serum triacylglycerol, fasting plasma glucose, Hb A_{1c}, and serum total, HDL, and LDL cholesterol in a group of apparently healthy Japanese women.

SUBJECTS AND METHODS

Subjects

The subjects in the present study were participants in the Japanese Multi-centered Environmental Toxicants Study (JMETS), the main purpose of which was to identify the threshold concentration in the dose-response relation of cadmium renal dysfunction (17, 18). For this purpose, the JMETS was conducted in female farmers in 4 moderately cadmium-polluted areas and 1 non-cadmium-polluted area in Japan; however, no difference in the effects of environmental exposure to cadmium was observed between the 4 polluted areas and 1 nonpolluted area, at least regarding renal function and bone density (17, 18). Thus, the study did not identify evidence that environmental exposure to cadmium, at the level found in the 4 polluted areas, has an adverse affect on health. The 5 areas surveyed consist of rural agricultural communities with inhabitants who remain in the community even after marriage. Thus, most of the farmers in these areas are assumed to have maintained traditional Japanese dietary patterns, consuming their own crops, including rice, for decades. During the winters of 2000 and 2001, female farmers in each area were recruited through the local Agricultural Cooperative to participate in a medical examination organized for the JMETS. One week before the examination, group orientations were held for the study participants, at which the study purpose and protocol were explained and written informed consent was obtained from each participant. In addition, participants were instructed on how to complete questionnaires regarding diet and other lifestyle factors and were asked to bring them to the examination. The protocol of the JMETS was approved by the ethical committee of Jichi Medical University. Additional details about the JMETS were reported elsewhere (17, 18).

A total of 1407 women aged 20–78 y completed both a medical examination and the lifestyle-related questionnaires. Subjects excluded from the present study were those with previously diagnosed diabetes (n = 15) or cardiovascular disease (n = 18), those with extremely low or high energy intakes (<600 or >4000 kcal/d; n = 10), and those with missing covariate information (n = 4). Furthermore, subjects with missing information regarding dependent variables, were excluded from the analysis of LDL cholesterol (n = 6), glucose (n = 609), and Hb A_{1c} (n = 527), and subjects who ate breakfast before blood was drawn were excluded from the analysis of fasting triacylglycerol and glucose (n = 5). Thus, the final sample was 1354 for BMI and serum total and HDL cholesterol, 1348 for serum LDL cholesterol, 1349 for fasting serum triacylglycerol, 764 for fasting plasma glucose, and 845 for Hb A_{1c}; however, some subjects were included in more than one exclusion category. Further exclusion of subjects with a diagnosis of hyperglycemia, dyslipidemia, hypercholesterolemia, or a combination thereof (n = 24 for BMI, cholesterol, and triacylglycerol and n = 17 for glucose and Hb A_{1c}) did not alter the findings of the present study; therefore, these subjects were included in the analyses.

Metabolic risk factors

At the medical examination site, each subject's weight (measured while wearing light clothes and no shoes) was measured with a set of balance scales calibrated to 0.01 kg. Body height was also measured at the site. The BMI of each subject was calculated as weight (kg) divided by the square of height (m). Peripheral blood samples were obtained from subjects after an overnight fast. Blood was collected in evacuated tubes containing no additives, allowed to clot, and centrifuged at 3000 × g for 10 min at room temperature to separate the serum. Blood samples for blood sugar measurement were collected in hydrogen fluoride–containing tubes. All of the following biochemical variables of the samples were assayed at Mitsubishi Kagaku Bio-Clinical Laboratories Inc (Itabashi, Tokyo, Japan) within 3 d of collection to avoid significant degradation. Total cholesterol, HDL cholesterol, and triacylglycerol were measured by enzymatic assay methods. Serum LDL-cholesterol concentrations were calculated by using the Friedewald equation (19) for subjects with fasting serum triacylglycerol concentrations <400 mg/dL. Hb A_{1c} was measured by latex agglutination–turbidimetric immunoassay. In-house quality-control procedures for all of the abovementioned assays were fulfilled at Mitsubishi Kagaku Bio-Clinical Laboratories Inc.

Dietary assessment

Dietary habits during the past month were assessed with a self-administered diet-history questionnaire (DHQ) (20–22), which was completed by each subject at home and was checked by ≥2 dietitians during the medical examination. The DHQ is a 16-page structured questionnaire that consists of the following 7 sections: general dietary behaviors, major cooking methods, consumption frequency and portion size of 6 alcoholic beverages, semiquantitative frequency of intake of 121 selected food and nonalcoholic beverage items, dietary supplements, consumption frequency and amount of 19 staple foods (rice, bread, noodles, and other wheat foods) and *miso* (fermented soybean paste) soup, and open-ended items for foods consumed regularly (≥1 time/wk) but not appearing in the DHQ. The food and beverage items and portion sizes in the DHQ were derived primarily from data in the National Nutrition Survey of Japan and several recipe books for Japanese dishes (20). Measures of dietary intake for 147 food and beverage items, energy, fat, total carbohydrate, alcohol, and dietary fiber were calculated by using an ad hoc computer algorithm developed for the DHQ, which was based on the Standard Tables of Food Composition in Japan (23). Information on dietary supplements and data from the open-ended questionnaire items were not used in the calculation of dietary intake. Detailed descriptions of the methods used for calculating dietary intake and the validity of the DHQ were published elsewhere (20–22). Pearson's correlation coefficients between the DHQ and 3-d dietary records were 0.48 for energy, 0.55 for fat, and 0.48 for total carbohydrate in 47 women (20). In addition, Pearson's correlation coefficients between the DHQ and 16-d dietary records were 0.79 for alcohol and 0.69 for dietary fiber in 92 women (S Sasaki, unpublished observations, 2004).

Calculation of dietary GI and GL

The GI of a food is defined as the 2-h incremental area under the blood glucose response curve after consumption of a food portion containing a specific amount (usually 50 g) of available carbohydrate, divided by the corresponding area after consumption of a portion of a reference food (usually glucose or white

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bread) containing the same amount of available carbohydrate, and multiplied by 100 to be expressed as a percentage (24). We calculated dietary GI by multiplying the percentage contribution of each individual food to daily available carbohydrate intake by the food's GI value and summed these products. Available carbohydrate was calculated as total carbohydrate minus dietary fiber (24). We also calculated dietary GL by multiplying the dietary GI by the total amount of daily available carbohydrate intake (divided by 100).

