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Effect of long-term resistance exercise on body composition, blood lipid factors, and vascular compliance in the hypertensive elderly men

Hyun-Sub Kim, Dae-Geun Kim*

Department of Social Sports, College of Natural Science, Dae Jeon University, Daejeon, Korea

Hypertension is designated as either essential (primary) hypertension or secondary hypertension and is defined as a consistently elevated blood pressure exceeding 140/90 mmHg. Hypertension is called "the silent killer" because it often causes no symptoms for many years, even decades, until it finally damages certain critical organs. In various causes of hypertension, obesity is an increasing health problem worldwide, and several epidemiological studies have identified a positive association between obesity and an increased incidence of hypertension. Therefore, in the present study, we investigated the effect of long-term resistance exercise on body composition, blood lipid profile, vascular compliance, and blood pressure in the elderly men. For this study, the InBody test, blood lipid profile, and analysis of vascular compliance and blood pressure were performing before and after in experiment. The twenty male subjects aged between 68 and 72 yr were recruited from the 'Y' senior towers in Korea. All subjects performed exercises on a weight training machines 40 min once a day for 52 weeks. The exercise intensity for resistance training was 60% of the 10 RM maximal voluntary contraction test. All subjects before performing resistance exercise showed an increase in hypertension following enhanced %fat, blood lipid factors (TC, LDL-C), whereas decreased lean body mass (LBM), vascular compliance. However, 52 weeks of resistance exercise suppressed %fat and LDL-C, whereas improved LBM, vascular compliance, resulting in reducing hypertensive levels in the elderly men. We suggest that resistance exercise can be a valuable tool for the remarkable improvement of hypertension.

Keywords: Hypertension, Elderly, Resistance exercise, Body composition, Blood lipid profile, Vascular compliance

INTRODUCTION

Hypertension is one of the most important public health problems affecting almost a million people around the world. Hypertension is designated as either essential primary hypertension or secondary hypertension and is defined as a consistently elevated blood pressure exceeding 140/90 mmHg. Hypertension is a common condition in which the force of the blood against artery walls in high enough that it may eventually cause health problem such as cerebrovascular disease (stroke), coronary artery disease (acute myocardial infarction), congestive heart failure (both systolic and diastolic dysfunction), and renal dysfunction (Chen et al., 2009; Wang et al., 2005). Moreover, together with hypertension, other cardiovascular risk factors, such as hyperlipidemia and/or diabetes, also contribute to the chain of events leading to atherosclerosis, vascular complications and death (Bakris, 2007; Safar et al., 2013).

To date, though the exact causes of hypertension are usually unknown, there are several factor that have been highly associated with the condition including smoking, genetic factor, sedentary lifestyle, high levels of salt intake, stress, obesity, and aging. Among them, aging is an increasing health problem, and several epidemiological studies have identified a positive association between aging and an increased incidence of hypertension (Acelajado and Oparil, 2009; Carlberg and Nilsson, 2010). It is estimated that by 2009, the total prevalence of hypertension reached approximately 5.29 million people in the Korea of adults (Korea Centers for Dis-

*Corresponding author: Dae-Geun Kim
Department of Social Sports, College of Natural Science, Dae Jeon University, 62 Deahak-ro, Dong-gu, Daejeon 300-716, Korea
Tel: +82-42-280-2114, Fax: +82-42-283-8808, E-mail: kdk0419@hanmail.net
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ease Control and Prevention, 2010). Furthermore, epidemiologic surveys have shown that the prevalence reaches 30.3%; in individuals aged 50 yr, it reaches 39.3%, aged 60 yr it reaches 55.1%, and in those over 70 yr it reaches 67.5% (Korea Centers for Disease Control and Prevention, 2010). These results showed that aging caused an increasing hypertension.

