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Original Article

Effect of the a circuit training program using obstacles on the walking and balance abilities of stroke patients

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Abstract. [Purpose] The aim of this study was to investigate the impact of a circuit training program on the walking and balance abilities of stroke patients using an up-to-date walking analysis device. [Subjects and Methods] The subjects of this study were 12 adults who were diagnosed with stroke. Evaluation was conducted using the Smart Step test for walking ability; (BBS) for balance ability; and the Timed Up and Go test (TUG) for functional mobility and movement ability. The 12 stroke patients were randomly recruited and divided into two groups; an experimental group which performed circuit training with obstacles, and a control group which performed flat gait training). [Results] Between-group comparison of the change in the 10-m walking speed found a statistically significant difference between the two groups. Between-group comparison of the changes in BBS and TUG found statistically significant differences between the two groups. [Conclusion] The circuit training program using obstacles had a positive effect on the gait and balance abilities of the stroke patients.

Key words: Task circuit program, Obstacles, Stroke

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INTRODUCTION

Stroke is a major reason for disability in adults. It results in weakening of the muscles, reducing victims' balance and mobility1). Stroke not only has a negative impact on left and right symmetry due to asymmetric posture, but also decreases the stride length of the non-paretic side, as the patients cannot use the ground reaction force effectively. Moreover, this decrease in stride length results in a slower walking cycle and walking speed. Because of this abnormal walking, patients with stroke tend to show an inefficient walking pattern that requires large energy consumption during walking2).

In patients with stroke, approximately 61–80% of total weight is borne on the unaffected lower limb in standing position due to the weakened muscle strength of the paretic upper and lower limbs3). The center of the body shifts to the unaffected side, and the ability to maintain balance decreases because a symmetric weight shift does not take place under conditions of external perturbation4). In the case of postural disturbance, abnormal muscle mobilization is caused, and the endurance necessary for weight-bearing decreases, which makes it hard for the patient to maintain his or her posture5). Asymmetric body alignment of the affected and unaffected sides results in diminishing balance ability; as a secondary effect, it also increases the risk of falling6).

Diverse therapeutic methods have been used to enhance the walking and balance abilities of patients with stroke. Bayouk et al. argued that exercise using tasks is effective at enhancing balance and mobility7). Moreover, Taube et al. reported that weighy-shift training on an unstable surface had significant effects on the balance and postural control of patients with stroke8). Said et al. reported that obstacle training had a significant impact on walking and balance9), stroke patients' and it has also been reported that diverse afferent stimuli and functional activities help to improve the ability to perform daily life

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*Corresponding author. Hyun-Joo Kim (E-mail: hkim@ut.ac.kr) activities[10].

In walking and balance training, a circuit training program using obstacles should have positive effects not only on level walking within the treatment room, but also on patients' ability to respond to environmental demands related to daily life, before they return to community living. Moreover, repetitive performance of tasks on diverse and unstable surfaces should help patients to maintain psychological stability. Previous studies mainly focused on the motor functions of patients with stroke, and to date, little research has been conducted on their responses to environmental changes such as when negotiating obstacles.

Hence, this preliminary study conducted a circuit program with a diverse environment created by obstacles for patients with stroke, and investigated the impact of the program on their walking and balance abilities using an up-to-date gait analysis device.

SUBJECTS AND METHODS

The subjects of this study were 12 adults who were diagnosed with stroke by specialists in rehabilitation medicine at Hospital C located in Cheongju City, Chungcheongbuk-do, Korea. The 12 stroke patients were randomly recruited and divided into two groups, an experimental group which performed a circuit training program using obstacles, and control group which performed flat gait training, after the subjects had answered a questionnaire survey. The inclusion criteria for the subjects were patients at least six months after the occurrence of stroke who understood the purpose of the research and were capable of independent walking over 40 meters and crossing over obstacles. Those with orthopedic diseases, those who were not capable of voluntary movement, as determined by a stiffness level of less than Level 2 on the Modified Ashworth Scale,and those who could not perform the Smart Step test were excluded from the study. All subjects provided their written informed consent before participating in the study in accordance with the ethical criteria defined by the Declaration of Helsinki.

Measurement tools for this study consisted of a tool for measuring walking ability and a tool for assessing balance. Evaluation of walking was conducted using the Smart Step test. Inflatable insoles of the Smart Step tool that fited the foot sizes of the patients were inserted inside the subjects' shoes. The patients walked while wearing the shoes, and plantar prints (forefoot, hindfoot), walking speed, walking cycle, and cadence were analyzed. Smart Step measures the air pressure of the insole and transmits the data by a wireless device. In this study, the Smart Step was used to analyze the foot on the paretic side twice, before and after the intervention, to measure the change in plantar prints, 10- m walking speed, and stride during walking.

