Original Article

Nutritional Characteristics of Middle-Aged Japanese Vegetarians

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Aim: Despite the possible overall health benefits of a vegetarian diet, research about the nutritional characteristics of Japanese vegetarians is small. Our objective was to investigate the nutritional characteristics of Japanese vegetarians compared with Japanese non-vegetarians.

Methods: The dietary intake, anthropometric and biochemical status of 75 middle-aged Japanese vegetarians (JV, 20 men and 55 women) were compared with those of 50 age- and sex- matched middle-aged Japanese non-vegetarians (JNV, 32 men and 18 women) in a cross-sectional study.

Results: JV men had significantly higher calcium, iron ($p < 0.001$) and dietary fiber ($p < 0.01$), and significantly lower vitamin B₁₂, cholesterol, animal fat intake and percentage of energy as animal protein ($p < 0.01$) than JNV men. In addition, JV men had significantly lower body mass index ($p < 0.05$), diastolic blood pressure ($p < 0.001$), systolic blood pressure ($p < 0.01$), aspartate transaminase, alanine transaminase ($p < 0.05$) and serum triacylglyceride ($p < 0.001$) than JNV men. JV women had significantly lower systolic pressure and serum triacylglyceride ($p < 0.05$) than JNV women.

Conclusions: JV men and women had better nutritional characteristics than JNV men and women from the standpoint of lifestyle-related diseases.

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Key words; Dietary intake, Body mass index, Blood pressure, Triacylglyceride

Introduction

Vegetarianism continues to gain in popularity in Japan and elsewhere due to scientific research supporting the health advantages of vegetarian-based diets¹⁻⁸. Despite the possible overall health benefits of a vegetarian diet having been revealed in western countries, there is little research about Japanese vegetarians.

Until about 150 years ago, the Japanese diet mainly consisted of vegetables, beans, especially soybeans, and occasionally seafood. Historically, the Japanese emperor was influenced by Buddhism, therefore establishing the imperial regulation not to eat any meat in A.D. 7-8⁹. After World War II, Japanese life expectancy improved dramatically. It increased from 1965

to 1986 by 7.5 years for men and 8 years for women while life expectancy in England and Wales increased by 3.4 for men and by 3.0 for women¹⁰. Although the recent Japanese diet is westernized¹¹⁻¹³, the longevity of Japanese is still the highest among the 192 countries that belong to the World Health Organization¹⁴.

An epidemiological study of Japanese with similar life-styles to Seventh-Day Adventists, whose unique characteristic is to abstain from animal products, except milk and eggs (lacto-ovo vegetarians), showed that they had an even lower risk for hypertension, subarachnoid hemorrhage, coronary heart disease, liver cirrhosis and certain cancers (mouth, pharynx, esophagus, lung, stomach and liver) than general Japanese¹⁵. It is important to reveal any factors of lowering the risk of lifestyle-related diseases in Japanese vegetarians.

In Japan, most research about Japanese vegetarians is related to monks¹⁶⁻¹⁹ and patients prescribed to treat their diseases with vegetarian diets²⁰⁻²⁴. Some research has studied general Japanese vegetarians; however, it calculated only the nutrient composition of the

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menu at a SDA school²⁵⁾ or in a hospital setting²⁶⁾, and did not calculate from actual intake, i.e., what individual vegetarians actually eat in a day. There are a few small studies of 10 healthy 30-69 year-old lacto-ovo vegetarians; however, this study calculated the dietary intake from a food frequency questionnaire not from a food record²⁷⁻²⁹⁾.

Therefore, in the present study we investigated the dietary intake from a food record, biochemical measurement and anthropometry of middle-aged general Japanese vegetarians compared with those of middle-aged general Japanese non-vegetarians. The aim of the present study is to clarify the advantages and disadvantages of being a Japanese vegetarian.

Subjects and Methods

Subjects

Seventy-five healthy middle-aged Japanese vegetarians (JV, 20 men and 55 women) who worked at V hospital (Tokyo, Japan), which usually offers vegetarian meals and recommends a vegetarian diet for employees and patients, and 50 age- and sex- matched healthy middle-aged Japanese non-vegetarians (JNV, 32 men and 18 women) who worked at O machinery manufacturing company (Tokyo, Japan) were recruited through advertising inside the hospital and company. The number of food records collected from JNV women was so few their dietary intake had to be dismissed in the present study. Thus, we compared only men from their dietary intake. Twenty-seven (9 men and 18 women) of 75 Japanese vegetarians reported themselves as lacto-ovo vegetarians. The rest (11 men and 37 women) were semi-vegetarians who occasionally ate meat and seafood. There were no pure vegetarians, who entirely avoid eating animal products, in this study. Non-vegetarians represented the general population and were defined as people eating food of both plant and animal origin. Informed consent was obtained from each subject before the study began. The procedures were in accord with the Helsinki Declaration of 1975, as revised in 1983.

