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Research Article

Comparing the Effect of Speedy and Endurance Walking on Postural Control and the Time for Returning to Baseline after Walking in Patients with Chronic Stroke and Healthy Subjects

Aliakbar Ghasemi[1], Ghorban Taghizade[*2], Kourosh Gharegozli[3]

1- MSc, Department of Occupational Therapy, School of Rehabilitation, Iran University of Medical Sciences, Tehran, Iran
2- Lecturer, Department of Occupational Therapy, School of Rehabilitation, Iran University of Medical Sciences, Tehran, Iran
3- Associate Professor, Department of Occupational Therapy, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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Corresponding Author:
Ghorban Taghizade
Emial:
gh_taghizade@yahoo.com
Tel: +982122220946
Fax: +989101462167

ABSTRACT

Introduction: Physical activity causes postural instability in patients with stroke and healthy subjects, but the impact of the type of physical activity and its durability on postural control in patients with stroke is not clear. Therefore, the aim of this study was to compare the effect of two types of speedy and endurance walking on postural control and the time for returning of postural control to baseline after walking in patients with chronic stroke and healthy subjects.

Material and Methods: In this non-experimental case-control study, 12 chronic stroke patients (4 female, 8 male; 4 with right hemiparesis and 8 with left hemiparesis) by mean age of 54.16 ± 12.18) years and mean passed duration of injury 28.66 ± 25.11) months and 12 height-, weight-, age- and sex-matched healthy subjects by mean age of 54.33 ± 13.04) years were selected by simple non-probability method. Walking for 6 minutes at maximum speed and walking for 18 minutes at normal speed were considered as speedy and endurance walking, respectively. Mean velocity and path length parameters of postural sway were measured by force platform in tandem standing before walking and immediately, 15 and 30 minutes after walking.

Results: The results of this study showed that the main effect of group was not significant in mean velocity ($P = 0.487$, $F = 0.499$) and path length parameters ($P = 0.375$, $F = 0.818$) while the both mean velocity ($P = 0.016$, $F = 6.83$) and path length ($P = 0.034$, $F = 5.13$) were greater in speedy walking than endurance walking. Furthermore, the main effect of time was significant in mean velocity ($P = 0.017$, $F = 4.26$) and path length ($P = 0.002$, $F = 5.31$). None of the interaction effects was significant in any of postural sway parameters.

Conclusion: The results of this study indicated that speedy walking results in postural instability more than endurance walking in both patients with chronic stroke and healthy subjects. Time for returning of postural stability to the baseline was 30 minutes after both speedy and endurance walking in both patients with chronic stroke and healthy subjects.

Keywords: Speedy and endurance walking; Chronic stroke patient; Postural stability

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Introduction

Postural stability or balance is referred to the ability to maintain the body's center of mass in stability limit when carrying out voluntary activities (1). Postural instability is one of the main causes of falling and loss of independence in activities of daily living in patients with stroke (2). Decrease of postural stability following physical activity has been reported in previous studies (3, 4). It seems possible that the effect of physical activity on postural stability is greater in patients with balance disorders such as stroke compared to healthy subjects (5). Carver et al. (6) showed that increase of postural sway after walking activity in stroke patients was more than normal subjects. However, a few researches have been conducted to compare the effect of different types of physical activity on balance. Fox et al. (7) compared the effect of two types of aerobic and anaerobic exercise protocols on postural control of athletes prone to brain injury and found the negative effect of both exercise protocols on postural control. It has been reported that 18 minutes walking at a normal speed have a greater impact on the postural stability compared to 6 minutes walking in patients with stroke (6). Nevertheless, no study has been found that reported the effect of two types of speedy walking (i.e., walking at maximum speed in a short time) and endurance walking (i.e., walking at normal speed in a longer time) on the postural stability of patients with stroke.

