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Effects of arginine intake during weight training on blood variables

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This experiment studied the effect of arginine intake on blood pressure and blood variables during weight training in 20 men in their 20s. The resistance exercise program was performed 3 times a week at 60% of one repetition maximum for 8 weeks. The arginine intake group consumed 1,000 mg of arginine 2 tablets per day before weight training for 8 weeks. The placebo group was instructed to consume two of placebo with water, the same as the arginine intake group. After 8 weeks, the day after the end of the resistance exercise program, systolic pressure, diastolic pressure, total cholesterol, triglyceride, high-density lipoprotein, low-density lipoprotein, muscle mass, and maximum muscle strength were measured. In changes in systolic blood pressure, the arginine intake group was 118.20±2.40 mmHg, showed a statistically significant decrease compared to the placebo group. Triglyceride in the arginine intake group was 112.62±2.40 mg/dL, showing a statistically significant decrease compared to the placebo group. Based on these results, arginine intake during resistance exercise is judged to have a positive effect on lowering blood pressure, and is also believed to reduce triglycerides, a blood lipid variable, so it is thought to function as a supplement during exercise.

Keywords: Arginine, Resistance training, Blood pressure, Triglyceride

INTRODUCTION

Professional athletes as well as the general public are choosing weight training as an effective exercise to reduce body fat and pursue body aesthetics. In order to maximize the effects of weight training, the consumption of various dietary treatments and exercise performance enhancing supplements is increasing. It has been known that regular resistance exercise reduces systolic and diastolic blood pressure, and that nitric oxide is at the center of this mechanism. Adverse reactions to regular exercise occur, and ways to identify and prevent predictors of such unwarranted responses will help form the basis of individualized exercise prescriptions (Bouchard et al., 2012). Nitric oxide acts as an important factor in blood circulation and metabolic control during physical activity, while increasing circulating blood flow to skeletal muscles and heart, increasing the transport of oxygen, substrates, and regulatory hormones, and increasing glucose intake (Brett et al., 1998). It also provides benefits for energy mobilization. Nitric oxide changes carbohydrate metabolism by increasing glucose uptake and inhibiting glyceraldehyde-3-phosphate dehydrogenase, which ultimately changes glycolysis (Mohr et al., 1996).

Interest in arginine as a supplement in resistance exercise is increasing. When the concentration of arginine in the blood increases, glucagon is secreted and the use of glucose increases. At this time, research has shown that reduced glucose is supplied from the liver and glucose utilization in muscles is improved, thereby promoting muscle synthesis (Trabelsi and Lavoie, 1996). Adrenal medulla is known to be activated in response to the acute stress of heavy resistance exercise (Bush et al., 1999). The main functions of arginine are involved in protein synthesis, detoxification of ammonia formed when amino acids decompose nitrogen through the formation of urea, and various biological synthesis activities such

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as nitric oxide, glutamate, ornithine, and citrulline, and are involved in numerous metabolic pathways (Campbell et al., 2004). In addition to these physiological functions, arginine's action in the human body increases the concentration of growth hormone and acts antagonistically with insulin, which is involved in energy metabolism, increasing glycogen breakdown and sugar production, which is also known to increase the concentration of triglycerides in the blood (Jobgen et al., 2009).

In a study contrary to the above, it was reported that intravenous L-arginine infusion had no effect on heart rate and blood pressure in healthy people and patients with coronary artery disease (Brett et al., 1998). In particular, L-arginine was administered to skeletal muscles during exercise. There were no changes in skeletal muscle blood flow in the injection study (Hickner et al., 1997). It has been suggested that intravenous L-arginine administered over a short period of time does not affect blood flow in skeletal muscles.

Most of the previous studies related to arginine were conducted on animals or mainly consisted of aerobic exercise as a form of exercise, and most of the studies were conducted on patients with diseases such as obesity, high blood pressure, or diabetes, which included weight training and supplements to improve exercise capacity. It appears that there is a lack of research on arginine intake. In this study, we examined changes in blood pressure and blood variables when consuming 2,000 mg of arginine per day in general adult men using an 8-week resistance exercise program to determine whether arginine can be helpful as a supplement during resistance exercise.

