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Relationship of Physical Impairment, function and Insulin Resistance in stroke patients

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ABSTRACT

Insulin resistance is a risk factor for stroke or recurrent stroke. Sedentary behavior increases insulin resistance. This study aimed to identify the relationship between physical impairments and functions and insulin resistance, examining which physical impairments specifically influence insulin resistance the most. The subjects of this study were 63 stroke patients. The subject's insulin resistance and physical impairments and functions were measured using the Chedoke-McMaster Stroke Assessment (CMSA) and Stroke Impairment Assessment Set (SIAS). The study results exhibited that insulin resistance is statistically significantly related to the variable of foot according to the CMSA(r=.95, p<.05) and to the variable of lower extremity sensory function (touch) in relation to the SIAS(r=.91, p<.05). This study also revealed close correlations between insulin resistance and the variables of ankle control(β=-1.05, p<.05) and low extremity tactile sensations(β=-1.82, p<.05).

***Key words**: stroke, hemiplegia, insulin resistance, physical impairment, function*

1. INTRODUCTION

In Korea, around 500,000 people annually suffer from stroke, which is the second leading cause of death [1]. The incidence rate of stroke is particularly high among elderly people. Thus, this condition is a serious medical issue in Korea, which is showing an increased trend in the aging population. Problems caused by stroke affect body structure and function as well as activity and participation [2]. From the perspective of body structure and function, stroke causes primary neurological impairments, such as hemiplegia, spasticity, and aphasia. Activity limitations are disabilities that reduce the ability to perform daily functions, such as dressing, bathing, and walking [3]. While about 14% of stroke survivors fully recover their original physical functions, 25% to 50% are known to require at least some assistance in activities of daily living. In addition, about 50% of stroke survivors develop severe long-term disabilities [4], [5]. Post-stroke individuals with mild or moderate severity have nearly 40% lower levels of cardiovascular and functional capacities than healthy individuals. Reduced motor capacity and activity due to neurological disorders, therefore, may result in sedentary behavior.

A sedentary lifestyle is characterized by long hours of seated activity in daily life and is one of the main risk factors for insulin resistance, obesity, and type 2 diabetes mellitus. Notably, physical activities contribute to about one quarter of insulin resistance [6]. Insulin resistance induces hyperglycemia by causing a disorder to glucose metabolism. In addition, insulin resistance and the subsequent hyperinsulinemia lead to increases in blood pressure and triglycerides, a decrease in high-density lipoprotein (HDL), vascular endothelial dysfunctions, and an increased risk of atherosclerosis. These conditions can eventually result in stroke and recurrent stroke [7]. The risk of stroke in the highest quartile group of insulin concentration is reported to be more than double that of the lowest quartile group,

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indicating a strong correlation between insulin resistance and the risk of stroke [8], [9]. Insulin resistance is related to the physical activities of overweight or obese people; an increase in physical activity results in a corresponding decrease in insulin resistance [10], [11]. Underweight individuals with a sedentary lifestyle also exhibit increased levels of insulin resistance [12]. Moreover, physical inactivity and insulin resistance were revealed to have a statistically significant correlation [13].

In addition to the close relationship between physical activity and insulin resistance, stroke reduces motor ability due to neurological impairments, and this eventually leads to a decrease in physical activity. Therefore, understanding the relationship between neurological disorders and physical functions in stroke patients and their insulin resistance is important for reducing the risk of stroke recurrence. In this study we aimed to understand the effects of physical impairments and functions in stroke patients with respect to insulin resistance.

2. MATERIALS AND METHODS

2.1 Participants of the study

The study's subjects were 63 patients who had been diagnosed with stroke within the past year and treated at a hospital. They also had to have no previous history of stroke or diabetes. All subjects received a full explanation of the study and agreed to participate in the test. Their general characteristics are shown in Table 1.