Dietary Assessment

Subjects were asked to keep a 3-day food record with the name of the dish or food items and beverages consumed during April to June. Portion sizes of foods were described in terms of household measures, sizes of the plate, cup and bowl and standard weights of food items. After submitting the food records, each subject was interviewed by trained dietitians within 1 week to confirm the amounts and kinds of food eaten. The reported dietary intake was calculated by the die-

tary analysis program *Eiyo-kun* for Windows (version 4.0, 2005; Kenpaku-sha, Tokyo, Japan). The average one-day intake over 3 days was used.

Biochemical Measurements

Serum total cholesterol (TC), aspartate transaminase (AST), alanine transaminase (ALT) and serum triacylglyceride (TG) were obtained from an medical examination at each facility during March to July.

Anthropometric Indexes

Body weight, height and blood pressure of subjects were obtained from the medical examination at the each facility during March to July. Body mass index (BMI) was calculated as weight divided by squared height (kg/m^2). Blood pressure was measured after 10-15 minutes of rest with a manual mercury manometer.

Statistical Analyses

Data are expressed as the mean $\pm$ standard deviation (SD). Differences between vegetarian and non-vegetarian groups were tested by unpaired *t*-test. A two-tailed *p* value of <0.05 was considered significant. All statistical analyses were performed with Dr. SPSS for Windows (version 10.0; SPSS, Inc. U.S.A.).

Results

Dietary Intakes

Table 1 shows that JV men had significantly higher mean intakes of calcium, magnesium, iron, copper, manganese, vitamin E, vitamin K, vitamin B₁, folate, dietary fiber, salt and vegetable fat, and significantly lower mean intakes of vitamin B₁₂, cholesterol, animal fat, including both meat and seafood fat, than JNV men. In addition, JV men had a significantly higher ratio of polyunsaturated fatty acids to saturated fatty acids (P:S) and ratio of n-6 fatty acids to n-3 fatty acids (n-6:n-3) and significantly lower % of energy as animal protein than JNV men.

The nutrients whose mean intake was below the mean intake of the National Health and Nutrition Survey in Japan, 2004 (JNHNS)³⁰⁾ were energy, protein, fat, zinc, vitamin D, vitamin B₂, niacin, vitamin B₆, vitamin B₁₂, cholesterol, salt and % of energy as animal protein in JV men, and all nutrients except zinc, vitamin A, vitamin B₁₂, folate, panthotenic acid and % of energy as animal protein in JNV men.

The % of subjects whose dietary intakes met their own individual requirements based on the Dietary Reference Intakes for Japanese, 2005 (JDRI, **Table 1**)³¹⁾ is shown in **Fig. 1A, B and C**. The nutrients for which the percentage of subjects meeting the JDRI was below

Table 1. Dietary intakes of vegetarian and non-vegetarian men^a, the National Health and Nutrition Survey in Japan, 2004 (JNHNS)^b and Dietary Reference Intakes for Japanese, 2005 (JDRI)^c(Mean $\pm$ SD)