To determine the GI value of each food for these calculations, each food item on the DHQ was directly matched to foods in the international table of GI (24), in several publications about the GI of Japanese foods (25–27), and in a recent article about the GI of potatoes (28). Glucose was used as the reference (GI for glucose = 100). The white bread–based GI values were transformed into glucose-based GI values by multiplying the white bread–based GI by 0.7, as in Western studies (24, 28), or by 0.73 [= 100/137 (white bread–based GI value of white bread/white bread–based GI value of glucose)] as in Japanese studies (27). The white rice–based GI values were transformed into glucose-based GI values by multiplying white rice–based GI by 0.82 [= 100/122 (white rice-based GI of white rice/white rice-based GI of glucose)] (25, 26). When more than one GI value was available, the mean GI values was used. Ten foods for which a GI value had not been determined were assigned a value according to the nearest comparable food, as follows: Chinese noodles were assigned the GI of instant noodles, Japanese-style pancakes were assigned the GI of pizza, jellies were assigned the GI of pudding, lotus roots were assigned the GI of carrots, vegetable juice was assigned the GI of tomato juice, curry and roux in stew were assigned the GI of white rice with curry, nutritional-supplement drinks were assigned the GI of sports drinks, nutritional supplement bars were assigned the GI of a sports bar, and ground fish-meat products and boiled-fish, shellfish, and seaweed in soy sauce were assigned the GI of fish fingers. Although alcoholic beverages contain little carbohydrate, large quantities of several alcoholic beverages, such as beer and sake, may raise glucose concentrations slightly; however, by definition, the GI is based on 50 g available carbohydrate. Thus, we ignored alcoholic beverages during the calculation of dietary GI and GL. Furthermore, foods with a very low available carbohydrate content were excluded because their GI values cannot be tested. The cutoff for exclusion of foods was set at 3.5 g available carbohydrate per serving (6). Of the total 147 food and beverage items included in the DHQ, 6 (4.1%) are alcoholic beverages, 8 (5.4%) contain no available carbohydrate, and 63 (42.9%) contain <3.5 g available carbohydrate per serving. The calculation of dietary GI and GL was thus based on the remaining 70 items with GI values ranging from 16 to 91. The GI value of each item is presented in **Table 1**. In the present study, the available carbohydrate content of these 70 items contributed to 94.0 ± 2.5% ($\bar{x}$ ± SD) of total available carbohydrate intake, which is comparable with previous studies (6, 10).

Other variables

Smoking status, menopausal status, dietary supplement use during the previous month, and rate of eating were self-reported in questionnaires. Body weight at age 20 y was also self-reported, and BMI at age 20 y was computed by dividing self-reported weight (kg) at age 20 y by the square of current measured height (m). In addition, the subjects reported the average times per week spent on 13 activities such as sleeping, household-related activities, leisure-time sporting activities, and leisure-time sedentary activities. The reported number of hours spent on each activity (per week) was divided by 7 to obtain the mean number of hours per day. For subjects whose recorded total hours per day were < or >24 h, the total number of hours spent daily were proportionately increased or decreased to equal 24. Each activity was assigned a metabolic equivalent (MET) value from a previously published table (29, 30). The mean number of hours spent per day on each activity was multiplied by the MET value of that activity, and all MET-hour products were summed to give a total MET-hour score for the day. Total energy expenditure was calculated by multiplying the total MET-hour score by body weight. Physical activity level was calculated by dividing total energy expenditure by basal metabolic rate, which was estimated as standard values of basal metabolic rate for Japanese women multiplied by body weight (31).

Statistical analysis

Dietary GI and GL were examined in relation to the 7 metabolic risk factors: BMI; serum total, HDL, and LDL cholesterol; fasting serum triacylglycerol; fasting plasma glucose; and Hb A_{1c}. We used crude values for dietary GI and energy-adjusted values for dietary GL (/1000 kcal) because, by definition, dietary GI is a measure of carbohydrate quality, not quantity, whereas dietary GL is a measure of the combination of carbohydrate quality and quantity. The mean (±SE) values for these metabolic factors were calculated according to quintiles of dietary GI and GL after multivariate adjustment for potential confounding variables. Confounding variables included residential area (5 categories), age (≤39, 40–49, 50–59, 60–69, and ≥ 70 y), menopausal status (premenopausal or postmenopausal), current smoking (no or yes), dietary supplement use (no or yes), rate of eating (fast, medium, or slow), physical activity level (quintiles), energy intake (quintiles), percentage of energy as fat (quintiles), alcohol intake (nondrinkers, >0 to <1% of energy, or ≥1% of energy), and energy-adjusted intake (g/1000 kcal) of dietary fiber (quintiles). In the analyses, except for the analysis of BMI, current BMI (quintiles) and BMI at age 20 y (quintiles) were also included as confounding variables. Linear trends with increasing levels of dietary GI and GL were tested by assigning each participant the median value for the category and modeling this value as a continuous variable. All statistical analyses were carried out by using SAS statistical software (version 8.2; SAS Institute Inc, Cary, NC). All reported P values are 2-tailed, and a P value <0.05 was considered statistically significant.

RESULTS

Basic characteristics of the 1354 subjects are shown in **Table 2**. The mean intakes of protein, fat, and carbohydrate were 14.0%, 25.3%, and 59.0% of energy, respectively. The mean dietary GI was 66.7 and the mean dietary GL was 88.0 (/1000 kcal; crude mean = 167.7). White rice was the major contributor to dietary GI and GL (58.5%), followed by confectioneries (10.6%), fruit (6.7%), sugars (5.5%), bread (4.3%), noodles (3.4%), other rice (3.2%), and potatoes (2.6%). Potential confounding variables of the 1354 subjects are shown in **Table 3** according to quintiles of dietary GI and GL. Fewer women in the higher quintiles of dietary GI used dietary supplements and more were nondrinkers of alcohol. Women in the higher quintiles of

TABLE 1
Glycemic index (GI) value of each food and beverage item used in the present study[1]

