Hyperlipidemia as a predictor of physical functioning for stroke

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Objective: Elevated cholesterol levels contribute to changes of the arterial endothelial permeability. Hyperlipidemia promotes atherosclerosis and is associated with an increased risk of stroke incidence. The purpose of this study was to investigate the effects of having a history of hyperlipidemia prior to a stroke incidence on postural balance, anticipatory dynamic postural control, gait endurance and gait performance in individuals with hemiparetic stroke.
Design: Cross-sectional study.
Methods: Fifty-two adults who were diagnosed with stroke 6 months ago or more were enrolled in this study. They were divided into two different groups according to hyperlipidemia history before stroke. All participants were assessed with the Activities-specific into Balance Confidence (ABC) scale, Berg Balance scale (BBS), Dynamic Gait Index (DGI), Timed Up and Go test (TUG), and the 6-minute walk test (6MWT). An independent t-test was used to analyze the difference between the hyperlipidemia group and non-hyperlipidemia group.
Results: After analysis, the BBS, TUG, and 6MWT scores were significantly different between the hyperlipidemia and non-hyperlipidemia group, but not the ABC and DGI scores.
Conclusions: The results of this study show that having a history of hyperlipidemia before stroke affects static and dynamic postural balance performance, anticipatory dynamic postural balance, and gait endurance in individuals with chronic hemiparetic stroke. Based on the results of this study, we also suggest treatment for hyperlipidemia should be implemented throughout the therapeutic interventions, such as pharmacological or exercise programs, in order to restore the physical function of stroke survivors.

Key Words: Gait, Hyperlipidemia, Postural balance, Stroke

Introduction

Stroke is a major global public health burden in Organization for Economic Cooperation and Development (OECD) countries and is the leading cause of permanent disabilities among adults caused by a disruption of the blood flow due to blood vessel injuries in the brain. Stroke and other cerebrovascular diseases accounted for approximately 7% of all deaths in OECD countries in 2013 [1]. Clinically, stroke survivors have a variety of focal deficits according to their brain injury areas including changes in the level of consciousness

and impairments of sensory, motor, cognitive, perceptual, and language functions [2]. Stroke survivors may suffer long-term or permanent disabilities caused by brain injury if they do not receive proper physical and cognitive training throughout rehabilitation programs [3].

A major contributory factor in stroke is atherosclerosis, which it is characterized by plaque formation with an accumulation of lipids, fibrin, complex carbohydrates, and calcium deposits on the arterial walls that leads to progressive narrowing of blood vessels [2,4]. Atherosclerosis can produce a thrombus, embolism, or conditions that yield to low

systemic perfusion pressures in the brain vessels, resulting in ischemic strokes, and small blood vessels are weakened by atherosclerosis, which may produce an aneurysm and bring about cerebral or nontraumatic spontaneous hemorrhage [2,4]. Therefore, atherosclerosis management is important in order to reduce the incidence of stroke within the public health.

One of major causes of atherosclerosis is hyperlipidemia caused by an excessive uptake of a high-cholesterol diet leading to high levels of blood lipids, especially cholesterol [5,6]. Elevated cholesterol levels contribute to changes in the arterial endothelial permeability since hyperlipidemia promotes atherosclerosis and is associated with an increased risk of stroke incidence [6]. Recently, one study investigated the influences of hyperlipidemia on the early outcome of stroke by estimating the odds ratio for the sequelae requiring care and hazard ratio for death [7]. They suggested that the outcome was favorable for patients with a history of hyperlipidemia in terms of both the remaining sequelae and hazard ratio for death. Factors that increase the incidence of the disease could have an influence on the severity of the disease in a favorable way [7]. However, they did not investigate the effects of having a history of hyperlipidemia before stroke on physical function for stroke survivors, and there is insufficient information on the effects of hyperlipidemia on physical activity performance ability following stroke, even though hyperlipidemia promotes atherosclerosis and affects both the brain and heart.

