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Association between language function and body composition characteristics in patients with subacute left hemispheric stroke

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Abstract

Background & Objectives: Stroke-related sarcopenia and language disorder are main sequelae of stroke. The aim of this study is to evaluate the association between language function and body composition characteristics in patients with subacute left hemiplegic stroke. *Methods:* Body mass index, skeletal muscle index (SMI), and body fat percentage using bioimpedance analysis, hand grip strength, and Medical Research Council (MRC) sum score were evaluated. Language function was evaluated using the Western Aphasia Battery (WAB). A partial correlation analysis was used to assess the relationship between body composition and language function. *Results:* A total of 54 patients with subacute left hemispheric stroke were enrolled in the study. The aphasia quotient (AQ) of WAB was significantly correlated with SMI, body fat percentage, MRC-sum score, MRC-sum score of unaffected side and hand grip strength. In the multiple regression analysis after adjusting for age and sex, the AQ of WAB was significantly correlated with SMI.

Conclusions: Skeletal muscle index showed highest correlation with language function in patients with left hemispheric stroke.

Keywords: Sarcopenia, language function, left hemispheric stroke, skeletal muscle index, body composition

INTRODUCTION

Sarcopenia is a syndrome characterized by the loss of skeletal muscle mass, low muscle strength, and physical dysfunction.[1,2] Sarcopenia is correlated with a high risk of mobility impairment, falls, poor quality of life, and mortality.[3] A recent study has shown that sarcopenia can affect cognitive function.[4] Risk factors for sarcopenia include age, sex, malnutrition, disuse, and decreased level of physical activity.[2,3]

Stroke is a leading cause of disability worldwide.[5] Stroke-induced symptoms, including motor disturbance, ataxia, and neuropathic pain, account for the impaired physical activity.[6] Muscle wasting is a common complication of stroke. Muscle wasting and weakness after stroke contribute to physical disability.[7] Previous studies have shown that the decrease in the motor unit number in muscle tissue after stroke might be related to transsynaptic inhibition of the spinal alpha motor neurons innervating the muscle.[8] Most stroke survivors experience loss of muscle mass in both paretic and non-paretic limbs.[9] These post-stroke skeletal muscle changes are referred to as “stroke-related sarcopenia”. The prevalence of stroke-related sarcopenia ranges from 42%–53.5%.[6,10] Several pre- and post-stroke factors, such as physical inactivity, poor nutritional status, and older age, are well known to cause sarcopenia after stroke.[11]

Language disorder, or aphasia, is one of the main sequelae of stroke, occurring in 28–38% of patients with stroke.[12] Language disorder can adversely affect the activities of daily living, return to work, and quality of life in patients with stroke.[13] Furthermore, the global cognitive level is often impaired in patients with left-hemispheric stroke.[14] Previous studies have shown that cognitive impairment and sarcopenia appear to occur simultaneously in patients with stroke.[15,16] However, there are few studies on the relationship between language function and sarcopenia in stroke patients.

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This study aimed to determine the correlation between body composition and language ability in patients with left hemispheric stroke. The hypothesis of this study was that there is a relationship between body composition and language function in patients with left hemispheric stroke.

METHODS

Study participants

Patients with subacute hemiplegic stroke, admitted to a tertiary hospital for rehabilitation treatment from January 2019 to December 2021, were included in this cross-sectional, retrospective study. Patients (i) aged > 20 years, (ii) with an onset of duration < 2 years, and (iii) with left hemispheric stroke were included. Patients who did not undergo body composition or language evaluations were excluded. Clinical characteristics, including age, sex, weight, body mass index (BMI), and cognitive and language function, were assessed within 1 week of admission. This study was approved by the Institutional Review Board of the hospital, which waived the need for informed consent (IRB No. 2022-05-033).