Food and beverage item	GI
White rice	77
White rice with barley	67
White rice with germs	66
50% Polished rice	66
70% Polished rice	70
Brown rice	55
Soba (buckwheat noodles) and udon (Japanese wheat noodles)	47
Instant noodles	47
Chinese noodles	47
Spaghetti	46
White bread	74
Cake bread	62
Butter roll	59
Croissant	67
Pizza	51
Japanese-style pancake	51
Pancake	67
Cornflakes	81
Potato chips	54
French fries	70
Other potatoes	78
Sweet potatoes, yams, and taros	51
Jam and marmalade	51
Sugar for coffee and tea	68
Sugar used during cooking	68
Rice crackers	91
Snacks made from wheat flour	63
Japanese sweets with azuki beans	49
Japanese sweets without azuki beans	68
Cakes	46
Cookies and biscuits	59
Chocolates	43
Candies, caramels, and chewing gum	74
Jellies	44
Doughnuts	76
Boiled beans	16
Raisins	64
Canned fruits	49
Fruit juice (100%)	47
Other fruit juice	47
Tomato juice	38
Oranges	39
Bananas	51
Apples	37
Strawberries	40
Grapes	50
Peaches	42
Pears	38
Persimmons	50
Kiwi fruit	53
Melons	42
Watermelons	58
Pumpkins	75
Lotus roots	47
Vegetable juice	38
Curry and roux in stew	67
Cocoa	51
Lactic acid bacteria beverages	42
Soft drinks	61
Nutritional supplement drinks	66
Ground fish meat products	38
Boiled fish, shellfish, and seaweed in soy sauce	38
Full-fat milk	27
Low-fat milk	30
Skim milk	32
Yogurt (sweetened)	24
Yogurt (nonsweetened)	36
Yogurt (moderately sweetened)	30
Ice cream	61
Nutritional supplement bars	48

[1] GI of glucose = 100. These 70 food and beverage items from the 147 items in the diet-history questionnaire were used for the calculation of GI. The remaining 77 items not used consisted of 6 alcoholic beverages (beer, sake, shochu, schochu highball, whiskey, and wine), 8 items containing no available carbohydrate (oils used during cooking, table salt, salt used during cooking, sugarless soft drinks, chicken, Chinese soup, noodle soup, and water), and 63 items containing <3.5 g available carbohydrate per serving [peanuts, other nuts, konnyaku, butter, margarine, mayonnaise, salad dressing, tofu, tofu products, natto, miso as seasoning, miso in miso soup, carrots, tomatoes, green peppers, broccoli, green leafy vegetables, salted pickled plums (umeboshi), other salted pickles, cabbage, cucumbers, lettuce, Chinese cabbage, bean sprouts, radishes, onions, cauliflower, eggplants, burdocks, mushrooms, wakame seaweed, laver, ketchup, nonoil salad dressing, soy sauce, green tea and oolong tea, tea, coffee, dried fish, small fish with bones, canned tuna, eel, white meat fish, blue-back fish, red meat fish, shrimp, squid and octopus, oysters, other shellfish, fish eggs, salted fish intestines, ground beef and pork, pork, beef, liver, ham and sausages, bacon, eggs (heno and quailo), cheese, cottage cheese, coffee cream, corn soup, and artificial sweeteners].

dietary GI had lower mean energy, fat, and dietary fiber intakes. In addition, women in the higher quintiles of dietary GL had higher mean values for age and physical activity level and lower mean energy, fat, and dietary fiber intakes. Fewer women in the higher quintiles of dietary GL were premenopausal, current smokers, and dietary supplement users and more were nondrinkers of alcohol. Similar patterns were observed for potential confounding variables according to quintiles of dietary GI and GL among the subjects included in the analyses of serum LDL cholesterol (n = 1348), fasting serum triacylglycerol (n = 1349), fasting plasma glucose (n = 764), and Hb A_{1c} (n = 845) (data not shown).

Multivariate-adjusted mean values for metabolic risk factors across quintile categories of dietary GI and GL are shown in **Table 4**. After adjustment for potential confounding variables, dietary GI was significantly positively correlated with BMI (mean difference between the lowest and highest quintiles = 0.7; P for trend = 0.017), fasting serum triacylglycerol (mean difference = 16.0 mg/dL; P for trend = 0.001), fasting plasma glucose (mean difference = 6.4 mg/dL; P for trend = 0.022), and Hb A_{1c} (mean difference = 0.2%; P for trend = 0.038). No correlation was observed between dietary GI and serum concentrations of total, HDL, and LDL cholesterol.

In contrast, after control for potential confounding variables, dietary GL was significantly negatively correlated with serum HDL cholesterol (mean difference = −6.4 mg/dL; P for trend = 0.004) and positively correlated with fasting serum triacylglycerol (mean difference = 14.4 mg/dL; P for trend = 0.047) and fasting plasma glucose (mean difference = 12.5 mg/dL; P for trend = 0.012). Other metabolic risk factors examined, including

TABLE 2
Basic characteristics of the 1354 Japanese women

	Value
Age (y)	55.3 ± 10.3[1]
≤39 y	69 (5.1)[2]
40–49 y	319 (23.6)
50–59 y	446 (32.9)
60–69 y	440 (32.5)
≥70 y	80 (5.9)
Body height (cm)	152.9 ± 5.9
Body weight (kg)	56.1 ± 8.3
Current BMI (kg/m^2)	24.0 ± 3.3
BMI at age 20 y (kg/m^2)	21.7 ± 2.6
Menopausal status	
Premenopausal	427 (31.5)
Postmenopausal	927 (68.5)
Current smoking	
No	1309 (96.7)
Yes	45 (3.3)
Dietary supplement use	
No	954 (70.5)
Yes	400 (29.5)
Rate of eating	
Fast	480 (35.5)
Medium	644 (47.6)
Slow	230 (17.0)
Physical activity level	1.84 ± 0.28
Energy intake (kcal/d)	1944 ± 497
Protein intake (% of energy)	14.0 ± 2.2
Fat intake (% of energy)	25.3 ± 5.8
Carbohydrate intake (% of energy)	59.0 ± 7.1
Alcohol intake (% of energy)	0.8 ± 2.3
Nondrinkers	836 (61.7)
>0% to < 1% of energy	271 (20.0)
≥1% of energy	247 (18.2)
Dietary fiber intake (g/1000 kcal)	7.6 ± 2.1
Dietary glycemic index[3]	66.7 ± 4.0
Dietary glycemic load (/1000 kcal)[3]	88.0 ± 15.1

[1] $\bar{x}$ ± SD (all such values).
[2] n; percentage in parentheses (all such values).
[3] Glycemic index for glucose = 100.

BMI, serum concentrations of total and LDL cholesterol, and Hb A_{1c} were not significantly correlated with dietary GL. Adjustment for the percentage of energy from carbohydrate instead of the percentage of energy from fat did not change the results materially, which suggests that the observed correlations between dietary GI and GL and metabolic risk factors are independent of carbohydrate intake (data not shown).

