

The Effects of Lower Extremity Muscle Strength Exercise for 8 Weeks on the Balance and Gait in Stroke Patients

Saet-Byeol Jeong PT, MPT¹, Byung-Il Yang PT, MPT², Sang-Ho Lee PT, PhD³

¹Dept. of Physical therapy, Yongin University, ²Dept. of Physical therapy, Bobath Memorial Hospital,

³Dept. of Physical Therapy, Seonam University

Purpose This study was performed to identify the effects of muscle strengthening program of lower extremity for 8 weeks on the balancing and gait in stroke patients to provide the effectiveness of therapeutic interventions and understandings of stroke patients. **Methods** The subjects were 14 patients who were diagnosed hemiplegia from stroke in over past 6 months. 14 subjects were randomized into 7 control group and 7 study group. The subjects in the study group received not only physical therapy but also muscle strengthening program of lower extremity for 8 weeks. However, no additional intervention was applied to the subjects in the control group. FRT, BBS, TUG, and 6MWT was performed before and after the intervention for comparison. **Results** Significant difference was observed in FRT in the study group. The range of arm extension increased from 12.8cm to 19.4cm in the study group($p=.018$, $p<0.05$) which was significant. Second, the scores in BBS showed increase in the study group but without significance($p=.727$, $p>0.05$). Third, there were changes in the time of completion for TUG test. The time in the study group decreased from 44.3 sec to 39.5 sec($p=.064$, $p>0.05$) and the one in the control group increased from 27.8 sec to 28.8 sec($p=.761$, $p>0.05$). Forth, both groups showed decrease in the completion distance before and after the intervention in 6MWT. Lastly, there was substantial amount of positive correlated($p<0.01$) between BBS and FRT which were to evaluate the balance among the tests of FRT, BBS, TUG, and 6MWT. **Conclusion** The muscle strengthening program of lower extremity for 8 weeks appears to show positive effects in the enhancement of balancing ability. Also, we could understand that the enhancement of balancing ability has correlated to the enhancement of gait as well. Based on these results, it is considered that the complex approach in the therapeutic intervention for the stroke patients including the muscle strengthening program of lower extremity will help the effective recovery of balancing and gait of stroke patients.

Key words Stroke, Lower extremity muscle strengthening exercise, Balance, Gait

Corresponding author Sang-Ho Lee(fetor07@hanmail.net)

Received date 31. December 2015

Revised date 28. January 2016

Accepted date 20. February 2016

I. Introduction

Stroke occurs due to blockage of the blood vessels or bleeding due to thrombosis or a trial embolism.¹⁾ Clinical symptoms include the limited movement and damage on motor, sensory, balance and muscle tension. Such symptoms cause independent functional performance of an individual.²⁾ Functional recovery of stroke patients continues even until 6 months after the occurrence of the disease and therapeutic intervention during this period is closely related to functional recovery of the stroke patients.³⁾ Muscle weakness and loss of sensory on paralyzed side of the body after the stroke brings limitation in balancing ability that

controls the position against the outer stimulation and align the segment of the body against surroundings.⁴⁾ Such limitation in balancing ability gives the patient more agitation of position compared to normal people in same as and it also shows decreased movement ability of the center of gravity on paralyzed side of the body. This leads to decreased stability limitation, the range of movement without basal area.⁵⁾ Larger stability limitation increases balancing ability as well as muscle activity.⁴⁾ This indicates that decreased muscle activity in lower limbs is related to decrease of stability limitation in stroke patients which means that lower limb strength in stroke patient affects the balance of the body. A significant influence in increasing bal-