2.2 Method of study

To evaluate physical impairments and functions, we used the Chedoke-McMaster Stroke Assessment (CMSA) and Stroke Impairment Assessment Set (SIAS) scales. The SIAS consists of nine motor functions: tone, sensory, function, range of motion, pain, trunk function, visuospatial function, and speech and sound-side functions. The nine items are further segmented into 22 sub-items. The CMSA consists of six items of motor function: shoulder pain, postural control, arm, hand, leg, and foot. Physical disabilities comprised gross motor function and walking. Two physical therapists with clinical careers of 7 and 5 years, respectively, participated in the assessment of physical impairments and functions. They collected blood after the subjects had fasted for more than 8 hours and then measured the blood concentrations of glucose and insulin. Insulin resistance was measured using the Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) index, which factors in the concentrations of insulin and glucose: HOMA-IR = [fasting insulin (μIU/mL) × fasting plasma glucose (mmol/L)/22.5]. Insulin resistance was defined as HOMA-IR>2.6.

2.3 Method of analysis

Data were analyzed using PASW 18.0 and presented as mean and standard deviation. To examine the correlations between physical impairments and functions and insulin resistance, we used a linear regression analysis and then a multiple linear regression analysis on those variables that exhibited statistically significant results. The significance level was set at 0.05.

Table 1. General characteristics of the subjects (N=63)

Age(year)	55.98 ± 14.73
Weight(㎏)	65.54 ± 8.51
Height(m)	1.67 ± 0.08
BMI(㎏/㎡)	23.40 ± 2.20
Sex	
Male	49(77.8)
Female	14(22.2)
Onset(month)	12.62 ± 10.34
Stroke type	
Hemorrhage	44(69.8)
Infarction	19(30.2)
Paretic side	
Left	39(61.9)
Right	24(38.1)
Hypertension	
Yes	39(61.9)
No	24(38.1)
Total cholesterol(㎎/㎗)	161.22 ± 33.25

Values are N(%) or mean ± standard deviation, BMI: Body Mass Index

3. RESULTS

The CMSA and SIAS scores that denote the functional levels of insulin resistance in the subjects are shown in Table 2.

This study examined which CMSA and SIAS items were related to insulin resistance. In regard to the CMSA, the variable of foot (r=-0.95, p<0.05) exhibited a strongly negative correlation with insulin resistance. The variable of walking (r=-0.79, p<0.05) also showed a negative correlation with insulin resistance. According to the SIAS, the variable of lower extremity sensory function (touch) (r=-0.91, p<0.05) exhibited a highly negative correlation. The lower extremity sensory function (position) (r=-0.88, p<0.05) also yielded a negative correlation (Table 3).

To understand how the CMSA and SIAS items that exhibited a correlation with insulin resistance specifically influence insulin resistance, a multivariate analysis was performed. The results are shown in Table 4. In summary, the CMSA variable of foot (β=-1.05, p<0.05) and the SIAS variable of lower extremity sensory function (touch) (β=-1.82, p<0.05) exhibited statistically significant correlations with insulin resistance (Table 4).

Table 2. Insulin resistance and functional levels of the study population

Variable		Mean ± SD		
Insulin resistance		3.23±5.90		
CMSA (score)	Shoulder pain	3.81±1.54		
	Postural control	4.29±1.45		
	Arm	3.57±1.53		
	Hand	3.27±1.68		
	Leg	3.78±1.62		
	Foot	3.49±1.66		
	Gross motor function	43.63±19.88		
	Walking	15.41±8.46		
		Upper Extremity	Lower Extremity	Other
SIAS (score)	Motor function			
	proximal	2.52±1.57	2.60±1.56 2.49±1.53	
	distal	1.98±1.65	2.29±1.67	
	Tone			
	deep tendon reflexes	1.89±0.94	1.98±0.91	
	muscle tone	1.87±0.92	1.95±0.94	
	Sensory function			
	touch	1.79±1.19	1.90±1.11	
	position	1.76±1.25	1.89±1.15	
	Range of motion	1.90±0.92	1.75±0.93	
	Pain			1.70±0.90
	Trunk function			
	verticality test			2.06±1.07
	abdominal MMT			1.63±0.82
	Higher cortical function			
	visuospatial function			1.43±0.94
	speech			2.24±0.91
	Unaffected side	1.63±0.82 (grip strength)	2.14±0.82 (quadriceps MMT)	