	Vegetarian men (<i>n</i> =20)	Non-vegetarian men (<i>n</i> =32)	JNHNS ^b men	Vegetarian women (<i>n</i> =50)	men	JDRI ^c women	
Age (y)	45.2 $\pm$ 8.3	44.2 $\pm$ 5.2	30-49	45.9 $\pm$ 8.8	30-49	30-49	JDRI
Energy and macronutrients							
Energy (kcal)	1,983 $\pm$ 558	1,843 $\pm$ 439	2,171	1,675 $\pm$ 515	2,650	2,000	EER
Protein (g)	65.4 $\pm$ 20.5	69.5 $\pm$ 16.7	77.3	61.3 $\pm$ 23.2	50	40	EAR
					<20% ^d	<20% ^d	DG
Fat (g)	54.9 $\pm$ 23.0	51.4 $\pm$ 20.1	61.3	52.5 $\pm$ 24.0	20-25% ^d	20-25% ^d	DG
Carbohydrate (g)	305.4 $\pm$ 98.2	265.7 $\pm$ 71.4	292.9	244.8 $\pm$ 86.6	50-70% ^d	50-70% ^d	DG
Minerals							
Potassium (mg)	2,782 $\pm$ 1,493	2,061 $\pm$ 861	2,226	2,719 $\pm$ 1,019	2,000	1,600	AI
					2,900	2,800	DG
Calcium (mg)	630 $\pm$ 268	381 $\pm$ 217***	462	555 $\pm$ 233	600	600	DG
Magnesium (mg)	381 $\pm$ 160	217 $\pm$ 68***	254	306 $\pm$ 110	310	240	EAR
Phosphorus (mg)	1,076 $\pm$ 378	971 $\pm$ 257	1,049	992 $\pm$ 360	1,050	900	AI
Iron (mg)	10.9 $\pm$ 4.0	6.3 $\pm$ 2.6***	7.8	9.5 $\pm$ 3.6	6.5	9	EAR
Zinc (mg)	8.1 $\pm$ 3.0	9.2 $\pm$ 3.8	9.2	7.0 $\pm$ 2.5	8	6	EAR
Copper (mg)	1.50 $\pm$ 0.64	1.21 $\pm$ 0.38*	1.25	1.20 $\pm$ 0.41	0.6	0.6	EAR
Manganese (mg)	4.19 $\pm$ 1.88	2.54 $\pm$ 0.71***		3.00 $\pm$ 1.10	4	3.5	AI
Vitamins							
Vitamin A (μ gRE) ^e	966 $\pm$ 667	877 $\pm$ 858	823	876 $\pm$ 500	550	450	EAR
Vitamin D (μ g)	3.6 $\pm$ 8.2	6.3 $\pm$ 7.1	7.7	5 $\pm$ 11	5	5	AI
Vitamin E (mg) ^f	11.0 $\pm$ 4.9	8.0 $\pm$ 3.1*	8.8	9.1 $\pm$ 4.2	8	8	AI
Vitamin K (μ g)	355 $\pm$ 289	204 $\pm$ 187*	228	296 $\pm$ 219	75	65	AI
Vitamin B ₁ (mg)	1.27 $\pm$ 0.74	0.88 $\pm$ 0.37*	1.12	1.04 $\pm$ 0.39	1.2	0.9	EAR
Vitamin B ₂ (mg)	1.25 $\pm$ 0.90	0.96 $\pm$ 0.42	1.36	1.11 $\pm$ 0.44	1.3	1.0	EAR
Niacin (mg) ^g	13.4 $\pm$ 6.6	14.6 $\pm$ 6.5	17.3	12.5 $\pm$ 6.8	13	10	EAR
Vitamin B ₆ (mg)	1.18 $\pm$ 0.54	1.09 $\pm$ 0.51	1.43	1.17 $\pm$ 0.46	1.1	1.0	EAR
Vitamin B ₁₂ (μ g)	1.9 $\pm$ 2.3	11.3 $\pm$ 11.8**	7.1	3.7 $\pm$ 7.9	2.0	2.0	EAR
Folate (μ g)	455 $\pm$ 297	276 $\pm$ 151*	275	365 $\pm$ 151	200	200	EAR
Panthenic acid (mg)	5.70 $\pm$ 2.21	5.68 $\pm$ 2.24	5.61	5.56 $\pm$ 1.78	6	5	AI
Vitamin C (mg)	105 $\pm$ 61	87 $\pm$ 58	89	119 $\pm$ 65	85	85	EAR

50% were energy, fat, zinc, vitamin A, vitamin D, vitamin B₂, vitamin B₁₂, vitamin C, dietary fiber, salt, saturated fatty acids (SFA) and n-3 fatty acids (n-3) in JV men (**Fig. 1A**), and energy, fat, calcium, manganese, vitamin D, vitamin E, dietary fiber, salt, SFA and n-3 in JV women (**Fig. 1B**), and energy, fat, calcium, magnesium, phosphorus, iron, manganese, vitamin A, vitamin D, vitamin E, vitamin B₁, vitamin B₂, vitamin B₆, panthotenic acids, vitamin C, dietary fiber, SFA and n-3 in JNV men (**Fig. 1C**).

Biochemical Measurements and Anthropometric Indexes

JV men had significantly lower BMI and blood

pressure than JNV men. In addition, JV men had lower mean values of BMI and both diastolic and systolic blood pressure than those in JNHNS (**Table 2**). JV men had significantly lower AST, ALT and TG than JNV men. JV men also had lower mean values of TC and TG than those in JNHNS (**Table 2**). JV women had significantly lower systolic pressure (**Table 2**) and TG (**Table 2**) than JNV women.

