Influence of Resistance Exercise Training to Strengthen Muscles across Multiple Joints of the Lower Limbs on Dynamic Balance Functions of Stroke Patients

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Abstract. [Purpose] The objective of this study was to evaluate the effects of resistance exercise training for strengthening muscles across multiple joints on the dynamic balance function of stroke patients. [Subjects and Methods] Subjects in the training group (n=14) and the control group (n=14) received conservative physical therapy for 30 minutes per day, five days per week, for a period of six weeks. The training group additionally performed three sets (eight to 10 repetitions per set) of resistance exercise at 70% of the 1-repetition maximum (1RM) to strengthen muscles across multiple joints. The control group did the same exercises for the same duration but without resistance. To assess dynamic balance function, before and after the intervention, we measured antero-posterior (A-P) and medio-lateral (M-L) sway distances, the Berg balance scale (BBS), and the timed up and go (TUG) times. [Results] Compared to pre-intervention values, the BBS score showed significant increases in both groups, and A-P and M-L sway distances and TUG times showed significant decreases in both groups. Changes in A-P and M-L sway distances, BBS scores, and TUG times were significantly different between the muscle training group and the control group. [Conclusion] Training involving muscle strength across multiple joints is an effective intervention for improvement of dynamic balance function of stroke patients.

Key words: Muscle strength exercise, Dynamic balance, Stroke

INTRODUCTION

Many factors, such as reduction in muscle strength and range of motion, abnormal muscle tone, and loss of sensory and motor coordination contribute to difficulties of postural control in stroke patients1–3). In addition, reduced balance function increases the risk of fall4, 5) and results in significant economic costs and increased hospitalization period6). In particular, the aim of rehabilitation for patients with stroke is to increase muscle strength, because muscle strength is closely related to functional balance and gait performance7–9). Resistance exercise is used in athletic and rehabilitation programs to increase muscle strength10). Several studies have reported that strength training has a positive impact on functional ability11–13). In general, resistance exercises can be distinguished by training involving muscle strength across a single joint and multiple joints. Most previous studies associated with resistance training for stroke patients have reported that training for strengthening muscles across a single joint, such as knee extension or flexion, is commonly used to improve the strength and functional abilities of the lower limbs8, 11, 14). However, previous study emphasized that resistance training for strengthening muscles across multiple joints is more closely related to functional movement15).

Until now, no studies have investigated resistance training for strengthening muscles across multiple joints on the dynamic balance of stroke patients. Therefore, the purpose of this study was to investigate the effects of six weeks of training for strengthening muscles across multiple joints on the dynamic balance ability of stroke patients.

SUBJECTS AND METHODS

The subjects were 28 patients with stroke who had been admitted to hospital and agreed with the study’s aim and methods. Eligibility criteria included the following: a Brunnstrom stage higher or equal to stage 3, ability to
back to the central target. After demonstrating the tests, the subjects shifted their weight forward toward the target when one of the peripheral targets and one central target, were shown on the monitor. Subjects were instructed to try to reach the targets as quickly and accurately as possible, and to avoid unnecessary and uneconomical movements. A-P, M-L, and total COP distance were measured. BBS assessments and TUG time measurements were performed twice, and the best trial was accepted. BBS and TUG were performed twice, and the best trial was accepted.

SPSS version 17.0 software was used for statistical analyses. Tests for normality were performed for all continuous variables. Pre- and post-intervention data were examined using the paired t-test for within group comparisons and the independent t-test was used for between the group comparisons. The level of statistical significance was chosen as 0.05.

