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THE INTAKE OF SOYBEANS AND SOYBEAN PRODUCTS IS MOST EFFECTIVE FOR THE PREVENTION OF VASCULAR AGING IN THE JAPANESE MIDDLE-AGED AND ELDERLY

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Abstract: *Background:* Vascular aging is the main pathogenic factor for heart and cerebrovascular disease. It is a critical challenge to prevent vascular aging in the rapidly aging Japanese society. *Objective:* This study was carried out to examine the impact of dietary habits on the progression of vascular aging in middle-aged and elderly Japanese individuals. *Participants:* Subjects were 16 healthy males and females aged 63 to 72 years who gave consent to participate in the present study. *Measurements:* Vascular aging was evaluated by the second derivative of the fingertip photoplethysmogram, and the subjects were divided into two groups: Group I (vascular age was older than actual age) and Group II (vascular age was younger than actual age). Subjects took photos of all food dishes consumed for 7 days to investigate their dietary habits. We collected information of types of foods and the amounts from the photos, and entered this information into a Food Frequency Questionnaire based on Food Group (FFQg) to analyze the data. *Results:* Group II showed significantly greater ($p < 0.05$) intakes of polyunsaturated fatty acids (Group I, 10.3 ± 1.9 g/day; Group II, 13.2 ± 2.0 g/day), n-3 fatty acids (Group I, 2.3 ± 0.4 g/day; Group II, 2.7 ± 0.3 g/day), and n-6 fatty acids (Group I, 7.9 ± 1.6 g/day; Group II, 10.5 ± 1.9 g/day). Despite no significant difference in the intake of seafood (Group I, 95.4 ± 33.7 g/day; Group II, 98.8 ± 29.5 g/day) containing large amounts of n-3 fatty acids, Group II showed a significantly greater ($p < 0.05$) intake of soybeans and processed soybean products (90.9 ± 32.7 g/day) than Group I (52.9 ± 24.8 g/day). *Conclusion:* Intake of soybeans and processed soybean products was considered most effective in preventing the progression of vascular aging in the middle-aged and elderly subjects who participated in this study.

Key words: Soybeans, vascular aging, dietary habits, second derivative of photoplethysmogram.

Introduction

According to statistics published by the Ministry of Health, Labour and Welfare in 2012, heart disease is a leading cause of death in Japan, of which the main pathogenic factor is vascular aging (VA) including atherosclerosis. In the rapidly aging Japanese society, it is a critical challenge to prevent excessive VA in extending life expectancy of the elderly. It is well known that VA is promoted by lipid metabolism disorders, diabetes, hypertension and other factors related to a person's lifestyle (1). Because dietary habits exacerbate other risk factors, these habits are one of the most important factors for the progression of VA; thus, it is urgently required to clarify the effects of dietary habits on the progression of VA. Numerous epidemiological studies have been carried out to investigate the relationship between dietary intake and heart disease (2–5). Additionally, many animal studies have reported the influence of dietary intake on lipid metabolism (6–8). However, only a few studies have examined the direct effects of dietary intake on the progression of VA in humans (9–11). Our study attempted to examine the impact of dietary habits on the progression of VA by measuring fingertip plethysmogram wave form. The measurement of the second derivative of photoplethysmogram (SDPTG) (12–14) is considered a useful, non-invasive method to evaluate arterial stiffness and VA. We attempted to show that the intake of soybeans and processed soybean products, which are traditional Japanese foods, were effective in reducing VA.

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Methods

This study was approved and carried out according to the guidelines of the ethics committee of human research of Kobe Women's University. The subjects gave written consent to participate in the study. This study was carried out in June, 2012.

Subjects and vascular age

Subjects in the present study were 16 healthy middle-aged and elderly individuals (6 males and 10 females) aged 63 to 72 years (65.7 ± 2.9), who were enrolled in an adult education program in the Kansai District of Japan. SDPTG wave form was measured at the fingertip with the BC Checker Ver.10.00 (Future Wave, Inc., Tokyo, Japan). The subject put the right forefinger on this devise for about 20 second. The machine measured the amount of light absorbed by hemoglobin reflecting blood flow, and analyzed SDPTG wave form of the fingertip which reflects arterial stiffness (12–14). Then the device showed vascular age. Subjects were categorized in two groups: Group I, in which the vascular age was older than the actual age; and Group II, in which the vascular age was younger than the actual age.

