

Original Article

Changes in Postural Sway According to Footwear Types of Hemiparetic Stroke Patients

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Abstract. [Purpose] The purpose of the current study was to investigate the influence of footwear type on postural sway of hemiparetic stroke patients. [Subjects] Thirty-two stroke patients who were undergoing a rehabilitation program were recruited on a voluntary basis from local rehabilitation unit. [Methods] This study had a single-group repeated-measures design. The Good Balance system was used to measure the postural sway velocity (anteroposterior and mediolateral) and velocity moment of the subjects under the eyes open and eyes closed conditions in the standing posture. Postural sway of the subjects in four types of footwear was measured, including barefoot, high heel-collar shoes, flat shoes, or slippers. [Results] The postural sway when wearing the flat shoes or slippers was significantly higher than that when barefoot or wearing high heel-collar shoes. In addition, postural sway velocity and velocity moment of all the footwear types were significantly higher under the eyes closed condition than under the eyes open condition. [Conclusion] Our results reveal that when the subjects wore flat shoes or slippers they had more difficulty than when they wore the high heel-collar shoes in postural control when maintaining standing balance. We believe that this result provides basic information for improvements in postural control and may be useful in balance training to prevent falls after stroke.

Key words: Footwear, Postural sway, Stroke

(This article was submitted Nov. 13, 2013, and was accepted Jan. 7, 2014)

INTRODUCTION

The important role of footwear is to protect the foot and to enable pain-free locomotion¹⁾. Footwear affects postural stability by providing somatosensory feedback to the foot and modifying friction between footwear and the sole^{1, 2)}. Previous studies have demonstrated that the possibility of the inappropriate footwear is an environmental risk factor that may cause a fall^{2, 3)}. Forty-five percent of falls by the elderly are caused by inappropriate footwear, and 75% of people who suffer a fall-related hip fracture were wearing inappropriate footwear at the time of the falls⁴⁾. According to previous evidences, footwear features including, heel height⁵⁾, heel collar height and sole thickness^{6, 7)}, have been shown to affect postural control of the elderly. Kerse et al.⁵⁾ reported that the properties of shoes were significantly related to risk of falls in the elderly, and that wearing shoes with heels lower than 2.5 cm and large contact area can help to reduce the risk of a fall. Menant et al.⁶⁾ reported that the hard soles are more effective than soft soles at improving

the postural control of the elderly. Despite many studies having demonstrated the effects of footwear on postural control of the elderly^{6, 7)}, there are still no guidelines for stroke patients with regard to optimal shoe features for postural control. Stroke patients usually have more difficulty than elderly people with postural control when maintaining balance.^{8, 9)}

Up to now, only one study⁸⁾ has investigated the effect of footwear on the balance of people recovering from stroke. That study reported that footwear type does not affect balance control (functional reach test, FRT). However, FRT may not be a sufficiently sensitive measure of standing balance. In addition, the authors suggested that further studies would be required to confirm or refute their findings using more sensitive measures of balance control⁸⁾. Therefore, the purpose of the present study was to investigate the influence of footwear types on postural sway of hemiparetic stroke patients. We hypothesized that the postural sway would show changes depending on the footwear type worn by hemiparetic stroke patients.

SUBJECTS AND METHODS

This study used a single-group repeated-measures design.

Thirty-seven stroke patients were recruited for this study. All the subjects were participating in a standard rehabilitation program, which included physical and occupa-

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tional therapy, during the experimental period. The subjects were screened using the following inclusion and exclusion criteria. The inclusion criteria were: hemiparesis resulting from a single stroke more than 6 months ago; ability to independently stand; ability to understand and follow simple verbal instructions (Korean version of Mini-Mental State Examination score > 24); and absence of serious visual impairment or hearing disorder. Exclusion criteria for the study were orthopedic and other postural control influencing diseases, such as arthrosis or total hip joint replacement, and participation in other studies. Five of the 37 potential subjects were excluded following the exclusion criteria. The remaining 32 subjects were included in this study (16 men and 16 women with a mean age of 63.5 years and post-stroke duration of 300.6 days). We explained the objective and requirements of our study to all the participants, and they voluntarily signed informed consent forms. Ethical approval for the study was granted by the Sahmyook University Institutional Review Board.