DISCUSSION

Because only limited evidence is available regarding associations between dietary GI and GL and metabolic risk factors, particularly in Asian populations, we investigated these associations in the present cross-sectional study of healthy Japanese female farmers with traditional dietary habits. We found that dietary GI was positively associated with BMI, fasting serum triacylglycerol, fasting plasma glucose, and Hb A_{1c} after control for potentially confounding lifestyle and dietary factors. We also found that dietary GL was independently negatively associated with serum HDL cholesterol and positively associated with serum triacylglycerol and fasting plasma glucose.

Concerns have been expressed regarding the utility of the GI for mixed meals (32, 33). However, many researchers have shown that the GI of a mixed meal can be predicted consistently as the mean of the GI values of each of the component foods, weighted according to their relative contribution to carbohydrate intake (34–36). In reality, studies using standardized techniques have observed high correlation coefficients between observed and calculated GI values, ranging from 0.84 to 0.99 (34–36). Dietary GI and GL values in the present study were similar when compared with those in a previous Japanese study (67 compared with 64 for GI and 168 compared with 150 for GL) (10). However, the dietary GI and GL values observed in the present and previous (10) Japanese studies were considerably higher than the corresponding values in Western countries (48–60 for GI and 84–120 for GL) (4–6, 7–9, 37–40). This may have resulted from the differences in the major food contributors. Dietary GIs and GLs in Western populations are determined by a variety of food items, including potatoes (7–8%), breakfast cereals (4–7%), bread (5%), and rice (5%) (41–43). However, white rice (GI = 77) was the major contributor in the present and previous (10) Japanese studies, accounting for 59% of dietary GI and GL in the present study.

All self-reported dietary assessment methods are subject to measurement error and selective underestimation or overestimation of dietary intake (44). In the present study, however, we used a previously validated DHQ (20–22) to minimize data inaccuracy. Additionally, dietary GI and GL values calculated in the present study are believed to be relatively accurate because the major determinant of dietary GI and GL in the present study, rice (62%), is more accurately reported than are other foods on the DHQ because it is consumed regularly in relatively fixed amounts. Moreover, the same tendency was observed in a repeated analysis of subjects with a physiologically plausible energy intake, ie, subjects with a ratio of energy intake to basal metabolic rate of 1.2–2.5 (45)—≈78% of the subjects included in the main analysis (data not shown). Thus, we considered that the correlations observed in the present study reflect true associations, not spurious associations resulting from inaccurate dietary data.

In the present study, dietary GI was positively correlated with BMI. A 5-wk crossover, randomized, controlled trial conducted in overweight nondiabetic men with ad libitum dietary intakes also showed a significantly lower fat mass and a tendency for a higher fat-free mass, but not a lower body weight, after a low-GI diet than after a high-GI diet (46). In contrast, other ad libitum trials conducted in subjects with type 2 diabetes showed no significant differences in body weight change between high-GI and low-GI diets (47–49). However, in a 10-wk ad libitum, randomized, controlled trial conducted in healthy overweight women, decreases in body weight and fat mass were larger in a low-GI diet group than in a high-GI diet group, although these differences were not statistically significant (50). Moreover, as was shown in this study, a recent observational study also showed a positive association between dietary GI and BMI and no association between dietary GL and BMI (6).

Dietary GL has consistently been shown to be inversely correlated with HDL cholesterol in cross-sectional studies (8–11). In contrast, the correlation between dietary GI and HDL cholesterol is not consistent. An inverse correlation has been reported

TABLE 3
Selected characteristics of the 1354 Japanese women according to quintiles of dietary glycemic index and load

	Quintiles of dietary glycemic index or load					
	1 (n = 270)	2 (n = 271)	3 (n = 271)	4 (n = 271)	5 (n = 271)	P[1]
Dietary glycemic index[2]	60.8 ± 2.6[3]	64.8 ± 0.7	67.0 ± 0.6	68.9 ± 0.6	71.8 ± 1.4	
Age (y)	55.8 ± 11.3	54.7 ± 10.4	55.1 ± 10.4	55.4 ± 9.7	55.7 ± 9.4	0.89
Current BMI (kg/m^2)	23.9 ± 3.3	23.9 ± 3.1	23.8 ± 3.1	24.2 ± 3.3	24.2 ± 3.5	0.23
BMI at age 20 y (kg/m^2)	21.7 ± 2.8	21.5 ± 2.2	21.6 ± 2.4	21.8 ± 2.5	21.9 ± 2.8	0.22
Premenopausal women (%)	27	31	35	30	34	0.21
Current smokers (%)	6	3	3	1	4	0.13
Dietary supplement users (%)	37	30	31	26	24	0.0005
Rate of eating (%)						0.45
Fast	37	36	33	39	33	
Medium	46	51	47	47	47	
Slow	17	13	20	14	20	
Physical activity level	1.82 ± 0.29	1.84 ± 0.28	1.83 ± 0.28	1.85 ± 0.28	1.84 ± 0.29	0.45
Energy intake (kcal/d)	2171 ± 559	2067 ± 453	1979 ± 467	1809 ± 404	1695 ± 440	<0.0001
Fat intake (% of energy)	27.7 ± 5.5	27.0 ± 5.4	25.6 ± 5.2	24.3 ± 5.4	22.2 ± 5.5	<0.0001
Alcohol intake (%)						0.0007
Nondrinkers	57	57	62	67	66	
> 0% to < 1% of energy	20	21	21	19	20	
≥1% of energy	23	22	17	14	15	
Dietary fiber intake (g/1000 kcal)	9.1 ± 2.3	7.9 ± 2.0	7.6 ± 1.7	7.2 ± 1.7	6.4 ± 1.6	<0.0001
Dietary glycemic load (/1000 kcal)[2]	67.6 ± 6.7	79.9 ± 2.4	87.4 ± 2.3	95.4 ± 2.5	109.7 ± 8.4	
Age (y)	53.5 ± 12.1	54.4 ± 10.6	54.5 ± 10.1	56.9 ± 8.9	56.9 ± 9	<0.0001
Current BMI (kg/m^2)	24.1 ± 3.3	23.8 ± 3.0	24.0 ± 3.4	24.1 ± 3.2	24.0 ± 3.4	0.70
BMI at age 20 y (kg/m^2)	21.6 ± 2.6	21.7 ± 2.4	21.6 ± 2.6	21.7 ± 2.5	21.9 ± 2.6	0.21
Premenopausal women (%)	38	34	32	28	27	0.002
Current smokers (%)	6	3	3	3	2	0.024
Dietary supplement users (%)	34	32	32	27	22	0.0007
Rate of eating (%)						0.58
Fast	39	32	36	34	37	
Medium	47	48	50	45	47	
Slow	14	20	14	21	16	
Physical activity level	1.79 ± 0.27	1.84 ± 0.29	1.84 ± 0.27	1.86 ± 0.29	1.85 ± 0.30	0.010
Energy intake (kcal/d)	2285 ± 549	2106 ± 438	1926 ± 404	1808 ± 396	1595 ± 378	<0.0001
Fat intake (% of energy)	31.8 ± 4.7	28.4 ± 3.0	25.6 ± 3.1	22.4 ± 2.8	18.5 ± 3.5	<0.0001
Alcohol intake (%)						<0.0001
Nondrinkers	49	54	63	67	75	
>0% to <1% of energy	17	23	22	21	18	
≥1% of energy	34	23	15	12	7	
Dietary fiber intake (g/1000 kcal)	8.1 ± 2.3	7.9 ± 2.0	7.6 ± 1.8	7.7 ± 2.1	6.9 ± 1.9	<0.0001