Another important characteristic of hypertension is obesity enhancing. Actually, the co-occurrence of obesity and hypertension has focused minds on understanding the pathphysiology of obesity related hypertension. Data from the Framingham Heart Study implicate obesity as a contributory factor in 60-70% of essential hypertension (Henry et al., 2012), and obese individuals have 3.5-fold increase in the likelihood of suffering from hypertension (Kotchen, 2010). According to a 2011 National Health Service survey in England, high blood pressure was recorded in 48% of men and 46% of women in the obese group, compared with around 30% of those in the overweight and 15% of those in the normal weight category (Aghamohammadzadeh and Heagerty, 2012). In addition, about 40% of hypertensive patients also have high blood cholesterol levels and factors that increase risk for coronary events in hypertensive individuals included elevated low-density lipoprotein cholesterol (LDL-C) or total cholesterol (TC), smoking, impaired glucose tolerance, and reduced high density lipoprotein cholesterol (HDL-C) (Lamina et al., 2012). The modulation of blood lipid levels would help the suppressed blood pressure. Therefore, there are minimal cost and side effects associated with lifestyle interventions, and they interact favorably with hypertension. Currently there is consensus that regular exercise is the main intervention determining the success in prevention of hypertension in adults with normal blood pressure levels and this reduction in hypertensive patients. It is well established that aerobic exercises are the most effective component in reducing blood pressure in hypertensive patients (Karagiannis et al., 2009; Pescatello et al., 2004). Its benefits are related to the metabolic muscle performance, reduced endothelial dysfunction, improvement of neuro-hormonal abnormalities and decreased insulin resistance, which results in the reduction of systemic vascular resistance, promoting a favorable effect on concomitant cardiovascular risk factors (Battagin et al., 2010; Fagard and Cornelissen, 2007). Moreover, resistance training has been less explored in this population (ACSM, 1998; Fagard, 2006). A meta-analysis on the effect of resistance training on blood pressure at rest suggests that it was carried out at moderate intensity, may be able to reduce the levels of blood pressure (Cornelissen and Fagard, 2005). Although the latest guidelines for control of hypertensive blood pressure have recommended that resistance exercise should be added to the aerobic exercise component in the physical training program targeted for hypertensive patients, it has not been widely incorporated yet into the clinical practice (Bjarnason-Wehrens, 2004; Williams et al., 2007). Additionally, it is not known whether resistance exercise of different body segments promotes distinct pressure responses.

Table 1. Physical characteristics of the subjects

Subject	Age (yr)	Height (cm)	Weight (kg)	BP (mmHg)	
				SBP	DBP
n=20	72.40±4.08	164.70±5.42	64.20±5.58	140.45±9.64	85.80±9.47

BP, blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Therefore, in the present study, we investigated the effects of long-term resistance exercise on obesity factor (body composition, blood lipid profile) and hypertensive degree (blood pressure, vascular compliance) in elderly men. For this study, the InBody test, blood lipid analysis, blood pressure, and vascular compliance analysis were performed.

MATERIALS AND METHODS

Subjects

The thirty-five male subjects aged between 68 and 72 years were recruited from the 'Y' senior towers in Korea. The exclusion criteria were past or present neurological disease and operation of various diseases. Prior to the study, the principal investigator explained all the procedures to the subjects in detail. The levels of hypertension in subjects are shown the hypertensive stage I level. Complete subject characteristics are shown in Table 1.

Experimental design

On the first day, subjects returned to the laboratory to complete baseline measurements, including the body composition test, blood lipid test, blood pressure analysis, and vascular compliance test. The subjects performed the resistance exercise for 30 min once day for 52 weeks. The follow-up testing included the same measures in the baseline testing (Fig. 1).

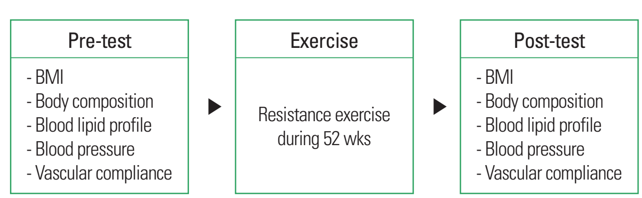

Fig. 1. Experimental design.

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Analysis of BMI and body composition

All subjects were assessed by the BMI and body composition test. In the BMI analysis, the subject heights were measured by using a wall-mounted ruler at the time of entry into the study. Body weights were measured using a digital scale before breakfast and after voiding. BMI was calculated as the weight in kilograms, divided by the height in meters squared. Body composition measurement was performed by bioelectrical impedance analysis, using InBody 4.0 (Biospace, Co., Korea). Body fat mass was calculated in percentage, and lean body mass expressed in kilogram. BMI and body composition were measured at baseline and at the last week of study.