Discussion

Cholesterol, animal fat intake and percentage of energy as animal protein in JV men were significantly lower than in JNV men. These results show that JV

(Mean $\pm$ SD)							
	Vegetarian men (<i>n</i> =20)	Non-vegetarian men (<i>n</i> =32)	JNHNS ^b men	Vegetarian women (<i>n</i> =50)	men	JDRI ^c women	
Age (y)	45.2 $\pm$ 8.3	44.2 $\pm$ 5.2	30-49	45.9 $\pm$ 8.8	30-49	30-49	JDRI
Fat							
Meat fat (g)	9.1 $\pm$ 8.1	21.2 $\pm$ 13.4**		13.8 $\pm$ 11.9			
Vegetable fat (g)	40.2 $\pm$ 20.7	23.8 $\pm$ 12.3**		34.2 $\pm$ 16.6			
Seafood fat (g)	0.6 $\pm$ 2.1	6.3 $\pm$ 8.0**		1.9 $\pm$ 6.9			
SFA (%) ^{d h}	5.59 $\pm$ 2.31	5.79 $\pm$ 2.21		6.84 $\pm$ 2.65	4.5-7.0	4.5-7.0	DG
SFA(g) ^h	12.45 $\pm$ 6.77	13.91 $\pm$ 6.17		13.33 $\pm$ 7.36			
MUFA (g) ^h	15.09 $\pm$ 7.68	18.45 $\pm$ 8.44		14.96 $\pm$ 7.99			
PUFA (g) ^h	14.36 $\pm$ 6.91	12.48 $\pm$ 5.23		11.97 $\pm$ 4.94			
PUFA:SFA ^{h i}	1.39 $\pm$ 0.73	0.97 $\pm$ 0.45*		1.14 $\pm$ 0.64			
n-6:n-3 ^j	7.00 $\pm$ 2.03	4.99 $\pm$ 2.40**		6.34 $\pm$ 1.79			
n-6 (%) ^{d j}	5.81 $\pm$ 2.34	5.90 $\pm$ 6.88		5.50 $\pm$ 1.81	<10% 11 g more than 2.6	<10% 9.5 g more than 2.2	DG AI DG
n-3 (g) ^j	1.88 $\pm$ 0.99	2.53 $\pm$ 1.62		1.85 $\pm$ 1.29			
Others							
Cholesterol (mg)	193 $\pm$ 140	338 $\pm$ 152**	345	253 $\pm$ 209	<750	<600	DG
Dietary fiber (g)	19.5 $\pm$ 8.4	11.4 $\pm$ 5.0**	12.8	16.3 $\pm$ 6.4	20	17	DG
Salt (g)	10.6 $\pm$ 4.4	7.9 $\pm$ 3.0*	11.6	8.6 $\pm$ 3.9	1.5 <10	1.5 <8	EAR DG
P:F:C ^k	13:25:62	15:24:61	14:25:61	15:28:58			
% of energy as animal protein	16.0 $\pm$ 11.4	56.5 $\pm$ 14.8**	53.1	26.7 $\pm$ 16.8			

^a All values of vegetarians and non-vegetarians are average 1 day intake of the 3 days recorded $\pm$ standard deviation (SD).

Unpaired Student's *t*-tests were used for statistical comparisons between vegetarians (JV) and non-vegetarians (JNV). Significant difference: **p* < 0.05, ***p* < 0.01, ****p* < 0.001

^b Mean dietary intake of 30-49-year-old men in JNHNS (reference 30).

^c JDRI for 30-49-year-old men and women, activity level II. JDRI are consisted of EER=estimated energy requirement, EAR=estimated average requirement, AI=adequate intake and DG=tentative dietary goal for preventing lifestyle-related diseases.

Standard height and weight used in JDRI are 170.0 cm and 68.0 kg for men, and 156.8 cm and 52.7 kg for women (reference 31).

^d % = Total kcal

^e Calculated 1 retinol equivalent (RE) as 1/6 β -carotene equivalent in vegetarian men, non-vegetarian men and JNHNS. Calculated 1 RE as 1/12 β -carotene equivalent in JDRI.

^f Shown vitamin E as α -tocopherol equivalent in vegetarian men, non-vegetarian men and JNHNS. Shown vitamin E as only α -tocopherol in JDRI.

