Possible Effects of Diets on Serum Lipids, Fatty Acids and Blood Pressure Levels in Male and Female Japanese University Students

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Abstract

Objectives: To prepare a dietary recommendation for young Japanese for the prevention of coronary heart disease, we surveyed the dietary habits, serum lipids, serum fatty acids and blood pressure levels among male and female students.

Methods: In this study, 175 male and 246 female university students were interviewed for the frequency of consumption of selected food items and the habit of skipping breakfast. Serum fatty acids were analyzed by gas chromatography.

Results: The frequencies of consumption of dishes cooked with oil and intake of vegetables were higher in female students than in male students. Serum n-6 polyunsaturated fatty acids were slightly higher in female students than in male students while that of serum n-3 polyunsaturated fatty acids was 6.4% in both sexes. For both males and females, those who skipped breakfast at least once a week were less likely to consume vegetables and fruits than those who did not. Female students who skipped breakfast were also less likely to consume fish and had lower composition of n-3 polyunsaturated fatty acid and higher systolic and diastolic blood pressure levels than males. For female, the intake of milk and dairy products correlated inversely with systolic blood pressure levels and the intake of n-3 polyunsaturated fatty acids correlated inversely with diastolic blood pressure levels. For males, the intake of fruits and consumption of dishes cooked with oil correlated inversely with systolic and diastolic blood pressure levels.

Conclusion: Our findings suggest that increased intake of fish, milk and dairy products, fruits and vegetables from early adulthood and a regular dietary pattern are important to reduce the risk factors for coronary heart disease.

Key words: diets, lipids, fatty acids, coronary risk factors, students

Introduction

In addition to regulation for serum lipids (1, 2), high serum levels of n-3 polyunsaturated fatty acids (3, 4) and balance of n-3 and n-6 fatty acids (5, 6) have a beneficial effect by preventing

coronary heart disease through inhibition of platelet aggregation and lowering of blood pressure levels. In a series of studies, we reported that fish consumption increased the proportion of serum n-3 polyunsaturated fatty acids (7–10). Furthermore, prospective studies in western countries confirmed the protective effect of fish consumption against coronary heart diseases (11) and ischemic stroke (12). A Japanese study also showed that high concentrations of serum n-3 polyunsaturated fatty acid was associated with a lower risk of coronary heart disease among middle-aged men (13).

The National Health and Nutrition Survey reported that young adults are more likely to skip breakfast and have lower

Received Feb. 5, 2004/Accepted Oct. 18, 2004

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intakes of fish, beans and vegetables, and higher intakes of meats and oil than middle-aged adults (14). Our previous studies also showed that female college students have lower fish consumption and higher intakes of oil, meat and dairy products than middle-aged adults (15, 16). These dietary habits among young Japanese men and women might lead to increased incidence of coronary heart disease in the future.

To prepare dietary recommendations for young Japanese for the prevention of coronary heart disease, we surveyed the dietary habits, serum lipids, serum fatty acids and blood pressure levels among female and male college students.

Methods

Population sample

The subjects consisted of 175 first-year male university students and 246 healthy female college students aged 18–20 living in Tokyo. Thirteen percent of male and 85 percent of female students lived with their parents. We explained fully the aim and procedures of the present study and informed consent was obtained from all male students enrolled between April, 1996 and April, 1997 and from 75 percent of female students enrolled between May, 1996 and May, 1998.

Protocol

The frequency of selected food consumption including fish, oil and dairy products was estimated by a questionnaire/interview, using five response categories: 1) less than once a week, 2) once or twice a week, 3) every other day, 4) once a day, and 5) twice or more a day. The above frequency of foods per week was adopted as 0, 1.5, 3.5, 7 and 14, respectively. The validity of this food frequency questionnaire was examined by comparison with serum fatty acid composition among 114 female college students (15) and 663 middle-aged women (15). Previous studies showed that the frequency of fish intake is positively associated with serum n-3 polyunsaturated fatty acid and the frequency of oil and meat intake is positively associated with the serum n-6 polyunsaturated fatty acids in a dose-response fashion (7, 15). The questionnaire also included a question on skipping of breakfast at least once a week.

