips can reduce postural sway, which may also be of benefit during walking. According to some reports, postural sway was reduced by the light touch of the fingertips on a fixed object during one-leg standing or eyes-closed standing[5)].

Many studies of treadmill training or light touch sense have been conducted. However, there is a lack of research focusing on the way handrails are held, regarding the elicitation of light touch sense or tactile sense, during treadmill walking by stroke patients. The purpose of this study was to investigate how the holding of handrails during treadmill walking affects the gait parameters of stroke patients.

SUBJECTS AND METHODS

Thirty participants with first onset of stroke were recruited for this study. Participants met the following inclusion criteria: onset of stroke at least six months before the study; the ability to walk independently on a treadmill; and the ability to hold the handrails (Chedoke-McMaster ≥3/7 for arm and hand).

All of the participants understood the purpose of this study and gave their written informed consent before participating in the experiment involvement. This study was performed in accordance with the Declaration of Helsinki, and was approved by the local committee of the Institutional Review Board of Daegu University. All the participants received conventional physical therapy in addition to training on treadmill (JT-4000M, SNSCARE, Korea). This treadmill has a front handrail and two handrails on both sides, so patients using this clinical equipment can walk using the handrails for assistance. Treadmill training began at a slow speed, which was slowly increased The subjects were randomly allocated to one of three groups according to the use of the handrails: treadmill walking without holding a handrail, the no handrail group (NHG); treadmill walking with holding

*Corresponding author. Kyoung Kim (E-mail: kykim257@hanmail.net)

Table 1. Comparisons of plantar foot pressure and contact area of foot of the affected side of the 3 groups

Parameters		NHG group		FHG group		BHG group	
		Pre	Post	Pre	Post	Pre	Post
Plantar foot pressure (N)	T1	27.1 ± 36.0	27.8 ± 20.3	17.5 ± 13.6	23.8 ± 16.3	13.8 ± 16.4	27.9 ± 28.2
	T2-5	4.7 ± 8.9	3.4 ± 2.7	3.8 ± 4.6	6.8 ± 7.4	10.1 ± 18.2	16.5 ± 20.6
	M1	30.0 ± 25.3	30.0 ± 19.4	5.4 ± 4.7	20.0 ± 18.7	16.1 ± 18.9	23.3 ± 23.4
	M2	27.4 ± 16.9	29.9 ± 13.1	12.5 ± 10.3	25.2 ± 17.0	21.8 ± 18.8	28.9 ± 30.3
	M3	25.4 ± 13.6	25.6 ± 12.1	16.8 ± 14.9	25.0 ± 16.0	19.0 ± 18.4	30.8 ± 27.9
	M4	24.8 ± 10.6	23.0 ± 12.6	17.4 ± 16.3	23.5 ± 19.4	29.1 ± 50.3	35.9 ± 33.9
	M5	14.3 ± 10.7	21.1 ± 26.3	25.5 ± 42.7	19.2 ± 18.3	21.7 ± 44.6	40.2 ± 52.9
	MF	28.5 ± 23.2	32.9 ± 54.1	53.9 ± 78.6	75.2 ± 88.0	28.9 ± 40.7	56.0 ± 45.9
	HM*	58.5 ± 34.1	53.6 ± 28.7	50.7 ± 50.9	78.3 ± 70.8	28.0 ± 45.3	65.4 ± 56.8
	HL*†	48.8 ± 26.9	41.0 ± 22.1	42.9 ± 49.3	74.8 ± 68.4	13.8 ± 22.7	47.0 ± 52.3
Contact area of foot (%)	Fore foot	54.2 ± 8.0	52.4 ± 5.6	46.5 ± 9.6	45.1 ± 8.8	54.4 ± 6.0	51.5 ± 7.7
	Mid foot	19.4 ± 8.9	21.5 ± 5.7	25.8 ± 8.3	25.2 ± 7.4	22.2 ± 4.4	26.8 ± 13.0
	Rear foot*	26.4 ± 4.0	26.1 ± 2.4	27.7 ± 4.7	29.7 ± 4.4	23.4 ± 4.4	27.7 ± 4.0

