Original Article

The Effect of Paretic Side Quadriceps Resistive Exercise on Weight-Bearing Asymmetry in Standing Position and Lean Muscle Mass of Subacute Stroke Patients

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ABSTRACT

Objectives: To evaluate the efficacy of paretic side quadriceps resistive exercise on weight-bearing asymmetry and lean muscle mass of stroke patients.

Study design: Experimental clinical study.

Setting: Physical Medicine and Rehabilitation Department, Faculty of Medicine, Hasan Sadikin Hospital, Bandung.

Subjects: Patients with subacute stroke (2 weeks-6 months after the first stroke), aged 45-59 years old.

Methods: All subjects were given paretic side quadriceps resistive exercise with the intensity of 40% 1 RM, 25 repetitions per set, 3 sets per time, 3 times a week, for 8 weeks. Lean muscle mass and weight-bearing asymmetry were evaluated pre- and post- intervention .

Results: Twelve patients (8 males and 4 females) with mean age of 55.5 (SD 5.1) years were recruited. Lean muscle mass assessed with bioelectrical impedance analysis was 9.09 (SD 2.81) in pre- and 8.87 (2.73) in post- intervention whereas weight-bearing asymmetry was 9.52 (SD 5.63) in pre- and 5.98 (SD 5.445) in post- intervention. When comparing pre- and post- intervention outcomes, there was a significant difference in weight-bearing asymmetry (p = 0.034) but lean muscle mass did not significantly change (p = 0.146).

Conclusion: Quadriceps resistive exercise of paretic side was not effective in increasing lean muscle mass but it reduced weight-bearing asymmetry of subacute stroke patients. Therefore, a unilateral resistive exercise of a paretic side may be an effective intervention for stroke rehabilitation during subacute phase to improve weight-bearing symmetry.

Keywords: stroke, quadriceps resistive exercise, lean muscle mass, weight bearing asymmetry

ASEAN J Rehabil Med 2019; 29(3): 77-80.

Introduction

Incidence of stroke increases globally but the mortality rates decrease, this changes it from a leading cause of deaths to a major cause of chronic disabilities[1-3] as it is commonly associated with specific neurological disorders including muscle weakness. Muscle weakness is a main factor of immobilization that leads to a sedentary behavior and finally contributes to a decrease in quality of live (QoL).[4] Pathophysiological consequences found in paretic skeletal muscles are muscle atrophy, protein degradation, muscle fiber shifting from a slow-twitch (type I) fiber to a fast-twitch (type II) fiber, and increasing of intramuscular fat due to replacement of muscle tissue by fat.[5,6] These make stroke patients suffer a significant decrease in lean muscle mass in the paretic limb. However, the increase in intramuscular fat was found in both sides, 9% in the paretic side and 6% in the non paretic side.[7] A decrease in lean muscle mass usually increases muscle weakness in the paretic limb causing more inactivity, atrophy, and motoric dysfunctions which aggravate decreased in lean muscle mass (LMM).[7,8]

Weight-bearing asymmetry (WBA) is frequently found in stroke patients. It occurs due to postural instability and balance disorder, and causes gait abnormality and ambulation limitation. An assessment of WBA can be performed in a standing position which requires quadriceps muscle strength. Quadriceps muscle maintains stability while standing and walking, and supports a normal postural line of knee joints. It is recommended for stroke patients to perform a quadriceps resistive exercise in order to improve several functions.[9,10]

A resistive exercise effectively improves poststroke functional performances including walking, climbing stairs, balancing, cardio respiration fitness and functional capacity in the musculoskeletal and cardiovascular system and shifting type 2 fibers to type 1.[11] Muscles adapt to resistive exercise by increasing their oxidative and metabolic capacities, which allow a better delivery and use of oxygen.[11] Using low levels of resistance in an exercise program minimizes adverse forces on joints, produces less irritation to soft tissues, and is more comfortable than heavy resistance training.[11] Therefore, this study aimed to evaluate an effect of paretic side quadriceps resistive exercise on weight bearing asymmetry and lean muscle mass in post-stroke patients.