Analysis of vascular compliance and blood pressure

Blood pressure was measured three times after the participant had rested for 5 min in a sitting position using a mercury sphygmomanometer. We used the average of second and third measurements of the systolic blood pressure and the diastolic blood pressure. Vascular compliance was determined using PWV3.0 (KM-Tec., Korea). All subjects rested for 15 min in the supine position, and measurements were taken immediately following determination of both right and left brachial arterial compliance.

Blood sampling and analysis

The blood lipid degrees for all subjects were assessed by blood sampling. Blood samples were obtained in the morning after 12 hours overnight fast. For the blood profiles, venous blood samples were collected in an EDTA-tube and centrifuged at 3,000 rpm for 15 min at 4°C. Plasma glucose was measured by a glucose oxidase method, and TC, LDL-C, HDL-C, and triglyceride (TG) levels by enzymatic procedures using an autoanalyzer (ABX Micros 60, Horiba ABX, USA).

Exercise protocol

All subjects took part in supervised progressive exercise training for 52 weeks (Table 2). Exercise sessions were observed from morning to afternoon, and lasted approximately 40 to 50 minutes. The subjects began the resistance exercise session with a warm-up including gentle lower and upper extremity stretching for 10 min during the period of this study.

Resistance training was carried out using weight training machines. The exercise intensity for resistance training was 60% of the 10 RM maximal voluntary contraction test. The order of resistance training was leg press, shoulder press, leg extension, leg curl, arm curl, back extension, abdominal flexion, and then rotary torso. Resistance training consisted of 2 sets. Also, the repetition of training initially consisted of 10 reps of each exercise.

Table 2. Resistance exercise protocol

Items	Exercise type	Intensity/Time	Period
Warm up	Stretching	10 min	5/wk
Work out	leg press shoulder press leg extension leg curl arm curl back extension abdominal flexion rotary torso	10 reps/2 sets	5/wk
Cool down	Stretching	10 min	5/wk

Statistical analysis

Data were analyzed using the IBM SPSS (ver. 20; IBM Corp., Armonk, NY, USA). Data were expressed as means ± standard errors mean (SEM). For comparisons between the pre-and the post, Wilcoxon's matched pairs test, non-parametric statistical hypothesis test, was performed. Delta differences (Δ%) of values between the pre and the post were calculated using following formula: $\Delta\% = (\text{post-pre})/\text{pre} \times 100$. Statistical significance was accepted at $P < 0.05$.

RESULTS

Effects of 52 weeks-resistance exercise on body composition in elderly men

The body composition items including BW, %fat, LBM, and BMI of all the subjects before and after resistance exercise 52 weeks were measured and their average values were shown in Table 3.

After 52 weeks, the analysis represented that average BW 0.81% increased compared with before resistance exercise was not significant ($P = 0.586$, $Z = -0.545$), %fat 3.79% decreased compared with before resistance exercise was significant ($P = 0.586$, $Z = -0.545$), LBM 2.81% increased compared with before resistance exercise was significant ($P = 0.001$, $Z = -3.221$), and BMI 0.28% increased compared with before resistance exercise was not significant ($P = 0.811$, $Z = -0.240$).

These results showed that resistance exercise during 52 weeks significantly decreased %fat in the elderly men. However, resistance exercise during 52 weeks significantly enhanced LBM in the elderly men.

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Table 3. Changes of body composition by the resistance exercise for 52 weeks

Items	Pre	Post	Δ%	Z	*P*
BW (kg)	64.20±1.24	64.70±1.25	0.81±0.73	-0.545	0.586
%Fat	24.11±0.39	23.17±0.44	-3.79±1.43	-2.227	0.023
LBM (kg)	49.97±0.75	51.34±0.74	2.81±0.74	-3.221	0.001
BMI (kg/m^2)	23.73±0.57	23.78±0.75	0.28±0.80	-0.240	0.811

BW, body weight; %Fat, percentage body fat; LBM, lean body mass; BMI, body mass index.

Effects of 52 weeks-resistance exercise on blood lipid factors in elderly men

The blood lipid items including TC, LDL-C, HDL-C, and TG of all the subjects before and after resistance exercise 52 weeks were measured and their average values were shown in Table 4.

