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The effects of a progressive resistance training program on walking ability in patients after stroke: a pilot study

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Abstract. [Purpose] The purpose of this study was to evaluate the effects of a progressive resistance training (PRT) program on the walking ability of chronic stroke patients with hemiparesis following chronic stroke. [Subjects and Methods] The participants of this study were fifteen hemiplegic patients. The main outcomes measured for this study were the peak torque of the knee extensor; the gait ability as measured by electric gait analysis of walking speed, walking cycle, affected side stance phase, affected side stride length, symmetry index of stance phase, and symmetry index of stride length; and 10-m walking speed; and the Berg balance scale test. [Results] Walking speed and affected side stride length significantly increased after the PRT program, and 10-m walking time significantly decreased after RPT in stroke patients. [Conclusion] These results suggest that the progressive resistance training program may, in part, improve the stride of the affected side leg of stroke patients after stroke and also positively impact walking speed.
Key words: Progressive resistance training program, Walking ability, Stroke

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INTRODUCTION

Stroke causes many pathological symptoms leading to functional disorders such as gait disturbance; therefore, restoration of optimal gait is a major goal of rehabilitation[1–4)]. The abnormal gait of stroke patients is characterized by several factors such as asymmetry of stride time and length, reduced velocity, poor joint and postural control, muscle weakness, abnormal muscle tone, abnormal muscle activation patterns, and other factors[5–8)]. Muscle weakness in particular is a common impairment following a stroke and is a leading cause of abnormal gait patterns in patients. Muscle strength of the lower extremities is closely related to walking ability, and one purpose of stroke rehabilitation is to increase muscle strength and thereby improve patients' ability to walk[6–8)]. Muscle strength is defined as the ability to generate force to resist a load; and peak torque is used for muscle strength assessment[9)]. Peak torque is measured using an isokinetic muscle testing system. We are used to assess muscle strength not only of patients with stroke or other disorders, but also of athletes[10–13)]. Many researchers have suggested that progressive resistance training (PRT) for the lower extremities would improve the gait ability of stroke

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patients, especially with their respect to walking speed and total distance walked[14–16]. According to some studies, the effect of PRT is maintained over the long-term in stroke patients who experience a stroke[17, 18]. It is also known that aerobic capacity increases the effect of PRT, and the use of an ergometer can be helpful for improving respect to muscle performance[19–21]. Accordingly, some studies have used an ergometer for PRT[16, 18]. Accurate analysis of the slow pace and asymmetric gait of stroke patients is very important for gait therapy. The GAITRite system measures temporospatial gait variables through pressure-sensitive mats that detect footfall location and timing during walking. This system can analyze the exact gait factor of stroke patients[22, 23]. The relationship between muscle strength and gait ability is now the subject of a great deal of research. However, research on the accurate analysis of gait factors after a PRT program is limited. Our study describes the effect of a PRT program on gait ability through exact analysis of gait factors of stroke patients who have experienced a stroke.

SUBJECTS AND METHODS

The participants of this study were fifteen hemiplegic patients (nine males and six females) who had a stroke diagnosis of stroke and were either admitted to or were receiving treatment at P outpatient center. The inclusion criteria were (1) a Mini-Mental State Examination (MMSE) score > 24 points, (2) the ability to walk independently, (3) the ability to overcome resistance of 30 kg in each exercise, and (4) did the absence of indications contrary to participate in PRT. All the volunteers provided their informed consent to participate in the study. The participants received PRT for the knee extensors after general therapy for 30 minutes. Interventions were performed three days a week for the six weeks. The PRT program was composed of three steps. The first step was a ten-minute ergometer cycle exercise for warm up and slight muscle-strength enhancement. After warming up, patients exercised their lower extremities using a leg press machine (Original Norsk, Inc., Germany) and leg extension machine (Compass. Inc., Japan). The PRT method was as follows: participants sat comfortably on a resistance-training machine with all safety considerations taken into account. All resistance training was bilateral for respect to the lower extremities, and resistance weight was progressively increased from 30 kg to 40 kg and then to 50 kg. Each patient performed three sets of 11 presses and extensions for each weight increment. Participants received one-minute breaks between the sets. The main outcomes of this study were the peak torque of the knee extensor; the gait ability as evaluated by using electric gait analysis of walking speed, walking cycle, affected side stance phase, affected side stride length, symmetry index of stance phase, and symmetry index of stride length; the 10-m walking speed; and the Berg balance scale (BBS) test. The peak torque of the knee extensors was measured using an isokinetic muscle testing system (Biodex® Multi-Joint System 3 PRO dynamometer, Biodex Medical Systems, Inc., Shirley, NY, USA) at an angular speed of 60°/s. Gait ability was measured using a motor-driven treadmill (Gait trainer 2 analysis system Inc, America, Biodex Medical Systems), which was adjusted to each subject's comfortable walking speed. This equipment can analyze walking factors such as walking speed, walking cycle, affected side stance phase, affected side stride length, symmetry index of stance phase, and symmetry index of stride length through a sensor installed on the treadmill floor. The 10-m walking speed and BBS were evaluated by a physical therapist. Outcomes were measured twice: before training and after 6 weeks of training. The protocol for this study was approved by the Committee of Ethics in Research of the University of Yongin, in accordance with the terms of Resolution 5-1-20, December 2006. Statistical analyses were conducted using PASW software (version 18.0; SPSS, Quarry Bay, Hong Kong) to calculate averages and standard deviations. The data are expressed as the mean ± standard error (SE) of the measurements. A paired t-test was conducted to compare the participants before and after the PRT. The statistical significance level was set at α=0.05.