Measurement of biological variables

Height on socks and weight in light clothing were measured and the body mass index (BMI) was calculated as weight (kg)/height (m)². Body fat composition was measured by fat meter TBF 305 (Tanita Co., Tokyo) by the impedance method. Systolic and diastolic blood pressure levels were measured using a standard mercury sphygmomanometer on the right arm of seated participants after five-minute rest. Fasting blood samples were drawn using two vacuum tubes (a 9 ml-tube for serum and a 2.7 ml-tube for plasma) by clinical technologists between 7:30 and 9:00 AM. The blood samples were left at room temperature for 30 minutes and centrifuged at 3,000 rpm for 15 minutes. The obtained serum was immediately frozen with dry ice and stored at –80°C until analysis. Serum total cholesterol and triglycerides were measured by the enzymatic method using a multi-channel autoanalyzer (SMC, Technicon Co.). Serum HDL-cholesterol was measured by the Lieberman-

Burchard method using an autoanalyzer (Auto Analyzer-II type, Technicon Co.) after separation of serum HDL by the heparin-manganese. For serum fatty acid analysis, total lipids were extracted with Folch liquid (17) and saponified with potassium hydroxide-ethanol solution. Fatty acids were etherified with boron trifluoride-methanol solution, and were analyzed by gas chromatography (column temperature, 220°C, G5,000, Hitachi, Tokyo). The details of the measurement methods and conditions were reported previously by our laboratories (18). The proportion of each fatty acid was expressed as percentage of the total peak area of the 13 major fatty acids from C14:0 to C22:6. A total of 13 saturated and unsaturated fatty acids were measured. Saturated fatty acids were myristic acid (C14:0), palmitic acid (C16:0), and stearic acid (C18:0). Monounsaturated fatty acids were palmitoleic acid (C16:1) and oleic acid (C18:1).

Of the polyunsaturated fatty acids, n-6 polyunsaturated fatty acids were linoleic acid (C18:2), γ -linolenic acid (C18:3), di-homo γ -linolenic acid (C20:3), and arachidonic acid (C20:4), and n-3 polyunsaturated fatty acids were α -linolenic acid (C18:3), icosapentaenoic acid (C20:5), docosapentaenoic acid (C22:5), and docosahexaenoic acid (C22:6). The concentration of each fatty acid (mg/dl) was also calculated using tricosanoic acid (C23:0, GL Sciences Inc.) as an internal standard.

Statistical analysis

Differences in mean values between female and male students were examined by the unpaired t-test. The proportions of female and male students with particular dietary habits (%) were compared by the χ^2 test. Predicted changes in systolic and diastolic blood pressure levels (mmHg) associated with one-unit increase in the frequency of consumption of selected foods (number per week), serum n-3 and n-6 polyunsaturated fatty acid (%) and body mass index (kg/m²) were estimated using multiple linear regression analysis. The regression analysis was also conducted for predicted changes in serum lipids such as total cholesterol, HDL-cholesterol and triglycerides, and in body mass index associated with one-unit increase in the frequency of selected foods (number per week). All independent variables were entered into multivariate regression models, and the R² of the model was computed. All analyses were conducted using a standard statistical package (SPSS II, version 11.0; SPSS Inc., Japan) and the significant level for statistical testing was 5%.

Results

Table 1 shows sex-specific mean values of known coronary risk factors among female and male college students. The mean body mass index was lower in female students than in male students while the mean body fat was higher in female students than in male students. Female students had a lower mean value of systolic blood pressure and higher mean values of total and HDL-cholesterol levels compared with male students.