MATERIALS AND METHODS

Research subjects

Twenty men in their 20s with at least 6 months of resistance exercise experience were selected. The purpose and methods of this study were explained, and they were asked to sign a consent form to participate in the experiment. The subjects were divided into an arginine intake group (n = 10) and a placebo group (n = 10) (Table 1). The effect of arginine intake on blood pressure and blood variables was examined after 8 weeks of resistance exercise. This study was approved by Eulji University (approval number, 2023-6-47).

Table 1. Physical characteristics of research subjects

Variable	Placebo group (n = 10)	Arginine intake group (n = 10)
Age (yr)	25.78 ± 0.38	26.03 ± 0.40
Height (cm)	174.50 ± 4.03	175.70 ± 3.76
Weight (kg)	71.50 ± 3.70	72.30 ± 4.17
Body fat percentage (%)	17.10 ± 6.90	17.30 ± 7.20
Body mass index (kg/m^2)	21.90 ± 4.20	21.40 ± 3.90

Values are presented as mean ± standard deviation.

Resistance exercise

The order was 10 min of warm-up, 40 min of main exercise, and 10 min of cool-down. The sports center was used 3 times a week for 8 weeks at 1 o'clock on Mondays, Wednesdays, and Fridays. The resistance exercise program was performed 3 times a week at 60% of one repetition maximum, dividing the body parts into eight areas (chest, biceps, triceps, back femoral, calf, deltoid, abdominal) and using a weight training machine and free weights in parallel. The rest interval was set to 1 min and 30 sec.

Arginine intake

The arginine (Jarrow formulas) intake group consumed 1,000 mg of arginine 2 tablets per day (one tablet each in the morning and one afternoon) before weight training for 8 weeks. The placebo group was instructed to consume two capsules (one capsule each in the morning and one afternoon) of placebo (flour 100%) with water, the same as the arginine intake group.

Determination

After 8 weeks, the day after the end of the resistance exercise program, systolic pressure, diastolic pressure, total cholesterol, triglyceride, high-density lipoprotein (HDL), low-density lipoprotein (LDL), muscle mass and maximum muscle strength were measured.

Data processing

This study used IBM SPSS Statistics ver. 23.0 (IBM Co., Armonk, NY, USA), and all calculated data were expressed as mean ± standard deviation. To verify differences between groups before and after intake, an independent-sample *t*-test was conducted. To verify differences before and after intake within the group, a paired-sample *t*-test was conducted. The level of statistical significance was set at $P < 0.05$.

RESULTS

Changes in systolic blood pressure

After implementing a resistance exercise program for 8 weeks, the change in systolic blood pressure showed that the arginine in-

Table 2. Changes in systolic blood pressure (mmHg) between and within groups before and after arginine intake

Variable	Arginine intake group (n=10)	Placebo group (n=10)	*t*	*P*-value
Before intake	120.40±2.45	120.00±2.43	0.35	0.72
After intake	118.20±2.40	120.50±3.28	-2.32	0.03*
t	2.36	-0.88		
P-value	0.04*	0.39		

Values are presented as mean±standard deviation unless otherwise indicated.
*$P<0.05$.

Table 3. Changes in diastolic blood pressure (mmHg) between and within groups before and after arginine intake

Variable	Arginine intake group (n=10)	Placebo group (n=10)	*t*	*P*-value
Before intake	70.10±1.57	69.60±1.26	0.79	0.43
After intake	68.80±1.59	69.85±1.20	-1.64	0.11
t	1.81	-0.37		
P-value	-0.10	0.71		

Values are presented as mean±standard deviation unless otherwise indicated.

take group's blood pressure was 118.20±2.40 mmHg, which was lower than the placebo group's 120.50±3.28 mmHg, indicating a statistically significant decrease ($P<0.05$). Additionally, in terms of changes within the group, the arginine intake group showed a statistically significant decrease from 120.40±2.45 mmHg before intake to 118.20±2.40 mmHg after intake ($P<0.05$) (Table 2).

Changes in diastolic blood pressure

After an 8-week resistance exercise program, the change in diastolic blood pressure in the arginine intake group was 68.80±1.59 mmHg, which was lower than the 69.85±1.20 mmHg in the placebo group, but there was no statistically significant difference ($P>0.05$). In addition, in terms of changes within the group, the arginine intake group showed a slight decrease, but there was no significant difference ($P>0.05$) (Table 3).