The Berg Balance Scale (BBS) is one of the most widely used clinical tools for evaluating postural control and walking function. It is mainly used to evaluate the balance of elderly people and patients with nervous system diseases who have a high risk of falling. The BBS assesses three elements; postural maintenance, postural control by voluntary movement, and responses to external disturbance. A total of 14 items are evaluated on a 5-point scale scored from 0 to 4, with a maximum possible score of 56.

Timed Up and Go testis a method that measures functional mobility and movement ability. The test measures the time it takes for a patient to stand up from a sitting posture on a chair after a starting signal and walk to the halfway point at 3 m distance, then return to sit down on the chair again. In this study, the patients were told to turn at the halfway point using the unaffected side as a pivot.

The circuit program using obstacles applied to the experimental group was circuit training making use of circulation obstacles used in the rehabilitation room at Hospital C. For safety reasons, the intervention program was implemented one-on-one with a therapist. The 30 min daily intervention was implemented for 3 weeks, for a total of 12 sessions. The obstacles were as follows.

1) In tandem gait, the patient walks in a straight line, stepping on a 10 m dotted line;

2) In slalom, the patients passes five cones with a 2 m distance in zigzags;

3) In climbing up and down stairs, the patients climbed up and down five 10 cm stairs with safety handles on both sides;

4) In climbing up and down the clivus, the patients climbed up and down a 150 cm tilted platform with a downward slope of 10 degrees and safety handle on both sides; and

5) In step box passing, the patients walk over one 5 cm box, one 10 cm box, and two 20 cm boxes in order that are located at a 2 m distance.

The control group performed 30 min level walking rehabilitation training on a firm indoor surface without obstacles 4 times a week for 3 weeks, a total of 12 sessions. The intervention was conducted one-on-one with a therapist.

For the research intervention, the 30-min circuit training program using obstacles was performed by the six patients in the experimental group, and the daily 30-min level walking training was performed by the six patients in the control group.

The SPSS Win. 20.0 package was used for data analysis. The results are described as means and standard deviations (Mean ± SD). The paired-sample t-test was conducted to examine the significance of within-group effects of the intervention on the experimental and control groups. The independent sample t-test was conducted to examine the significance of intervention, effects between the experimental and control groups. Significance was accepted for values of $p<0.05$.

RESULTS

The change in plantar prints was statistically significant in neither the experimental group nor the control group (p>0.05), and there was no statistically significant difference in the intervention effect between the two groups (p>0.05).

The change in hindfoot plantar prints was statistically significant in neither the experimental group nor the control group (p>0.05), and there was no statistically significant difference in the intervention effect between the two groups (p>0.05). The change in forefoot plantar prints was neither statistically significant in the experimental group nor the control group (p>0.05), and there was no statistically significant difference in the intervention effect between the two groups (p>0.05). The change in cadence was statistically significant in neither the experimental group nor the control group (p>0.05), and there was no statistically significant difference in the intervention effect between the two groups (p>0.05).

For the 10 m walking time, the experimental group showed a decrease from 22.71 sec to 18.15 sec a statistically significant difference (p<0.05). The control group showed a decrease from 20.76 sec to 19.91 sec, but the difference was not statistically significant (p>0.05). The between-group comparison of the changes revealed a statistically significant difference between the two groups (p<0.05; Table 1).

In the comparison of balance ability, the experimental group showed an increase in the Berg Balance Scale score from 43.67 to 45.17, a statistically significant difference (p<0.05). The control group showed an increase from 44.67 to 45.00, but the difference was not statistically significant (p>0.05). Between-group comparison of the changes revealed showed a statistically significant difference between the two groups (p<0.05).

In the Timed Up and Go test, the experimental group showed a decrease from 20.27 sec, 18.58 sec with a statistically significant difference (p<0.05). The control group showed a decrease from 19.30 sec to 19.25 sec with no statistically significant difference (p>0.05). The between-group comparison of the changes revealed a statistically significant difference between the two groups (p<0.05; Table 1).