[1] For continuous variables, tests for linear trend used the median value in each quintile as a continuous variable in linear regression; a Mantel-Haenszel chi-square test was used for categorical variables.
[2] Glycemic index for glucose = 100.
[3] $\bar{x}$ ± SD (all such values).

in 3 (7, 8, 10), but not in another 2 (9, 37), cross-sectional studies. Furthermore, recent randomized controlled trials have not supported the beneficial effect of a low-GI diet on HDL cholesterol in contrast with a high-GI diet (46–50). In the present study, we also found an inverse correlation between dietary GL and HDL cholesterol, but no correlation between dietary GI and HDL cholesterol.

Both dietary GI and GL were positively correlated with fasting triacylglycerol in 2 cross-sectional studies (9, 10); however, no association between dietary GI and fasting triacylglycerol was observed in a study of elderly men (37). In the present study, both dietary GI and GL were positively associated with fasting triacylglycerol. Several randomized controlled trials have also shown the beneficial effect of a low-GI diet on triacylglycerol (51), although the lack of an effect of GI has been observed in subjects with low triacylglycerol concentrations (52).

We identified a positive correlation between dietary GI and GL and fasting glucose, whereas no correlation was observed in a cross-sectional study of elderly men (37). Several prospective cohort studies (4, 5, 38), but not others (39, 40, 53), in the United States have shown a positive association between dietary GI, GL, or both and the incidence of type 2 diabetes, which is not in conflict with our finding. Recently, several (48, 49), but not all (46, 47, 50), randomized controlled trials have also shown lower fasting glucose concentrations after consumption of a low-GI diet than after a high-GI diet.

TABLE 4

Metabolic risk factors according to quintiles of dietary glycemic index and load in Japanese women

	Total *n*	Quintiles of dietary glycemic index or load					*P* for trend[1]
		1	2	3	4	5	
Dietary glycemic index[2,3]	1354	61 (46.1–63.4)	65 (63.5–65.9)	67 (66.0–67.9)	69 (68.0–70.0)	72 (70.1–76.5)	
BMI (kg/m^2)[4]	1354	23.7 ± 0.2 (270)[5]	23.9 ± 0.2 (271)	23.8 ± 0.2 (271)	24.2 ± 0.2 (271)	24.4 ± 0.2 (271)	0.017
Serum total cholesterol (mg/dL)[4,6]	1354	212.1 ± 2.2 (270)	211.8 ± 2.0 (271)	211.6 ± 2.0 (271)	216.5 ± 2.0 (271)	211.5 ± 2.2 (271)	0.74
Serum HDL cholesterol (mg/dL)[4,6]	1354	64.7 ± 0.9 (270)	62.5 ± 0.9 (271)	63.0 ± 0.9 (271)	63.8 ± 0.9 (271)	63.6 ± 1.0 (271)	0.58
Serum LDL cholesterol (mg/dL)[4,6]	1348	130.0 ± 2.1 (269)	129.4 ± 1.9 (269)	128.2 ± 1.9 (269)	133.2 ± 1.9 (271)	127.3 ± 2.1 (270)	0.73
Fasting serum triacylglycerol (mg/dL)[4,6]	1349	87.1 ± 3.0 (269)	99.1 ± 2.8 (270)	101.7 ± 2.7 (270)	98.0 ± 2.8 (270)	103.1 ± 3.0 (270)	0.001
Fasting plasma glucose (mg/dL)[4,6]	764	92.9 ± 2.0 (152)	97.0 ± 1.8 (153)	97.0 ± 1.8 (153)	99.8 ± 1.8 (153)	99.3 ± 1.9 (153)	0.022
Glycated hemoglobin (%)[4,6]	845	5.0 ± 0.1 (169)	5.1 ± 0.1 (169)	5.1 ± 0.1 (169)	5.2 ± 0.1 (169)	5.2 ± 0.1 (169)	0.038
Dietary glycemic load (/1000 kcal)[2,7]	1354	69 (31.1–75.7)	80 (75.8–83.7)	87 (83.8–91.2)	95 (91.3–100.2)	107 (100.3–148.5)	
BMI (kg/m^2)[4]	1354	24.2 ± 0.3 (270)	23.8 ± 0.2 (271)	24.0 ± 0.2 (271)	24.2 ± 0.2 (271)	23.8 ± 0.3 (271)	0.48
Serum total cholesterol (mg/dL)[4,6]	1354	212.6 ± 3.0 (270)	215.1 ± 2.4 (271)	212.1 ± 2.1 (271)	212.2 ± 2.4 (271)	211.6 ± 3.2 (271)	0.87
Serum HDL cholesterol (mg/dL)[4,6]	1354	67.2 ± 1.3 (270)	65.5 ± 1.0 (271)	62.1 ± 0.9 (271)	61.9 ± 1.0 (271)	60.8 ± 1.4 (271)	0.004
Serum LDL cholesterol (mg/dL)[4,6]	1348	127.2 ± 2.8 (267)	130.4 ± 2.3 (271)	130.7 ± 2.0 (270)	130.0 ± 2.2 (270)	129.9 ± 3.0 (270)	0.56
Fasting serum triacylglycerol (mg/dL)[4,6]	1349	91.0 ± 4.1 (269)	96.8 ± 3.3 (270)	95.6 ± 2.9 (270)	100.1 ± 3.2 (270)	105.4 ± 4.4 (270)	0.047
Fasting plasma glucose (mg/dL)[4,6]	764	90.9 ± 2.7 (152)	97.0 ± 2.1 (153)	97.5 ± 1.9 (153)	97.2 ± 2.1 (153)	103.4 ± 2.9 (153)	0.012
Glycated hemoglobin (%)[4,6]	845	5.0 ± 0.1 (169)	5.1 ± 0.1 (169)	5.1 ± 0.1 (169)	5.1 ± 0.1 (169)	5.2 ± 0.1 (169)	0.10

[1] Linear trends were tested with increasing dietary glycemic indexes and loads by assigning each participant the median value for the category and modeling this value as a continuous variable.