Measurement of body composition

Bioimpedance analysis (BIA) was used to estimate the volume of fat and lean body mass. BIA is a non-invasive, portable, quick, and inexpensive method for measuring body composition. A previous study showed that the results of BIA correlated well with the predictions of magnetic resonance imaging. In this study, BIA was measured using InBody S10^{R}; InBody, Seoul, Korea.[17] The validity of bioelectrical impedance analysis has been documented in previous studies.[18,19] BMI, skeletal muscle index (SMI, kg/m^2), and body fat percentage were analyzed using BIA. SMI was calculated by dividing the limb skeletal muscle mass (kg) by the square of the height (m^2), and low muscle mass was defined as SMI <7.0 kg/m^2 in men and <5.7 kg/m^2 in women.[20]

Medical Research Council-sum score (MRC-sum score)

The MRC-sum score evaluates global muscle strength. A previous study showed that the MRC-sum score is a reliable tool for evaluating sarcopenia in patients after stroke.[21] Manual strength of the six muscle groups (shoulder abductor, elbow flexor, wrist extensor, hip flexor, knee extensor, and ankle dorsiflexor) on both sides was evaluated using the MRC scale. The summation of the scores gives the MRC-sum score, which ranges from 0 to 60.[22] In this study, The MRC-sum score and the MRC-sum score of unaffected side were evaluated.

Hand grip strength

Handgrip strength is a rapid, simple, and objective tool that is measured using a handheld dynamometer and represents global muscle strength. Hand grip strength is one of the criteria used for the diagnosis of sarcopenia.[23] The Asian Working Group for Sarcopenia (AWGS) defined low hand grip strength as <26 kg for men and <18 kg for women, using the lower 20th percentile of participants with low handgrip strength in the Asian population. [2] In this study, a hydraulic-type handheld dynamometer was used to measure hand grip strength, which can measure a grip force up to 90 kg. The needle automatically recorded the highest force exerted to provide an easy and accurate reading. In this study, hand grip strength of the unaffected side was measured.

Language function assessment

Language function was evaluated using the Western Aphasia Battery (WAB), which includes the assessment of speech content, speech fluency, comprehension, repetition, and naming. The WAB assesses linguistic ability typically affected by aphasia and is designed for use with those with neurological impairments.[24] It can determine the presence, type, and severity of aphasia. It describes the severity of aphasia as the aphasia quotient (AQ).[25] The WAB was administered by an experienced speech therapist.

Functional ability and cognitive function assessment

Functional ability was assessed using the National Institute of Health Stroke Scale (NIHSS), functional independence measure (FIM), and modified Barthel index (MBI) scores. The FIM assesses six areas of function (self-care, sphincter control, transfers, locomotion, communication, and social cognition) that fall under two domains (motor and cognitive). The NIHSS, MBI, and FIM scores were evaluated at the time of the language function assessment. The NIHSS and FIM scores were evaluated by an experienced physical medicine and rehabilitation doctor, and the MBI score was evaluated by an experienced occupational therapist.

For the evaluation of cognitive function, Mini-Mental State Examination (MMSE) and Clinical Dementia Rating (CDR) were used. The MMSE and CDR were performed by an experienced occupational therapist.

Statistical analysis

Statistical analysis was performed using SPSS 20.0 for Windows. Descriptive values were expressed as mean ± standard deviation. A partial correlation analysis was used to assess the association between body composition and cognitive function, language function, and activities of daily living. Scatter plots were constructed by plotting the outcomes against the regression. Multiple regression analysis was used to assess the relationship between body composition and language function, after adjusting for age and sex. Statistical significance was set at $p < 0.05$.

RESULTS

Clinical characteristics of the participants

A total of 54 patients with subacute left hemispheric stroke were identified. The demographic, clinical, cognitive, language, and functional characteristics of the participants are summarized in Table 1.