General characteristics of age, post-stroke duration, weight, height and stroke features was collected using a structured interview and record review. Postural sway was measured using a Good Balance force platform system (Good Balance system, Metitur Ltd., Jyvaskyla, Finland). The Good Balance force platform system is an equilateral triangle (800 mm) that is connected to a 3-channel DC amplifier. Signals from the amplifier are converted into digital form using a 12-byte converter (sampling frequency=50 Hz) and stored on the hard disk of a personal computer. The X and Y coordinates of the center of pressure (COP) are derived from the data. The following variables are calculated: the extent of the mediolateral movement of the COP (X movement), the extent of the anteroposterior movement of the COP (Y movement), and the mean value of all of the measurement points in relation to the midline of the platform (lateral displacement). To measure postural sway under the eyes open and eyes closed conditions, subjects stood on the force plate with their legs apart 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 quietly in comfortable upright position on the force plate while looking straight ahead. Three repeats of each measurement were performed and the average was used in the statistical analysis. A resting time of 3 minutes was provided between measurements. The distance between the subject and the monitor was set to 1.5 m. Postural sway of the subjects was measured while they were barefoot or wore high heel-collar shoes, flat shoes or slippers (Fig. 1). All subjects wore socks during postural sway measurement when wearing the high heel-collar shoes, flat shoes and slippers, and the distance between the hallux and shoe end was approximately 1.5 cm when wearing the high heel-collar shoes and the flat shoes. The distance between the hallux and shoe end when wearing the high heel-collar shoes and flat shoes was confirmed by palpating the shoe end. In addition, the assessor confirmed that the level of tension of both the left and right shoe laces were similar when wearing the high heel-collar shoe⁶.

SPSS ver. 12.0 statistical software was used for all anal-



Fig. 1. The footwear worn during measurements of postural sway: (A) high heel-collar shoes, (B) flat shoes and (C) slippers

yses. Descriptive statistics were used to describe patient characteristics after confirming the normality of the data. Descriptive statistics were used to describe patient characteristics. Differences of postural sway according to the type of footwear data were analyzed using one-way repeated analysis of variance. The LSD post hoc test was used when significant differences between groups were indicated. To compare the postural sway between the eyes open and eyes closed conditions, the paired t test was used. A significance level of 0.05 was chosen for all analyses.

RESULTS

General characteristics of the subjects are shown in Table 1.

Differences of postural sway according to the footwear type are summarized in Table 2. In all measurements, AP and ML postural sway velocity and postural sway velocity moment with eyes open and closed significant differences were observed according to the footwear type ($p < 0.05$). According to the post hoc analyses, the postural sway when wearing the flat shoes or slippers was significantly higher than when barefoot or wearing high heel-collar shoes ($p < 0.05$). In addition, for all types of footwear, postural sway velocity (anteroposterior and mediolateral) and velocity moment were significantly higher under the eyes closed condition than under the eyes open condition ($p < 0.05$).

DISCUSSION

The present study was conducted to investigate the effect of footwear types on the postural sway of Korean stroke patients. The results of this study revealed that when the subjects wore the flat shoes or slippers, they had more difficulty than when they wore the high heel-collar shoes with postural control when maintaining standing balance.

Possible reasons for the differences in postural sway among the types of footwear may be the stability of the ankle joint and the facilitation of proprioceptive input. According to previous evidences targeting older people, postural control when wearing high heel-collar shoes is better than that of other types of shoe^{6, 7}. The material surrounding the ankle region of the high heel-collar shoe provides mechanical stability to the ankle joint¹⁰, and the high heel-collar might evoke better balance control via an ankle postural strategy¹¹. The feet are involved in the ankle strategy for coping with postural sway in the standing position, and it was well known that the ankle strategy plays an important role in stable postural control^{12, 13}. In stroke patients, par-

Table 1. General characteristic of the subjects

parameters	Male (n=16)	Female (n=16)	Overall (n=32)
Paretic side Left/Right	11/5	2/14	13/19
Etiology Infarction/Hemorrhage	7/9	13/3	20/12
Age (years)	63.1±4.3	64.0±5.2	63.5±4.7
Height (cm)	168.5±2.8	158.0±5.1	163.3±6.7
Weight (kg)	66.8±4.0	58.3±4.6	62.5±6.1
Onset duration (days)	329.7±84.3	271.5±56.9	300.6±76.6
MMSE-K (scores)	25.6±1.8	27.0±1.7	26.3±1.9
BBS (scores)	37.1±3.5	35.2±1.9	36.1±2.9
TUG (scores)	20.4±5.1	24.3±3.5	22.4±4.7
Brunnstrom stage (2/3/4)	10/4/2	5/8/3	15/12/5