^g Shown niacin only in JDRI as niacin equivalent (NE). Niacin equivalent (mg) = niacin (mg) + 1/60 tryptophan (mg).

^h SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids

ⁱ PUFA:SFA = PUFA to SFA ratio

^j n-6 = n-6 fatty acids, n-3 = n-3 fatty acids, n-6:n-3 = n-6 to n-3 ratio.

^k P:F:C = Protein total kcal:Fat total kcal:Carbohydrate total kcal

men had better nutritional characteristics in the prevention of lifestyle-related diseases than JNV men.

However, vitamin B₁₂ intake of JV men was significantly lower than that of JNV men. The percentage of JV who met their own individual requirement of vitamin B₁₂ intake based on JDRI was 35% for men and 50% for women. Since the main foods supplying vitamin B₁₂ are of animal origin^{1, 32, 33}, vegetarians, especially those who avoid all animal foods (pure

vegetarians) are at a higher risk for vitamin B₁₂ deficiency. Low intake of vitamin B₁₂ is associated with increased blood homocysteine, which is a risk factor for cardiovascular diseases^{34, 35}. Vegetarians may need to take vitamin B₁₂ fortified foods or/and supplements.

Vitamin D and n-3 fatty acid were at risk for deficiency in JV since 1) the % of subjects who met the JDRI of vitamin D and n-3 fatty acids was below 50% in both JV men and women, 2) the mean vita-

Fig. 1. Percentage of subjects whose dietary intakes met their own requirements based on the Dietary Reference Intakes for Japanese^{a, b}.

A: Vegetarian men, B: Vegetarian women, C: Non-vegetarian men.

^a JDRI = Dietary Reference Intakes for Japanese, 2005. The JDRI of 30-49-year-old men, activity level II (shown in Table 1) is taken as 100% for A and C, and the JDRI of 30-49-year-old women, activity level II (reference 31) is taken as 100% for B.

^b SFA = saturated fatty acids, n-6 = n-6 fatty acids, n-3 = n-3 fatty acids.

Table 2. Anthropometric indexes and biochemical measurements of vegetarians and non-vegetarians^a and the National Health and Nutrition Survey in Japan, 2004 (JNHNS)^b

	Men			Women		
	Vegetarians (n=20)	Non-vegetarians (n=29)	JNHNS ^b	Vegetarians (n=55)	Non-vegetarians (n=18)	JNHNS ^b
Age (y)	45.2 ± 8.3	43.4 ± 3.8		45.9 ± 8.9	43.8 ± 7.2	
Anthropometric indexes						
Height (cm)	164.5 ± 6.9	169.2 ± 5.2**	172.0	154.0 ± 5.0	157.1 ± 5.0*	158.0
Weight (kg)	58.1 ± 7.2	66.3 ± 7.1***	69.3	50.4 ± 5.3	54.1 ± 4.9**	52.3
Body mass index (kg/cm ²)	21.4 ± 2.1	23.2 ± 2.4*	23.4	21.3 ± 2.3	21.9 ± 1.8	21.0
Diastolic blood pressure (mmHg)	71.7 ± 9.1	83.3 ± 11.4***	78.2	67.0 ± 9.9	72.8 ± 10.4	71.5
Systolic blood pressure (mmHg)	118.3 ± 13.2	129.4 ± 14.7**	121.3	111.7 ± 15.8	118.4 ± 11.1*	113.5
Biochemical measurements						
	(n=19)	(n=24)		(n=45)	(n=18)	
TC (mg/dL) ^c	189.4 ± 47.2	213.0 ± 34.3	200.3	193.7 ± 33.4	195.5 ± 36.0	184.8
AST (IU/L) ^d	16.2 ± 4.9	22.3 ± 9.7*		13.3 ± 2.7	18.2 ± 4.5	
ALT (IU/L) ^e	14.3 ± 9.0	22.4 ± 12.7*		8.0 ± 3.2	12.0 ± 4.8	
TG (mg/dL) ^f	119.6 ± 63.3	228.8 ± 93.2***	158.9	85.9 ± 42.6	133.7 ± 96.4*	92.9

^a All values of vegetarians and non-vegetarians are average 1 day intake of the 3 days recorded ± standard deviation (SD).

Unpaired Student's *t*-tests were used for statistical comparisons between same sex vegetarians and non-vegetarians. Significant difference: **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

^b Mean value of 30-49-year-old men and women in the National Health and Nutrition Survey in Japan, 2004 (JNHNS) (reference 30).