The purpose of this study was to evaluate the effects of having a history of hyperlipidemia on physical activities in persons with chronic hemiparetic stroke. We divided the subjects into two groups, including the hyperlipidemia group and non-hyperlipidemia group, to evaluate the effects of having a history of hyperlipidemia on physical activities. The hypothesis of this study was that having a hyperlipidemia history will affect the performance of physical activities, such as postural balance and gait performance in persons with chronic hemiparetic stroke.

Methods

Participants

Fifty-two persons who had been diagnosed with stroke 6 or more months ago participated in this study. The participants had been informed about the purpose and procedures of the study and had voluntarily agreed to participate. The inclusion criteria for the participants were as follows: (a) first stroke with an onset of 6 months or more, (b) no severe visuoperceptual impairment, (c) no severe somatosensory impairment, (d) the ability to maintain a sitting position in a chair for longer than 20 minutes, (e) the ability to walk independently with or without an assistive device for 10 meters, (f) the absence of any orthopedic disorders that could potentially affect the results of the study, and (g) the absence of neurological disorders except for stroke. The study protocol was approval by the Baekseok University Human Research Ethics Committee (Approval No. BUIRB-201706-HR-008), and written informed consent was obtained from all participants. Table 1 shows the common characteristics of all the participants in this study.

Procedures

This was a cross-sectional study to observe for any differences in physical function, such as postural balance efficacy

Table 1. Common characteristics of participants (N=52)

Variable	Non-hyperlipidemia group (n=37)	Hyperlipidemia group (n=15)	t	*p*-value
Age (y)	60.14 (10.76)	60.93 (12.60)	−0.231	0.819
Height (cm)	164.08 (6.80)	166.27 (7.67)	−1.012	0.316
Weight (kg)	67.31 (14.76)	63.84 (7.94)	0.858	0.395
Drug intake (n)	6.95 (2.29)	5.87 (2.39)	1.524	0.134
Post-disease duration (mo)	27.11 (26.20)	28.33 (24.36)	−0.156	0.877
MMSE (score)	27.43 (2.21)	26.07 (2.28)	2.003	0.051
Sex (male/female)	26/11	9/6	-	-
Etiology (infarction/hemorrhage)	27/10	11/4	-	-
Brunnstrom stage (4/5/6)	9/10/18	6/7/2	-	-
Paretic side (right/left)	24/13	9/6	-	-

Values are presented as mean (SD) or number only.
MMSE: Mini-Mental Status Examination.

and performance, anticipatory dynamic postural balance, and gait performance and endurance between hyperlipidemia and non-hyperlipidemia groups. First, this study divided all participants into either the hyperlipidemia or non-hyperlipidemia group according to their medical history before stroke. After applying the inclusion and exclusion criteria, 52 participants were eligible to participate in the study (37 hyperlipidemia group and 15 non-hyperlipidemia group). All participants conducted four performance-based clinical measures including the Berg Balance scale (BBS), Dynamic Gait Index (DGI), Timed Up and Go test (TUG), 6-minute walk test (6MWT), and one interview-based clinical measure, the Activities-Specific Balance Confidence (ABC) scale. All clinical measures were assessed in a calm and well-organized therapy room by two rehabilitative therapists who had a clinical experience for 10 years or more.

Outcome measures

The ABC scale is an interview-based questionnaire developed to measure the aspect of the psychological impact of postural balance impairment or falls risk. The tool is based on the self-efficacy theory reported by Tinetti *et al*. [8]. It indicates the patient's level of confidence in doing the activity without losing postural balance or becoming unsteady from choosing one of the percentage points on the scale from 0% (no confidence) to 100% (completely confident). An average percentage for each of the 16 items is calculated [9]. The cut-off score for the ABC is 67%, and was reported to have a sensitivity of 84% and specificity of 87% in a cross-sectional study on community-dwelling elderly people [10]. The tool has been shown to have excellent reliability and validity [11,12].