Correlation analysis of body composition and language function

AQ score of the WAB was significantly correlated with SMI (r=0.286, p=0.036), body fat percentage (r=-0.320, p=0.018), MRC-sum score (r=0.504, p=0.000), MRC-sum score of unaffected side (r=0.331, p=0.014), and hand grip strength (r=0.365, p=0.024). However, there was no

Table 1: Clinical characteristics and anthropometric data of the subjects

No. of patients			54
Demographics	Sex (Male:Female)		30:24
	Age (years)		64.24±78.13
	Etiology	Ischemic	29
		Hemorrhage	25
	Days since stroke onset		66.24±78.13
	Hand preference(Rt:Lt:Both)		50: 2: 2
Brain Imaging	Location (Cortical: Subcortical: Both)		19:26:9
	Size (Large: Lacunar)		49: 5
	ASPECTS score		7.76±1.57
Functional	NIHSS		12.17±3.95
	MBI		41.57±28.00
	FIM (total)		52.42±23.19
	FIM (motor)		35.52±17.69
	FIM (cognition)		16.69±9.93
Sarcopenia related	Weight (kg)		65.12±13.78
	Body mass index (kg/m^2)		24.12±3.90
	Hand grip strength (kg)		19.80±10.78
	MRC sum		41.31±10.77
	MRC sum in unaffected site		27.87±4.84
Cognitive	K-MMSE		11.70±9.28
	CDR		1.80±1.28
Language	KWAB (AQ)		46.09±34.92

Values are mean ± standard deviation

NIHSS, National Institute of health stroke scale; MBI, Modified Bathel index; FIM, Functional Independence Measure; MRC sum, Medical Research Council-sum score; K-MMSE, Korean version of mini mental state examination; CDR, Clinical Dementia Rating; KWAB, Korean version of the Western Aphasia Battery.

significant relationship between the AQ score and BMI (Table 2). We additionally analyzed the relationship between body composition and the subdomains of language function (Table 3). Speech content was significantly correlated with body fat percentage (r=-0.298, p=0.029), MRC-sum score (r=0.542, p=0.00), MRC-sum score of unaffected side(r=0.367, p=0.006), and hand grip strength (r=0.365, p=0.024). Speech fluency was significantly correlated with SMI (r=0.290, p=0.034), body fat percentage (r=-0.283, p=0.038), MRC-sum score (r=0.505, p=0.00), MRC-sum score of unaffected side (r=0.411, p=0.002), and hand grip strength (r=0.422, p=0.008). Comprehension significantly correlated with SMI (r=0.302, p=0.026), body fat percentage (r=-0.380, p=0.005), MRC-sum score (r=0.516, p=0.000), MRC-sum score of unaffected side (r=0.368, p=0.006) and hand grip strength (r=0.353, p=0.030). Repetition was significantly correlated with SMI (r=0.278, p=0.042), body fat percentage (r=-0.309, p=0.023), MRC-sum score (r=0.380, p=0.005), and hand grip strength (r=0.350, p=0.031). Naming was significantly correlated with the MRC-sum score (r=0.450, p=0.001). SMI, MRC-sum score, and hand grip strength were positively correlated with language function; however, body fat percentage was negatively correlated with language function (Table 3). The scatter plot between body composition, including SMI, body fat percentage, MRC-sum score, and hand grip strength, and the AQ score showed a linear correlation (Figure 1).

After adjusting for age and sex, the multiple regression analysis showed that the AQ score was significantly correlated with SMI (R^2=0.082, p=0.036). The equation is as follows:

$$AQ = -1.506+ 6.294*SMI$$

Correlation analysis of body composition and functional ability

The MRC-sum score was significantly correlated with MBI (r=0.83, p=0.00) and the total FIM score (r=0.792, p=0.000) (Table 2). Hand grip strength was significantly correlated with the total FIM score (r=0.410, p=0.012). The motor subscale score of the FIM significantly correlated with the MRC-sum score (r=0.730, p=0.000) and MRC-sum score of unaffected side (r=0.428, p=0.002), whereas the cognitive subscale score significantly correlated with body fat percentage (r=-0.304, p=0.036), MRC-sum score (r=0.511, p=0.000), and hand grip strength (r=0.427, p=0.008).