After 52 weeks, the analysis represented that average TC 3.50% decreased compared with before resistance exercise was not significant (P=0.765, Z=-0.299), LDL-C 10.40% decreased compared with before resistance exercise was significant (P=0.028, Z=-2.203), HDL-C 4.25% increased compared with before resistance exercise was not significant (P=0.204, Z=-1.270), and TG 5.76% decreased compared with before resistance exercise was not significant (P=0.151, Z=-1.438).

These results showed that resistance exercise during 52 weeks significantly decreased LDL-C in the elderly men. However, resistance exercise during 52 weeks significantly did not change TC, HDL-C, and TG in the elderly men.

Effects of 52 weeks-resistance exercise on blood pressure and vascular compliance in elderly men

The blood pressure items including SBP and DBP, the vascular compliance items including RBAC and LBAC of all the subjects before and after resistance exercise 52 weeks were measured and their average values were shown in Table 5.

In the blood pressure after 52 weeks, the analysis represented that average SBP 6.26% decreased compared with before resistance exercise was significant (P=0.018, Z=-2.356), and DBP 5.24% decreased compared with before resistance exercise was significant (P=0.038, Z=-2.072). In vascular compliance after 52 weeks, the analysis represented that average RBAC 2.02% increased compared with before resistance exercise was significant (P=0.003, Z=-2.969), and LBAC 2.94% enhanced compared with before resistance exercise was significant (P=0.003, Z=-2.937).

These results showed that resistance exercise during 52 weeks significantly suppressed blood pressure in the elderly men. Moreover, resistance exercise during 52 weeks significantly improved vascular compliance in the elderly men.

Table 4. Changes of blood lipid factors by the resistance exercise for 52 weeks

Items	Pre	Post	Δ%	Z	*P*
TC (mg/dL)	199.66±7.25	190.80±6.96	-3.50±3.88	-0.299	0.765
LDL-C (mg/dL)	134.21±6.70	118.74±5.97	-10.40±4.47	-2.203	0.028
HDL-C (mg/dL)	50.85±1.93	53.20±2.98	4.25±3.68	-1.270	0.204
TG (mg/dL)	98.00±7.66	88.10±5.99	-5.76±5.71	-1.438	0.151

TC, total cholesterol; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; TG, triglyceride.

Table 5. Changes of blood pressure and vascular compliance by the resistance exercise for 52 weeks

Items	Pre	Post	Δ%	Z	*P*
SBP (mmHg)	140.45±2.15	131.60±3.39	-6.26±2.22	-2.356	0.018
DBP (mmHg)	85.80±2.11	79.10±2.19	-5.24±2.49	-2.072	0.038
RBAC (ms)	190.40±3.06	194.05±2.66	2.02±0.66	-2.969	0.003
LBAC (ms)	189.10±3.82	194.20±2.99	2.94±0.91	-2.937	0.003

SBP, systolic blood pressure; DBP, diastolic blood pressure; RBAC, right brachial arterial compliance; LBAC, left brachial arterial compliance.

DISCUSSION

Hypertension is an important risk factor for cardiovascular morbidity and mortality, particularly in the elderly. Treatment of hypertension reduces the risk of stroke, heart failure, myocardial infarction, all-cause mortality, cognitive impairment, and dementia in elderly patients with hypertension (Dickerson and Gibson, 2005). A healthy lifestyle helps hypertension management, with benefits extending beyond lowering of blood pressure. Generally, the therapeutic goal for patients aged from 60 to 80 yr is SBP less than 140 mmHg and a DBP less than 90 mmHg, without orthostatic hypotension. However, blood pressure elevation in the elderly is due to structural and functional changes in body that occur with aging. Therefore, finding the major causes of hypertension in elderly should be improved. Of the various causes of hypertension, obesity increases the risk of the development of hypertension. The prevalence of hypertension increases with age and is greater among obesity compared with normal weight individuals.