ancing ability of stroke patient through 8 weeks of muscle strengthening in foot flexor.⁶⁾ And significant increase in muscle strength and balancing ability of a patient with damaged balancing ability through 10 weeks of intensive muscle strengthening training.⁷⁾ Thus, it is shown that muscle strengthening training is necessary to enhance the balancing ability in stroke patient. Decrease in muscle strength and balancing ability on paralyzed side of the body may cause limited ability for walking.⁸⁾ Characteristics of walking in stroke patient are decreased walking speed and longer swing phase.⁹⁾ Weakening of muscle by brain stroke uses compensation strategy. Such strategies increase the energy consumption during walking and it eventually becomes inefficient walking.^{10,11)} Such decrease in energy efficiency due to weakening of the muscle in lower limbs on paralyzed side is related to decrease of walking speed and endurance in stroke patients.⁸⁾ That weakening of the muscle in stroke patient is an important goal to consider when conducting medical intervention.¹²⁾ As a result, approaches for enhancing walking ability of stroke patients are being made through muscle strengthening exercise. A significant increase in walking symmetry in stroke patient through strengthening of pelvis extensor.¹³⁾ Recently, Study mentioned that position training in standing position and accompanying muscle strengthening training of lower limbs have positive effect on recovering muscle strength.¹⁴⁾ Muscle strengthening training should be done on both paralyzed and non-paralyzed side of the body. The stroke patient shows decreased muscle strength on both paralyzed and non-paralyzed side.¹⁵⁾ Most of previously conducted studies included muscle strengthening training on lower limbs used as means

of intervention for functional recovery of stroke patients.^{6,13,16,17)} However, studies on conducting muscle strengthening training on both paralyzed side and non-paralyzed side are insufficient. Thus, this study will investigate the effect of 8 week lower limbs strengthening training on the balance and walking of the stroke patient and their correlations.

II. Materials and Methods

1. Subjects

This study is conducted on 14 hemiplegia patients from stroke. 6 months had passed since the patients experienced stroke and they are able to walk on their own. Subjects understood the purpose of this study and agreed on it. In order to minimize the prejudice in selection, experimental group and general treatment group are randomly selected. Out of 14 subjects, 5 are men and 9 are women. The average age of the experimental group is 52.4 years old while general treatment group is 53.1 years old. The average height of the experimental group is 161cm while the average height of the general treatment group is 163cm. Also, the average body weight of the experimental group is 65.7kg while general treatment group is 58.7kg(Table 1).

2. Measurements

(1) Berg Balance test

BBS is a testing tool used for testing balancing ability at the standing position of elder people and patients with neural damages who are prone to fall. The tool is composed of 14 items in total and each item is in 5-point scale. These items are used to evaluate 3 as-

Table1. General characteristics of participant

	experimental group (n=7)	general group (n=7)	p
Age	52.4±10.8 (36~65)	53.1±14.1 (31~74)	0.9
Sex			
Male	3	2	0.6
Female	4	5	
Height (cm)	161.0±5.2 (153~167)	163.1±16.3 (153~198)	0.7
Weight (kg)	65.7±8.3 (55~80)	58.7±11.0 (44~80)	0.2

pects including position maintenance, position control towards voluntary movement, and the reaction towards the outer interference. The total score is 56 points.¹⁸⁾ In order to reduce the error in measurement, 1 inspector conducted the measurement before/after the study.

(2) Functional Reaching test

Functional Reaching Test (FRT) is simple and trustable measuring tool that can evaluate balancing ability. This tool was developed to test the change in balance performing ability in clinical circumstances.²⁾ In this study, FRT was used to evaluate static balancing ability before/after the study. Fourteen subjects were given with one attempt and the average score from three attempts were used for the measurement.

(3) Timed up and go test

It is a tool that can evaluate the walking ability easily and simply, and it is a trustable tool for measuring the walking speed of a stroke patient.¹⁹⁾ Stroke patient starts from the chair with an armrest. When researcher gives a signal, patient stands up, walk 3m, walk around the turning point, and return to the original position on the chair while the time is being recorded. Auxiliary equipment or walker is allowed when the patients are walking, but the help from the assistant is not allowed. However, the therapist are allowed walk behind the patient while he/she walking in order to prevent any kind of accident. One person measured the time, and the average value from 3 trials is used for the research to reduce error. 1 minute break is allowed between each measurement.

(4) 6minute walking test

6 minute walking test is a tool to measure the maximum distance the patient can walk within 6 minutes and it is a useful tool to evaluate walking endurance. Marker with 1m interval was marked on 25m pathway and the distance the patient walked for 6 minutes back and forth in this pathway without any help was measured. One inspector is walking this pathway half a step behind the patient in case of accident but no directions or chant was given that may affect the

test.⁸⁾ Also, use of auxiliary equipment is not limited depending of the need of patient and the patients also can take a test when needed, but they were encouraged to move as far as then can.