RESULTS

The characteristics of the patients in the training group [8 males and 6 females: age: 57.4 years; type of stroke: ischemic 7/ hemorrhagic 7; paretic side: right 6/ left 8; height: 165.4 cm/ weight: 67.3 kg/ time since stroke onset: 17.9month] did not differ significantly from those of the control group [7 male and 7 females: age: 56.6/ type of stroke: ischemic 8/ hemorrhagic 6; paretic side: right 7/ left 7; height: 166.7 cm/ weight: 69.2 kg/ time since stroke onset: 18.7 month]. After six weeks of intervention, compared to pre-intervention, the BBS score showed a significant increase in both groups (p<0.05). In addition, A-P and M-L sway distances, and TUG times showed significant decrease in both groups (p<0.05).

Changes in A-P and M-L sway distances, BBS scores, and TUG times differed significantly between the muscle training group and the control group (p<0.05) (Table 1).

DISCUSSION

In the current study, we investigated the effects of muscle strength training across multiple joints of the lower limbs on the dynamic balance of chronic stroke subjects. The results of our study showed improvements in A-P and M-L sway distances, BBS score, and TUG time in the training group, which were better than those in the control group. These results imply that muscle strength training across multiple joints of the lower limbs enhances balance ability.

Many studies have reported a correlation between muscle strength and functional balance, and resistance exercise training leads to increased muscle strength and walking. Positive effects associated with motor performance on strength training have been demonstrated in several studies. Using the Motor Assessment Scale, Bale and Strand reported that progressive resistance training performed by chronic stroke patients led to improvements in their lower limb function, and Jorgensen et al. also reported a significant increase in gait speed in the six-minute walk test. Conflicting results regarding the effect of lower
limb strength gains on functional motor performance have been reported especially in studies using resistance training as the sole intervention for the lower limbs. These differences may reflect varying degrees of stroke severity, the exercise training protocol, or the recruitment of the number of training joints (one or multiple joints). Our study can be distinguished from previous studies by the fact that resistance exercise training was conducted not for a single joint, but across multiple joints of the lower limbs, including the hips, knees, and ankles. Training involving muscle strength across multiple joints requires use of all the muscles of the lower limbs. Resistance training of multiple joints, which induces movement of the entire lower limbs, is closer to the functional movement. Therefore, training to strengthen muscles across multiple joints may result in a greater increase in motor unit activity and muscle re-education, compared to training of muscle strength across a single joint of the lower limbs, thereby influencing dynamic balance functions due to improved motor coordination in the lower limbs.

Resistance exercise training involving muscle strength across multiple joints of the lower limbs resulted in significant improvements in four clinical measures of postural balance (dynamic balance) of stroke patients. Our findings distinguished from previous studies by the fact that resistance exercise training was conducted not for a single joint, but across multiple joints of the lower limbs, including the hips, knees, and ankles. Training involving muscle strength across multiple joints results in significant improvement in four clinical measures of postural balance (dynamic balance) of stroke patients. Thus, we are more than confident that this training can be used as an effective rehabilitation program for stroke patients who have a fear of falling. The limitations of our study are that it only investigated the effects of training for muscle strength across multiple joints. Therefore, we did not consider effects on multiple joint training, compared with single joint training. Further studies may be needed in order to clarify this issue.

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### Table 1. Comparisons of mean dynamic balance of the two groups

| Parameters                  | Training group | Control group |
|-----------------------------|----------------|---------------|
|                           | Pre            | Post          | Pre            | Post           |
| A-P sway distance (mm)      | 1,681.7±47.3   | 1,467.6±47.5† | 1,681.7±44.6† | 1,630.8±46.1*  |
| M-L sway distance (mm)      | 1,740.8±29     | 1,540.6±27†   | 1,741.7±30.9   | 1,689.6±27.8*  |
| BBS (score)                 | 33±2.6         | 37.2±2.6†     | 32.7±2.6       | 33.8±2.5*      |
| TUG (sec)                   | 24.4±1.5       | 18.6±0.5†     | 25.9±2.1       | 25.1±1.9*      |

* significant difference between pre- and post-test (p<0.05).
† significant difference compared with the control group (p<0.05).
A-P (Anteroposterior), M-L (Mediolateral)