On the other hand, one of the issues studied on the effects of physical activities on postural stability is the time for returning of postural stability to baseline after performing these activities. These studies would help clinicians to be more informed about increased risk of falling or damage after performing these activities in patients with stroke. Previous studies have shown that the time for returning to the baseline (i.e., pre-activity state) after performing exercise protocols was about 20 minutes in healthy subjects (7, 8). Carver et al. (6) found that the time for returning of postural stability to the baseline after 18 minutes walking at normal speed was 15 minutes for both healthy subjects and patients with stroke. So far, however, no research has been carried out to compare the time for returning of postural stability to the baseline after performing speedy activities (i.e., activities that are performed at high speed in a short time) and endurance ones (i.e., activities that are performed at normal speed in a long time) in patients with stroke. Therefore, the aim of this study was to compare the effect of two types of speedy and endurance walking on postural stability and the time for returning of postural stability to the baseline after walking in patients with chronic stroke and healthy subjects. The results of this study could provide more information for researchers and clinicians about the effect of different walking types on postural control of patients with chronic stroke. Moreover, this study would inform the clinicians about the rest time needed for returning of perturbed postural control to the baseline after walking in these patients.

Materials and methods

In this non-experimental case-control study, 12 patients with chronic stroke (8 male, 4 female; 8 with left hemiparesis and 4 with right hemiparesis) by mean time since injury of 28.66 ± 25.11 months, mean age of 54.16 ± 12.18 years, mean height of 165.29 ± 11.00 cm, and mean weight of 69.17 ± 12.55 kg were selected from Rehabilitation Clinics of School of Rehabilitation Sciences, Iran University of Medical Sciences, Iran Red Crescent Society, Shafa Yahyaeian Hospital and Firoozgar Hospital by simple non-probability method. Furthermore, 12 sex-, age-, height- and weight-matched healthy subjects (8 male, 4 female) by mean age of 54.33 ± 13.04 years, mean height of 165.54 ± 11.28 cm, and mean weight of 67.16 ± 12.20 kg were participated. After conducting a pilot study on 5 patients with chronic stroke and 5 sex-, age-, height- and weight-matched healthy subjects, the sample size of 12 were determined for each stroke and healthy group based on mean velocity parameter of postural sway at the statistical power of 80% and 95% confidence interval. Inclusion criteria for patients with stroke were the following: passing at least 6 months of brain injury induced by first experience of stroke, having the ability to understand and execute verbal instructions, having the ability to standing up from a chair and walking with or without assistive device for 18 minutes, not having vision and hearing problems non-rectified with eyeglasses and hearing aids, not having orthopedic and other neurologic disorders, not having any heart disease, hypertension, epilepsy, joint arthritis, and diabetes based on patients' or physician's report. Inclusion criteria for healthy subjects were the following: not having any history of balance, vestibular and visual impairments as well as any neurologic or orthopedic disorders. In the case of inability to complete the tests, repeated falling and lack of cooperation during testing, participants were excluded. This study was approved by the Ethics Committee of Iran University of Medical Sciences (code number: 94/d/105/195). All subjects signed a written informed consent document to participate in the study.

After a full description of how to perform the tests and ensure understanding by participants, one of two types of speedy and endurance walking was randomly selected. First, participants warmed up (i.e., they walked 5 minutes in the biomechanical laboratory), and then, they were asked to perform speedy or endurance walking. At least 2 hours after the end of one type of walking, another type was performed. In speedy walking, subjects were asked to walk at the maximum speed in a specified distance for 6 minutes. In endurance walking, they were asked to walk at the normal speed in the same distance for 18 minutes. During the speedy walking, participants were encouraged verbally by the examiner. Postural stability was measured before walking as well as immediately, 15 and 30 minutes after walking using Kistler force platform (Model: 2812A; version: 4.D.X, Kistler group, Winterthur, Switzerland). This method has been reported in the study of Carver et al. (2011). Subjects were asked to stand barefoot, arms along their side, on the force platform and look at a white paper mounted on the wall at the level of their eyes. Measurement of postural stability was performed in tandem standing, in which the heel of the affected leg of stroke patients was placed along the toe of unaffected leg. The distance between two legs was as much as four fingers of the examiner. In healthy subjects, feet were placed in a position similar to their matched patients. Postural sway was recorded in 35 seconds at a sampling frequency of 100 Hz. Mean velocity and path length parameters of the center of pressure (COP) were calculated. The high reliability of these parameters has been reported in previous studies (9).