Methods

An experimental study was conducted to compare pre- and post- intervention outcomes. The subjects were subacute-phase stroke patients who visited the Department of Physical Medicine and Rehabilitation Clinic and the Department

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Received: 31st March 2019 Revised: 4th April 2019 Accepted: 27th November 2019

of Neurology Clinic at Dr. Hasan Sadikin General Hospital, Bandung. A consecutive sampling and a simple paired categorical analytic numeric design were used with a confidence interval (CI) 95% and a power test 90%. Twelve samples were obtained from a samples calculation.[12]

Inclusion criteria were hemiparesis, in subacute phase (2 weeks-6 months after the first stroke), age 45–59 years old, able to standing with a minimal support, knees with a full extention and flexion range of movement, able to perform a quadriceps resistive exercise, able to grasp, Modified Asworth Scale (MAS) graded 1 in the lower extremity, no sensory impairments, able to follow verbal instructions, and willing to participate in the study. Exclusion criteria were uncontrolled hypertension and diabetes mellitus, cardio-embolic, vertebrobasilar and cerebellum strokes, and musculoskeletal disorders of the lower extremities. Dropout criteria were having an acute injury and not attending twice in a row during the intervention.

Patients's data were obtained from the medical records of Dr. Hasan Sadikin General Hospital, Bandung and sorted based on the criteria of age and sex, history of illness and physical examination. Those who met the inclusion criteria were given information related to the study and signed an informed consent after agreement. They were informed that they had the right to quit the study anytime and were subjected to confidentiality.

Lean muscle mass was assessed by using an electrical conduction measurement (Bio Impedance Analysis Tanita type BC 601). This device is a valid method for assessment of body composition and an alternative to more invasive and expensive methods like dual-energy x-ray, computerized tomography and magnetic resonance imaging. BIA could measure lean muscle mass of the whole body or segmental.[13] The subjects stood on the device with barefoot and held it at a waist level. Weight-bearing asymmetry was assessed in a static anatomical position with head upright and shoulder level on two digital weight scales. Each foot was on one of the scale and placed with its longitudinal axis pointing outward 15 degrees. The weight-bearing asymmetry values were the differences between the two scales.

Before the intervention started, a 1-RM (repetition maximum) was assessed with the Holten Method. Every 2 week, 1-RM was re-assessed.[14] Then, each subject was conducted to do an isotonic resistive quadriceps exercise by sitting on an NK table with the trunk and non-paretic lower extremity stabilized by a strap; a paretic lower extremity was given resistance on the dorsal aspect of the leg (tibia) with an intensity of 40% of 1 RM, did 3 sets of 25 repetitions exercise with 2 minutes of rest period between each set; and did 3 times a week for 8 weeks.

The LMM of the paretic lower extremity and the WBA were assessed pre- and post- intervension; and data were analyzed by using SPSS program 21.0 for Windows version. Numerical data such as age and weight were reported as mean, standard deviation (SD), median, and range. Categorical data were reported as number, frequency and percentage.

The Shapiro-Wilk test was used to gain a normality analysis of the numerical data. The paired t-test (normal distributed data) or the Wilcoxon test (non-normal distributed data) was used to signify the mean or the median values from the pre- and the post- intervention assessments. The statistical analysis for the categorical data was the Chi square test or the Fisher Exact test for table 2 x 2. The McNemar's test was used to compare and analyze the categorical variables of the pre- and the post-intervention.[15] A $p \leq 0.05$ was determined as statistically significant.

The study was conducted at the Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Universitas Padjadjaran-Dr. Hasan Sadikin General Hospital, Bandung, Indonesia in the period of Agustus 2017 until January 2018 after approval by the Ethical Comittee was issued.(LB.04.01/A05/EC/116/IV/2017)

Results

There were 12 subacute phase stroke patients, 8 males and 4 females, with mean age of 55.5 years old. The subjects' characteristics are presented in Table 1. And, Table 2 shows the comparisons between the pre- and the post- intervention of lean muscle mass and weight-bearing asymmetry. There was no significant difference of lean muscle mass in the paretic lower extremity between the pre- and the post- intervention [9.09 (SD 2.81) vs 8.87 (SD 2.73), paired t-test, $p = 0.146$]. The mean pre- intervention WBA was 9.52 (SD 5.63) and the post-intervention was 5.98 (SD 5.45); however, the data were not normally distributed, and the difference between the pre- and the post- intervention data was analyzed with the Wilcoxon test and showed statistically significant ($p = 0.034$).