Table 2 shows sex-specific frequency of selected food intake. There was no sex-difference in the frequency of consumption of fish, meat, egg, milk and dairy product, beans or fruits. The frequency of dishes cooked with oil and intake of

Table 1 Sex-specific mean $\pm$ SD values of known coronary risk factors among college students

	Male students (n=174)	Female students (n=240)	p value
Age (year)	19.4 $\pm$ 1.0	19.2 $\pm$ 0.5	0.02
Body mass index (kg/m ²)	21.9 $\pm$ 2.9	21.1 $\pm$ 3.0	0.007
Body Fat composition (%)	25.3 $\pm$ 5.3	18.4 $\pm$ 4.9	<0.001
Systolic blood pressure (mmHg)	115.6 $\pm$ 12.5	99.2 $\pm$ 9.4	<0.001
Diastolic blood pressure (mmHg)	61.2 $\pm$ 11.0	60.4 $\pm$ 7.9	0.41
Serum total cholesterol (mg/dL)	165.8 $\pm$ 29.9	173.0 $\pm$ 27.9	<0.001
Serum HDL-cholesterol (mg/dL)	56.3 $\pm$ 11.1	63.0 $\pm$ 12.2	<0.001
Serum triglycerides (mg/dL)	70.8 $\pm$ 42.6	65.7 $\pm$ 36.0	0.19

Table 2 Sex-specific frequency of selected food intake among college students

	Frequency					p value
	<1/week	1–2/week	1/2 days	1/day	>2/day	
Fish						
Males	8.0	43.4	36.0	12.0	0.6	0.84
Females	9.4	42.1	39.1	9.0	0.4	
Meat						
Males	2.9	28.6	43.4	21.1	4.0	0.33
Females	4.3	34.1	37.1	22.8	1.7	
Egg						
Males	6.9	32.0	29.7	29.7	1.7	0.65
Females	5.2	31.5	32.8	30.2	0.4	
Milk and dairy products						
Males	7.4	15.4	25.1	41.1	10.9	0.15
Females	6.9	25.0	19.4	40.5	8.2	
Beans						
Males	10.3	44.0	29.1	16.0	0.6	0.20
Females	5.6	42.5	37.3	13.3	1.3	
Vegetables						
Males	4.0	14.9	35.4	38.3	7.4	<0.001
Females	2.1	11.2	24.2	39.9	22.7	
Fruits						
Males	13.1	29.7	32.6	23.4	1.1	0.54
Females	14.7	36.8	27.7	19.9	0.9	
Dishes cooked with oil						
Males	1.1	8.0	27.6	40.2	23.0	<0.001
Females	2.3	7.4	8.0	28.6	53.7	

vegetables were higher in female students than in male students.

Table 3 shows sex-specific composition (%) of serum fatty acids in female and male students. There was no substantial difference in the composition of saturated and monounsaturated fatty acids between female and male students. The compositions of total n-6 polyunsaturated fatty acids were slightly higher in female students than in male students. Female students had a higher percentage of linoleic acid and lower percentages of dihomo- γ -linolenic acid and arachidonic acid than male students. The percentage of n-3 polyunsaturated fatty acids was 6.4% in both female and male students. The percentages of α -linolenic acid and icosapentaenoic acid were higher in female students than in male students. The ratio of n-3/n-6 polyunsaturated fatty

