

The Effects of Isokinetic Eccentric Resistance Exercise for the Hip Joint on Functional Gait of Stroke Patients

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Abstract. [Purpose] The purpose of this study was to determine the effects of resistance exercise strengthening the hip flexor and extensor muscles on functional gait of stroke patients. [Subjects and Methods] Twenty patients were randomized into two groups. Both groups performed conventional physical therapy for six weeks. The experimental group also performed isokinetic eccentric resistance exercises for the hip flexor and extensor muscles. The hip muscle strength, stair up and down time, TUG time (timed up and go test), and 10 m gait velocity were measured at the baseline, and after 3 weeks, and 6 weeks of treatment. [Results] The experimental group showed significant improvements compared to the baseline in hip muscle strength, stair up and down time, TUG time and 10 m gait velocity after 3 and 6 weeks of treatment. After 3 and 6 weeks of treatment, there were gains in hip muscle strength and 10 m gait velocity. The control group showed no significant increase in hip muscle strength, stair up and down time, TUG time or 10 m gait velocity. [Conclusion] We consider that conventional physical therapy contributes to the improvement of functional gait of stroke patients. However, it is more desirable to perform isokinetic eccentric resistance exercises for hip flexor and extensor muscles combined with conventional physical therapy for the improvement of hip muscle strength, stair up and down time, TUG time and 10 m gait velocity.

Key words: Functional gait, Isokinetic exercise, Stroke patients

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INTRODUCTION

Muscle weakness in the affected lower limb of stroke patients is a major factor inhibiting gait ability¹⁾. Isometric exercise, isotonic exercise, and isokinetic exercise are used as resistance exercises to increase muscle strength^{2, 3)}. Isokinetic exercise is a method that enables the muscle to exert maximum strength within the exercise range of all joints at a constant speed⁴⁾. Various exercise methods are performed with the purpose of strengthening the muscles in the affected lower limb of stroke patients, and isokinetic exercise has been proposed as an effective exercise method⁵⁾. It has been reported that eccentric isokinetic exercise is effective at muscle strengthening of stroke patients, and includes eccentric contraction which is used in our daily lives, as well as providing more independent and economic movement⁶⁾. In 1988, Dean proposed that eccentric exercise is a better exercise treatment for patients with limited exercise ability than concentric exercise. This is because it is more effective at muscle strengthening, yet requires low oxygen consumption⁷⁾. The advantage of isokinetic eccentric resistance exercise for stroke patients lies in the improvement in muscle strength of weak muscles, and the fact that isokinetic contraction is widely used for movement in our daily lives⁶⁾.

Also, it has been suggested that the muscle strengths of the hip joint flexor and plantar flexor muscles determine the gait velocity of stroke patients, and muscle strength of the knee extensor and stability of gait are highly related to one another⁸⁾. Muscles surrounding the hip joint play a role in maintaining the stability of the trunk in the stance phase and control the lower limb in the swing phase. Therefore, the weakening of these muscles may become a main cause of abnormal gait⁹⁾. Particularly, hip joint extensor strength is related to gait velocity and is the dominant muscle in stability control and posture maintenance of the knee joint⁹⁾. Therefore, when the extensor of the hip joint is weakened, anterior weight shift of the lower limb becomes difficult and the flexor of the hip joint is used to increase the velocity of the lower limb in gait initiation and the stance phase. However, it is a small muscle compared to the extensor⁹⁾. Hip joint extensors and flexors are considered to be very important muscles throughout the stance phase and they are essential for safe and functional gait. Previous studies have only focused on the knee joint, and there is a lack of understanding about improvement of muscle strength and function of stroke patients from a broader perspective.

SUBJECTS AND METHODS

Subjects

Twenty in-patients of J general hospital, Gyeonggi-

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Table 1. General characteristics of subjects

| Characteristics | | Experimental group (n=10) | Control group (n=10) |
|-----------------|------------|------------------------------|-------------------------|
| Age (yr) | | 53.40±9.71 | 53.86±10.56 |
| Diagnosis | Infarction | 6 | 7 |
| | Hemorrhage | 4 | 3 |
| Sex | Male | 7 | 6 |
| | Female | 3 | 4 |
| Affected Side | Right | 5 | 6 |
| | Left | 5 | 4 |

(Mean±SD)

Table 2. Changes in outcome measures with time

| Variables | Experimental group (n=10) | | | Control group (n=10) | | |
|------------------------|---------------------------|-------------|--------------|----------------------|-------------|-------------|
| | baseline | 3 wk | 6 wk | baseline | 3 wk | 6 wk |
| PT Flex. | 28.80±24.33 | 29.70±24.60 | 30.80±24.43* | 26.80±8.13 | 25.70±8.45 | 26.80±8.14 |
| (Nm) ^ε Ext. | 69.80±38.75 | 71.40±38.63 | 72.10±38.71* | 71.80±11.84 | 71.40±11.90 | 71.10±11.47 |
| ST (sec) ^ε | 19.80±8.30 | 18.91± 8.06 | 17.82±8.07* | 21.00±11.54 | 20.85±12.04 | 20.88±11.60 |
| GV (m/s) ^ε | 0.37±0.33 | 0.41±0.30 | 0.44±0.28* | 0.41±0.19 | 0.42±0.21 | 0.41±0.22 |
| TUG (sec) ^ε | 23.58±14.32 | 22.22±13.90 | 21.12±12.96* | 22.88±10.68 | 22.52±10.71 | 22.40±10.73 |

¹ Mean±SD, PT: peak torque, ST: stair up & down, GV: gait velocity, TUG: timed up & go

*significant difference from baseline, $p < 0.05$, ^εsignificant difference between the groups, $p < 0.05$

do, were selected as subjects. They were divided into two groups. Isokinetic eccentric resistance exercise for the hip joint flexor and extensor muscles was carried out for 60 minutes per day, 3 days per week for 6 weeks in addition to conventional physical therapy treatment for the experimental group, and the control group received only conventional physical therapy (Table 1).