The BBS is a performance-based, postural balance measurement and was developed to measure postural balance among elderly persons with postural impairments by assessing their performance in functional tasks [13]. The BBS is used to objectively determine a patient's ability to safely balance during a series of predetermined tasks. It is a 14-item list with each item consisting of a 5-point ordinal scale ranging from 0 (the lowest level of function) to 4 (the highest level of function) and takes approximately 20 minutes to complete [13]. This tool has been reported to have excellent reliability and validity [14].

The DGI was developed as a clinical tool to assess walking, postural balance, and risk of falls. The tool evaluates the usual steady-state walking and more challenging dynamic gait performances. Eight functional gait tests are performed by the patient [2]. The tool is graded on a four-point ordinal scale, ranging from 0 (the lowest level of function) to 3 (the highest level of function), with 24 as the total possible individual score. Scores of 19 or less have been related to increase risk of falls and scores of 22 or more have been related to safe ambulation. Equipment needed is a shoebox, cones, stairs, and a walkway (20 feet length, 15-inch wide). The completion time of the tool is appropriately 15 minutes [2]. The DGI shows sufficient validity, responsiveness, and reliability for the assessment of gait performance in persons with stroke undergoing rehabilitation [15].

The TUG was developed to determine fall risk and to measure the progress of postural balance, sit-to-stand, and walking designed for elderly persons initially. Materials needed are a chair with armrests, stop watch, and tape to mark 3 meters [16]. The client starts in a seated position on a chair with armrests, stands up upon the therapist's command, "Go," walks 3 meters, turns around, walks back to the chair and sits down. The client is allowed to use an assistive device during the assessment. The participant is classified as high-risk for falling if he or she takes 14 seconds to complete the test [16]. The TUG has been reported to have excellent reliability and validity [17].

The 6MWT is a performance-based measure and a submaximal exercise test of functional exercise capacity and gait tolerance developed in 1963 by Balke [18]. The tool measures the distance covered over a time of 6 minutes as the outcome in order to be able to compare changes in performance capacity. Equipment required is a stopwatch, measuring wheel to measure distance covered, 30-meter stretch of unimpeded walkway, pulse oximeter for measuring heart rate and SpO2, and the Borg Dyspnea Scale. First of all, the evaluator places cones at either ends of the 30-meter stretch as turning points and has a chair set up on either side and halfway along the walkway. The participant is to walk as far as possible for 6 minutes. If he or she become short of breath or become exhausted, he or she is permitted to slow down, stop, and to rest as necessary [19]. The 6MWT has been reported to have excellent reliability and validity [20,21].

Statistical analysis

In order to analyze the general characteristics of the participants, descriptive statistics was used, and the frequency, percentage, mean and standard deviation values were obtained. The independent variable is the history of hyper-

lipidemia before stroke, and the dependent variables are postural balance confidence and performance, and gait performance and endurance. The independent t-test was used to compare the dependent variables between the two groups. In order to compare postural balance and gait performance between the two groups, a regression analysis was used. Data collection was analyzed using the PASW Statistics ver. 18.0 (IBM Co., Armonk, NY, USA), with a significant level set at $p<0.05$.

Results

This study analyzed postural balance and gait performance with hyperlipidemia or without hyperlipidemia history for individuals with chronic hemiparetic stroke (Table 2). The ABC, BBS, and DGI scores were higher in the non-hyperlipidemia group compared to those in the hyperlipidemia group. The TUG scores were faster in the non-hyperlipidemia group compared to the hyperlipidemia group. The distance of the 6MWT was greater in the non-hyperlipidemia group compared to the hyperlipidemia group. Although the BBS, TUG, and 6MWT were significantly different between the two groups, the ABC and DGI scores were not significantly different (Table 2). The BBS, TUG, and 6MWT were significantly different between the hyperlipidemia and non-hyperlipidemia group (Table 3).

Discussion

This study examined the postural balance confidence and performance, and gait endurance and performance in persons with chronic hemiparetic stroke who had a history or without a history of hyperlipidemia prior stroke. The main results of this study were as follows: poostural balance, anticipatory dynamic balance, and gait endurance was superior in the non-hyperlipidemia history compared to the hyperlipidemia history group.