Table 1. Comparison of gait and balance abilities of the experimental and control groups (Mean±SD)

		Experimental group	Control group
		(n=6)	(n=6)
Plantar prints (%)	pre	58.1 ± 13.3	60.6 ± 11.3
	post	57.1 ± 11.9	56.8 ± 9.8
	post-pre	−1.1 ± 7.9	−3.8 ± 9.8
Hindfoot (%)	pre	37.5 ± 10.1	41.8 ± 10.2
	post	37.5 ± 9.7	39.0 ± 8.0
	post-pre	−0.1 ± 9.4	−2.8 ± 9.4
Forefoot (%)	pre	38.0 ± 16.9	38.1 ± 19.6
	post	38.0 ± 16.2	36.9 ± 18.0
	post-pre	−0.1 ± 10.5	−1.2 ± 6.0
Cadence (steps/min)	pre	76.2 ± 8.8	84.4 ± 7.1
	post	88.9 ± 11.9	89.0 ± 10.4
	post-pre	12.6 ± 13.5	4.6 ± 12.1
10MWT (sec)*	pre	22.7 ± 7.7	20.8 ± 6.9
	post	18.2 ± 5.6	19.9 ± 7.1
	post-pre	−4.6 ± 3.6	−0.9 ± 1.4
BBS (score)*	pre	43.7 ± 6.0	44.7 ± 4.5
	post	45.2 ± 5.3	45.0 ± 4.4
	post-pre	1.5 ± 1.1	0.3 ± 0.5
TUG (sec)*	pre	20.3 ± 7.7	19.3 ± 4.7
	post	18.6 ± 5.2	19.3 ± 4.1
	post-pre	−1.7 ± 1.4	−0.5 ± 0.9

*p<0.05, 10MWT: 10-meter walking times, BBS: Bergbalancescale, TUG: timed up and go test

DISCUSSION

Balance and walking disturbances that appear after stroke are important issues that require remediation to enhance patients' mobility and daily life[11]. An obstacle training program has a positive impact on balance and walking enhancement[12, 13]. This study examined the effects of a circuit training program using obstacles on walking ability and balance.

The results of this study indicate circuit training program using obstacles resulted in significant improvements in the 10-m walking time, an index of walking ability, and the Berg Balance Scale and the Timed Up and Go test, indices of balance ability. However, no statistically significant results were observed in the plantar prints, forefoot, hindfoot, or cadence in terms of walking ability. Meanwhile, the control group, which received level walking therapy, showed no statistically significant improvements in walking ability or balance ability.

Chun performed an analysis of the obstacle negotiating ability and kinematic characteristics of 12 patients with hemiparesis due to stroke, and reported that performing obstacle course training resulted in a significant difference in the 10-m walking speed, compared to level walking, due to increases in hip joint, shoulder joint, and ankle joint control[14]. Kim conducted a study on the effect of task-oriented training including obstacles on trunk control ability, and balance and walking ability using a sample of 20 patients with stroke. He reported a decrease of 5.53±4.26 sec in 10-m walking time after the intervention[15], and conjectured that walking speed increased due to increased of walking efficiency of the lower limbs after performing obstacle tasks, such as climbing up and down the stairs, climbing up and down a ramp, and stepping over boxes.

Jeong conducted research on task-oriented circuit exercise including obstacles using a sample of 30 patients with stroke[16]. In that study, the experimental group showed a statistically significantly increase in the Berg Balance Scale, from 43.7±6.0 before the training to 45.2±5.3 after the training. In the Timed Up and Go test, the experimental group showed a statistically significantly decrease from 20.3±7.7 before the training to 18.6±5.2 after the training. Moreover, in a study by Yoo et al., both the experimental and control groups showed a significant decrease in performance time in the Timed Up and Go test, which was greater in the combined exercise group[17, 18]. These findings are consistent with our study results. It is our conjecture that balance ability was improved by exposure of the vestibular organs to diverse visual information and afferent information, and that somesthesia developed from performing the circuit training program using obstacles.

This study had several limitations. The participants included only patients who were capable of walking and performing obstacle training. Moreover, as the sample consisted of only patients who satisfied the research criteria, it is difficult to generalize the study results to all patients with stroke. The study did not include an evaluation of the persistence of the effect over time after the end of the 3-week intervention. It will be necessary to supplement the training period and continuously examine the persistency of the effect in a follow-up. Moreover, the effects of training using obstacles on the confidence and psychological efficacy of the patients also deserves attention.

This study showed that a circuit training program using obstacles at effective in improving the walking speed and balance of the patients with stroke. The results suggest that a circuit training program using obstacles is an intervention method that improves walking ability and enhances the balance of patients with stroke.

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