^c TC: total cholesterol.

^d AST: aspartate transaminase.

^e ALT: alanine transaminase.

^f TG: triacylglyceride.

min D intake of JV men was lower than the mean intake of JNHNS, and 3) vitamin D and n-3 fatty acids have also been a concern regarding nutritional deficiency in the North American vegetarians¹⁾.

Calcium, zinc, vitamin A and vitamin B₂ intake may also be at risk for deficiency in JV since 1) the % of subjects who met the JDRI of zinc, vitamin A and vitamin B₂ was below 50% in JV men and calcium was below 50% in JV women, 2) the mean zinc and vitamin B₂ intakes of JV men were lower than the mean corresponding nutrient intake in JNHNS, 3) calcium, zinc, vitamin A and vitamin B₂ are a concern regarding nutritional deficiency in North American vegetarians¹⁾.

In men, the BMI and blood pressure of JV were significantly lower than JNV. In women, the systolic blood pressure of JV was significantly lower than JNV. Most epidemiologic studies have shown that vegetarians had lower blood pressure than non-vegetarians³⁶⁾. A study showed that possible explanations for vegetarians having lower blood pressure were lower BMI and higher intake of potassium³⁶⁾. Lower BMI may relate to why JV men had lower blood pressure than JNV in

the present study.

JV men had a tendency toward lower TC (*p* = 0.065) and significantly lower cholesterol intake and a higher ratio of polyunsaturated fatty acids to saturated fatty acids (P:S ratio), and intake of dietary fiber and beans (not shown in the table; JV 177 ± 137, JNV 41 ± 62, *p* < 0.01) than JNV men. Studies in not only the western world but also China and Africa showed that vegetarians had lower serum total cholesterol values than non-vegetarians³⁷⁾ as well as studies in Japan^{20, 22-24, 29)}. A study showed that serum total cholesterol values were increased by dietary cholesterol, and decreased by unsaturated fatty acids, soluble dietary fiber, phytosterol, tocotrienol³⁷⁾ and nuts, soybeans as food that contain abundant unsaturated fatty acids³⁸⁾. The P:S ratio, and intake of cholesterol, dietary fiber and beans may relate to the lower total cholesterol in JV men.

Serum triacylglyceride values in JV men were significantly lower than in JNV men. JV men had a significantly lower ratio of starchy food intake (total intake of cereals and starchy vegetables to total food intake, not shown in the table; JV 38.7 ± 10.0, JNV 48.4 ±

11.1, $p < 0.01$) and significantly higher dietary fiber intake than JNV men. Some studies showed that low carbohydrate intake^{39, 40)}, and a low glycemic index diet (40% carbohydrates, 35% fat)⁴¹⁾ decreased serum triacylglyceride values. A lower ratio of starchy food intake to total food intake and significantly higher dietary fiber intake may relate to significantly lower serum triacylglyceride values in JV men in the present study.

In conclusion, these results showed that JV men had better anthropometric and biochemical measurements than JNV men; however, they also indicated that JV are at risk for vitamin D, vitamin B₁₂ and n-3 fatty acid deficiency, and may be at risk for calcium, vitamin A and vitamin B₂ deficiency.