The Shapiro–Wilks test was used to study the normal distribution of the data. The effects of type of walking and time of the tests on the COP measures in both stroke and healthy groups (main effects and interaction of these effects) were analyzed using a 2 × 2 × 4 (group × type of walking × time) mixed model analysis of variance. The Bonferroni adjustment method was used for multiple comparisons. α level was considered at 0.05.

Results

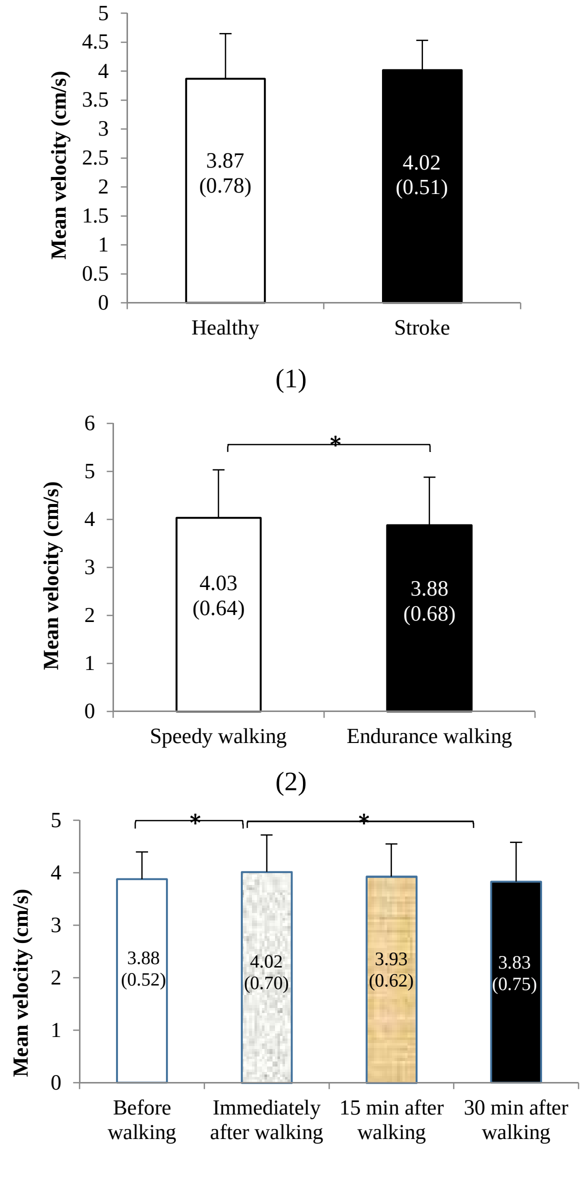
Table 1 shows the mean (± standard deviation) for measures of postural sway before and immediately, 15 and 30 minutes after speedy and endurance walking in both stroke and healthy groups. Investigation of normal distribution showed that both measures of postural sway (mean velocity and path length) were normally distributed in all times of measurement before and after both types of walking in stroke as well as healthy group.

The results of this study indicated that the main effects of time (before walking, immediately, 15 and 30 minutes after walking) and type of walking were significant for both measures of postural sway (i.e., mean velocity and path length). However, the main effect of group and interaction effects of time × type of walking, type of walking × group, and time × type of walking × group were insignificant for these measures (Table 2).

The results of multiple comparisons showed that both measures of postural sway (i.e., mean velocity and path length) were significantly different immediately after walking compared to before walking as well as 30 minutes after walking (Table 3, Figures 1 and 2).

Discussion

The aim of this study was to compare the effect of two types of speedy and endurance walking on postural stability and the time for returning of postural stability to the baseline after walking in patients with chronic stroke and healthy subjects.