Table 1. General characteristics of the hemiplegic stroke patients

Variable	Hemiplegic stroke patients
Age (yrs)	45.9 ± 4.1
Gender	
Male (%)	9 (60.0)
Female (%)	6 (40.0)
Height (cm)	166.9 ± 2.3
Weight (kg)	68.5 ± 3.7
BMI (kg/m^2)	24.4 ± 0.9
Caused of Stroke	
Infarction (%)	10 (66.7)
Hemorrhage (%)	5 (33.3)
Paretic Side	
Right (%)	8 (53.3)
Left (%)	7 (46.7)
Onset (mo)	16.5 ± 3.2
Comorbid Disease	
Hypertension (Y%/N%)	8 (53.3) / 7 (46.7)
Diabetes (Y%/N%)	8 (53.3) / 7 (46.7)
Psychiatric problem (Y%/N%)	0 (0.0) / 15 (100.0)

All data are presented as the mean±SE. Y: yes; N: NO

RESULTS

Table 1 shows the general and clinical characteristics of the fifteen stroke patients. There was no significant difference between the pre-training and post-training in peak torque values, though it tended to increase (19.1±2.7 to 21.3±2.8) (Table 2). Walking speed and affected side stride length significantly increased after the PRT program, and the 10-m walking time significantly decreased after the PRT in stroke patients (Table 2). There was a slight increase in the affected side stance phase, but it was not statistically

Table 2. Changes after six weeks of progressive resistance training in stroke patients

Variable	Hemiplegic stroke patients	
	Pre-PRT	Post-PRT
Peak torque (Nm)	19.1 ± 2.7	21.3 ± 2.8
Walking speed (m/sec)	0.46 ± 0.01	0.52 ± 0.02**
Walking cycle (cycle/sec)	0.62 ± 0.02	0.63 ± 0.02
Affected side stance phase (%)	46.3 ± 1.9	48.1 ± 1.4
Affected side stride length (cm)	0.37 ± 0.03	0.41 ± 0.02**
Symmetry index of stance phase (%)	89.4 ± 6.9	92.1 ± 5.4
Symmetry index of stride length (%)	92.7 ± 7.0	94.8 ± 6.3
10-m walking time (sec)	26.6 ± 11.6	25.6 ± 11.3*
BBS (score)	38.9 ± 2.7	40.0 ± 3.0

All data are presented as the mean±SE; PRT: progressive resistance training; BBS: Berg balance scale; *: $p < 0.05$, **: $p < 0.01$

significant (Table 2).

DISCUSSION

It has been shown that maximal neurological recovery is achieved in 95% of patients at an average of 11 weeks post stroke, and maximal functional recovery is accomplished in 13 weeks[14]. Accordingly, the goals of physical therapy for chronic stroke patients 6 months after the event often shift from improving capacity to maintenance training[24]. The participants in our study received a PRT program regularly over the course of six weeks. All of the subjects of our study were chronic stroke patients; therefore, their muscle strength did not increase significantly in our study participants. Nevertheless, PRT did have some beneficial effects on gait in our patient cohort. Many randomized clinical trials and meta-analyses on the relationship between PRT and gait ability of patients recovering from stroke have shown the effect of PRT on gait. Specifically, improvements in walking speed and total walking distance in patients after a stroke are reported as a typical effect of PRT[14–16]. However, the aim of our study was to discover the effect of a PRT program on temporospatial gait variables of stroke patients after a stroke. According to our data, improved gait factors in our subjects were increased walking speed, 10-m walking time, and affected side stride length. The affected side stance phase also showed towards an increase, but it was not significant. These results mean that the PRT program can solved two major problems in stroke gait. The PRT program helped increase the stride and stance phases of the affected legs because the muscle strength of the affected leg was enhanced, thereby affecting walking speed. Optimal gait is a major goal of stroke patients. Use of a PRT program is a sure method for achieving the rehabilitation goals of stroke patients. Resistance training has also been shown to improve insulin sensitivity in this patient group[25]. To summarize, a PRT program is very useful during rehabilitation of patients who have experienced a stroke. In our study, the PRT program improved the walking speed and stride of the affected leg. In future studies, the effects on hemiplegic stroke patients of various forms of treatments such as electrical stimulation and other methods for improving walking should be needed to be investigated in hemiplegic stroke patients[26–30].

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