Changes in total cholesterol

After an 8-week resistance exercise program, the change in total cholesterol was found to decrease in both groups: 158.10±2.40 mg/dL in the arginine intake group and 162.30±3.28 mg/dL in the placebo group, but the difference was statistically significant. did not appear ($P>0.05$). In the before and after changes within the group, the total cholesterol concentration of the arginine intake group was 158.10±2.40 mg/dL compared to before intake, indicating a statistically significant decrease ($P<0.05$) (Table 4).

Table 4. Changes in total cholesterol (mg/dL) between and within groups before and after arginine intake

Variable	Arginine intake group (n=10)	Placebo group (n=10)	*t*	*P*-value
Before intake	165.80±2.45	165.60±2.43	0.07	0.93
After intake	158.10±2.40	162.30±3.28	-1.56	0.13
t	-0.21	1.31		
P-value	0.02*	0.22		

Values are presented as mean±standard deviation unless otherwise indicated.

Table 5. Changes in triglyceride between and within groups before and after arginine intake (mg/dL)

Variable	Arginine intake group (n=10)	Placebo group (n=10)	*t*	*P*-value
Before intake	118.30±2.45	117.00±2.43	0.28	0.78
After intake	112.62±2.40	119.70±3.28	-2.59	0.01*
t	1.78	-0.69		
P-value	0.10	0.50		

Values are presented as mean±standard deviation unless otherwise indicated.
*$P<0.05$.

Table 6. Changes in high-density lipoprotein (mg/dL) between and within groups before and after arginine intake

Variable	Arginine intake group (n=10)	Placebo group (n=10)	*t*	*P*-value
Before intake	50.70±2.40	51.50±2.43	-0.20	0.83
After intake	52.90±2.45	52.60±3.28	-0.80	0.43
t	-0.95	0.35		
P-value	0.36	0.79		

Values are presented as mean±standard deviation unless otherwise indicated.

Changes in triglyceride

There was a statistically significant difference in changes in triglyceride after arginine intake, with the arginine intake group being 112.62±2.40 mg/dL and the placebo group being 119.70±3.28 mg/dL ($P<0.05$). In the before and after changes within the group, the triglyceride concentration of the arginine intake group decreased compared to before intake, but there was no statistically significant difference ($P>0.05$) (Table 5).

Changes in HDL

The change in HDL was 52.90±2.45 mg/dL in the arginine intake group and 52.60±3.28 mg/dL in the placebo group. There was an increase in HDL concentration in both groups, but there was no statistically significant difference ($P>0.05$). Within-group change, a slight increase was observed in both groups, but no statistically significant difference was found ($P>0.05$) (Table 6).

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Table 7. Changes in low-density lipoprotein between and within groups before and after arginine intake (mg/dL)

Variable	Arginine intake group (n=10)	Placebo group (n=10)	*t*	*P*-value
Before intake	83.70±2.45	82.40±2.43	0.20	0.84
After intake	81.10±2.40	80.00±3.28	0.15	0.87
t	0.67	2.27		
P-value	0.05	0.04		

Values are presented as mean±standard deviation unless otherwise indicated.

Table 8. Changes in muscle mass (mg/dL) between and within groups before and after arginine intake

Variable	Arginine intake group (n=10)	Placebo group (n=10)	*t*	*P*-value
Before intake	35.26±6.08	35.16±4.48	1.68	0.06
After intake	37.41±9.51	37.36±4.17	-0.09	0.46
t	-5.24	-13.54		
P-value	0.00	1.36		

Values are presented as mean±standard deviation unless otherwise indicated.

Changes in LDL

The change in LDL showed a decrease in LDL concentration in both groups: 81.10±2.40 mg/dL in the arginine intake group and 80.00±3.28 mg/dL in the placebo group, but there was no statistically significant difference ($P>0.05$). There was a statistically significant difference in the change within the group in the placebo group ($P>0.05$) (Table 7).