Discussion

This study demonstrated that the protocol of resistive quadriceps exercise on an NK table with an intensity of 40% 1-RM, 3 sets of 25 repetition per days, and 3 days per week for 8 weeks, could improve weight-bearing asymmetry but not change lean muscle mass of subacute stroke patients.

The improvement of weight-bearing asymmetry was proved with less difference in weight-bearing on both scales after completion of the intervention. This might be due to neurological recovery of the lower extremity induced by this 8-week quadriceps

Table 1. The Subjects' characteristics

Variables	N=12
Paretic[1]	
Right	4 (33.3)
Left	8 (66.7)
Weight (kg)[2,3,4]	64.2 (14.2) ,62.8, 35.5–86.6
Age (years)[2,3,4]	55.5 (5.1), 58.5, 45.0–59.0
1-RM	9.15 (5.27), 6.94, 1.4-17

[1]Number (%), [2]mean (SD), [3]median, [4]range

Table 2. Comparisons of weight-bearing asymmetry and lean muscle mass between pre- and post- intervention

Variable	Pre- intervention (n=12)	Post- intervention (n=12)	*p*-value
Weight-bearing asymmetry[1,2]	9.52 (5.63), 6.70	5.98 (5.45), 4.40	0,034*¥
Lean Muscle Mass[1]	9.09 (2.81)	8.87 (2.73)	0,146#

[1]Mean (SD), [2]median,

*Statistical significance, # Paired test, ¥Wilcoxon test

resistive exercise with 40% of 1-RM. Decrease in weight-bearing asymmetry without increased muscle mass might be influenced by neural adaptation of exercise such as increasing of recruitment and firing motor unit, improvement of motor unit synchronization, good coordination of motor unit to make movement.[16] We could not conclude that less weight-bearing asymmetry was due to improvement of standing balance and/or stronger quadriceps muscle as muscle power/strength post-intervention was not recorded. However, muscle strength improvement is commonly associated with increasing muscle mass.[17] A previous study elucidated improvement of lower extremity muscle strength particularly in quadriceps muscles associated with functional performances such as change of emphasizing weight while performing sit to stand.[17]

A study of Ryan et al. (2011) showed the effectiveness of a 12 week progressive resistive protocol to strengthen the muscles of both lower extremities of individuals with chronic stroke (> 6 months after onset) on muscle hypertrophy of the thigh muscles.[18] We then hypothesized that our resistive exercise protocol might be effective on lean muscle mass (of the paretic extremity). However, our protocol was not a progressive resistive exercise like the protocol of Ryan et al. Moreover, skeletal muscle mass could be increased by performing high intensity resistance exercise (75-85% 1 RM) for healthy individuals[19] but our protocol used 40% 1-RM. Such low intensity might improve only endurance, not strength of local muscles but it was considered safe for stroke patients with muscle weakness. Nutrition is another factor influencing muscle mass and low nutrition can decrease muscle mass.[19] During the 8-week intervention, we did not control or record nutrition and insufficient nutrition might cause less lean muscle mass. However, we did prevent bias of aging by excluding subjects older than 60 years old.

In addition, we dicided to use a Bioelectric Impedance Analysis (BIA) device which was available to predict lean mass but not a gold standard of measurement of lean muscle mass like CT scan or MRI.[20] Recently there was a study proposed new BIA equations for accurate estimation of appendicular lean mass in elder individuals.[21]

This study had several limitations. Subject's comorbilities, body weight, nutritional status, Brunstrom motor recovery stage, muscle power/strength of quadriceps, and functional performance before and after intervention were not assessed or recorded. These might influence the results of the study. In addition, to confirm that this protocol really decrease weight-bearing asymmetry, a randomized controlled trial with adequate data collection should be done.

In conclusion, an 8 –week quadriceps resistive ex]ercise protocol, 3 sets of 25 repetitions of 40% 1-RM resistance per times, 3 times per week, was effective in reducing weight-bearing asymmetry but not increasing lean muscle mass of the paretic extremity of stroke patients in subacute phase.

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Disclosure

The authors have no conflict of interest.

Acknowledgment

The authors thank the staff at the Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Universitas Padjadjaran-Dr. Hasan Sadikin General Hospital, Bandung, Indonesia.

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