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References

- 1) The American Dietetic Association: Position of the American Dietetic Association and Dietitians of Canada: Vegetarian diets. *J Am Diet Assoc*, 2003; 103:748-765
- 2) Dwyer JT: Health aspects of vegetarian diets. *Am J Clin Nutr*, 1988; 48:712-738
- 3) Fraser GE: Associations between diet and cancer, ischemic heart disease, and all-cause mortality in non-Hispanic white California Seventh-day Adventists. *Am J Clin Nutr*, 1999; 70(suppl):532S-538S
- 4) Singh PN and Fraser GE: Dietary risk factors for colon cancer in a low-risk population. *Am J Epidemiol*, 1998; 148:761-774
- 5) Singh PN: Does low meat consumption contribute to greater longevity? In: *Vegetarian Nutrition*, ed by Sabate J, pp761-774, CRC Press LLC, Florida, USA, 2001
- 6) Singh PN, Sabaté J, and Fraser GE: Does low meat consumption increase life expectancy in humans? *Am J Clin Nutr*, 2003; 78(suppl):526S-532S
- 7) Snowdon DA and Philips RL: Does a vegetarian diet reduce the occurrence of diabetes? *Am J Public Health*, 1985; 75:507-512
- 8) Snowdon DA: Animal product consumption and mortality because of all causes combined, coronary heart disease, stroke, diabetes, and cancer in Seventh-day Adventists. *Am J Clin Nutr*, 1988; 48:739-748
- 9) Kakimoto M: A scientific and cultural approach to vegetarianism [in Japanese]. *Vegetarian Research*, 2000; 1:3-10
- 10) Marmot MG and Smith GD: Why are the Japanese living longer? *BMJ*, 1989; 299:1547-1551
- 11) Japan Health Promotion and Fitness Foundation, Ministry of Health, Labour and Welfare, Japan: *Health Japan 21* [in Japanese]. Available at http://www1.mhlw.go.jp/topics/kenko21_11/top.html. accessed Jan. 17, 2005
- 12) Egusa G and Yamane K: Lifestyle, serum lipids and coronary artery disease: comparison of Japan with the United States. *J Atheroscler Thromb*, 2004; 11:304-312
- 13) Hata Y and Nakajima K: Life-style and serum lipids and lipoproteins. *J Atheroscler Thromb*, 2000; 7:177-197
- 14) Memorva: The average longevity ranking in the world (Men); the World Health Organization report, 2006 [in Japanese]. Available at http://memorva.jp/ranking/unfpa/who_2006_life_expectancy_man.php. accessed Sep. 14, 2007
- 15) Hirayama T: Mortality in Japanese with life-styles similar to Seventh-day Adventists: strategy for risk reduction by life-style modification. *Natl Cancer Inst Monogr*, 1985; 69:143-153
- 16) Higashiguchi M, Shinohara Y, Matsumoto N, and Tatsuyuki S: Nutritional analysis of dietary records at a zen monastery [in Japanese]. *Journal for the Integrated Study of Dietary Habits*, 2005; 16:276-282
- 17) Ieda A, Muroya A, and Kanie T: The study of actual dietary lifestyle at certain Rinzaï temple [in Japanese]. *Rinsho Eiyo*, 1985; 67:275-281
- 18) Kita T, Yokode M, Kume N, Ishii K, Nagano Y, Mikami A, Kita M, Fujii K, Kawai C, Domae N, Ishihara H, Kimura M, and Itokawa Y: The concentration of serum lipids in zen monks and control males in Japan [in Japanese]. *Jpn Circ J*, 1988; 52:99-104
- 19) Otani H, Kita T, Ueda Y, Kawai C, Takama T, Matsuzawa Y, Nakaya N, Ishihara H, Domae N, Yoshii M, and Miyazaki S: Long-term effects of a cholesterol-free diet on serum cholesterol levels in zen monks. *N Engl J Med*, 1992; 326:416
- 20) Higuchi H, Sasaki K, Kogirima M, Ioku K, Kajiwarra N, Washio Y, Okada M, and Okuda T: Effects of the Vegetarian Diet on the Blood Rheology of Middle-aged Women [in Japanese]. *Memoirs of Osaka Kyoiku University II Social Science and Home Economics*, 2005; 54:1-9
- 21) Okuda T, Nishimura H, Makita T, Katayama Y, Hazama T, Simizu T, and Yamaguchi Y: Protein Metabolism in Vegans [in Japanese]: *The Annals of physiological anthropology*. 1994; 13:393-401
- 22) Okuda T, Mori T, Tabei T, and Takeuchi A: The study of clinical nutrition in the subjects with very low energy diet [in Japanese]. *Zessyoku Kenkyu*, 1999; 21·22:3-9
- 23) Sasaki K, Kogirima M, Kajiwarra N, Okada M, Ioku K, and Okuda T: The Nutritional Status of Middle-aged Women consuming Vegetarian Diet – The Effects of Diet, Physique, Body Composition and Hematological Status on the Blood Fluidity- [in Japanese]. *Memoirs of Osaka Kyoiku University II Social Science and Home Economics*, 2004; 53:15-26
- 24) Shintaku K, Miyatani S, Okada M, Koda M, and Okuda T: Effects of a Low-energy and Low-protein Vegan Diet on Body Composition and Plasma Lipid [in Japanese]. *Memoirs of Osaka Kyoiku University Ser. II Social Science and Home Economics*, 2000; 49:49-59
- 25) Yurino F and Umezawa M: Nutrient Intakes on Lacto-ovo-vegetarian Diet in Junior High School Students [in Japanese]. *Bulletin of Koshien University, A, Faculty of*

