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Effects of Regularly Performed Walking on the Bilateral Limb Compositions of Post-Stroke Korean Men

The purpose of this study was to examine the effects of hemispheric damage in body composition of male adults with stroke experiences. The Fourth and Fifth Korea National Health and Nutrition Examination Surveys (KNHANES) with body composition results obtained from the DXA (dual-energy X-ray absorptiometry) assessments were used for this study. Survey data of 18 post-stroke men and 28 healthy controls were obtained. Both the lean and fat masses of the upper and lower limbs were utilized to compare for the compositions between the limbs in post-stroke subjects. In addition, the effect of exercise habit was also observed for the influence of physical activity in body composition. Mixed results in left and right limb compositions were shown between the groups. When the subjects were further divided based on walking days per week, sedentary (walk ≤2 d/wk) post-stroke group showed significantly greater fat mass and less lean mass than the physically active people (walk ≥ 3d/wk). In comparison to the healthy sedentary and physically active controls, two post-stroke groups showed greater variations. The results indicate that physical activity maintains or improve the quality of both the upper and lower limb composition in patients with post-stroke men.

Key words: *Stroke; Atrophy; Denervation; Physical activity*

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INTRODUCTION

Maintaining adequate amount of skeletal muscle allow independency and amicable daily living, especially during the stage of old age. However, injury or illness often leads to accelerated muscular atrophy in addition to age-related degeneration. Neurological injury or degeneration has also been known to promote muscular atrophy. Expedited muscular atrophy in neurologically damaged persons may be related to several causes [1,2]. A prolonged period of bed rest after an event has been known to accelerate atrophy in muscular. In addition, injured or damaged nerve has also been known to promote muscular atrophy due to denervation to particular muscular areas. Impaired neurological signaling to innervated muscle not only reduce muscular strength but myofiber diameter [3].

Muscular atrophy in stroke patients has long been reported in previous studies [4-6]. Serious long-term complications may promote additional muscular atrophy in stroke patients. Unfavorable prognosis after a stroke event is a common understanding among general public. More than 50% stroke patients live with certain form of disability and about 30% live dependent of an assistant [3,7]. Living with certain form of paralysis and denervation disuse may promote immobility and functional limitations in daily living. Limited bodily function may also aggravate muscular atrophy and so on. It is a vicious circle for aggravating both muscular atrophy and functional limitations.

Stroke events usually occur in one hemisphere leading denervation to one side of the body and hemiparetic disability. This may lead to imbalance in skeletal muscle and asymmetrical movements. Muscular atrophy between upper limbs with greater asymmetrical fat contents was observed through previously published cross-sectional study with adult post-stroke women [8]. However, men with significantly greater lean body mass and tendency for greater rate of exercise habit may show difference in muscular atrophy. As for the female post-stroke subjects, studies on post-stroke patients and sarcopenia have rarely been reported especially for Korean public. Previous reports on sarcopenia report of significant influence of regularly performed physical activity on deterring the rate of sarcopenia in old age. Such deterring effects of physical activity have also been reported for denervation related sarcopenia [9]. In order to provide scientific information of the denervation effects of stroke and influence of regularly performed physical activity evidence-based reports must be provided for both genders. Therefore, this study aims to compass muscle mass, percent body fat, bone mass, and bone mineral density of left and right upper extremities of male post-stroke patients to elucidate the differences in body composition post stroke event.

SUBJECTS AND METHODS

Subjects

The Fourth and Fifth Korea National Health and Nutrition Examination Surveys (KNHANES) of the years 2008 to 2011 were utilized. The second and third year KNHANES III and first and second year KNHANES IV assessment data conducted between 2008 and 2011. Data were approved by the ethics committee of the Korea Centers for Disease Control and Prevention (2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, and 2011-02CON-06C). The KNHANE surveys are cross-sectional and nationally representative surveys conducted by the Division of Chronic Disease Surveillance, Korea Centers for Disease Control and Prevention. The survey results including the health behavior questionnaires, anthropometric measurements, and the DXA (dual-energy X-ray absorptiometry) measurements were utilized for the study. Adult men aged between 35 or older, those who with stroke history, and DXA assessed body composition results were included. In order to minimize the influence of body composition difference, men with body mass index (BMI) greater than 30 kg/m^2 were excluded from both the post-stroke and health control groups. Subjects with history of neurological or orthopedic disorder, or movement limiting factor were excluded for the controls. Post-stroke subjects with other previous or current medical histories were also excluded. After exclusion, out of 2934 final 18 post-stroke patients with mean (SD) age of 55.11(±6.38) years and 28 healthy subjects with mean age of 56.43(±7.34) were included for the study. Furthermore, 4 subjects were excluded for the comparisons of the physically active (walk ≥ 3 days/wk) and non-active comparison in post-stroke patients. Lastly, those who reported post-stroke events were included instead of limiting to post-stroke subjects with indicated partial paralysis in order to observe on the influence of physical activity in stroke related sarcopenia.

