Effects of stationary cycling exercise on the balance and gait abilities of chronic stroke patients

Sung-jin Kim, PT, MS(1), Hwi-young Cho, PT, PhD(2), You Lim Kim, PT, MS(1), Suk-min Lee, PT, DDS, PhD(1)*

1) Department of Physical Therapy, College of Health Science, Sahmyook University: 815 Hwarangro, Nowon-gu, Seoul 139-742, Republic of Korea
2) Department of Physical Therapy, College of Health Science, Gachon University, Republic of Korea

Abstract. [Purpose] The objective of this study was to investigate the effects of stationary cycling exercise on the balance and gait abilities of chronic stroke patients. [Subjects] Thirty-two chronic stroke patients were randomly assigned to an experimental group (n=16) or a control group (n=16). [Methods] All of the subjects received the standard rehabilitation program for 30 minutes, while the experimental group additionally participated in a daily session of stationary cycling exercise for 30 minutes, 5 times per week for 6 weeks. To assess balance function, the Berg Balance Scale and timed up-and-go test were used. The 10-m walking test was conducted to assess gait function. [Results] Both groups showed significant improvements in balance and gait abilities. The improvements in the Berg Balance Scale and timed up-and-go test scores (balance), and 10-m walking test score (gait) in the stationary cycling exercise group were significantly greater than those in the control group. [Conclusion] This study demonstrated that stationary cycling exercise training is an effective intervention for increasing the balance and gait abilities of chronic stroke patients. Therefore, we suggest that stationary cycling training is suitable for stroke rehabilitation and may be used in clinical practice.

Key words: Gait, Balance, Stationary cycling

INTRODUCTION

Post-stroke gait dysfunction is a major impediment that affects functional ambulation. It is caused by a complex interplay of motor, sensory, and cognitive impairments. These neurological deficits are the prime cause of reduced quality of life and social participation. Thus, gait and balance recovery is regarded as a chief goal in stroke rehabilitation.

Until now, various exercise programs such as progressive exercise, muscle strength exercise, rhythmic pattern exercise, and virtual training have been used to regain the balance, mobility, and endurance of stroke patients in clinical and research settings. Among these interventions, repetitive motor training can alter brain representation maps and is mainly and basically used for managing the motor function recovery in stroke patients. However, which specific therapeutic modalities most efficient repetitive motor training remains unclear.

Skilled activity is necessary to drive brain changes that might lead to improvements in functional activities such as gait. Stationary cycling, which requires less balance capability, has been used for training patients with or without nervous system disorders who have difficulty in maintaining balance and independent gait. Cycling and walking share similar locomotor patterns of reciprocal flexion and extension movements and alternating muscle activation of antagonists. Cycling can improve functional mobility and acts as a pseudo walking task-oriented exercise. Besides improving muscle strength, cycling exercise also facilitates muscle control of the lower limbs, which may allow putting more weight on the affected leg while standing. For this reason, stationary cycling exercise has been used with various other interventions in the clinical environments. However, the pure effect of cycling exercise is uncertain in chronic stroke patients. Therefore, this study investigated the effects of stationary cycling exercise on the balance and gait abilities of chronic stroke patients.

SUBJECTS AND METHODS

This study was designed as a randomized, double-blind, pretest-posttest controlled trial. In this study, 38 chronic stroke patients who were hospitalized were recruited. All experimental procedures and contents were explained to each participant, who provided written informed consent thereafter. All of the experimental procedures were approved by the institutional review board of Sahmyook University. The inclusion criteria were as follows: presence of hemiparesis secondary to stroke that had occurred in the past 6 months, ability to understand and follow instructions, ability to walk independently, and ability to perform activities of daily living.

The experimental group participated in a daily session of stationary cycling exercise for 30 minutes, 5 times per week for 6 weeks. The control group received the standard rehabilitation program for 30 minutes.

The primary outcomes were balance and gait function. Balance was assessed using the Berg Balance Scale and timed up-and-go test. Gait function was assessed using the 10-m walking test.

RESULTS

Both groups showed significant improvements in balance and gait abilities. The improvements in the Berg Balance Scale and timed up-and-go test scores (balance), and 10-m walking test score (gait) in the stationary cycling exercise group were significantly greater than those in the control group.

CONCLUSION

This study demonstrated that stationary cycling exercise training is an effective intervention for increasing the balance and gait abilities of chronic stroke patients. Therefore, we suggest that stationary cycling training is suitable for stroke rehabilitation and may be used in clinical practice.
Table 1. General characteristics of the subjects

|                        | Experimental group (n = 16) | Control group (n = 16) |
|------------------------|----------------------------|------------------------|
| Gender (male/female)   | 12/4                       | 13/3                   |
| Age (years)            | 65.2 ± 6.4                 | 61.7 ± 6.1             |
| Height (cm)            | 165.0 ± 7.9                | 169.0 ± 6.1            |
| Weight (kg)            | 69.5 ± 10.4                | 66.8 ± 10.0            |
| Lesion side (right/left)| 7/9                        | 10/6                   |
| MMSE score             | 26.10 ± 1.74               | 25.80 ± 2.12           |

Data are expressed as mean ± SD.