Previous studies have reported that appropriately half of ischemic stroke patients exhibit hyperlipidemia, and patients with hyperlipidemia in turn have an elevated stroke mortality [22-24]. Hermann and Chopp [22] reported that impaired angiogenesis in stroke survivors with hypercholesterolemia parallels disturbances in synaptic plasticity, and lipid-lowering drugs are widely prescribed for individuals with stroke as secondary stroke prevention. Horenstein *et al*. [24] evaluated the risk of death caused by stroke, age, and cholesterol rate in 24.343 women with no previous history of cardiovascular diseases. They reported that cholesterol levels is a risk factor for non-hemorrhagic stroke death in women aged 55 years or less and is more powerfully associated with mortality in black women aged 55 years or less than in white women, and that cholesterol level is important in addition to established risk factors for predicting stroke mortality in young women and to guide prevention strategies. Zechariah *et al*. [25] reported that hyperlipidemia de-

Table 2. Postural balance confidence and physical functioning and gait endurance and performance (N=52)

Variable	Non-hyperlipidemia group (n=37)	Hyperlipidemia group (n=15)	t	*p*-value
ABC (score)	58.44 (27.69)	46.59 (23.65)	1.455	0.152
BBS (score)	45.41 (9.8)	39.53 (9.20)	2.046	0.049
DGI (score)	16.54 (5.75)	14.07 (5.18)	1.511	0.142
TUG (s)	25.60 (20.73)	44.29 (29.03)	−2.615	0.012
6MWT (m)	223.96 (118.47)	150.45 (86.20)	2.175	0.034

Values are presented as mean (SD).
ABC: Activities-Specific Balance Confidence, BBS: Berg Balance scale, DGI: Dynamic Gait Index, TUG: Timed Up and Go test, 6MWT: 6-minute walk test.

Table 3. Regression between hyperlipidemia and postural balance, and gait performance (N=52)

Variable	B	SE	β	t	*p*-value
BBS	−5.872	2.950	−0.271	−1.991	0.049
TUG	18.693	7.149	0.347	2.615	0.012
6MWT	−73.503	33.789	−0.294	−2.175	0.034

BBS: Berg Balance scale, TUG: Timed Up and Go test, 6MWT: 6-minute walk test.

creases vascular endothelial growth factor-induced angio-genesis, damages blood flow in the brain, and interrupts stroke recovery via decreased pericyte coverage of brain endothelial cells. They also reported that the compromised vessel formation and hemodynamics question the concept of therapeutic angiogenesis in ischemic stroke where hyperlipidemia is highly prevalent [25].

This study evaluated the effects of having a history of hyperlipidemia before stroke on physical function, such as postural balance and gait performance, in individuals with stroke. The participants chronic hemiparetic stroke survivors and received physical therapeutic interventions in rehabilitation centers since they had been diagnosed with stroke. This study divided the participants into two different groups according to their medical history of hyperlipidemia prior to stroke. The results of this study suggest that hyperlipidemia disturbs restorative recovery of postural and anticipatory dynamic postural balance as well as gait endurance following stroke. Oza *et al*. [26] reported that hyperlipidemia should be well-managed through pharmacological interventions, such as aspirin, to prevent recurrent ischemic stroke, although they did not analyze the same dependent variables of this study. Gan *et al*. [27] reported that population-based public health intervention programs and policies targeting hyperlipidemia and hypertension control and encouragement of physical activity should be high prioritized for middle-aged and older adults in order to prevent stroke.

This study was a cross-sectional observational study design, which examined the physical function between those with or without hyperlipidemia history before stroke. This study suggests future studies should further investigate the therapeutic effects of hyperlipidemia management on physical function after stroke. Based on the results of this study, having a history of hyperlipidemia showed a disturbance on postural balance, anticipatory dynamic balance, and gait endurance for individuals with chronic hemiparetic stroke.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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