Effect of a muscle strengthening exercise program for pelvic control on gait function of stroke patients

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Abstract. [Purpose] The purpose of this study was to investigate the effects of strengthening exercises for the hip extensors on the gait performance and stability of patients with hemiplegia. [Subjects and Methods] The subjects were fifteen stroke patients (ten males, five females). The experimental subjects performed a hip extensor strengthening exercise (HESE) program for a total of four weeks. [Results] The experimental subjects showed significant improvements after the HESE program. Especially, walking speed and the affected side stance phase time significantly increased after the HESE program. Furthermore, the affected side stride length and symmetry index in the stance phase significantly increased after HESE program. [Conclusion] These results suggest that the HESE program may, in part, help to improve gait performance ability and stabilize physical disability after stroke. Key words: Stroke patients, Hip extensor strengthening exercise (HESE) program, Gait function

INTRODUCTION

Most hemiplegic patients who suffer from stroke experience restrictions on mobility at home and in the community, and they especially have difficulty with independent walking1). Turnbull et al.2) suggested that the recovery of gait ability is an important goal of physical therapy for a stroke patient, because gait is an important element of functional independence. With regard to this, Mumman3) suggest that the biggest loss after stroke is gait ability, and hemiplegic patients show disorders in the selective ability of regulated and coordinated movements, which results in a slow gait velocity and compensatory movements by the lower extremity of the unaffected side. Perry4) also suggested that hemiplegic patients show a short stride length and slow gait velocity for result of damage to the joint and to the regulatory function of the muscles that are necessary for normal gait. Furthermore, gait is closely connected with the environment, since gait adapts and is modified to overcome obstacles and the varied geography that are faced during walking5). Due to central nervous system damage, stroke patients show muscle weakness, abnormal muscle tone, and disorders of balance and posture control, which result in difficulty in the control of movement6). For these reasons, problems occur with the quality and adaptation of the gait pattern, resulting from imbalance in the low extremity stance phase of the affected side and of the low extremity stance phase of the unaffected side, a decline in cadence and gait velocity, asymmetrical weight distribution, and a difference between step length and stride length7, 8). In particular, gait disorder after stroke reduces the functional independence level and results in a negative prognosis, which is a reason why regaining gait ability is a critical element directly connected with patients’ independence and is one of the goals of rehabilitation9). Neurotherapy methods, which include Bobath therapy and proprioceptive neuromuscular facilitation, mainly focus on the control of abnormal muscle tone and of the asymmetrical movement which leads to gait disorder10). These methods require many therapists and time, because they mainly consist of muscle strengthening movements in a static position...
through manual handling by a therapist. However, studies on the effects of neurophysiotherapy performed by therapist handling are inconclusive. Therefore, we hypothesized that gait function would improve with pelvic control following a hip extensor strengthening exercise (HESE) program for the paretic lower extremity. We examined whether the HESE program promotes functional improvement of the paretic lower extremity of stroke patients.

SUBJECTS AND METHODS

The participants in this study were fifteen hemiplegic patients who had been diagnosed with stroke (Table 1) who were receiving inpatient or outpatient treatment at hospital P rehabilitation center. The following were the conditions for inclusion in the study. The present study had a single-group pre-post design. All the subjects participated in a four-week six-method hip extensor strengthening exercise (HESE) program. This program was performed by a therapist manipulating the subjects for about half an hour a day in the supine position, side-lying position, and prone position. The HESE program comprised six steps:

1. Hip extension and posterior tilt movement;
2. Rotation extension movement of both the legs;
3. Hip joint and pelvis movement using a therapeutic ball;
4. Hip joint and pelvis movement using a therapeutic ball;
5. Hip joint extension muscle strengthening movement in the side-lying position; and
6. Hip joint extension muscle strengthening movement in the prone position.

The program was performed three times a week for four weeks. Each session consisted of three sets of 15 performances of the 6-step program lasting about half an hour, with 30 seconds of relaxation time between the sets. Each participant was assessed by a physical therapist before and after the intervention in order to examine its effects on gait performance and stability. The 10-m walking velocity test and the Berg Balance Scale (BBS) were used to evaluate the changes in gait performance and stability. BBS is a widely used clinical test which was developed to evaluate both the static and kinetic balance abilities of stroke patients. It consists of 14 assessment items: sitting to standing, standing without support, sitting without support, standing to sitting, transfers, standing with eyes closed, performing the Romberg test with eyes open, reaching, turning and looking over the shoulder, making 360° turn to the right and left, and standing on one leg. Each item is scored from 1 to 5. It has been shown that subjects with BBS scores >41 have a low risk of fall, medium risk of fall for BBS scores of 21–40, and high risk of fall for BBS scores of less than 20. BBS can be used to evaluate the balance ability of patients with hemiplegia caused either by senile disorder or stroke. A GAITRite (Gait trainer 2 analysis system, USA) was used to measure the spatiotemporal variables of gait. When GAITRite was used in the study, it helped the participants observe in real time their feet touching the ground on a monitor. GAITRite can compare gait velocity (meter/sec), gait cycle (cycle/sec), and the symmetry index (%) of the stance phase and the swing phase, with normal category values on a histogram. Statistical analyses were performed using SPSS Version 20.0. The Shapiro-Wilk test was used to verify the normal distribution. The assumption of a normal distribution was confirmed. All data are presented as mean ± standard error. The chi-square test was used to compare the general and medical characteristics of the participants and the paired t-test was conducted to compare the results of before and after the treatment. The statistical significance level was chosen as α=0.05. The formulas for the symmetry indexes of the stance phase and stride length used in the study were: symmetric index of length (%) = non-affected side low extremity length (cm)/affected side low extremity length (cm) × 100%; and symmetric index of the stance phase (%) = affected side low extremity stance phase (sec)/non-affected side low extremity stance phase (sec) × 100%. The protocol of 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. Furthermore, all subjects provided their informed consent to participation in the present study.