3. procedure

This study randomly separated 14 subjects into experimental group (7 subjects) and general treatment group (7 subjects). Each evaluation tool was used before/after the study and the average value from 3 measurements was used to evaluate each category. Experimental group and general treatment group received general physical therapy twice a day, 30 minutes per session. Additionally, experimental group carried out training for strengthening lower limb for 8 weeks. Prior to conducting all experimental procedure, researcher explained the purpose and the method of this study to the subjects sufficiently and made sure the experimental group understands the method and the position of intervention thoroughly.

4. data analysis

SPSS ver. 12.0 was used for statistical analysis of the data and Shapiro-Wilk normality test was done to test the normality of the data. From regular distribution of the data, paired T-test was used to compare walking & balancing data of experimental group before/after the study. For group comparison between experimental group and general treatment group, independent T-test was used. Also, Pearson correlation analysis was used to analyze the relationship between balancing ability and walking ability. The level of significance used for all qualifications was set to $\alpha=0.05$.

III. Results

1. Comparison within the group before/after intervention

In experimental group, average FRT for evaluate balancing ability increased from 12.8cm measured at the beginning or the study to 19.4cm measured later which showed 6.6cm increase. This indicates statistically significant difference ($p < 0.05$). No statistically

significant difference was shown in BBS, TUG, and 6 minute walking. In general treatment group, there was no significant difference shown in FRT, BBS, TUG, and 6 minute walking (Table 2).

2. Comparison within the group after intervention

There were no significant differences shown in FRT, BBS, TUG, and 6 minute walking test before/after intervention in both experimental and general treatment group (Table 2).

3. Correlation between balancing ability and walking ability

As a result of analyzing correlation between second BBS, FRT< TUG and 6 minute walking test conducted on all subjects participated in the study, high negative

correlation between TUG test for testing walking speed and 6 minute walking test for testing walking endurance ($r = -.835, p < .001$) and BBS test for evaluating balancing ability showed moderate negative correlation ($r = -.596, p < .05$). 6 minute walking test for testing walking endurance and BBS test for testing balancing ability showed moderate positive correlation ($r = .634, p < .05$). High positive correlation was shown between BBS and FRT for testing balancing ability ($r = .799, p < .001$) (Table 3).

IV. Discussion

This study is conducted to see what effect does 8 weeks of lower limb strengthening training has on

Table 2. Comparison within the group after intervention

	Experimental group (n=7)			t	general group (n=7)			p
	pre	post			pre	post		
FRT (cm)	12.8	19.4	-3.218*	13.6	18.1	-1.298	.767	
BBS (score)	39.4	42.1	-1.546	41.8	41.8	.000	.953	
TUG (sec)	44.3	39.5	2.265	27.8	28.8	-.318	.288	
6MW (m)	127.5	124.1	.366	194.1	190	.495	.231	

mean±SD,*p<0.05.

TUG, Timed Up and Go test; 6MW, 6minute walking test; BBS, Berg Balance test; FRT, Functional Reaching Test.

Table 3. Correlation between BBS, TUG, FRT, 6MWT (n=14)

	BBS		FRT		TUG		6MW T	
	r	p	r	p	r	p	r	p
BBS (score)	1		.799**	.001	-.596*	.024	.634*	.015
FRT (cm)			1		-.412	.143	.521**	.056
TUG (sec)					1		-.835**	.000
6MWT (m)							1	

*p<0.05, **p<0.01

TUG, Timed Up and Go test; 6MW, 6minute walking test; BBS, Berg Balance test; FRT, Functional Reaching Test.

balancing and walking of stroke patients. This study is Interference of blood flow in the brain or bleeding in the vessel caused by stroke damage motor and sensory nerve. This causes difficulty in controlling the movement, and this is shown as the weakness of the muscle abnormal muscle tension, and abnormal movement.⁹⁾ The stroke patients show weakness in muscle strength on both paralyzed and non-paralyzed lower limbs.¹⁵⁾ This indicates that exercising both lower limbs is necessary in stroke patients.