(3)

Figure 1. Comparison of the main effect of group (1), type of walking (2), and time of measurement (3) for mean velocity measure of center of pressure in tandem standing

Table 1. Mean ± SD for postural sway measures in different times before and after speedy and endurance walking during tandem standing in patients with chronic stroke and healthy subjects

Dependent Variables	Before walking		Immediately after walking		15 minutes after walking		30 minutes after walking	
	Speedy	Endurance	Speedy	Endurance	Speedy	Endurance	Speedy	Endurance
Path length (cm)								
Stroke	58.39 ± 6.12	57.41 ± 5.95	63.00 ± 9.48	62.95 ± 9.61	61.47 ± 7.79	59.30 ± 7.33	59.49 ± 8.18	59.51 ± 4.72
Healthy	56.28 ± 6.58	54.37 ± 7.19	62.92 ± 12.95	58.97 ± 10.35	59.04 ± 11.72	56.04 ± 10.26	57.42 ± 10.17	53.48 ± 17.93
Mean velocity (cm/s)								
Stroke	3.95 ± 0.45	3.83 ± 0.39	4.20 ± 0.63	4.19 ± 0.64	4.10 ± 0.51	3.95 ± 0.49	3.97 ± 0.54	3.97 ± 0.31
Healthy	3.90 ± 0.59	3.83 ± 0.67	4.20 ± 0.86	3.93 ± 0.69	3.94 ± 0.78	3.74 ± 0.68	3.83 ± 0.67	3.57 ± 1.19

Table 2. Summary of ANOVA for COP measures: The main and interaction effects of time (before walking, immediately, 15 and 30 minutes after walking), type of walking (speedy and endurance), and group (stroke and healthy) in tandem standing

Parameters	Degree of freedom	Mean of square	F	$P_{(v)}$	Effect size
Path length (cm)					
Time	3	258.62	5.31	0.002*	0.194
Type of walking	1	182.59	5.13	0.034*	0.189
Group	1	385.06	0.818	0.375	0.036
Time × Type of walking	3	3.49	0.103	0.958	0.005
Time × Group	3	9.28	0.19	0.903	0.009
Type of walking × Group	1	64.467	1.82	0.192	0.076
Time × Type of walking × Group	3	10.47	0.31	0.819	0.014
Mean velocity (cm/s)					
Time	3	1.122	4.26	0.017*	0.162
Type of walking	1	0.864	6.83	0.016*	0.237
Group	1	1.149	0.499	0.487	0.022
Time × Type of walking	3	0.01	0.062	0.979	0.003
Time × Group	3	0.128	0.652	0.585	0.029
Type of walking × Group	1	0.211	1.67	0.210	0.070
Time × Type of walking × Group	3	0.072	0.431	0.732	0.019

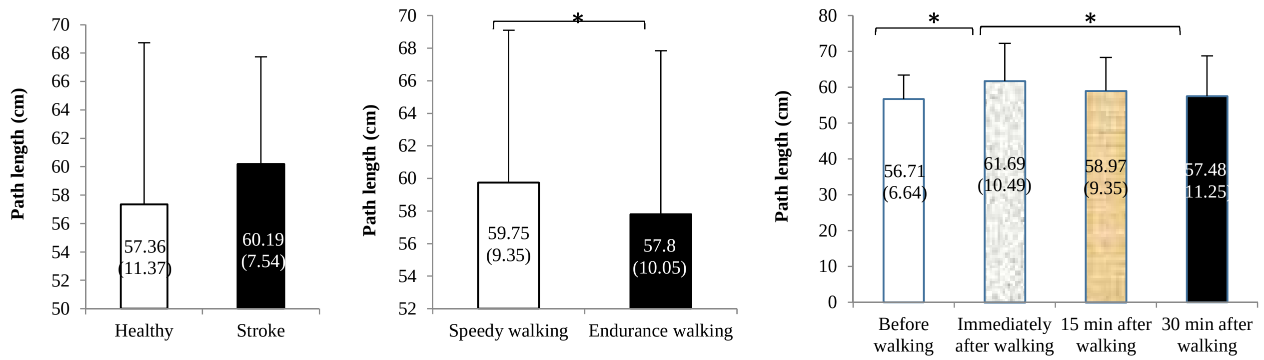
*$P_{(v)} < 0.050$. COP: Center of pressure