Nutritional analysis

For the investigation of dietary habits, subjects were requested to take photographs of their breakfasts, lunches, dinners, and snacks for 7 consecutive days immediately before eating and with scales that show the approximate volumes of foods. Subjects were requested to take notes when they left dishes unfinished. An example of one of the photos is shown in Figure 1. We made a list of all the food materials and amounts of foods measured by the scale beside the dishes and entered the necessary information collected from the pictures into the software Food Frequency Questionnaire based on Food Group (FFQg; Kenpaku-Sha, Tokyo, Japan) (15) to analyze food intake and nutritional values.

Statistical analysis

Food groups and nutritional values were compared between the two groups. Two-tailed student's t-test, followed by the F-test checking variance, was performed and $p < 0.05$ was considered significantly different.

Results

Subjects in Group I and Group II

Table 1 shows subjects' mean ages, body mass indexes (BMI) and the difference between vascular age and actual age for each group. Mean age (Group I, 66.1 ± 3.5 years; Group II, 65.3 ± 2.1 years) and BMI (Group I, 22.8 ± 5.9 kg/m^2; Group II, 22.9 ± 2.0 kg/m^2) showed no significant difference between the two groups. The difference between vascular age and actual age in Group I was 4.4 ± 3.8, while that of Group II was 13.1 ± 9.7.

Table 1
Age, body mass index (BMI) and the difference between vascular age and actual age

	Group I	Group II
Age	66.1±3.5	65.3±2.1
BMI (kg/m^2)	22.8±5.9	22.9±2.0
(Vascular age) − (Actual Age)	4.4±3.8	− 13.1±9.7

Nutrition intake

Figure 2 shows protein, fat and carbohydrate in the diet by percentage of energy (PFC ratio). No significant difference was found between the two groups. Table 2 displays the intake of nutrients that affect the progression of VA by group. Group II had significantly greater intakes ($p < 0.05$) of polyunsaturated fatty acids (Group I, 10.3 ± 1.9 g/day; Group II, 13.2 ± 2.0 g/day), n-3 fatty acids (Group I, 2.3 ± 0.4 g/day; Group II, 2.7 ± 0.3 g/day), and n-6 fatty acids (Group I, 7.9 ± 1.6 g/day; Group II, 10.5 ± 1.9 g/day). There was no significant difference between the two groups in the intake of saturated fatty acids, monounsaturated fatty acids, cholesterol and dietary fiber.

Table 2
Intakes of nutrients which affect the progression of vascular aging in each group

	Group I	Group II
Saturated fatty acid (g/day)	15.0± 2.9	15.5± 3.4
Monounsaturated fatty acid (g/day)	16.4± 3.8	19.1± 4.4
Polyunsaturated fatty acid (g/day)	10.3± 1.9	13.2± 2.0*
Cholesterol (mg /day)	313.6±58.5	342.4±88.6
n-3 fatty acid (g/day)	2.3± 0.4	2.7± 0.3*
n-6 fatty acid (g/day)	7.9± 1.6	10.5± 1.9*
Dietary fiber (g/day)	13.0±2.3	13.4±2.0

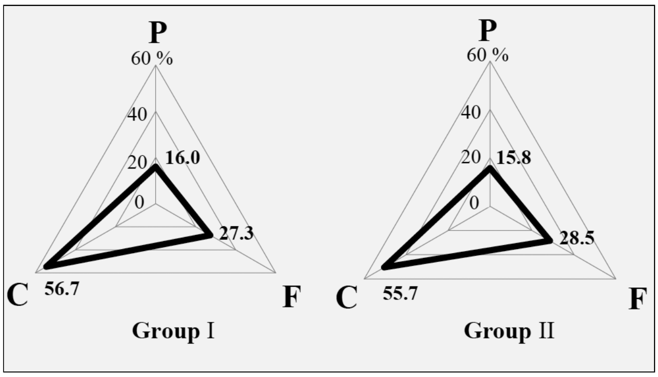
Values are mean±S.D. Group II showed significantly greater intakes in polyunsaturated fatty acids, n-3 fatty acids and n-6 fatty acids (*$p<0.05$).

Food group

As shown in Table 3, Group II had a significantly greater intake ($p < 0.05$) of soybeans and processed soybean products than Group I (Group I, 52.9 ± 24.8 g/day; Group II, 90.9 ± 32.7 g/day). However, there was no significant difference between the two groups in the intake of seafood (Group I, 95.4 ± 33.7 g/day; Group II, 98.8 ± 29.5 g/day). Intake of cereals, meats, and sweets in Group II was higher than in Group I, and the intake of tubers, green and yellow vegetables, seaweed, and dairy in Group I was higher than in Group II. However, there was no significant difference.