Table 3 Sex-specific composition (%) of serum fatty acids among college students

	Male students (n=175)	Female students (n=246)	p value
Saturated fatty acids	27.3 $\pm$ 1.7	27.1 $\pm$ 1.8	0.20
Myristic acid (14:0)	0.7 $\pm$ 0.3	1.0 $\pm$ 0.4	<0.001
Palmitic acid (16:0)	19.6 $\pm$ 1.6	19.7 $\pm$ 1.4	0.15
Stearic acid (18:0)	6.9 $\pm$ 1.2	6.5 $\pm$ 1.1	<0.001
Monounsaturated fatty acids	23.8 $\pm$ 3.1	23.3 $\pm$ 2.7	0.09
Palmitoleic acid (16:1)	2.7 $\pm$ 0.6	2.9 $\pm$ 0.7	0.001
Oleic acid (18:1)	21.1 $\pm$ 2.8	20.4 $\pm$ 2.4	0.006
Polyunsaturated fatty acids	48.9 $\pm$ 3.6	49.6 $\pm$ 3.6	0.04
n-6 Polyunsaturated fatty acids	42.6 $\pm$ 3.5	43.2 $\pm$ 3.4	0.07
Linoleic acid (18:2)	34.0 $\pm$ 3.3	35.4 $\pm$ 3.4	<0.001
γ -Linolenic acid (18:3)	0.3 $\pm$ 0.2	0.3 $\pm$ 0.2	0.36
Dihomo- γ -linolenic acid (20:3)	1.1 $\pm$ 0.3	0.9 $\pm$ 0.3	<0.001
Arachidonic acid (20:4)	7.1 $\pm$ 1.3	6.6 $\pm$ 1.1	<0.001
n-3 Polyunsaturated fatty acids	6.4 $\pm$ 1.6	6.4 $\pm$ 1.8	0.59
α -Linolenic acid (18:3)	1.0 $\pm$ 0.5	1.1 $\pm$ 0.4	0.04
Icosapentaenoic acid (20:5)	1.5 $\pm$ 0.7	1.7 $\pm$ 0.9	0.01
Docosapentaenoic acid (22:5)	0.5 $\pm$ 0.2	0.4 $\pm$ 0.1	0.18
Docosahexaenoic acid (22:6)	3.4 $\pm$ 0.9	3.2 $\pm$ 1.0	0.05
n-3/n-6 ratio	0.15 $\pm$ 0.04	0.15 $\pm$ 0.04	1.00
Total fatty acids	344 $\pm$ 111	406 $\pm$ 163	<0.001

Data are mean $\pm$ standard deviation.

acid was 0.15 for both female and male students.

Table 4 shows the sex-specific frequency of selected food intake, and mean values of serum fatty acid (%) and coronary risk factors according to the skipping of breakfast. Among male students, the frequencies of intake of egg, milk and dairy products, vegetables, fruits were lower in the breakfast skipping group than in the non-skipping group. Among female students, the intake frequency of fish, vegetables and fruits was lower in the breakfast skipping group than in the non-skipping group. The compositions of n-3 polyunsaturated fatty acid and icosapentaenoic acid were lower in the breakfast skipping group than in the non-skipping group among female students, but not among male students. Among female students, the skipping group also had a higher systolic blood pressure than the non skipping group.

Table 5 shows predicted changes in blood pressure levels associated with dietary habits, serum fatty acids and body mass index based on multivariate linear regression analysis. The intake of milk and dairy product and n-3 polyunsaturated fatty acid correlated inversely with systolic blood pressure levels and tended to correlated inversely with diastolic blood pressure levels among female students. The fruits correlated inversely with systolic and diastolic blood pressure levels, and consumption of dishes cooked with oil correlated inversely with diastolic blood pressure levels among male students. The inverse association between dishes cooked with oil and systolic blood pressure levels among male students was of borderline statistical significance. Body mass index correlated with systolic and diastolic blood pressure levels among female students, but not among male students. We also analyzed the predicted changes in blood lipids and body mass index, but found no significant association with the frequency of selected food intake (data not shown in the table).

Table 4 Sex-specific mean frequency of selected food intake and mean values of serum fatty acids and coronary risk factors according to the skipping of breakfast