*Significant difference between the NHG exercise and BHG exercise groups ($p < 0.05$). †Significant difference between the NHG exercise and FHG exercise groups ($p < 0.05$).
NHG: No Handrail group; FHG: Front handrail group; BHG: Bilateral Handrail group; T1: Toe1; T2–5: Toe2–5; M1–5: Metatarsal 1, 2, 3, 4, 5; MF: Midfoot; HM: Heel-medial; HL: Heel-lateral

the front handrail with both hands, the front handrail group (FHG); and treadmill walking holding the bilateral handrails with both hands, the bilateral handrail group (BHG). NHG trained while their arms hanging at their sides. FHG held the front handrail height of 95 cm with both hands shoulder width apart. All subjects were instructed to keep their heads up and look forward, so that they did not lean excessively to the front. BHG trained holding the handrails on both sides, which are 83 cm in height and 69 cm in length with both hands approximately 15 cm in front of the midline. All subjects wore a safety harness suspended from the ceiling that bore no weight, but would provide support in the event of a fall. Each group had 10 subjects. During treadmill walking, subjects walked at a self-selected comfortable walking speed. All participants performed treadmill walking for 30 min, five days a week, for a period of eight weeks.

This study measured gait variables using the RS-scan system (RS scan Ltd., German). The subjects walked on the RS-scan plate, for determination of plantar foot pressure and contact area of the foot. All subjects walked without shoes over the plate. Gait variables including pressure and contact area were calculated using RS-scan software. This study measured the foot pressure data using the RS-scan system which includes a normalization procedure. The plantar pressure area was divided into 10 regions: Toe1, Toe2–5, Metatarsal 1, 2, 3, 4, 5, Midfoot, Heel-medial and Heel-lateral. The contact area was separated into fore, mid, and rear foot. Subjects began walking 50 cm in front of the RS-scan plate following a “Start” cue, and walked continuously over the RS-scan plate at a comfortable speed. The mean of two trials at pre-test and post-test after eight weeks was used for analysis, and only paretic limb data were used. Data were collected at a rate of 126 frame/sec using Footscan 7 gait 2nd generation, a software program of the RS-scan system.

Group demography was compared using one-way ANOVA and the LSD procedure as a post hoc test. Two-way analysis of variance (ANOVA) of Condition (NHG vs. FHG vs. BHG) × Period (pre and post), with repeated measures of both factors, was performed for each group of subjects. When ANOVA yielded a significant interaction ($p < 0.05$), post hoc analyses were performed using the t-test with LSD correction for multiple comparisons. All data were analyzed using SPSS 12.0 statistical software.

RESULTS

There were no significant differences in gender (male/female, NHG: 8/2, FHG: 6/4, BHG: 6/4), age (NHG: 57.60±19.92, FHG: 53.60±8.40, BHG: 61.60±14.66), height (NHG: 166.20±4.36, FHG: 163.20±11.53, BHG: 161.40±9.41), or weight (NHG: 61.30±10.45, FHG: 62.30±9.95, BHG: 60.20±9.70) among the groups ($p>0.05$).

The results of the analysis confirmed significant interaction between the HM and HL areas. The comparison of changes and post hoc analysis revealed a statistically significant difference in the HM area between BHG and NHG ($p<0.05$). Statistically significant differences in the HL area were observed between BHG and NHG, and between FHG and NHG ($p<0.05$).

The results of the analysis confirmed significant interaction in the rear foot area. The comparison of changes and post hoc analysis revealed a statistically significant difference between BHG and NHG ($p<0.05$) (Table 1).

DISCUSSION

The purpose of this investigation was to determine whether holding the handrails during treadmill walking affects the gait parameters of stroke patients. In each group, we measured gait parameters before and after training. As a result of the training, significantly better gait parameters were observed in FHG and BHG than in NHG.

According to results of the present study, plantar pressure and the contact area of the rear foot showed more significant increases in the handrail holding groups than in the no handrail group. Inappropriate coordination, short step length, long stance phase, and short swing phase are general characteristics of the gait of stroke patients, and may be caused by a spastic pattern of hamstring and calf muscles. Shortening of the calf muscle, in particular, causes a decrease in plantar pressure of the heel during gait[6]. Chen et al.[7] reported that stroke patients' contact area ratio of the rear foot was lower than that of normal persons. This finding was interpreted as an effect of the extensor synergy pattern on the lower limb, post stroke. Extensor synergy pattern interferes with coordination of the ankle dorsiflexors and knee extensor, and causes the forefoot to make contact with the ground earlier than the rear foot[8].