The lesion location and size of stroke could affect the result. In the partial correlation analysis, age, sex, lesion location, lesion size, and ASPECTS score were set as control variables and the analysis was performed (Table 4). MRC sum score was significantly correlated with MMSE (r=0.427, p=0.015), CDR(r=-0.391, p=0.027), MBI (r=0.804, p=0.000), total FIM score (r=0.710, p=0.000) and AQ score of WAB (r=0.512, p=0.003). And MRC sum score of unaffected side was significantly correlated with MBI (r=0.471, p=0.006), total FIM score(r=0.361, p=0.043), AQ score of WAB (r=0.490, p=0.004). And hand grip strength was significantly correlated with MMSE (r=0545, p=0.001), CDR(r=--0.443, p=0.011), MBI (r=0.385, p=0.030), total FIM score (r=0.468, p=0.007) and AQ score of WAB (r=0.421, p=0.016) (Table 4).

Table 2: Partial correlation coefficient (r) between body composition and cognitive and language ability

Variable	MMSE		CDR		MBI		FIM_total		WAB_AQ	
	r	***p***	**r**	***p***	**r**	***p***	**r**	***p***	**r**	***p***
BMI	-.049	.734	.062	.674	-.033	.822	-0.015	0.917	-.004	.978
SMI	**.287**	**.044***	-.257	.074	.234	.105	0.225	0.123	**.286**	**.036***
Body Fat percentage	**-.350**	**.013***	**.328**	**.021***	-.246	.089	-0.225	0.123	**-.320**	**.018***
MRC Sum	**.507**	**.000***	**-.567**	**.000***	**.833**	**.000***	**0.792**	**0.000***	**.504**	**.000***
MRC Sum (Unaffected)	**0.302**	**0.033***	**-0.371**	**0.009***	**0.500**	**0.000***	**0.457**	**0.001***	**0.331**	**.014***
Hand grip strength	**.490**	**.002***	**-.463**	**.003***	.304	.064	**0.410**	**0.012***	**.365**	**.024***

BMI, Body mass index; SMI, Skeletal muscle index; MRC sum, Medical Research Council-sum score; MMSE, mini mental state examination; CDR, Clinical Dementia Rating; MBI, Modified Bathel index; FIM, Functional Independence Measure; KWAB, Korean version of the Western Aphasia Battery; AQ, Aphasia Quotient.

* *p* –value <0.05

Table 3: Partial correlation coefficient (r) between body composition and language function

Variables	WAB(AQ)		Speech Content(AQ)		Speech Fluency(AQ)		Comprehension(AQ)		Repetition(AQ)		Naming(AQ)	
	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*
BMI	-.004	.978	.003	.983	.050	.722	-.049	.727	-.012	.934	-.012	.934
SMI	**.286**	**.036***	.254	.064	**.290**	**.034***	**.302**	**.026***	**.278**	**.042***	.204	.139
Body Fat percentage	**-.320**	**.018***	**-.298**	**.029***	**-.283**	**.038***	**-.380**	**.005***	**-.309**	**.023***	-.238	.083
MRC Sum	**.504**	**.000***	**.542**	**.000***	**.505**	**.000***	**.516**	**.000***	**.380**	**.005***	**.450**	**.001***
MRC Sum (Unaffected)	**.331**	**.014***	**.367**	**.006***	**.411**	**.002***	**.368**	**.006***	0.249	0.707	.213	.129
Hand grip strength	**.365**	**.024***	**.365**	**.024***	**.422**	**.008***	**.353**	**.030***	**.350**	**.031***	.271	.100

BMI, Body mass index; SMI, Skeletal muscle index; MRC sum, Medical Research Council-sum score; KWAB, Korean version of the Western Aphasia Battery; AQ, Aphasia Quotient.

* p –value <0.05

Table 4: Partial Correlation Coefficient (r) between Body Composition and Cognitive and Language Ability When Lesion Location and Size, ASPECTS were set as Control Variables

Variable	MMSE		CDR		MBI		FIM_total		WAB_AQ	
	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*
SMI	0.231	0.204	-0.091	0.621	0.078	0.670	0.110	0.548	0.310	0.084
Body Fat percentage	-0.204	0.2652	0.217	0.232	-0.260	0.151	-0.226	0.214	-0.142	0.437
MRC Sum	**0.427**	**0.015***	**-0.391**	**0.027***	**0.804**	**0.000***	**0.710**	**0.000***	**0.512**	**0.003***
MRC Sum(Unaffected)	0.292	0.105	-0.322	0.072	**0.471**	**0.006***	**0.361**	**0.043***	**0.490**	**0.004***
Hand grip strength	**0.545**	**0.001***	**-0.443**	**0.011***	**0.385**	**0.030***	**0.468**	**0.007***	**0.421**	**0.016***