	non-skipping n=68	skipping n=107	p value n=175
Males			
Females	n=138	n=94	n=232
Meat (number/week)			
Males	3.9	4.0	0.84
Females	4.8	5.1	0.46
Fish (number/week)			
Males	2.9	2.8	0.69
Females	2.9	2.4	0.04
Egg (number/week)			
Males	4.6	3.4	0.005
Females	4.0	3.5	0.17
Milk and dairy products (number/week)			
Males	6.3	5.0	0.04
Females	5.4	4.6	0.11
Vegetables (number/week)			
Males	6.1	4.6	0.003
Females	7.5	6.3	0.03
Fruits (number/week)			
Males	4.0	3.0	0.02
Females	3.5	2.4	0.001
Dishes cooked with oil (number/week)			
Males	5.0	4.4	0.30
Females	8.4	7.5	0.25
Saturated fatty acids (%)			
Males	27.0	27.5	0.07
Females	27.0	27.0	0.93
Monosaturated fatty acids (%)			
Males	23.2	24.1	0.08
Females	23.2	23.5	0.41
Polyunsaturated fatty acids (%)			
Males	49.8	48.4	0.02
Females	49.8	49.5	0.50
n-6 polyunsaturated fatty acids (%)			
Males	43.2	42.3	0.90
Females	43.1	43.4	0.56
n-3 polyunsaturated fatty acids (%)			
Males	6.6	6.2	0.10
Females	6.7	6.1	0.01
Icosapentaenoic acids (20:5) (%)			
Males	1.6	1.4	0.15
Females	1.9	1.5	0.01
n-3/n-6			
Males	0.2	0.2	0.32
Females	0.2	0.1	0.01
Body mass index (kg/m ²)			
Males	22.2	21.8	0.36
Females	21.1	21.3	0.64
Systolic blood pressure (mmHg)			
Males	115.6	115.6	1.00
Females	97.8	101.8	0.004
Diastolic blood pressure (mmHg)			
Males	61.4	61.1	0.86
Females	59.7	61.8	0.08
Total serum cholesterol (mg/dL)			
Males	166.1	165.5	0.91
Females	172.3	174.4	0.57
Serum triglyceride (mg/dL)			
Males	74.5	68.0	0.33
Females	63.7	68.9	0.28
HDL-cholesterol (mg/dL)			
Males	56.6	56.2	0.78
Females	63.1	62.7	0.78
Plasma fibrinogen (mg/dL)			
Males	215.6	219.2	0.55
Females	246.4	247.7	0.90

Discussion

The present study showed that the frequencies of consumption of food cooked with oil and vegetables and intake fruits were higher and the composition of total n-6 polyunsaturated fatty acids was slightly higher in female students than in male students. There was no difference in the frequency of consumption of fish or the composition of saturated, monounsaturated or n-3 polyunsaturated fatty acids between female and male students. Our subjects were not representative samples of Japanese male and female college students, but we assume that our samples of students have similar mean body mass index and smoking rate as do the samples aged 20–29 in the National Health and Nutrition Survey (14).

Among the enrolled subjects in the present study, 87% of male students did not live with their parents while only 15% of female students did. The high proportion of male students living alone among our subjects is a different characteristic from that in the general population. However, we found no differences in known coronary risk factors, the frequency of intake of selected foods or serum fatty acids between men living alone and those living with their parents (data not shown in the table).

Our results of college students on the frequency of food intake and serum fatty acid compositions can be compared with our previously reported data of adult women in Japan (an urban-community, an inland farming-community, a coastal farming-community, and fishing-households) and adult American women since we measured them in the same laboratory (7). The frequency of fish consumption once a day or more was 10% among both female and men students, 37% among urban-community females, 29% among inland farming-community females, 75% among fishing-household females and 3% among American women, which paralleled the compositions of serum n-3 polyunsaturated fatty acids: 6%, 9%, 9%, 12%, and 3%, respectively. The National Health and Nutrition Survey also showed that fish intake was lower in young adults than in middle-aged adults (14). For example, fish intake was 84 g/day in women aged 20–29 years and 125 g/day in women aged 50–59 years. The respective frequency of meat intake once a day or more was 25%, 25%, 29%, 12% and 18%, which paralleled serum composition of n-6 polyunsaturated fatty acids: 43%, 37%, 38%, 33% and 44%, respectively. The percentages of n-3 polyunsaturated fatty acids in male and female students were lower than that in Japanese female adults and higher than that in American female adults. The percentage of n-6 polyunsaturated fatty acids in male and female students was higher than that in Japanese female adults and similar to that in American female adults. There was no significant correlation between the frequency of food intake and serum lipids probably because we did not have the large number of selected foods enough to detect the associations.