- Nutrition, 2001; 29:51-56
- 26) Watanabe S, Watanabe M, Yamamoto M, and Matsumura Y: On the evaluation of protein qualities in lacto-ovo vegetable dietetics [in Japanese]. *Journal of Kagawa Nutrition University*, 1984; 15:69-75
 - 27) Tsuchida M and Fujimoto EK: Differences in plasma amino acid distribution and serum insulin and glucagons levels between Japanese vegetarian and Japanese on typical diets [in Japanese]. *MOA Health Science Foundation Research Reports*, 1996; 5:1-9
 - 28) Tsuchida M, Fujimoto E, Mizukami O, Tominaga K, Watanabe Y, Suzuki K, Ohtake Y, Miyazaki K, Inaba H, Kurosawa M, Ihara K, and Nakamura K: Relationship of Plant-based Protein Consumption to Serum Insulin Levels in Japanese Middle-aged Vegetarians [in Japanese]. *Vegetarian Research*, 2003; 4:1-8
 - 29) Tsuchida M and Fujimoto EK: Nutritional intake, blood component levels, and body fat in Japanese vegetarians [in Japanese]. *Journal of Seki University*, 2007; 1:127-134
 - 30) Health and Nutrition Data Research Group; Ministry of Health, Labour and Welfare of Japan: The National Health and Nutrition Survey in Japan, 2004 [in Japanese], Daiichi Shuppan Publishing Co, Tokyo, Japan, 2006
 - 31) Ministry of Health, Labour, and Welfare, Japan: Dietary Reference Intakes for Japanese, 2005 [in Japanese], Daiichi Shuppan Publishing Co, Tokyo, Japan, 2005
 - 32) Craig WJ and Pinyan L: Nutrients of concern in vegetarian diets. In: *Vegetarian Nutrition*, ed by Sabate J, pp299-332, CRC Press LLC, Florida, USA, 2001
 - 33) Messina V, Mangels R, and Messina M: Vitamins. In: *The dietitian's Guide to vegetarian diets- issues and applications 2nd Ed*, ed by Messina V, Mangels R and Messina M, pp170-217, Jones and Bartlett Publishers, Inc, Massachusetts, USA, 2004
 - 34) SatoY, Kaji M, Kondo I, YoshidaH, Satoh K, and Metoki N: Hyperhomocysteinemia in Japanese patients with convalescent stage ischemic stroke: effect of combined therapy with folic acid and mecobalamine. *J Neurol Sci*, 2002; 202:65-68
 - 35) Moriyama Y, Okamura T, Kajinami K, Iso H, Inazu A, Kawashiri M, Mizuno M, Takeda Y, Sakamoto Y, Kimura H, Suzuki H, and Mabuchi H: Effects of serum B vitamins on elevated plasma homocysteine levels associated with the mutation of methylenetetrahydrofolate reductase gene in Japanese. *Atherosclerosis*, 2002; 164:321-328
 - 36) Fraser GE: Risk factors for cardiovascular disease and cancer among vegetarians. In: *Diet, life expectancy, and chronic disease- studies of Seventh-day Adventists and other vegetarians*, ed by Fraser GE, pp203-230, Oxford University Press, Inc, New York, USA, 2003
 - 37) Key TJ and Appleby PN: Vegetarianism, coronary risk factors and coronary heart disease. In: *Vegetarian Nutrition*, ed by Sabate J, pp33-54, CRC Press LLC. Florida, USA, 2001
 - 38) Fraser GE: Diet and the risk of coronary heart disease. In: *Diet, life expectancy, and chronic disease- studies of Seventh-day Adventists and other vegetarians*, ed by Fraser GE, pp59-83, Oxford University Press, Inc, New York, USA, 2003
 - 39) Dansinger ML, Greason JA, Greffith JL, Selker HP, and Schaefer EJ: Comparison of the Atkins, Ornish, Weight Watchers, and Zone diets for weight loss and heart disease risk reduction: a randomized trial. *JAMA*, 2005; 293:43-53
 - 40) Egusa G, Watanabe H, Ohshita K, Fujikawa R, Yamane K, Okubo M, and Kohno N: Influence of the extent of westernization of lifestyle on the progression of preclinical atherosclerosis in Japanese subjects. *J Atheroscler Thromb*, 2002; 9:299-304
 - 41) Ebbeling CB, Leidig MM, Feldman HA, Lovesky MM, and Ludwig DS: Effects of a low-glycemic load vs low-fat diet in obese young adults: a randomized trial. *JAMA*, 2007; 297:2092-2102