[2] Glycemic index for glucose = 100. Values are medians; ranges in parentheses.

[3] The median values shown are the same for BMI, triacylglycerol, and total, HDL, and LDL cholesterol but are different for glucose and glycated hemoglobin: 61, 64, 67, 69, and 71, respectively.

[4] Adjusted for residential area (5 categories), age (≤39, 40–49, 50–59, 60–69, and ≥70 y), menopausal status (premenopausal or postmenopausal), current smoking (no or yes), dietary supplement use (no or yes), rate of eating (fast, medium, or slow), physical activity level (quintiles), energy intake (quintiles), percentage of energy as fat (quintiles), alcohol intake (nondrinker, >0% to <1% of energy or ≥1% of energy), and energy-adjusted dietary fiber intake (quintiles).

[5] $\bar{x}$ ± SE; *n* in parentheses (all such values).

[6] Additionally adjusted for current BMI (quintiles) and BMI at age 20 y (quintiles).

[7] The median values shown are the same for BMI, triacylglycerol, glycated hemoglobin, and total, HDL, and LDL cholesterol but are different for glucose: 68, 79, 87, 95, and 107/1000 kcal, respectively.

We found a positive correlation between dietary GI and Hb A_{1c}. A positive association was also reported in cross-sectional studies conducted in patients with type 2 diabetes treated by dietary restriction alone (12) and in patients with type 1 diabetes (13). Additionally, a low-GI diet reduced Hb A_{1c} more than did a high-GI diet in several randomized controlled trials (48, 49). Furthermore, a recent meta-analysis of 14 randomized controlled trials has shown the amelioration of Hb A_{1c} through a low-GI diet (54).

Both total and LDL cholesterol were not correlated with dietary GI or GL in the present study, although randomized controlled trials have generally shown that low-GI diets result in lower total and LDL cholesterol concentrations (54). However, similar to our findings, no correlation between dietary GI or GL and total or LDL cholesterol was observed in several cross-sectional studies (7, 10, 37).

Our results may not be extrapolated into general Japanese populations because the subjects in the present study were selected female farmers. Additionally, our DHQ, although similar to most previous epidemiologic studies, was not designed specifically to measure dietary GI and GL; however, the satisfactory validity of this DHQ for total carbohydrate (20) provides some reassurance. Moreover, although we attempted to adjust for a wide range of potential confounding variables, we could not rule out residual confounding because of these or other unknown variables. Furthermore, because the study population consisted of generally healthy persons, the clinical relevance of our findings remains to be elucidated. However, our results should provide valuable insight from a prevention perspective.

In summary, after adjustment for a variety of confounding factors, we observed positive correlations between dietary GI and BMI, fasting serum triacylglycerol, fasting plasma glucose, and Hb A_{1c} and between dietary GL and fasting serum triacylglycerol and fasting plasma glucose and negative correlations between dietary GL and serum HDL cholesterol in healthy Japanese female farmers whose dietary GI and GL were primarily determined by white rice. Because the cross-sectional nature of the present study precludes any causal inferences, more observational and experimental studies are needed before any firm conclusions can be drawn with regard to the effect of dietary GI and GL on metabolic risk factors.

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KM created a table of glycemic index, conducted the statistical analyses, and wrote the manuscript. SS was involved in the design of the dietary study and assisted in the creation of the table and the manuscript. YT assisted in the creation of the table. HO was involved in the management of the dietary dataset and data collection during the dietary study. YH was involved in the data collection for the dietary study. HH and EO were responsible for the research design, data collection, and data management. FK was responsible for the research design, data collection, and overall management. All authors provided suggestions during the preparation of the manuscript and approved

the final version submitted for publication. None of the authors had any conflict of interest to declare.

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Applied nutritional investigation

No relation between intakes of calcium and dairy products and body mass index in Japanese women aged 18 to 20 y

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Abstract

Objective: This cross-sectional study examined possible associations of intakes of calcium and dairy products to body mass index (BMI; kilograms per square meter) in young Japanese women.
Methods: Subjects were 1905 female Japanese dietetic students who were 18 to 20 y of age. Dietary intake was assessed over a 1-mo period with a validated, self-administered diet history questionnaire. BMI was computed by using self-reported weight and height. BMI among quartiles of energy-adjusted intakes (per 1000 kcal) of calcium and dairy products was compared while controlling for intakes of protein, fat, and dietary fiber, self-reported rate of eating, and other non-dietary variables.
Results: Mean BMI ± standard deviation was 20.8 ± 2.6 kg/m^2. Mean estimated intakes were 268 ± 93 mg/1000 kcal for calcium and 80 ± 63 g/1000 kcal for dairy products. Intakes of calcium and dairy products were not significantly associated with BMI (adjusted means in the lowest and highest quartiles were 20.7 and 20.8 for calcium, P for trend = 0.48, and 20.6 and 20.6 for dairy products, P for trend = 0.81). These results were also observed after excluding 481 energy under- and over-reporters for calcium (20.4 and 20.5, respectively, P for trend = 0.73) and dairy products (20.3 and 20.4, respectively, P for trend = 0.73).
Conclusions: Intakes of calcium and dairy products may not necessarily be associated with BMI among young Japanese women who not only are relatively lean but also have a relatively low intake of calcium and dairy products.

Keywords: Calcium intake; Dairy product intake; Body mass index; Japanese women; Epidemiology

Introduction

A recently emerging body of literature suggests that the intake of calcium and/or dairy products may protect humans against the development of obesity [1–15]. A possible theory is that a low calcium intake causes high intracellular calcium concentrations, which in turn promote lipogenesis, inhibit lipolysis, and decrease thermogenesis, whereas a high calcium intake reverses these trends [3]. It seems that the effect of calcium in the form of dairy products may be greater than that of elemental calcium [16]. However, several published reports have not supported the potentially favorable effects of calcium and/or dairy products on measurements of obesity [17–22]. Thus, the relation of calcium and/or dairy product intake to obesity remains unclear. In addition, research on this issue has been conducted mainly in Western countries, whereas information is quite limited in non-Western countries including Japan, where the prevalence of obesity and dietary intakes of calcium and dairy products are relatively low [23]. Therefore, we investigated possible associations of intakes of calcium and dairy products with body mass index (BMI) in young Japanese women.