The National Health and Nutrition Survey showed that persons who skip breakfast had lower intake of energy, calcium, iron and vitamin D, and higher mean levels of blood pressure and serum total cholesterol and were physically inactive (14). Skipping breakfast is also reported to be associated with lower energy intake, poor consumption of fruits, vegetables and dairy foods (19), a higher body mass index (20–22) and dysmenor-

Table 5 Predictive changes (95% confidence intervals) in systolic and diastolic blood pressure levels associated with the frequency of selected food intake, serum fatty acids and body mass index using multivariate linear regression analysis

	Male students	p value	Female students	p value
Systolic blood pressure (mmHg)				
Frequency of food intake (number/week)				
Fish (number/week)	-0.28 (-1.26, 0.70)	0.58	0.64 (-0.15, 1.43)	0.11
Meat (number/week)	-0.17 (-0.90, 0.56)	0.64	0.04 (-0.44, 0.52)	0.88
Milk and dairy products (number/week)	0.20 (-0.32, 0.72)	0.44	-0.55 (-0.92, -0.18)	0.004
Egg (number/week)	0.80 (-0.03, 1.62)	0.06	0.22 (-0.39, 0.83)	0.47
Vegetables (number/week)	0.09 (-0.57, 0.76)	0.78	0.02 (-0.33, 0.37)	0.90
Fruits intake (number/week)	-1.07 (-1.87, -0.28)	0.008	-0.28 (-0.82, 0.27)	0.32
Dishes cooked with oil (number/week)	-0.51 (-1.05, 0.04)	0.07	0.05 (-0.21, 0.31)	0.69
n-3 polyunsaturated fatty acids (%)	0.98 (-0.20, 2.17)	0.10	-0.81 (-1.59, -0.03)	0.04
n-6 polyunsaturated fatty acids (%)	0.03 (-0.54, 0.59)	0.93	-0.12 (-0.52, 0.27)	0.55
Body mass index (kg/m ²)	0.56 (-0.10, 1.22)	0.10	0.98 (0.55, 1.42)	<0.001
	R ² =0.065 (p=0.022)		R ² =0.125 (p<0.001)	
Diastolic blood pressure (mmHg)				
Fish (number/week)	-0.04 (-0.89, 0.82)	0.94	0.05 (-0.62, 0.73)	0.88
Meat (number/week)	0.46 (-0.18, 1.10)	0.16	-0.29 (-0.70, 0.11)	0.16
Milk and dairy products (number/week)	-0.37 (-0.82, 0.08)	0.11	-0.30 (-0.62, 0.02)	0.06
Egg (number/week)	0.42 (-0.30, 1.14)	0.25	0.13 (-0.39, 0.66)	0.62
Vegetables (number/week)	0.35 (-0.24, 0.93)	0.24	0.11 (-0.19, 0.41)	0.47
Fruits (number/week)	-0.96 (-1.65, -0.27)	0.007	0.17 (-0.30, 0.63)	0.47
Dishes cooked with oil (number/week)	-0.50 (-0.98, -0.02)	0.04	0.10 (-0.13, 0.32)	0.39
n-3 polyunsaturated fatty acids (%)	0.37 (-0.67, 1.40)	0.49	-0.62 (-1.28, 0.05)	0.07
n-6 polyunsaturated fatty acids (%)	-0.20 (-0.70, 0.29)	0.42	-0.01 (-0.35, 0.32)	0.93
Body mass index (kg/m ²)	0.18 (-0.40, 0.75)	0.55	0.78 (0.41, 1.16)	<0.001
	R ² =0.063 (p=0.023)		R ² =0.081 (p=0.004)	

Multivariate linear regression analysis was conducted using the variables listed above.

rhea (23). Our results showed that students who skipped breakfast were less likely to consume fish, milk, dairy product, fruits, vegetables and had low composition of n-3 polyunsaturated fatty acid, and higher systolic and diastolic blood pressures levels. These findings suggest that having breakfast may be important to reduce the risk factors for coronary heart disease.