Measurement Methods

Body composition

Fat content (g), lean body mass (g), body mass (g), and fat percent (%) measured by DXA (Dual-energy X-ray absorptiometry) of Hologic Discovery (Hologic Inc., Bedford, MA, USA) were utilized for this study. These four measured variables were used to compare the degree of atrophy between the left and right upper and lower extremities in the post-stroke subjects in comparison to the healthy subjects or controls.

Data analysis

The data of this study were analyzed using the SPSS statistical processing program for Windows version 18.0. Descriptive statistics were used to calculate the subjects' characteristics and were expressed in mean and standard error. The Levene's test was used to assess the homogeneity of the variables prior to conducting the comparative analyses. One-way ANOVA was performed between the body composition variables of muscle and fat masses between the right and left upper and lower extremities. Additional comparative analysis via one-way ANOVA was performed between the physically active (walk ≤ 2 days/wk) and non-active (walk ≥ 3 days/wk) post-stroke subjects. The results were considered significant when the probability was less than .05 (a = .05).

RESULTS

Comparisons of limb compositions between post-stroke and control subjects

Mean age of post-stroke male subjects were 55.11±6.38 years and the healthy subjects were 51.69±7.59 years. Mean BMI (body mass index), waist circumference, and total body weight were 24.02±2.40 kg/m^2, 85.24±8.58 cm, and 59.76±13.91 kg for the post-stroke subjects and 24.56±2.30 kg/m^2, 86.02±6.88 cm, and 61.17±11.99 kg for the controls, respectively.

The left and right upper and lower limb compositions were compared by subtracting mean fat mass (g), lean mass (g), and total limb weight (g), and fat ratio (%) of the right and left limbs (Table 1). Fat mass, lean mass, total weight, and fat ratio differences of the upper limbs were not significant for both the stroke subjects and the healthy controls. Fat mass, lean mass, total weight, and fat ratio differences of the lower limbs also did not show significances for the stroke subjects and for the healthy controls. Mixed results were show for the post–stroke and controls.

Table 1. . Differences in left and right limb weights in post–stroke and control subjects

	Variables	R–L fat mass (g)	R–L lean mass (g)	R–L limb weight (g)	R–L fat ratio
Upper limbs	Post–stroke	44.44	166.05	210.49	.44
	Controls	19.82	141.37	161.18	.93
Lower limbs	Post–stroke	37.36	97.44	134.80	.05
	Controls	64.45	121.78	186.22	.13

Comparisons of limb compositions between sedentary and physically active post–stroke subjects

Left and right upper and lower limb compositions of the right and left limbs were compared between sedentary (walk ≤2 days/wk) and physically active (walk ≥3 days/wk) subjects (Table 2). Fat mass, lean mass, and fat ratio for the left upper limbs, right upper limbs, left lower limbs, and right lower limbs did not show significance in the sedentary post–stroke subjects. However, the right upper limb weight was significantly greater than the left upper limb for the sedentary post–stroke subjects (p=.03). Fat mass, total weight, and fat ratio were also not significant for the left upper limbs, right upper limbs, left lower limbs, and right lower limbs of physically active post–stroke subjects, respectively. However, the right upper limb lean mass was significantly greater than the upper left lean mass for the active post–stroke subjects (p=.01).

Table 2. .Left and right limb compositions of the sedentary and physically active post–stroke subjects

	Variables	Fat mass (g)	Lean mass (g)	Limb weight (g)	Fat ratio
Upper limbs	S Left	1000.00±135.92	1967.07±217.96	2967.07±217.67	34.13±4.21
	S right	1117.81±162.09	2056.38±210.24	3174.19±221.39*	35.19±4.44
	A left	758.86±72.58	1890.59±198.80	2649.45±200.27	30.01±2.84
	A right	768.08±70.13	2025.54±195.04*	2793.62±207.20	28.49±2.50
Lower limbs	S Left	2710.62±319.86	6117.49±494.45	8828.11±471.90	30.95±3.59
	S right	2836.62±385.76	6244.54±531.74	9081.16±565.57	31.33±3.81
	A left	2509.25±219.66	6337.46±468.98	8846.71±496.27	28.81±2.28
	A right	2530.49±230.65	6496.06±494.52	9026.56±523.90	28.48±2.36

p〈0.05, mean±standard error of mean, S: sedentary (walk ≤2 days/wk), A: active (walk ≥3days/wk), fat ratio: fat/body weight

Comparisons of limb compositions were further compared between sedentary and physically active post–stroke subjects by subtracting left and right fat mass, lean mass, total weight, and fat ratio for the upper and lower limbs (Table 3). The right and left differences in lean mass, total mass, and fat ratio of the upper limbs between the sedentary and active post–stroke subjects were not significant. Significance was shown for the difference in right and left fat mass of the upper limbs between the sedentary and active subjects (p〈.01). The differences in lean mass, total mass, and fat ratio for the lower limbs of the sedentary post–stroke subjects were not significant. Significance was shown for the difference in right and left fat mass of the lower limbs between the sedentary and active subjects (p〈.01).