Materials and methods

Subjects were students who entered dietetic courses at 22 colleges and technical schools in three of the four main islands of Japan in April 1997 (n = 2069) [24–26].

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A total of 2063 students (2017 women and 46 men) participated in the survey (response rate 99.7%). For statistical analysis, we selected female subjects who were 18 to 20 y of age ($n = 1960$). We excluded from the 1960 women those who were currently receiving dietary counseling ($n = 33$), those with an extremely low or high reported energy intake (<775 or >3950 kcal/d, $n = 18$), and those with missing information on variables used in the present study ($n = 6$). Because some subjects were in more than one exclusion category, the final analytic sample contained 1905 subjects.

Dietary habits during the previous month were assessed by using a previously validated, self-administered diet history questionnaire (DHQ) [27–29]. Measurements of dietary intake for 147 food and beverage items, energy, protein, fat, carbohydrate, alcohol, dietary fiber, and calcium were calculated by using an ad hoc computer algorithm developed for the DHQ, which was based on the *Standard Tables of Food Composition in Japan* [30]. Although dietary supplement usage was queried in the DHQ, intake from dietary supplements was not included in this study due to the lack of a reliable composition table of dietary supplements in Japan. Dairy products consisted of full-fat, low-fat, and skimmed milk, sweetened and non-sweetened yogurt, cheese, cottage cheese, ice cream, and coffee cream [31]. Pearson's correlation coefficient between DHQ and 3-d diet records was 0.49 for calcium intake that was adjusted for energy intake by using a residual model among 47 women [27]. For dairy products (grams per 1000 kcal), Spearman's correlation coefficient between DHQ and 16-d diet records was 0.52 among 92 women (unpublished observations, S. Sasaki, 2004).

Body weight and height were self-reported as part of the DHQ. BMI was computed as weight (kilograms) divided by the square of height (meters). In the DHQ, subjects also reported their rate of eating (very slow, relatively slow, medium, relatively fast, or very fast) and intentional dietary change (no, changed within 1 y, changed within 3 y, or changed >3 y ago). In addition, a self-administered questionnaire on general lifestyle during the previous month asked about the following four variables: current smoking (yes or no), experience of dieting (≥2 kg intentional decrease in body weight within 1 mo, yes or no), residential area, and participation in sports club activities (times per month) without inquiring into the types of sports, intensity, or duration. Residential areas were categorized into 12 regional blocks according to the *National Nutrition Survey in Japan* [23]. Because relatively few subjects were categorized into three of these blocks (Hokkaido, Tohoku, and Hokuriku), they were included in their adjacent blocks, resulting in nine categories (Kanto II, Hokkaido, and Tohoku; Kanto I; Tokai and Hokuriku; Kinki I; Kinki II; Chugoku; Shikoku; Kita-kyushu; and Minami-kyushu). The residential areas were also divided into three categories according to population (city with population ≥1 million, city with population <1 million, or town and village). Subjects who participated in sports club activities at least once per week were regarded as "active" and all others as "sedentary" without consideration of other kinds of activities.

All statistical analyses were performed with SAS 8.2 (SAS Institute, Cary, NC, USA). For analyses, subjects were categorized into quartiles according to the energy-adjusted intakes (per 1000 kcal) of calcium and dairy products. Mean BMI ± standard error (SE) was calculated by quartiles of these variables while controlling for a series of covariates that could affect body weight (residential block [nine categories], size of residential area [three categories], current smoking [two categories], alcohol drinking [yes or no because of extremely low alcohol intake, mean 0.8 g/d], physical activity [two categories], experience of dieting [two categories], intentional dietary change [four categories], rate of eating [five categories], protein intake [percentage of energy intake, continuous], fat intake [percentage of energy intake, continuous], and dietary fiber intake [grams per 1000 kcal, continuous]). We did not include percentage of energy intake from carbohydrate as a covariate because of its very high correlation with percentage of energy intake from fat (Pearson's correlation coefficient −0.94). We tested for linear trends with increasing levels of intakes of calcium and dairy products by assigning each participant the median value for the category and modeling this value as a continuous variable. We also calculated the partial regression coefficient (β) and SE for intakes of calcium and dairy products by multiple regression analysis with BMI as the dependent variable, with adjustment for the potential confounding variables indicated above. All reported P values are two-tailed, and $P < 0.05$ was considered statistically significant.

In a previous study [7], the size of the effect of calcium intake on BMI was −0.26 kg/m^2 per 100 mg per 1000-kcal increase in calcium intake. In our population [24], mean calcium intake ± standard deviation was 306 ± 148 mg/1000 kcal, and the standard deviation of BMI was 2.6 kg/m^2. Using these values, power calculations revealed that a sample of 532 women (133 women in each quartile category) was sufficient to demonstrate the expected difference (−0.89 kg/m^2) between the highest and lowest quartile categories (excepted medians 477 and 136 mg/1000 kcal, respectively), with 80% power at the $\alpha = 0.05$ significance level. Because these calculations for t test (not for analysis of variance or test for linear trend) did not take into consideration the adjustment for potential confounding variables, a larger number of subjects was needed in practice. However, our sample ($n = 1905$) was much larger than the calculated sample size, indicating that its size was sufficient for detecting the difference in BMI between extreme quartiles, if the size of the effect of calcium on BMI similar to that observed in the previous study [7] was really present in our population.

Results

Basic characteristics of the subjects are presented in Table 1. Mean BMI ± standard deviation of subjects was 20.8 ± 2.6 kg/m^2, and mean intakes were 268 ± 93 mg/1000 kcal for calcium and 80 ± 63 g/1000 kcal for dairy products. Potential confounding variables of the subjects are listed in Table 2 according to quartiles of intakes of calcium and dairy products. Among women in the higher quartiles of those intakes, more were defined as physically active and reported recent intentional dietary changes. Women in the higher quartiles of those intakes also had higher means of protein, fat, and dietary fiber intake. There were more subjects with dieting experience and more slower eaters in the higher quartiles of calcium intake.