RESULTS

Table 1 summarizes the clinical characteristics of the subjects. Walking speed, stance phase and stride length of the affected side, and the symmetry index of the stance phase significantly improved after the HESE program (p<0.05) (Table 2).

DISCUSSION

The distinctive gait patterns of hemiplegic patients include a slow gait cycle and velocity, differences between the affected side and unaffected side step length, a short stance phase, and a relatively long swing phase on the affected side. Restoration of the ability to gait is a very important goal for stroke patients, and therefore, evaluating

| Age (yr) | Gender (% | Height (cm) | Weight (kg) | Cause of disease (%) | AS (%) | K-MMSE (score) | Time post-stroke (mo) |
|----------|-----------|-------------|-------------|----------------------|--------|----------------|-----------------------|
| 44.2±3.9 | M 10 (66.7) | F 5 (33.3) | 168.5±2.1 | In 12 (80.0) | Rt 7 (46.7) | 26.5±2.5 | 20.5±6.2 |

Data are presented as means ± SE. M: male; F: female; In: infarction; He: hemorrhage; AS: affected side; Rt and Lt: right and left side; K-MMSE: Korean version of mini mental status examination.
eight weeks chronic stroke patients, gradual resistance movement by
resistance movement on the leg muscle, involving twenty
onset were the subjects of a ten-week program
ment, a muscle strengthening movement program using
addition, in order to discover effective movement methods
the phase symmetry index. However, it did not affect gait abili
to every hemiplegic patient is limited. Further study of
changes, the ability to generalize the present study’s results
to be considered. From this it can be understood that for hip
joint muscle power strengthening movements to influence
hemiplegic patients’ stable gait, several things are required
at the same time: a long enough treatment period, a variety of
movements and muscle power strengthening movements of
the hip joint, knee joint, and ankle joint. Despite positive
changes, the ability to generalize the present study’s results
to every hemiplegic patient is limited. Further study of
more methods for improving stable gait through hip flexor
muscle power strengthening movements is required, with
larger numbers of participants, a longer treatment period,
and a follow-up after the treatment. Furthermore, scientific
multi-dimensional investigations on the effects of neuro-
physiotherapy related to gait and muscle function should be
conducted for stroke patients.

**Table 2. Effects of hip extensor strengthening exercise program
on the hemiplegic stroke patients**

| Variables                        | Hemiplegic stroke patients |
|----------------------------------|----------------------------|
|                                  | Pre-HESE       | Post-HESE       |
| Walking speed (m/sec)            | 0.5 ± 0.0      | 0.6 ± 0.0*      |
| Walking cycle (c/sec)            | 0.6 ± 0.0      | 0.6 ± 0.0       |
| AS stance phase (sec/%)          | 470 ± 1.2      | 485 ± 1.1*      |
| AS stride length (cm)            | 38.1 ± 3.0     | 41.8 ± 2.8*     |
| SI of stance phase (%)           | 90.0 ± 4.2     | 94.0 ± 4.0*     |
| SI of stride length (%)          | 90.6 ± 6.4     | 93.1 ± 5.7      |
| 10WVT (m/sec)                    | 29.8 ± 11.8    | 29.2 ± 11.6     |
| BBS (score)                      | 37.1 ± 2.5     | 37.3 ± 2.8      |

Data are presented as means ± SE. HESE: hip extensor strenthening exercise; AS: affected side; SI: symmetry index; 10WVT: 10 m walking velocity test; BBS: Berg Balance Scale. *: significantly different from pre-HESE, p<0.05.

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it seems that a treatment program using hip joint muscle strengthening movements and therapist handling provides an appropriate environment for improvement of gait ability and for motivation of patients. Wade et al. reported that the 10-m walking velocity test for hemiplegic patients is a simple, objective measurement for evaluating functional recovery. However, Sharp and Brouwer reported that after a six-week intervention of knee joint isokinetic resistance movement involving fifteen chronic stroke patients, muscle power and gait velocity improved, whereas walking up and down stairs and TUG times showed no significant differences with respect to functional performance ability. Page reported that the effect of movement treatment on stroke patients depends on the treatment time, the movement form, and the patient’s positive participation. Hendrickst et al. suggested that the degree of recovery from stroke weakens as time passes and that the recovery of movement regulation ability occurs no later than three months after a stroke. A limitation of their study was that the disease period of the participants ranged from 6 months to 91 months, and no improvement of movement regulation function resulted. The reason why there was no significant improvement in all test items after four weeks of movement therapy was the order of movement and other factors during the intervention. To elicit an improvement in hemiplegic patients’ stable gait, a much longer treatment period is required, and the stage and duration of stroke and a variety of forms of movement also need to be considered. From this it can be understood that for hip joint muscle power strengthening movements to influence hemiplegic patients’ stable gait, several things are required at the same time: a long enough treatment period, a variety of movements and muscle power strengthening movements of the hip joint, knee joint, and ankle joint. Despite positive changes, the ability to generalize the present study’s results to every hemiplegic patient is limited. Further study of more methods for improving stable gait through hip flexor muscle power strengthening movements is required, with larger numbers of participants, a longer treatment period, and a follow-up after the treatment. Furthermore, scientific multi-dimensional investigations on the effects of neuro-physiotherapy related to gait and muscle function should be conducted for stroke patients.
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