Table 3. .Weight differences in left and right limb compositions between sedentary and physically active post–stroke subjects

	Variables	R–L fat mass (g)	R–L lean mass (g)	R–L limb weight (g)	R–L fat ratio
Upper limbs	Sedentary	117.81*	89.31	207.12	1.06
	Active	9.22	134.94	144.16	1.52
Lower limbs	Sedentary	125.99*	127.05	253.05	.39
	Active	21.24	158.60	179.85	.34

p⟨0.05, R–L: right limb mass – left limb mass, sedentary: (walk ≤2 days/wk), active (walk ≥3days/wk)

Limb compositions of the healthy sedentary and physically active controls were also calculated for comparison (Table 4). The differences in fat mass, lean mass, total mass, and fat ratio were not significant for the upper limbs between the sedentary and physically active controls. The differences in fat mass, lean mass, total mass, and fat ratio were also not significant for the lower limbs of the sedentary and physically active controls.

Table 4. .Weight differences in left and right limb compositions between sedentary (walk ≤2 days/wk) and physically active (walk ≥ 3days/wk) healthy controls

	Variables	R–L fat mass (g)	R–L lean mass (g)	R–L limb weight (g)	R–L fat ratio
Upper limbs	Sedentary	7.82	137.98	145.81	1.12
	Active	5.15	133.14	138.29	1.17
Lower limbs	Sedentary	7.82	137.98	145.81	1.12
	Active	5.15	133.14	138.29	1.17

p⟨0.05, R–L: right limb mass – left limb mass, sedentary: (walk ≤2 days/wk), active (walk ≥3days/wk)

DISCUSSION

Musculature changes inevitably occur with the progress of senescence or aging. Imbalance of musculature between the affected contralateral and ipsilateral sides of the body may promote kinesiological dysfunction and aggravate functional disorder. Reduction in the influence and the number of motor units to various muscle groups within a human body has been reported to lead to decreased muscle mass and increased lipid content as well as reduced muscular strength. Maintaining adequate amount lean and fat contents have been promoted to obtain minimally required strength for independent daily living. Sarcopenia or atrophy in skeletal muscle has previous been reported in patients with illness or injury related nerve damage. Total or partial denervation to skeletal muscle with disrupted motoneuron pathway has been reported to reduce motor function and degradation of skeletal muscle function [9]. Stroke is an event which leads to a partial hemispheric damage and loss of motor control over contralateral side of the body. Stroke events have also been reported to aggravate muscular atrophy [10]. Although various reasons such as mental and physiological causes may promote muscular atrophy, it is vital to elucidate the effects of stroke and effective means to reverse or deter the negative influence of stroke [3,9].

This study was conducted to investigate the differences in limb composition in the post–stroke adult men in comparison to the healthy controls. Limb composition differences were further compared by dividing subjects by the amount of physical activity to observe the influence of regularly performed physical activity in limb composition. This study first compared the lean mass and fat mass differences between the post–stroke subjects and controls. Mixed results were shown as shown in Table 1. Trend for greater fat and lean masses with overall greater overall limb weight were shown for the upper limbs while reverse results were shown for the lower limbs of the post–stroke subjects without significances. Mixed results also have been reported in previous studies. In a study which traced lean mass contents of both the contralateral and ipsilateral limb sides after a stroke event for the course of 24 weeks, the degree of atrophy in the contralateral side progressively decreased to that of the ipsilateral side. For example, the cross-sectional area differences of the lean tissue of the contralateral and ipsilateral upper limbs increased from 35.9±2 to 42.7±10 cm2 and the lower limb increased from 65.5 to 92.8 cm2 [11]. However, in other studies, for the contralateral and ipsilateral sides, respectively [12]. Interestingly, although smaller in the absolute values in comparison to the control group, muscle mass of the non-parentic and parentic limbs in chronic chronic stroke subjects were shown to be similar with 456.8±92.4 mg/mm and 460.5±83.4 mg/mm with difference of 3.74 mg/mm, which is smaller than that of the controls with 8.88 mg/mm. However, the subacute stroke subjects showed doubled the difference in muscle mass (20.63 mg/mm) than the controls. MacIntyre and colleagues' study was also with small number of subjects for limited representation of the general post-stroke patients, large amount variations in confidence interval for the stroke patients show wider individual variations in body composition [12]. A longitudinal study by Carin-Levy et al. also did not show significant changes in cross-section areas between the contralateral and ipsilateral limbs. After 24 weeks of observation, lean tissue areas of the contraleral and ipsilateral upper limbs rarely changed to 59.7 and 60.2 cm2 from the initial first week values of 60.5 and 62.9 cm2, respectively. Lean tissue areas of the contraleral and ipsilateral lower limbs (thigh) also showed comparatively little changes. At 24 weeks, the areas changed to 124.1 and 128.1 cm2 from the initial first week values of 143.6 and 155.4 cm2, respectively [13]. Although reductions in lean tissue areas seem to occur over the course of 24 weeks, difference between contralateral to ipsilateral masses were minor in their study. However, greater number of studies showed a wide variant in body composition between the contralateral and ipsilateral side of the limbs [12,14].