We found that the intake of milk and dairy products and n-3 polyunsaturated fatty acids correlated inversely with systolic or diastolic blood pressure levels among female students while the intakes of fruits and dish cooked with oil correlated inversely with systolic and diastolic blood pressure levels only among male students. The lack of the latter associations among female students may be in part due to their smaller range of blood pressure levels. Milk and dairy products are rich in calcium; fruits are rich in potassium and antioxidants; and dishes cooked with oil are rich in linoleic acids. These findings emphasize the blood pressure-lowering effect of calcium (24), potassium (25), antioxidants (26) and linoleic acid (27). Reduced blood pressure levels associated with these food intakes seem to

be small from the viewpoint of clinical practice. However this small reduction in mean blood pressure levels over an entire population translates to substantial effects on the risk of cardiovascular disease. In our previous study of Japanese, a 1 mmHg reduction of mean systolic blood pressure was associated with a 3% reduction of stroke (24). A meta-analyses of 9 cohort studies showed that a 1 mmHg reduction of mean diastolic blood pressure was associated with a 6% reduction of stroke and a 4% reduction of coronary heart disease (28).

In conclusion, our study suggest that increased intake of fish, milk and dairy products, fruits and vegetables during early adult life with a regular dietary pattern are probably important in reducing the risk factors for coronary heart disease.

Acknowledgments

We are most grateful to Ms. Masako Fuwa and Sayuri Watanabe for their assistance with our experiments. We also thank the students who participated in this study.

References

- (1) Kitamura A, Iso H, Naito Y, et al. High-density lipoprotein cholesterol and premature coronary heart disease in urban Japanese men. *Circulation* 1994; 89: 2533–2539.
- (2) Iso H, Naito Y, Sato S, et al. Serum triglycerides and risk of coronary heart disease among Japanese men and women. *Am J Epidemiol*. 2001; 153: 490–499.
- (3) Dyerberg J, Bang HO, Stofferson E. Eicosapentaenoic acid was prevention of thrombosis and atherosclerosis? *Lancet*. 1978; ii: 117–119.
- (4) Imano H, Ohira T, Kudo M, et al. The effects of fish supplementation on platelet function, count and metabolism healthy Japanese. *Jpn J Hyg*. 1999; 53: 601–610. (in Japanese)