The increasing of body fat is caused increased cholesterol in blood. Excess cholesterol settles on the inner walls of blood vessels, narrowing them and promoting blood clots. This can slow down of even stop the flow of blood passing through the vessels. Especially, LDL-C is caused increasing level of blood pressure, resulting in the elevation of the cardiovascular disease. In meta-analysis, it is showed that a 1.0 mmol/L reduction in LDL-C is associ-

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ated with a more that 20% reduction in the risk of cardiovascular disease, and 8% reduction of hypertensive rate (Baigent et al., 2005). Meanwhile, high levels of HDL-C may have a protective role against coronary atherosclerosis, and decreasing blood pressure because of its role as a lipid scavenger involved in the reverse transport of cholesterol from the peripheral vascular compartment and tissues to the liver for excretion as bile (Lamina and Okoye, 2012).

This study showed that all subjects with high %fat and BMI were related to increasing age, whereas decreasing LBM. This has been explained secondary to the changes in appetite, food intake, energy expenditure, and body composition that normally occur with aging, with an increase in fat mass and a decrease in muscle mass (Seidell and Visscher, 2000). These results indicated that %fat and BMI caused increasing blood lipid factors, thus increasing blood pressure in the elderly men.

Large artery stiffness in the cardiothoracic region increases with age in humans. Age-related arterial stiffening is amplified among individuals with visceral obesity and other characteristics of the metabolic syndrome (Orr et al., 2009; Watson et al., 2011). In this regard, arterial stiffness can viewed as a time-integrated index of an individual's risk factor exposure. Indeed, arterial stiffness has long been regarded as an indicator of disease and is an independent predictor of cardiovascular events and mortality in both healthy and diseased populations (Watson et al., 2011). These alterations decreased the vascular compliance, and showed the enhanced arterial stiffness, resulting in increased blood pressure.

Resistance training has long been known to increase functional abilities and health status, primarily by changing body composition (Lo et al., 2012; Nindl et al., 2000) and physical performance (Fatouros et al., 2002). Moreover, resistance training can induce alterations in whole-body lean mass and fat mass, which also correspond to improved health and fitness (Nindl et al., 2000). Resistance training increases lean body mass, decreases total fat mass, and substantially increases both upper and lower body strengths (Hubal et al., 2005; Treuth et al., 1994). Furthermore, resistance exercise is known to reduce weight and maintain good body composition, decrease the TC, LDL-C, TG levels, and thus reduce the risk of cardiovascular disease among hypertensive patients (Fagard, 2006; Mota et al., 2009).

The present study showed that resistance exercise during 52 weeks alleviated the body composition compared to those before performing resistance exercise. Especially, 52 weeks resistance exercise decreased %fat levels in the body composition, whereas enhanced the LBM. In addition, 52 weeks of resistance exercise significantly suppressed LDL-C compared to before performing resistance training. And although not significant, 52 weeks of resistance exercise enhanced HDL-C level, and suppressed TC, TG levels compared to before performing resistance training. Our findings support previous reports indicating that resistance exercise improved the imbalance of body composition and blood lipid factors (Cottell et al., 2011; Gelecek et al., 2012; Hernán Jiménez and Ramírez-Vélez, 2011).

Decreasing rates of body fat and blood lipid factors has gained effect of improving functions of blood vessels. In particular, decreasing LDL-C level can be seen with improvement of vascular compliance with removal plaque in vessels. Resulting, improvement in vascular compliance reduces cardiac morbidity or mortality, and blood pressure (Balcher et al., 1999).

In the present study it was shown that 52 weeks resistance exercise significantly increased vascular compliance levels compared to those before performing resistance exercise in hypertensive elderly men. Furthermore, resistance exercise during 52 weeks significantly reduced blood pressure including SBP and DBP compared to before performing resistance exercise. These results demonstrate the suppressed blood pressure with improvement of vascular compliance following performing resistance exercise.

In this study, we evaluated the effect of 52 weeks of resistance exercise on the aging-induced alteration of hypertension, body composition, blood lipid profiles, and vascular compliance. All subjects before performing resistance exercise showed an increase in hypertension following enhanced %fat, blood lipid factors (TC, LDL-C), whereas decreased LBM, vascular compliance. However, 52 weeks of resistance exercise suppressed %fat and LDL-C, whereas improved LBM, vascular compliance, resulting in reducing hypertensive levels in the elderly men. Here in this study, we suggest that resistance exercise can be a valuable tool for the remarkable improvement of hypertension.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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