We found that both types of speedy and endurance walking immediately results in significant increase of COP sway in both stroke and healthy groups which indicate the increase of postural instability and could be explained by the following reasons: (1) Decreased motor output under the effect of the activity of Group III and V muscle afferents, which are sensitive to fatigue following physical activities such as walking (10), (2) increased breathing rhythm and heart rate due to metabolic activity caused by walking (7, 11), (3) dysfunction of vestibular system due to decreased labyrinth pressure caused by physical activity-induced dehydration (12), (4) disturbances of visual information (13, 14), (5) dysfunction of proprioceptive sense, especially position sense and force perception sense caused by walking (15), and (6) disturbed function of central nervous system induced by physical activity (e.g., walking) (16). The results of this study about the endurance walking in patients with chronic stroke are in accordance with the result of Carver et al. study (6), which showed that walking at normal speed resulted in increased postural instability in these patients.

Table 3. Results of multiple comparisons of COP measures for the main effect of time (before walking, immediately, 15 and 30 minutes after walking) in tandem standing in patients with chronic stroke and healthy subjects)

COP measures	Path length (cm)	Mean velocity (cm/s)
Before walking compared to immediately after walking	0.000*	0.002*
Before walking compared to 15 minutes after walking	0.022	0.428
Before walking compared to 30 minutes after walking	0.592	0.626
Immediately after walking compared to 15 minutes after walking	0.020	0.020
Immediately after walking compared to 30 minutes after walking	0.004*	0.004*
15 minutes after walking compared to 30 minutes after walking	0.261	0.260

*$P_{(v)} < 0.0081$. COP: Center of pressure



(1) (2) (3)

Figure 2. Comparison of the main effect of group (1), type of walking (2), and time of measurement (3) for path length measure of center of pressure in tandem standing

However, they reported that 18 minutes walking at normal speed did not increase COP sway in healthy subjects, which are inconsistent with the results of this study. A possible explanation for this might be the postural task used for evaluating COP sway. They used quiet double leg standing with 20 and 24 cm distance between heels and toes, respectively, while we use more difficult postural task (i.e., tandem standing). Therefore, the more difficult postural task may better show the increase of COP sway in healthy subjects.

Moreover, the results of this study indicated that the effect of speedy walking on COP sway is significantly greater than endurance walking in both stroke and healthy groups. This result may be explained by the fact that disrupting the visual inputs induced by further movement of the visual field (14), decreased role of vestibular information in maintaining postural stability due to further vertical movements and changed sensitivity of the otoliths (17, 18) and further momentary damage of mechanoreceptors in foot skin, joints, tendons, and muscle involved in proprioception due to stronger eccentric and concentric contractions (3, 19) in speedy walking may result in greater postural instability compared to endurance walking.

Besides, the current study found that postural sway of both stroke and healthy groups returned to baseline 30 minutes after both types of speedy and endurance walking. However, Carver et al. (6) observed that postural sway of patients with stroke returned to the baseline 15 minutes after walking at normal speed. Nardone et al. also found that postural sway of healthy young adults returned to the baseline 15 minutes after performing physical activity on a treadmill (20). Fox et al. (7) reported that 13 minutes is needed for returning of postural sway to the baseline after aerobic and anaerobic exercise in athletes. Susco et al., (8) Yaggie and McGregor (21), and Derave et al. (17) found that the time needed for returning of postural sway to the baseline after physical activity was about 20 minutes. It seems possible that these differences are due to different protocols of physical activity and task used for evaluating postural stability in these studies. The main limitation of this study was non-identical walking speed (in both types of speedy and endurance walking) in patients with stroke and healthy subjects, which are suggested to be considered in future studies.

Conclusion

The results of this study showed that both types of speedy and endurance walking results in postural instability in patients with chronic stroke as well as healthy subjects. The effect of speedy walking on postural stability was markedly greater than endurance walking. Moreover, the results of this study indicated that 30 minutes is needed for returning of postural stability to baseline after speedy and endurance walking in both stroke and healthy groups which are suggested to be considered as a rest time needed after physical activity to prevent possible impairments in clinics and future researches.

Conflict of Interests

Authors have no conflict of interests.

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