Values are mean ± standard deviation, CMSA: Chedoke-McMaster Stroke Assessment, SIAS: Stroke Impairment Assessment Set MMT: Manual Muscle Testing

Table 3. Correlation coefficients of insulin resistance and motor function

	Insulin resistance	p
CMSA postural control	.75	.041*
leg	.70	.008*
foot	.95	.018*
walking	.79	.039*
SIAS distal upper extremity motor function	.84	.037*
proximal lower extremity motor function (hip flexion)	.82	.029*
distal lower extremity motor function (foot tap)	.84	.010*
upper extremity muscle tone	.88	.013*
lower extremity muscle tone	.73	.020*
upper extremity sensory function (touch)	.81	.020*
lower extremity sensory function (touch)	.91	.006*
upper extremity sensory function (position)	.77	.033*
lower extremity sensory function (position)	.84	.009*
upper extremity range of motion	.76	.039*

*p<.05

Table 4. Multiple linear regression analysis of the relationship between insulin resistance and selected motor function items

	Regression coefficient	Standard error	*p*
CMSA foot	-1.05	0.43	.010*
SIAS lower extremity sensory function (touch)	-1.82	0.63	.006*

Dependent variable: insulin resistance, the model r^2 is 0.545, $^*p<.05$

4. DISCUSSION

Stroke is a leading cause of long-term disabilities. Around 67% of post-stroke patients are known to experience walking dysfunctions, and about 50% of stroke survivors develop dysfunctions in movements related to daily activities [14]. Reduced motor capacity and activity cause sedentary lifestyles that can act as a risk factor for insulin resistance, which can markedly increase the risk for the occurrence of stroke. In this study we aimed to identify the factors that affect insulin resistance by examining the relationship between CMSA and SIAS items, which evaluate neurological impairments and physical functions in stroke patients and insulin resistance. Our results confirmed that insulin resistance had negative correlations with the CMSA items of foot and walking and the SIAS items of lower extremity sensory function (touch) and lower extremity sensory function (position). The CMSA item of foot and the SIAS item of lower extremity sensory function (touch) were two factors that were independently associated with insulin resistance.

Hemiparesis in stroke survivors is a persistent burden that lasts a long time [15]. Residual impairments that remain in skeletal muscle strength are correlated with the gait capacity of stroke survivors [16], [17]. In particular, adequate ankle control is an important part of walking, but insufficient power of the plantarflexors reduces gait velocity [18]. Inadequate control of ankle dorsiflexors during gait increases the swing phase time of the affected leg and the double-leg support time, which eventually slows gait velocity [19]. Compared to able-bodied individuals with comparable body weights, hemiplegic patients exhibit higher levels of energy consumption during gait due to weakened ankle muscles [20].

Sensory impairments are commonly exhibited after a stroke. Tactile impairment is more frequent than proprioceptive loss. The patients with sensory and motor impairments have poorer prognosis than those with pure motor paresis [21]. The most significant factors that affect sensory losses are reported to be gait, upper extremity recovery, balance, mobility disability, and activities of daily living [22]. An examination of the correlation between sensory losses and functions of 120 stroke patients revealed that post-stroke sensory losses were an independently negative prognostic indicator that influenced the recovery of daily activities [23]. Insufficient ankle control and tactile sensations in the lower legs result in impaired functioning. In the present study we found that such impaired functioning is an influential factor on insulin resistance as it reduces physical activity. While the association between insulin resistance and sedentary behavior has not been evaluated in previous research, a number of studies have focused on the relationship between insulin resistance and physical activity [24]-[26]. Physical activity influences insulin resistance by increasing the transport of glucose into muscle cells. Higher scores in the variables of foot on the CMSA and the lower extremity sensory function (touch) on the SIAS resulted in corresponding decreases in insulin resistance. This suggests that the variables of ankle control and lower extremity tactile sensations among physical impairments are closely related to insulin resistance. We consider these variables, therefore, to serve as important factors in treating stroke patients. The importance of physical activity with respect to the levels of disability in ankle control and tactile sensations in the lower legs of stroke patients must be emphasized and education of the respective functions needs to be provided during treatment.

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