BMI, Body mass index; SMI, Skeletal muscle index; MRC sum, Medical Research Council-sum score; MMSE, mini mental state examination; CDR, Clinical Dementia Rating; MBI, Modified Bathel index; FIM, Functional Independence Measure; KWAB, Korean version of the Western Aphasia Battery; AQ, Aphasia Quotient.

* *p* –value <0.05

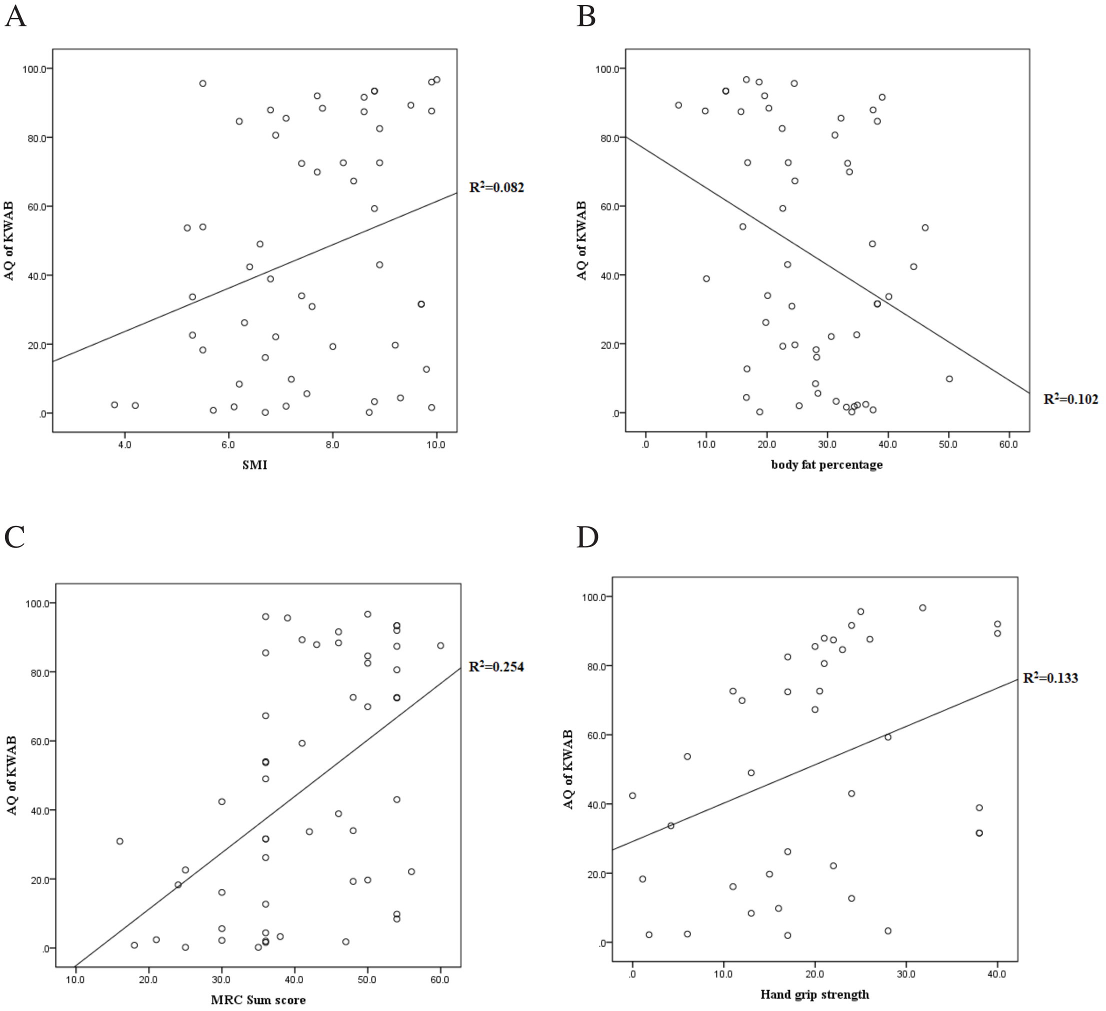

Figure 1. The scatter plot between the AQ of WAB and (A) SMI, (B) body fat percentage, (C) MRC sum score and (D) hand grip strength.