Figure 1
One of the photographs of meal taken by a subject. Subjects took photos of all the dishes for consecutive 7 days

Figure 2
Protein, fat and carbohydrate in the percentage of energy (PFC ratio)



Discussion

In this study, the progression of VA was assessed with SDPTG. This measuring method is known as a useful, non-invasive way to evaluate arterial stiffness and VA (12–14). Measurement results can be considered reliable with strict adherence to the instructions, e.g., measuring while subjects relax under quiet circumstances to exclude functional vessel wall induration and placement of the fingertip on the device while keeping the elbow stable on the table.

The FFQ method is occasionally considered to lack reliability for the investigation of nutrient intake, and is useful only for epidemiological study in which meal intakes are based only on the subject's memory. FFQg was developed from FFQ by Takahashi et al. in 2001 (15). In this method, the analysis of food intake is based on 29 food groups, the portion of food is categorized into 3 sizes, and an estimation of the subject's energy and nutrient intake can be considered useful. Furthermore, in this study, we attempted to improve the accuracy of the FFQg method by having subjects take photographs of actual meals for 7 days. We considered that this new analytical method was effective in investigating dietary habits of the middle-aged and elderly.

Table 3
Food groups taken by subjects

	Group I (g/day)	Group II (g/day)
Cereals	338.3±45.7	354.0±118.3
Tubers	41.7±39.1	30.9±19.4
Green and yellow vegetables	113.3±63.5	72.6±23.1
Other vegetables mushrooms	125.4±36.8	123.7±42.1
Seaweed	6.9±6.0	4.1±3.0
Soybeans and processed soybean products	52.9±24.8	90.9±32.7*
Seafood	95.4±33.7	98.8±29.5
Meats	43.7±25.1	58.1±33.9
Eggs	33.3±13.6	36.1±21.9
Dairy	158.9±65.2	103.9±59.1
Fruits	101.0±24.2	103.6±56.5
Sweets	29.9±19.4	38.1±39.5
Sugar	10.0± 3.5	10.8± 3.4
Nuts	4.9±7.3	5.3±14.1

Values are mean±S.D. Intake of soybeans and processed soybean products in Group II was significantly greater than in Group I (* $p<0.05$).

There was no significant difference in PFC ratios between groups, and the dietary habits of both groups are considered well balanced. However, Group II had significantly greater intakes in polyunsaturated fatty acids, n-3 fatty acids, and n-6 fatty acids. Harris et al. (16) reported that 5 to 10% of energy from n-6 fatty acids was considered to reduce heart disease and the lower intake than this level might increase the risk for heart disease. In this study, energy ratio from n-6 fatty acids in Group I was 4.4%, and that in Group II was 5.3% (data not shown). Therefore, the energy ratio of Group II was considered to be within the heart disease preventive range. Because it is well known that intake of n-3 fatty acids prevent atherosclerosis and heart disease (17–19), significantly greater intake of n-3 fatty acids in Group II played a role in preventing arterial stiffness and VA in this study.

Despite a significant difference between two groups in the intake of n-3 fatty acids, no significant difference was found in the intake of seafood containing large amounts of n-3 fatty acids. However, Group II had a significantly greater intake of soybeans and processed soybean products than Group I. n-3 fatty acids of soybean origin in Group II were shown to be effective in preventing VA. A number of studies related to dietary soy have reported that soy protein with isoflavone would play a crucial role in the prevention of atherosclerosis, including lowering LDL-cholesterol in the serum, reducing inflammation and oxidation, and lowering blood pressure by enhancing the release of nitric oxide from endothelial cells (20–24).

These protective effects of soy protein and/or isoflavone against the formation of atherosclerosis lead to the prevention of coronary heart disease. We did not evaluate the progression of atherosclerosis in each subject, but we measured SDPTG, which closely estimates arterial stiffness indicating atherosclerosis. Therefore, these effects of dietary soy were considered to reduce VA in Group II in the present study.

We conclude that soybeans and many kinds of processed soybean products (e.g., tofu, fried tofu, natto, dried bean curd, soybean paste (miso), and soy sauce), traditional Japanese foods, were most effective for the prevention of VA. Dietary soy was more effective than seafood, and would promote healthy aging in Japanese society, which has attained the best longevity in the world in 2013. We realize this is a very limited study, but we hope it will stimulate further thinking and research on the role of soybeans in diet. We intend to increase the number of subjects and carry out more detailed studies in the future to confirm our current findings.

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