In this study, BBS and FRT were conducted to test balancing ability to see the effect of 8 weeks of lower limbs strengthening training to balancing and walking. In order to evaluate the walking ability, TUG and 6 minute walking test was used to see the difference between lower limbs strengthening group and general treatment group before and after intervention. Pilot study a significant change on extensor strengthening group though extensor strengthening training.¹³⁾ However, BBS score conducted in order to evaluate the balancing ability did not show any significant change. Increase in muscle strength was derived both paralyzed and non-paralyzed side during the exercise, but there was no significant change appeared in BBS score. In this study, there was increase in the score by 3 points (39.4→42.1) in lower limbs strengthening group after intervention. However, there was no statistically significant difference and general treatment group showed no difference in the score before and after intervention (41.8). This shows that in order to have clinically significant change in BBS score obtained from stroke patient, more than 6 points increase is required.²⁰⁾ Also, BBS score of less than 45 points have higher chance of falling. Also increase in BBS score by 1~2 points decreases the risk of falling by 2~7%.²¹⁾ As a result of this study, the average BBS score in lower limbs strengthening group increase by 3 percent approximately and no change was shown in general treatment group. Although it is not statistically significant, it is considered that the risk of falling had decreased.

This showed that muscle strengthening in foot flexor on the ankle caused significant change in FRT range for measuring balancing ability.⁶⁾ Pilot studied

the effect of lower limbs strengthening to balancing showed that muscle strengthening in foot flexor on the ankle and sole flexor caused significant change in FRT range.²²⁾ Also, Eccentric muscle strength of foot flexor on the ankle that has an important role in maintaining the balance and FRT have a significant correlation.²³⁾ As a result of this study, changes in FRT within lower limbs strengthening group for measuring the balance showed statistically significant change ($p<0.05$), which is an identical result as previously conducted studies. When carrying out the ascending movement among different squat movements, flexing the top of the foot appears as flexing of the sole, and muscle activity of anticus and soleus muscle also increases.²⁴⁾ Repetition of flexing sole and top of the feet is shown in semi-squatting position. It is considered that repeated semi-squatting position used as means of intervention in this study yielded muscle strength of sole flexor and foot flexor on top of the feet, and increased the range of FRT. FRT test in order to investigate the effect of lower limbs strengthening training on balancing ability of elder women.²⁵⁾ As a result, lower limbs strengthening group increased from 16.2cm to 20.7cm. Control group increased from 18.5cm to 19.8cm which coincides with the result of previously conducted studies that did not show any significant difference between experimental group and control group.

Pilot study decreased TUG speed significantly through muscle strengthening of sole flexor and foot flexor on top of the feet.²²⁾ However, even though there is a significant increase in muscle when conducting isokinetic muscle training on knee joint flexor and extensor on paralyzed side of stroke patients, there was a significant increase in muscle strength while there is no significant change in TUG speed.²⁶⁾ In this study, test time in muscle strengthening group decreased by 4.8 seconds (44.8→39.5). However, no significant difference was found before/after intervention. In general treatment group, test time slowed down from 27.8 seconds to 28.8 seconds, which showed no significant difference. Although there are no significant changes shown, there was slight change in speed in muscle strengthening group.

The functional ability and degree of muscle strengthening after conducting 12 weeks of intensive resistance training on both knee extensor, foot extensor on the ankle, and sole extensor.²⁷⁾ Result of study showed that muscle strengthening training had a significant effect in enhancement of muscle strength. Also, in order to evaluate the functional ability, climbing stairs, 6 minutes walking test, and repetitive standing from the chair were conducted to record general walking speed and maximum walking speed. No significant difference was shown in the results other than 6 minute walking. Although 6 minute walking showed significant difference, it is interpreted as a result of walking training to visit the lab 3 times a week rather than the result that gave significant difference on the test. Decrease in functional ability in stroke patients is not a single problem of muscle weakening, but it contains various factors such as stiffening, reduction of damaged proprioceptive sensory muscles, and imbalance of the muscle. Thus, it is considered that only muscle strengthening training cannot solve the problems in stroke patients with complex issues. In this study, muscle strengthening group decreased by 6m (from 127.5m → 124.1m) There was no significant difference shown between two groups. As it is shown in previous study, it is considered that focusing on improving the weak muscle in individual stroke patients rather than overall muscle strengthening training and approaching integratively to various problems in stroke patients other than weakening of the muscle will lead to significant increase in walking ability. BBS, TUG and 6 minutes walking test score that indicate dynamic balancing ability showed moderate correlation. It is considered that enhancement in dynamic balancing ability may affect the enhancement of walking ability. Integrative result of this study indicates that 8 week muscle strengthening training had positive effect on enhancing both balancing ability and dynamic balancing while it didn't show any significant change in enhancing the walking ability. Previously conducted studies indicate that when there are no neurological damage in patients, increase in muscle strength yielded significant effect on the enhancement of functional ability, balancing and