Table 2. Changes in balance and gait abilities

|                        | Experimental group | Control group |
|------------------------|--------------------|---------------|
|                       | Pretest            | Posttest      |
| BBS score             | 36.15 ± 5.98       | 37.06 ± 5.61  |
|                       | 37.90 ± 5.65*      | 37.44 ± 5.62  |
|                       | 1.75 ± 1.52†       | 0.40 ± 0.88   |
| TUG (sec)             | 25.11 ± 5.40       | 24.19 ± 3.47  |
|                       | 16.74 ± 3.07*      | 19.48 ± 3.90* |
|                       | −8.4 ± 4.35†       | −4.71 ± 4.86* |
| 10MWT (sec)           | 44.75 ± 18.40      | 45.93 ± 13.22 |
|                       | 37.74 ± 15.70*     | 43.96 ± 12.04* |
|                       | 7.02 ± 7.02†       | 1.96 ± 3.13*   |

BBS: Berg Balance Scale; TUG: timed up-and-go; 10MWT: 10-m walking test

Post−Pre values were significant (p < 0.05). The significance difference, paired t test: *p < 0.05; significant difference, independent t test: †p < 0.05

The Statistical Package for the Social Sciences (SPSS) ver. 18.0 was used for data analysis. Descriptive statistics were used to analyze the general characteristics of the subjects. In order to examine the effects of the intervention in each group, a paired t test was conducted. In order to investigate differences between the groups, an independent t test was performed. For all data, the α level was set at 0.05.

RESULTS

The demographic characteristics of the participants are shown in the Table 1. No statistically significant differences in baseline values were observed between the 2 groups.

As shown in Table 2, the experimental group showed significant improvements in BBS, TUG test, and 10MWT scores after the intervention (p < 0.05), whereas the control group showed significant improvements in their TUG test and 10MWT scores, but not in their BBS score (p > 0.05). Moreover, the experimental group showed greater improvement than the control group in 3 outcome measurements (p < 0.05).
DISCUSSION

The aim of this study was to test the effects of cycling exercise on the balance and gait abilities of chronic stroke patients. The results demonstrated that the stationary cycling exercise supplemented with conventional therapy led to better balance and gait abilities than the conventional therapy alone.

First, the stationary cycling training was found to have a positive effect on dynamic balance as measured by using the TUG test. The results are similar to those obtained in a previous study by Kim et al., who compared ergometer bicycle training with treadmill walking training in stroke patients and reported significant improvement in TUG test scores in both groups, although the differences between the groups were not significant[18]. This suggests that the effectiveness of cycling training in improving locomotor function is similar to the effectiveness of treadmill exercise in stroke patients. Preliminary evidence suggests that cycling training programs reduce musculoskeletal impairment after stroke. In terms of muscle strength, cycling exercise enabled patients to bear more weight on the affected leg. A study by Kuo and Zajac suggested that the muscles that may be particularly important for this purpose are the hamstrings, rectus femoris, gastrocnemius, and tibialis anterior. These were all activated during the cycling task, which requires reciprocal flexion and extension movements of the hip, knee, and ankle[19]. It is interesting that Lustosa et al. reported a significant correlation between muscle strength and improvement in TUG test score. Therefore, we assumed that in this study the mechanism of TUG test score improvement in stroke patients was muscle strengthening[20].

Second, cycling exercise improved gait abilities in chronic stroke patients. This result is similar to those of previous studies. Repetitive bilateral training and treadmill walking with or without suspension have a positive effect on walking ability[21]. Repetitive practice is known to be important for motor learning, as the repetitions enable the system to coordinate muscle synergies[5]. Cycling and walking share similar locomotor patterns of repetitive reciprocal flexion and extension movements. Hence, stationary cycling exercise, which employs reciprocal movement of the lower limbs and requires coordination of corresponding muscles, effectively increased the gait ability.

Cycling training stimulates motor regions in the central nervous system and activates the cerebral cortex which eventually improves motor learning and balance. This effect certainly applies to chronic stroke patients. Based on the results, stationary cycling training can be effective in rehabilitation of stroke patients with gait and dynamic balance deficits.

This study has the following limitations that we plan to address in future studies, including the small sample size and relatively short intervention duration. Further large-scale, long-term controlled clinical studies are required to verify the clinical benefits of stationary cycling exercise training.

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