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

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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 ambulation1. It is caused by a complex interplay of motor, sensory, and cognitive impairments2. These neurological deficits are the prime cause of reduced quality of life and social participation3. Thus, gait and balance recovery is regarded as a chief goal in stroke rehabilitation4.

Until now, various exercise programs such as progressive exercise5, 6), muscle strength exercise1, rhythmic pattern exercise8, 9), and virtual training10) 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 patients11). 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 gait12). 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 gait13). Cycling and walking share similar locomotor patterns of reciprocal flexion and extension movements and alternating muscle activation of antagonists14). Cycling can improve functional mobility and acts as a pseudo walking task-oriented exercise2). 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 environments15). 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 walk 10 m independently with or without an assistive device; ability to communicate and understand, with a Mini-Mental Status Examination score of more than 21 points; no visual disorders or visual field deficit; and no known musculoskeletal conditions that would affect the ability to walk safely. The 6 subjects who refused to participate in the present program or did not meet the inclusion criteria were excluded from the study.

The subjects were randomly assigned to the following 2 groups by using a table of random sampling numbers: the experimental and the control group. Evaluation and data analysis were performed by a single physical therapist. Both the subjects and the therapist were blinded to group assignments of the patients. All of the participants were evaluated before training and at the end of the 4-week training period. The patients in the experimental group performed the cycling exercise 30 minutes a day, 5 times a week for 6 weeks. Both groups received traditional therapy for 30 minutes per session, 5 times a week for 4 weeks. Stationary bicycle training has been used in order to improve the balance and walking abilities of stroke patients. In this study, only the lower extremity part of a dual-extremity ergometer (Super Dynamic 3000, Shingwang Medical) was used.

To perform the exercise, the patient mounted a stationary bicycle safely under supervision, and the therapist adjusted the position of the seat and tied the ankles and calf to the pedals. The therapist was fully aware of the order and method of the stationary bicycle training, and the patients performed the exercise after receiving instructions and familiarizing themselves with the ergometers, including test runs. The resistance was set at 1 of 4, which corresponded to 25–30 W starting level was set at 0.05.

The subjects' balancing skills were rated using the Berg Balance Scale (BBS; range, 0–56), and the timed up-and-go (TUG) test was used to evaluate dynamic balance abilities. The patients were instructed to walk as usual at a comfortable speed. The 10-m walking time was measured with a stopwatch for the period from the moment the subject's feet passed the starting line to the moment they crossed the finish line. The subjects practiced once, and all measurements were made 3 times, using the average value of the 3 measurements in the analysis. For the 10MWT, the test-retest and inter-rater reliability have been reported to be 0.95 and 0.90, respectively; both of these values are very high

As shown in Table 1, 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).

<table>
<thead>
<tr>
<th>Table 1. General characteristics of the subjects</th>
<th>Experimental group (n = 16)</th>
<th>Control group (n = 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (male/female)</td>
<td>12/4</td>
<td>13/3</td>
</tr>
<tr>
<td>Age (years)</td>
<td>65.2 ± 6.4</td>
<td>61.7 ± 6.1</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>165.0 ± 7.9</td>
<td>169.0 ± 6.1</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.5 ± 10.4</td>
<td>66.8 ± 10.0</td>
</tr>
<tr>
<td>Lesion side (right/left)</td>
<td>7/9</td>
<td>10/6</td>
</tr>
<tr>
<td>MMSE score</td>
<td>26.10 ± 1.74</td>
<td>25.80 ± 2.12</td>
</tr>
<tr>
<td>Data are expressed as mean ± SD. MMSE: Mini-Mental State Examination</td>
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</tbody>
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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).

<table>
<thead>
<tr>
<th>Table 2. Changes in balance and gait abilities</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBS score</td>
<td>Pretest: 36.15 ± 5.98</td>
<td>37.06 ± 5.61</td>
</tr>
<tr>
<td>Posttest: 37.90 ± 5.65*</td>
<td>37.44 ± 5.62</td>
<td></td>
</tr>
<tr>
<td>Post−Pre: 1.75 ± 1.52*‡</td>
<td>0.40 ± 0.88</td>
<td></td>
</tr>
<tr>
<td>TUG (sec)</td>
<td>Pretest: 25.11 ± 5.40</td>
<td>24.19 ± 3.47</td>
</tr>
<tr>
<td>Posttest: 16.74 ± 3.07*</td>
<td>19.48 ± 3.90*</td>
<td></td>
</tr>
<tr>
<td>Post−Pre: −8.4 ± 4.35*†</td>
<td>−4.71 ± 4.86*</td>
<td></td>
</tr>
<tr>
<td>10MWT (sec)</td>
<td>Pretest: 44.75 ± 18.40</td>
<td>45.93 ± 13.22</td>
</tr>
<tr>
<td>Posttest: 37.74 ± 15.70*</td>
<td>43.96 ± 12.04*</td>
<td></td>
</tr>
<tr>
<td>Post−Pre: 7.02 ± 7.02*‡</td>
<td>1.96 ± 3.13*</td>
<td></td>
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</table>

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

The Statistical Package for the Social Sciences (SPSS) ver. 18.0 was used for data analysis. Descriptive statistics was 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. 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. 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.

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. Repetitive practice is known to be beneficial for walking with or without suspension and treadmill walking in stroke patients and reported significant improvement in TUG test scores in both groups, although the differences between the groups were not significant. 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. 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.

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.

REFERENCES