Values are expressed as Mean±SD

BBS: berg balance scale, TUG: timed up and go test, MMSE-K: mini mental state examination-Korean

Table 2. Difference of postural sway according to the footwear type (n=32)

parameters	conditions	Barefoot (A)	High heel-collared shoes (B)	Flat shoes (C)	Slippers (D)	F(p) values	Post-hoc (LSD)
AP-PSV (mm/s)	Eyes open	5.90±1.61	6.09±1.63	7.38±2.07	7.91±2.28	14.675(<0.000)	A-C, A-D, B-C, B-D
	Eyes closed	9.86±3.56	10.74±4.74	14.94±5.61	18.36±9.23	15.829(<0.000)	A-C, A-D, B-C, B-D, C-D
	Change	3.96±3.82	4.65±3.82	7.55±5.09	10.45±8.26		
	t (p)	5.584 (<0.000)*	6.550 (<0.000)*	7.996 (<0.000)*	6.813 (<0.000)*		
ML-PSV (mm/s)	Eyes open	8.82±2.82	8.95±2.27	14.33±3.93	15.23±3.76	33.255(<0.000)	A-C, A-D, B-C, B-D
	Eyes closed	13.90±4.92	15.01±5.86	23.70±7.43	31.96±29.21	21.528(<0.000)	A-C, A-D, B-C, B-D
	Change	5.07±5.03	6.05±5.33	9.36±6.29	16.72±27.85		
	t (p)	5.426 (<0.000)*	6.120 (<0.000)*	8.009 (<0.000)*	3.234 (.003)*		
PSVM (mm ²)	Eyes open	27.36±19.38	27.97±21.00	39.58±15.80	43.12±15.82	10.626(<0.000)	A-C, A-D, B-C, B-D
	Eyes closed	61.97±42.25	66.31±38.57	136.86±56.75	157.21±63.61	42.881(<0.000)	A-C, A-D, B-C, B-D, C-D
	Change	34.61±32.09	38.34±33.15	97.27±51.58	114.08±56.42		
	t (p)	5.808 (<0.000)*	6.227 (<0.000)*	10.156 (<0.000)*	10.889 (<0.000)*		

Values are expressed as Mean±SD.

AP: anteroposterior, ML: mediolateral, PSV: postural sway velocity, PSVM: postural sway velocity moment.

A-C: significant differences between Barefoot and Flat shoes (p<0.05).

A-D: significant differences between Barefoot and Slippers (p<0.05).

B-C: significant differences between High heel-collared shoes and Flat shoes (p<0.05).

B-D: significant differences between High heel-collared shoes and Slippers (p<0.05).

C-D: significant differences between Flat shoes and Slippers (p<0.05).

*: significant difference between eyes open and eyes closed conditions (p<0.05)

ticularly, postural control is the best predictor of achieving independent living, and loss of postural control has been recognized as a major problem¹⁴). In addition, a previous study demonstrated that proprioceptive input induced by a circumferential ankle pressure device improves postural stability and joint position sense¹⁵). We believe that the material surrounding the ankle region of the high heel-collared shoe may be a circumferential ankle pressure device, leading to increased ankle stability and proprioceptive input, and reduced postural sway in stroke patients.

Another finding of the current study was that significantly higher postural sway was observed under the eyes open condition than under the eyes closed condition. This result

can be explained by the fact that postural control is dependent upon the interaction of multiple systems¹⁶). Humans need information, including equilibrium, proprioception, and visual cues, in order to maintain postural control¹⁷). In particular, proprioceptive input applied to the ankle and foot has a tendency to have an enhanced role in maintaining balance in the absence of vision¹⁸). This finding of the present study is consistent with previous studies of elderly women¹⁹) and stroke patients¹⁸).

Our results revealed that when the subjects wore the flat shoes or slippers, they had more difficulty than when they wore the high heel-collared shoes with postural control when maintaining standing balance. We believe that this result

provides basic information regarding improvements to postural control, and that it may be useful in balance training to prevent falls after stroke. This study had some limitations. First, the statistical power was not calculated and only a small number of subjects were recruited. Thus, future studies should be conducted using a larger sample size in order to fully understand the effect of footwear type on postural sway of stroke patients. Second, despite the possibility that the degree of sensory disturbance may affect the measurement of postural sway, this study did not investigate sensory disturbance of the subjects. Thus, more research is required to address this issue.

ACKNOWLEDGEMENT

This study was financially supported by the research fund of Sahmyook University in 2013.

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