walking.^{6,22,23,25)} However, regardless of significant increase in muscle strength stroke patients showed limited enhancement in functional ability.^{26,27,28)} This shows that muscle strengthening is important in stroke patients but only simple muscle strengthening has limitations in enhancing functional ability of the patients. This implies that integrative approach to various problems in stroke patients is necessary.²⁷⁾ The result of this study also showed limited change in balancing and walking. This indicates that integrated approach is needed on stroke patients including muscle weakening.

Purpose of this study was to investigate functional enhancement after conducting 8 week lower limbs strengthening training, but enhancement of lower limbs strength was not demonstrated. In future studies, proving the effect of the exercise through sufficient intervention period will be needed including enhancement of lower limbs strength. Also, it is considered that studies on integrative method of exercise to enhance functions of stroke patients are necessary.

V. Conclusion

This study is conducted on 14 patients who experienced stroke. 7 patients were selected for lower limb strengthening group and 7 patients were selected for general treatment group. For lower limb strengthening group, special training for strengthening lower limbs are provided for 8 weeks, while no additional intervention other than general physical therapy was applied to general treatment group. The results of experience are as follows:

First, when comparing differences within the groups before/after intervention, lower limb strengthening group showed significant change in FRT result ($p < 0.05$) while there was no significant change in general treatment group. Both groups didn't show significant change in BBS, TUG and 6 minute walking test.

Secondly, when comparing difference between the groups before/after intervention, both groups didn't show significant change in BBS, FRT, TUG, and 6 minute walking test.

Thirdly, as a result of studying the relationship between static balance and dynamic balance, walking speed and walking endurance, there was high positive correlation between BBS and FRT ($p < 0.01$) and high negative correlation between TUG and 6 minute walking ($p < 0.01$). Also, there is negative correlation between BBS and TUG ($p < 0.05$) and there is positive correlation between BBS and 6 minute walking ($p < 0.05$). Based on such result, 8 weeks of lower limb strengthening training has a positive effect on increasing balancing ability of stroke patient, especially increasing static balancing ability. There is also a significant correlation between dynamic balancing ability and walking ability which indicates that enhancement of balancing ability affects the enhancement of walking ability. Based on the result of this study, it is considered that applying complex exercise program along with 8 weeks of lower limb strengthening training can be helpful in effective recovery of enhancement of balancing and walking ability in stroke patients.