Correlation analysis of body composition and cognitive function

SMI was significantly correlated with the MMSE score (r=0.287, p=0.044). Body fat percentage was positively correlated with CDR (r=0.328, p=0.021), and negatively correlated with MMSE (r=-0.35, p=0.013) and the cognitive subscale score of FIM (r=-0.304, p=0.036). The MRC-sum score was positively correlated with the MMSE score (r=0.51, p=0.00) and cognitive subscale score of FIM (r=-0.511, p=0.000), and negatively correlated with CDR (r=-0.567, p=0.00). Hand grip strength was positively correlated with the MMSE score (r=0.049, p=0.00) and cognitive subscale score of FIM (r=0.427, p=0.008) and negatively correlated with CDR (r=-0.463, p=0.003).

The cutoff of 24 points on the MMSE is usually used to detect cognitive impairment.[26,27] After setting the cutoff value of the MMSE score to 24 points, the presence or absence of cognitive impairment was determined. The logistic regression analysis was conducted between the presence of the cognitive impairment and body composition (body weight, BMI, SMI, body fat percentage, MRC sum score, MRC sum score of unaffected side, hand grip strength). There was a statically significant correlation between body fat percentage and cognition by logistic regression analysis (exp (B)=1.179, p=0.011). In other words, a 1% increase in body fat percentage increases the likelihood of cognitive impairment by 1.179 times.

DISCUSSION

Sarcopenia and language impairment are common consequences of stroke; however, there is less awareness of the concurrent nature of these conditions. In this study, in a group of 54 patients with left hemispheric stroke, we found that language function was significantly correlated with SMI, body fat percentage, MRC-sum score, and hand grip strength. When analyzing the subdomains of WAB, speech fluency, comprehension, and repetition correlated with SMI, body fat percentage, MRC-sum score, and hand grip strength. SMI, MRC-sum score, and hand grip strength had a positive association with language function, whereas body fat percentage showed a negative association.

In the multiple regression analysis that we performed after adjusting for age and sex, only SMI was significantly correlated with the AQ score measured by WAB. Therefore, among the various body compositions evaluated in this study, SMI showed the highest correlation with language function in patients with left hemispheric stroke. Muscle tissue plays important functional and metabolic roles.[28] A previous study showed that SMI calculated by appendicular skeletal muscle mass, adjusted for height squared, was significantly associated with fragility or physical disability.[29] Since SMI is a value directly related to the skeletal muscle mass, SMI would have best reflected sarcopenia; therefore, SMI probably showed the highest correlation with AQ scores in this study.

The specific mechanism underlying the association between language impairment and sarcopenia could be explained via the 'common cause hypothesis.'[30,31] This theory explains the presence of an underlying mechanism that drives the association between physical and cognitive functions and the simultaneous presence of both impairments. Skeletal muscles are the main generators of the forces that execute functional tasks. However, the magnitude and temporal parameters of muscle contraction are controlled by the central nervous system. Thus, the force-generating capacity of a muscle is determined not only by its structural features but also by the neuromotor control systems mediated by the central nervous system.[32] After stroke, not only changes in brain structure related to language function but also changes in muscle structure (i.e., loss of muscle mass and quality) occur. The brain-derived neurotrophic factor (BDNF), an important neurotrophic growth factor for nervous system development and the survival of existing neurons, is considered a protective factor against stroke. An integrative review reported lower BDNF levels in patients with stroke[33]; a previous study reported that BDNF is associated with post-stroke aphasia.[34] Another study found that BDNF levels increase during motor rehabilitation after stroke.[35] That is, a decrease in language function and sarcopenia would occur together with a low BDNF level after stroke. With these mechanisms, there is an association between sarcopenia and language function in patients with left-hemispheric stroke.