Significant reductions in muscle mass in both limbs were reported in a study within 2 weeks of the stroke event [13]. Muscular atrophy is a rapid process upon hemispheric damage and prolonged bed rest. However, regularly performed rehabilitation exercise could deter and even improve stroke related muscular atrophy. Although greater intensity of physical activity may increase muscle mass and strength, walking, a weight-bearing physical activity, could allow regain of muscle mass in both paretic and non-paretic limbs with the risk of injury from more intense physical activity. Due to neurological damage and increase risk of fall from reduced balance control, exercise modality may be limited for stroke patients. Despite the rapid reduction, slight but a significant gain in muscle mass through physical activity and neurological recovery was reported [10]. However, physical activity seems to greatly promote muscle gain in stroke-related recovery [10,15].

Mixed results in fat compositions were also previously reported in both the contralateral and ipsilateral limbs [8,10,16,17]. The limb fat mass differences were noticeably greater in the sedentary post-stroke subjects in this study as shown in table 3. Such differences are more prominent between in sedentary post-stroke subjects and healthy controls. Table 4 show that the differences are minimal between the sedentary and active healthy controls. Ongoing inflammation, intramuscular lipid deposition, and alteration to insulin sensitivity have been reported with consequent muscle wasting [18]. Hemiparesis after stroke has been associated with abnormal metabolic function resulting from altered neural innervation. As early as 4 hours after a stroke event, noticeable reduction motor units have been noticed to affect skeletal muscle [19]. Increased fat deposition, type I and II muscle fiber atrophy, or muscle fiber alteration attribute to either disuse atrophy or abnormal central neural innervation [20]. Although some of the previous studies report of greater muscle wasting prior to the observation of fat deposition, disparity in observations indicate variety of influential factors related to sacopenia after a stroke event. Moreover, individual genetic predisposition may also play a significant role in changes in body composition. Nutritional status post stroke also has been studied in recent year to elucidate stroke related sarcopenia. In addition, prolonged life style habits, hormonal factors, degree of previous physical activity habits have been indicated as strong influential factors in stroke-related sarcopenia [21,22].

As also shown in this study, physical activity played significant role in prevention of muscle mass reduction and fat deposition in post-stroke male subjects. Other forms of physical activity such as resistance and endurance exercise also have been highly recommended for prevention or rehabilitation from stroke related sarcopenia. However, due to physiological limitations, safe weight-bearing walking could also significantly influence sarcopenia [23-27]. Stroke is one of the most disabling diseases with life time aftereffect. With increase in the aging population, prevention of stroke-related complications should be fully elucidated. This study had several limitations. Although 4 years of nationally conducted KNHANE data was utilized to analyze stroke related sarcopenia, small sample size was utilized for this study. In order to exclude the influential factors as much as possible, a significant amount of data was excluded. Second, important information such as history of the subjects' previous physical activity habits, post-stroke duration, affected side, or degree of severity could not be utilized to further exclude influential factors. Lastly, previous studies were conducted with sex-matched small number of subjects. Large longitudinal studies should be conducted to exclude known influencing factors. Regardless of such limiting factors, this study further elucidated the importance of low intensity physical activity of walking in post stroke subjects.

CONCLUSION

In this study, the left and right upper and lower limb compositions of post-stroke subjects were compared for the possibility of unilateral atrophy. The subjects were further compared by regularly performed physical activity of walking. The results indicated the importance of regularly performed physical activity in attenuating or recovering stroke related sarcopenia. In comparison to sedentary post-stroke subjects, physically active subjects showed less fat accumulation and greater lean body mass in both the upper and lower limbs. Therefore, regular walking should be promoted in post-stroke men for maintenance of proper body composition.

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