Methods

The muscle strengthening exercise was executed on a Cybex 770 dynamometer (Cybex Inc, USA) and muscle tension of the lower limbs was relieved by executing 5-minute warm-up exercises using a cycle ergometer before execution of the isokinetic exercise. The muscle strength test was executed at an angular velocity of 90°/sec, and there was no restriction on the range of the hip joint exercise. Eight repetitions per set for 4 sets were carried out for a single exercise with a 30 second break between each set. The exercise was carried out 3 times a week and the muscle strength evaluation was conducted after 3 and 6 weeks of treatment. SPSS version 12.0 was used for the data analysis. The Friedman test was carried out to compare values among baseline, and at 3 weeks and 6 weeks of treatment, and the post hoc test was the Wilcoxon test. The Mann-Whitney U test was used for inter-group comparison. The level of statistical significance was chosen as $\alpha = 0.05$.

RESULTS

Compared to the baseline, the experimental group presented significant differences in muscle strength, stair up and down time, gait velocity and TUG time; thus, they were

compared using the post hoc test. Among the items that presented differences, muscle strength and gait velocity presented significant differences both after 3 and 6 weeks of treatment, and TUG time presented a significant difference from baseline to 3 weeks of treatment ($p < 0.05$). The stair up and down time presented a significant difference from baseline after 3 weeks of treatment ($p < 0.05$). However, the control group showed no significant difference for any item. After 3 and 6 weeks of treatment, the experimental group showed greater improvements in hip muscle strength, stair up and down time, gait velocity and TUG time than the control group ($p < 0.05$) (Table 2).

DISCUSSION

Hemiplegic stroke patients experience considerable impairment in for functions of daily living. Particularly, gait is essential for leading an independent life. Thus, it is important to analyze the gait of hemiplegic patients and related aspects. The main causes of abnormal gait in hemiplegic patients are decreases in muscle activity, decrease in weight support ability and lack of balance¹⁰. Therefore, in order to resolve the problem of abnormal gait, we conducted muscle strengthening exercises and examined their influence on balance and gait velocity which were evaluated using functional tests.

In this study, the experimental group showed significant increases compared to before the experiment in muscle strength, gait velocity, and TUG and stair up and down times after 3 and 6 weeks of treatment.

These results agree with the result of Seo et al., who showed that the maximum couple force of the knee joint

flexor and extensor muscles and the total amount of work were significantly correlated with angular velocity, gait velocity, and stair up and down and sit and stand times¹¹). Seo et al. also found a statistically significant improvement the modified Rankin scale after 6 weeks execution of isokinetic eccentric exercises for the affected lower limb of chronic hemiplegic patients¹¹).

Chon et al.⁵) conducted a comparative analysis with an isokinetic exercise treatment group that performed isokinetic exercise in addition to normal exercise treatment, and a control group that performed only normal exercise treatment. The maximum couple force, total amount of work, gait velocity and the circumference of the thigh had significantly increased in the isokinetic exercise treatment group after 6 weeks⁵). From the above results, we infer that the addition of isokinetic exercise treatment to normal exercise treatment is of great help in the functional recovery of stroke patients. Reviewing the results of isokinetic exercise reported in previous studies, we found that better results were displayed with changes in angular velocity as it motivated subjects or provided an environment facilitating the efficient improvement of muscle strength.

However, in a study that examined the effects of 6 weeks of muscle strengthening by isokinetic resistance exercise on the functional improvement of the knee joint of chronic stroke patients, no significant differences were displayed in stair up and down and TUG times even though there were improvements in muscle strength and gait velocity¹²). Another study examined the effect of isokinetic exercise on the improvement of gait, muscle strength, and quality of life of 20 chronic stroke patients. The results showed there was no significant functional improvement, even though there was improvement in muscle strength. In that study, isokinetic resistance exercise was performed by the flexor and extensor muscles of the hip, knee, and ankle joints for 45 minutes per day, 3 days per week for 6 weeks¹³). The recovery of motor control ability normally occurs within 3 months after stroke onset¹⁴) and we consider that the improvement in motor control was rather small because the subjects of preceding studies were chronic stroke patients more than 6 months from stroke onset. Therefore, it is necessary to reset the intervention period for qualitative improvement. In order to promote improvement in the function of chronic stroke patients, the results of previous studies suggest that more treatment time is required considering the fact that the duration since stroke onset was longer. Also, it can be considered that sufficient treatment time and period is necessary for the recovery of motor functions. With regard to the exercise type, the common factor in preceding studies that accelerated improvement in the function of stroke patients, through additional exercise, was the provision of task-

oriented and multidimensional exercise¹⁵). This means that additional application of comprehensive exercise tasks is necessary since not one, but several motor abilities are impaired by stroke. In conclusion, the present study revealed that not only sufficient treatment time and muscle strengthening exercises for the hip joint are required, but also muscle strengthening exercises for the knee and ankle joints are necessary for the functional improvement of chronic stroke patients. Future studies should investigate treatment methods that may be of great help in the improvement of not only muscle strength but also various functions.

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