Cognitive impairment and sarcopenia appear to be reported simultaneously in stroke patients, indicating the likely parallel progression of comorbid sarcopenia and cognitive decline.[16] In this study, the CDR, MMSE score, and cognitive subscale score of the FIM were correlated with hand grip strength, consistent with the results of previous studies.[31] A previous study explained that hand grip strength is associated with tasks that require higher neurocognitive processes, which may reflect the general health of higher brain functions and the decline in brain health.[31] Strong handgrip strength may reflect the integrity of the neuromuscular system, and higher resistance to oxidative stress and inflammation may extend to the preservation of cognitive function.[36,37] Therefore, it is important to consider handgrip strength when measuring cognitive decline in patients with left hemisphere stroke.

This study showed significant correlations between cognitive function and language function in patients with left hemispheric stroke. In this study, besides comprehension, it was found that all WAB subdomains, including fluency, repetition, and naming, were significantly correlated with cognitive function. This result is consistent with those of previous studies. The left hemisphere houses the brain regions responsible for language. Language function is an essential higher cognitive function supported by large-scale brain networks. A previous study showed that the left frontoparietal network affects not only language function but also cognitive function.[38] The superior temporal cortex (Wernicke's area) and inferior frontal cortex (Broca's area) are classically associated with language comprehension and production. The involvement of the inferior frontal cortex in aphasic patients reflects the impairment of the working memory system for semantic information, whereas the middle frontal cortex has been attributed to deficits in the general cognitive control process.[39] There was a significant correlation between cognition and language function in patients with left-hemispheric stroke. Therefore, evaluation of cognitive function and language function in patients with left hemispheric stroke is necessary.

After stroke, immobilization and dysfunctional atrophy, impaired feeding, inflammation, sympathetic overactivation, and denervation result in a decrease in muscle mass and strength, a condition described as stroke-induced sarcopenia.[40] Moreover, the loss of muscle mass after stroke is commonly accompanied by fat deposition, often associated with a common stroke risk factor, such as obesity, which worsens the outcome.[41] In this study, the SMI, MRC-sum score, and hand grip strength were positively correlated with language function; however, body fat percentage was negatively correlated with language function. In other words, an increase in skeletal muscle mass and a decrease in body fat in patients with left hemispheric stroke can help to improve not only other activities of daily living but also language function. Hence, rehabilitation treatment should be prescribed with the goal of increasing skeletal muscle mass, reducing body fat, and improving language function. Adequate nutritional support after a left hemispheric stroke is needed to improve language function and sarcopenia.

This study has several limitations. First, appropriate continuous follow-up evaluation should have been included periodically. Subsequent studies are needed to examine the relationship between the degree of improvement in language function and changes in body composition by conducting follow-up assessments in addition to initial assessments. Second, only a small number of participants were included in the study. Third, only the WAB was used to evaluate language function. This was a limitation of the retrospective nature of this study. Fourth, the gait speed, which is a representative sarcopenia measurement, was not included in this study.[31,42] Gait speed slows not only in musculoskeletal, but also in peripheral/central nervous system diseases. Walking requires motor coordination, strength, and balance, which are regulated by the cerebellum in connection with cortical associative areas (supporting higher mental function), including the prefrontal cortex, which regulates several aspects of fluid cognition.[31] Given these, it would be necessary to evaluate the gait speed in a follow-up study.

Language function in patients with left hemispheric stroke showed significant independent correlations with SMI, body fat percentage, and motor-related measures. However, in the multiple regression analysis adjusting for age and sex, SMI was the only measure that correlated with language function. Thus, an association was observed between these two deficits after stroke.

In summary, through this study, the improvement of the skeletal muscle index by physical performance could affect the language function by improving brain functionality. This study suggests an important point that exercise therapy should not be overlooked as increasing muscle strength helps improve aphasia in patients with left hemispheric stroke.

DISCLOSURES

Data availability: The datasets generated during and/or analyzed during the current study are available from the corresponding authors on reasonable request.

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Conflict of interest: None

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