In this study, holding handrails on a treadmill provided a sensation of light touch sense or tactile stimulus. According to Dickstein et al.[9], light touch sense affected postural stability as measured by body sway during treadmill training. In addition, according to Duysens et al.[10], stable posture and performance of core stability is important for heel contact with the ground in stroke patients. In the present study, the sense originating at the hands decreased body sway, which would have helped patient's heel contact with the ground as well. We consider that light touch sense or tactile sense occurred through holding of the handrails, which resulted in better postural stability. As a sensorimotor process, postural control can alter the force generating capacity as well as the peripheral proprioceptive system. It is thought that improved postural stability can change the proprioception sense of the lower extremity and affect the heel contact ratio. In other words, increased postural stability can alter the joint angles of the lower extremities and increase the heel contact ratio making it similar to that of normal gait[11].

The results of this study show that holding handrails during treadmill training had a positive effect on gait parameters. Patients training on a treadmill are usually not concerned about their hands, however, the results of this study provide a reminder that the use of handrails is very important for postural stability. It can also improve the ratio of plantar pressure and the landing area of the rear foot. Therefore, in the clinic, physical therapists should pay attention to patient's method of treadmill training for better improvement of their gait. In addition, the further direction of study should be to provide more evidence for this result.

This study had a few limitations. The number of subjects was small, and the subjects were capable of using their affected limb to hold handrails. Therefore, our findings might not be generalizable to other stroke patients. In addition, because the period of study was only eight weeks, we could not confirm whether or not the effect of training persisted after the experiment.

REFERENCES

1) Kim CS, Gong WT, Kim SG: The effects of lower extremitiy muscle strengthening exercise and treadmill walking exercise on the gait and balance of stroke patients. J Phys Ther Sci, 2011, 23: 405–408. [CrossRef]
2) Froelicher VF Jr, Thompson AJ Jr, Davis G, et al.: Prediction of maximal oxygen consumption. Comparison of the Bruce and Balke treadmill protocols. Chest, 1975, 68: 331–336. [Medline] [CrossRef]
3) Jeka JJ, Schöner G, Dijkstra T, et al.: Coupling of fingertip somatosensory information to head and body sway. Exp Brain Res, 1997, 113: 475–483. [Medline] [CrossRef]
4) Lackner JR, DiZio P, Jeka J, et al.: Precision contact of the fingertip reduces postural sway of individuals with bilateral vestibular loss. Exp Brain Res, 1999, 126: 459–466. [Medline] [CrossRef]
5) Jeka JJ, Lackner JR: Fingertip contact influences human postural control. Exp Brain Res, 1994, 100: 495–502. [Medline] [CrossRef]
6) Lee NK, Son SM, Nam SH, et al.: Effects of progressive resistance training integrated with foot and ankle compression on spatiotemporal gait parameters of individuals with stroke. J Phys Ther Sci, 2013, 25: 1235–1237. [Medline] [CrossRef]
7) Chen CY, Hong PW, Chen CL, et al.: Ground reaction force patterns in stroke patients with various degrees of motor recovery determined by plantar dynamic analysis. Chang Gung Med J, 2007, 30: 62–72. [Medline]
8) Den Otter AR, Geurts AC, Mulder T, et al.: Gait recovery is not associated with changes in the temporal patterning of muscle activity during treadmill walking in patients with post-stroke hemiparesis. Clin Neurophysiol, 2006, 117: 4–15. [Medline] [CrossRef]
9) Dickstein R, Peterka RJ, Horak FB: Effects of light fingertip touch on postural responses in subjects with diabetic neuropathy. J Neurol Neurosurg Psychiatry, 2003, 74: 620–626. [Medline] [CrossRef]
10) Duysens J, Duysens JP, Bastiaanse CM, et al.: How trunk turns affect locomotion when you are not looking where you go. Hum Mov Sci, 2008, 27: 759–770. [Medline] [CrossRef]
11) Vuillerme N, Anziani B, Rougier P: Trunk extensor muscles fatigue affects undisturbed postural control in young healthy adults. Clin Biomech (Bristol, Avon), 2007, 22: 489–494. [Medline] [CrossRef]