Changes in muscle mass

After an 8-week resistance exercise program, the change in muscle mass showed that the arginine intake group was 37.41±9.51 kg and the placebo group was 37.36±4.17 kg, showing an increase in skeletal muscle mass in both groups, but no statistically significant difference did not ($P>0.05$). In the before and after changes within the group, the skeletal muscle mass of the arginine intake group showed a statistically significant increase compared to before intake ($P<0.05$) (Table 8).

Changes in maximum muscle strength

After an 8-week resistance exercise program, the change in maximum muscle strength was found to increase in both groups, with the arginine intake group reaching 47.40±8.71 kg and the placebo group reaching 48.10±6.76 kg, but there was no statistically significant difference ($P>0.05$). Changes before and after within the group showed a statistically significant increase in maximum muscle strength in the placebo group compared to before intake ($P<0.05$) (Table 9).

Table 9. Changes in maximum muscle (mg/dL) strength between and within groups before and after arginine intake

Variable	Arginine intake group (n=10)	Placebo group (n=10)	*t*	*P*-value
Before intake	43.40±12.93	44.10±10.32	0.81	0.21
After intake	47.40±8.71	48.10±6.76	0.95	0.18
t	-8.94	-4.67		
P-value	4.49	0.00		

Values are presented as mean±standard deviation unless otherwise indicated.

DISCUSSION

In 1980, Furchgott and Zawadzke discovered that endothelium-derived relaxing factor (EDRF) dilated when exposed to the muscarinic agonist acetylcholine (Arcaro et al., 2002). Under physiological conditions, the endothelium exerts a vasoprotective effect, but endothelial dysfunction is known to contribute to atherosclerotic vascular disease (Lüscher and Noll, 1995). Nitric oxide, called EDRF, is an unstable molecule with a short half-life. Nitric oxide is synthesized within cells from the amino acid L-arginine, molecular oxygen, nicotinamide adenine dinucleotide phosphate hydrogen, and other factors by nitric oxide synthase (NOS), a NOS, and citrulline is produced as a by-product. There are three main types of NOS: inducible NOS, endothelial NOS, and neuronal NOS.

Blood pressure changes depending on cardiac output, blood vessel diameter, and circulating blood flow. During exercise, blood flow resistance increases due to arterial constriction, so the heart increases heart rate to produce more stroke volume, ultimately resulting in an increase in blood pressure. Oral administration of 6 g of L-arginine per day for 3 days improved exercise capacity (Ceremużyński et al., 1997). It is known that the mechanism of blood pressure reduction due to resistance exercise is that the liquid component of the plasma moves into the interstitial area after exercise, resulting in a decrease in plasma volume and thus a decrease in stroke volume (Bush et al., 1999). Reduced stroke volume reduces the preload of the heart and increases the afterload, which reduces cardiac output and thus reduces blood pressure. Nitric oxide has a high diffusion capacity, is easily soluble in lipid layers, and exists in gaseous or dissolved form in the body. Nitric oxide is produced by the main enzyme, L-arginine, and is a substance that relaxes vascular endothelial cells and can suppress the rise in blood pressure. It is known to cause vasodilation and increase exercise performance (Tousoulis et al., 2006). Dietary arginine supplementation may provide a useful treatment option to shift nutrient distribution to promote muscle mass, improve metabolic profile in diet-induced obese rats, and reduce body white fat (Jobgen et al., 2009).

In this study, after taking arginine and performing a resistance exercise program for 8 weeks in men in their 20s, the change in systolic blood pressure showed that the blood pressure of the arginine intake group was 118.20±2.40 mmHg, which was lower than the 120.50±3.28 mmHg of the placebo group, showed a statistically significant decrease. In this experiment, it is believed that a decrease in blood pressure occurred due to the effects of vascular relaxation and improved blood flow due to the intake of arginine. Neutral fat is a major energy source, accounts for approximately 95% of blood lipids, and is known to be a risk factor for coronary artery disease (Durstine et al., 2002). In this study, after consuming arginine and performing a resistance exercise program for 8 weeks in men in their 20s, the change in triglyceride in the arginine intake group was 112.62±2.40 mg/dL, which was statistically significant compared to 119.70±3.28 mg/dL in the placebo group showed a decrease.

As mentioned above, it is believed that arginine intake after 8 weeks of resistance exercise lowered blood pressure and reduced triglyceride, thus functioning as an exercise supplement.

CONFLICT OF INTEREST

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

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