References

1. Sims NR, Muyderman H. Mitochondria, oxidative metabolism and cell death in stroke. *Biochim Biophys Acta*. 2009;1802(1):80-91.
2. Duncan PW, Weiner DK, Chandler J, et al. Functional reach: A new clinical measure of balance. *J Gerontology Med Sci*. 1990;45(6):192-97.
3. Skilbeck CE, Wade DT, Hewer RL, et al. Recovery after stroke. *J Neurol Neurosurg Psychiatry*. 1983;46:5-8.
4. Tyson SF, Hanley M, Chillala J, et al. Balance disability after stroke. *Phys Ther*. 2006;86:30-38.
5. Hwang BY. Characteristics of LOS and body sway in the patients with hemiplegia. Institute of Natural Sciences Yong-In University. 2002.;7(1):135-40.
6. El-Kader SMA, Rahmy AF. Balance performance and ankle dorsiflexor muscles force in elderly: a correlational study. *Bull Fac Ph Th Cairo Univ*. 2004.
7. Hess JA, Woollacott M. Effect of high-intensity strength-training on functional measures of balance ability in balance-impaired older adults. *J Manipulative Phys Ther*. 2005;28:582-90.
8. Phol PS, Duncan PW, Perera, et al. Influence of stroke-related impairments on performance in 6-minute walk test. *J Rehabi Res Dev*. 2002;39(4):1-6.
9. Olney SJ, Richards C. Hemiparetic gait following stroke. Part I: Characteristics. *Gait Posture*. 1996;4:136-48.
10. Chen G, Pattern C, Kothari D, et al. Gait differences between individuals with post-stroke hemiparesis and non-disabled controls at matched speeds. *Gait Posture*. 2004;22:51-6.
11. Sims NR, Muyderman H. Mitochondria, oxidative metabolism and cell death in stroke. *Biochim Biophys Acta*. 2009;1802(1):80-91.
12. Bohannon R. Muscle strength and muscle training after stroke. *J Rehabil Med*. 2007;9:14-20.
13. Park BS. Effects of strengthening training for the hip extensors on gait and functional performance ability in patients with hemiplegia. Yong-in university. 2011.
14. Ada L, Dorsh S, Canning CG. Strengthening interventions increase strength and improve activity after stroke: a systematic review. *Aust J Phys*. 2006;52:241-8.
15. Carvalho C, Sunnerhagen KS, Willen C. Walking performance and muscle strength in the later stage poststroke: a nonlinear relationship. *Arch Phys Med Rehabil*. 2013;94:845-50.
16. Hess JA, Woollacott M. Effect of high-intensity strength-training on functional measures of balance ability in balance-impaired older adults. *J Manipulative Phys Ther*. 2005;28:582-90.
17. Cramp MC, Greenwood RJ, Gill M, et al. Low intensity strength training for ambulatory stroke patients. *Disabil Rehabil*. 2006;28:883-9.
18. Berg K, Wood-Dauphinee S, Williams JI, et al. Measuring balance in the elderly: preliminary development of an instrument. *Physiother Canada*. 1989;41:304-11.
19. NG SS, Hui-Chan CW. The timed up & go test: its reliability and association with lower-limb impairments and locomotor capacities in people with chronic stroke. *Arch Phys Med Rehabil*. 2005;86:1641-7.
20. Stevenson TJ. Detecting change in patients with stroke using the berg balance scale. *Aust J Physiother*. 2001;47:29-38.
21. Thorbahn LDB, Newton RA. Use of the berg balance test to predict fall in elderly persons. *Phys Ther*. 1996;76:576-83.
22. Ribeiro F, Teixeira F, Brochado G, et al. Impact of low cost strength training of dorsi- and plantar flexors on balance and functional mobility in institutionalized

- elderly people. *Geriatr Gerontol Int.* 2009;9:75-80.
23. Daubney ME, Culham EG. Lower-extremity muscle force and balance performance in adults aged 65 years and older. *Phys Ther.* 1999;79:1177-85.
 24. Hwang SH, Kim YE, Kim YH. Biomechanical Analysis of Lower Limb Joint Motions and Lumbar Lordosis during Squat and Stoop Lifting. *Journal of the Korean Society of Precision Engineering.* 2008;25(11):107-18.
 25. Lee HJ, Han SW. Effects of lower extremity muscle strengthening exercise using elastic resistance on balance on elderly women. *J Korean Acad Community Health Nurs.* 2009;20(1):59-66.
 26. Sharp SA, Brouwer BJ. Isokinetic strength training of the hemiparetic knee: effects on function and spasticity. *Arch Phys Med Rehabil.* 1997;78:1231-6.
 27. Ouellette MM, LeBrasseur NK, Bean JF, et al. High intensity resistance training improves muscle strength, self-reported function and disability in long-term stroke survivors. *Stroke.* 2004;35:1404-9.
 28. Mercer VS, Chang SH, Williams CD, et al. Effects of an exercise program to increase hip abductor muscle strength and improve lateral stability following stroke: a single subject design. *J Geriatric Phys Ther.* 2009; 32(2):6-15.