- (5) Korpela R, Seppo L, Laakso J, et al. Dietary habits affect the susceptibility of low-density lipoprotein to oxidation. *Eur J Clin Nutr.* 1999; 52: 802–807.
- (6) Puiggrós C, Chacón P, Armadans LI, Clapés J, Planas M. Effects of oleic-rich and omega-3-rich diets on serum lipid pattern and lipid oxidation in mildly hypercholesterolemic patients. *Clin Nutr.* 2002; 21: 79–87.
- (7) Umemura U, Koike AK, Iso H, et al. Population-based comparative study on dietary habits and serum fatty acid compositions. *Jpn J Hyg.* 1993; 48: 939–954. (in Japanese)
- (8) Iso H, Sato S, Folsom AR, et al. Serum fatty acid and fish intake in rural Japanese, urban Japanese, Japanese American and Caucasian American men. *Int J Epidemiol.* 1989; 18: 374–381.
- (9) Umemura U, Yokota K, Inagawa M, et al. Effectiveness of a health education class to increase fish intake evaluated by serum fatty acid compositions. *Jpn J Public Health.* 1997; 44: 901–909. (in Japanese)
- (10) Umemura U, Ishimori M, Watanabe S, et al. Effects of intake of fish rich in n-3 polyunsaturated fatty acid on serum lipids, serum fatty acid component and hemostatic factors. *J Jpn Soc Nutr Food Sci.* 2000; 53: 1–9. (in Japanese)
- (11) Kromhout D, Bosschieter EB, Coulander C de L. The inverse relation between fish consumption and 20-year mortality from coronary heart disease. *N Engl J Med.* 1985; 312: 1205–1212.
- (12) Iso H, Rexrode KM, Stampfer MJ, et al. Intake of fish and Omega-3 fatty acids and risk of stroke in women. *JAMA.* 2001; 285: 304–312.
- (13) Sato S. Epidemiological study on new risk factors for cardiovascular disease: serum fatty acids and plasma fibrinogen. *J Epidemiol.* 1998; 8 suppl 1: 70.
- (14) The Study Circle of Health and Nutrition Information. The National Nutrition Survey in Japan 2001. Dai-ichi Shuppan, Tokyo, 2003. p. 44–45. (in Japanese)
- (15) Umemura U, Ito K, Iso H, et al. Dietary habits and serum fatty acid compositions of women college students-changes in serum lipids and fatty acid by dietary education. *Jpn J Public Health.* 1993; 40: 1139–1153. (in Japanese)
- (16) Ito K, Shiratori M, Kanbayashi M, Sugiyama S. An Investigation of the actual health conditions of female student and consciousness. *Tokyo Bunka Junior Coll Bulletin.* 1987; 7: 1–19. (in Japanese)
- (17) Folch J, Lees M, Stanley GHS. A simple methods for the isolation and purification of total lipids from animal tissues. *J Biol Chem.* 1957; 226: 497–509.
- (18) Umemura U, Koike AK, Sato S, Iso H, Shimamoto T, Komachi Y. The effect of storage on serum fatty acids. *Jpn J Hyg.* 1991; 46: 976–983. (in Japanese)
- (19) Videon TM, Manning CK. Influences on adolescent eating patterns: The importance of family meals. *J Adolescent Health.* 2003; 32: 365–373.
- (20) Sakata K, Mathumura Y, Yoshimura N, et al. Relationship between skipping breakfast and cardiovascular disease risk factors in the national nutrition survey data. *Jpn J Public Health.* 2001; 48: 837–841. (in Japanese)
- (21) Sungsoo C, Marion D, Coralie JPB, Celeste AC, Gladys B. The effect of breakfast type on total daily energy intake and body mass index: Results from the third national health and nutrition examination survey (NHANES III). *J Am Coll Nutr.* 2003; 4: 296–302.
- (22) Berkey CS, Rockett HRH, Gillman MW, Field AE, Colditz GA. Longitudinal study of skipping breakfast and weight change in adolescents. *Int J Obesity.* 2003; 27: 1258–1266.
- (23) Fujiwara T. Skipping breakfast is associated with dysmenorrhea in young women in Japan. *Int J Food Sic Nut.* 2003; 54: 505–509. (in Japanese)
- (24) Iso H, Shimamoto T, Yokota K, Sankai T, Jacobs DR Jr., Komachi Y. Community-based education classes for hypertension control. A 1.5-year randomized controlled trial. *Hypertension.* 1996; 27: 968–974.
- (25) Whelton PK, He J, Cutler JA, et al. Effects of oral potassium on blood pressure. Meta-analysis of randomized controlled clinical trials. *JAMA.* 1997; 277: 1624–1632.
- (26) John JH, Ziebland S, Yudkin P, Roe LS, Neil HA. Effects of fruit and vegetable consumption on plasma antioxidant concentrations and blood pressure: a randomized controlled trial. *Lancet.* 2002; 359: 1969–1974.
- (27) Iso H, Sato S, Umemura U, et al. Linoleic acid, other fatty acids, and the risk of stroke. *Stroke.* 2002; 33: 2086–2093.
- (28) MacMahon S, Peto R, Cutler J, et al. Blood pressure, stroke, and coronary heart disease: part 1, prolonged differences in blood pressure: prospective observational studies corrected for the regression dilution bias. *Lancet.* 1990; 335: 765–774.