As presented in Table 3, after adjustment for potential confounding variables, calcium and dairy product intakes were not significantly associated with BMI (adjusted means in the lowest and highest quartiles were 20.7 and 20.8 kg/m^2 for calcium, P for trend = 0.48, and 20.6 and 20.6 kg/m^2 for dairy products, P for trend = 0.81). Similar insignificant associations were observed when calcium and dairy products were treated as continuous variables in multiple regression analyses ($\beta \pm$ SE −0.0002 ± 0.0008 kg/m^2 for calcium, P = 0.77, and −0.0004 ± 0.0001 kg/m^2 for dairy products, P = 0.71). A repeated analysis of 1424 women with plausible reported energy intakes (ratio of energy intake to basal metabolic rate of 1.2 to 2.5) [32], conducted because of possible selective misreporting of dietary intake [33], also showed no relation between intakes of calcium and dairy products and BMI (adjusted means in the lowest and highest quartiles were 20.4 and 20.5 kg/m^2 for calcium, P for trend = 0.73, and 20.3 and 20.4 kg/m^2 for dairy products, P for trend = 0.73; $\beta \pm$ SE 0.0001 ± 0.0008 kg/m^2 for calcium, P = 0.90, and 0.0006 ± 0.0010 kg/m^2 for dairy products, P = 0.54).

Discussion

Using cross-sectional data of relatively lean young Japanese women with relatively low intakes of calcium and dairy products, we found no clear association of intakes of calcium and dairy products with BMI. This finding was consistent regardless of exclusion of implausible energy reporters.

An inverse relation of intakes of calcium and/or dairy products to measurements of obesity has been indicated in a considerable number of case-control [2], cross-sectional [3,5,7–10,12], and longitudinal [1,4,6] studies and intervention trials [13–15] conducted in Western countries. In addition, the frequency of dairy consumption has been inversely associated with BMI in Iranian adults [11]. In contrast, no significant relation has been shown in two longitudinal studies [18,21] or in several intervention trials [17,19,20] in Western countries. A recent longitudinal study

Table 1
Basic characteristics of subjects (n = 1905)*

Variable	
Age (y)	18.1 ± 0.4
Body height (cm)	157.9 ± 5.2
Body weight (kg)	51.8 ± 7.3
Body mass index (kg/m^2)	20.8 ± 2.6
Residential block†	
Kanto II, Hokkaido, and Tohoku	84 (4)
Kanto I	434 (23)
Tokai and Hokuriku	278 (15)
Kinki I	152 (8)
Kinki II	118 (6)
Chugoku	294 (15)
Shikoku	156 (8)
Kita-kyushu	214 (11)
Minami-kyushu	175 (9)
Size of residential area	
City with population ≥1 million	318 (17)
City with population <1 million	1106 (58)
Town and village	481 (25)
Current smoking	
No	1849 (97)
Yes	56 (3)
Current alcohol drinking	
No	1514 (79)
Yes	391 (21)
Physical activity‡	
Sedentary	1647 (86)
Active	258 (14)
Experience of dieting§	
No	1160 (61)
Yes	745 (39)
Intentional dietary change	
No	1481 (78)
Changed within 1 y	213 (11)
Changed within 3 y	127 (7)
Changed >3 y ago	84 (4)
Rate of eating	
Very slow	92 (5)
Relatively slow	431 (23)
Medium	683 (36)
Relatively fast	610 (32)
Very fast	89 (5)
Use of calcium supplement	
No	1868 (98)
Yes	37 (2)
Energy intake (kcal/d)	1911 ± 517
Protein intake (% energy)	13.7 ± 2.2
Fat intake (% energy)	30.5 ± 6.1
Carbohydrate intake (% energy)	54.4 ± 6.8
Dietary fiber intake (g/1000 kcal)	6.3 ± 1.7
Calcium intake (mg/1000 kcal)	268 ± 93
Dairy product intake (g/1000 kcal)	80 ± 63

* Values are means ± standard deviations or numbers of subjects (%).

† Residential blocks were categorized into 12 blocks according to the National Nutrition Survey of Japan [23]. Because relatively few subjects were categorized into three of these blocks (Hokkaido, Tohoku, and Hokuriku), they were included in their adjacent blocks.

‡ Subjects who took part in sports club activities at least once per week were defined as "active" and others as "sedentary."

§ "Dieting" was defined as at least 2 kg of intentional decrease of body weight within 1 mo.

Table 2
Selected characteristics of subjects by quartiles of energy-adjusted intakes of calcium and dairy products (n = 1905)*

Variable	Quartiles of intakes of calcium or dairy products				$P^{\dagger}$
	1 (n = 476)	2 (n = 476)	3 (n = 477)	4 (n = 476)	
Calcium intake (mg/1000 kcal)	166 ± 26	227 ± 15	283 ± 17	394 ± 74	
Current smokers (%)	4	2	3	2	0.27
Current alcohol drinkers (%)	19	22	19	23	0.26
Subjects with active lifestyle (%)	9	15	14	16	0.0019
Subjects with experience of dieting (%)	36	36	43	42	0.0061
Intentional dietary change (%)					<0.0001
No	87	81	77	66	
Changed within 1 y	8	10	11	16	
Changed within 3 y	3	6	8	10	
Changed >3 y ago	2	3	4	8	
Rate of eating (%)					0.0073
Very slow	3	5	4	7	
Relatively slow	21	22	23	24	
Medium	38	33	37	35	
Relatively fast	31	36	31	29	
Very fast	7	3	5	4	
Protein intake (% energy)	12.1 ± 1.9	13.2 ± 1.7	14.1 ± 1.8	15.2 ± 2.1	<0.0001
Fat intake (% energy)	28.4 ± 6.9	31.1 ± 5.7	31.2 ± 5.6	31.1 ± 5.5	<0.0001
Dietary fiber intake (g/1000 kcal)	5.4 ± 1.2	6.0 ± 1.3	6.7 ± 1.5	7.2 ± 2.0	<0.0001
Dairy product intake (g/1000 kcal)	19 ± 8	49 ± 10	86 ± 12	166 ± 59	
Current smokers (%)	3	3	3	3	0.71
Current alcohol drinkers (%)	18	20	23	21	0.14
Subjects with active lifestyle (%)	10	14	14	16	0.0197
Subjects with experience of dieting (%)	40	37	38	42	0.42
Intentional dietary change (%)					<0.0001
No	83	79	80	69	
Changed within 1 y	9	12	9	15	
Changed within 3 y	6	4	6	10	
Changed >3 y ago	3	5	4	6	
Rate of eating (%)					0.14
Very slow	3	5	6	6	
Relatively slow	22	24	21	23	
Medium	39	34	33	38	
Relatively fast	31	33	35	30	
Very fast	6	4	5	4	
Protein intake (% energy)	12.8 ± 2.1	13.5 ± 2.1	13.8 ± 2.1	14.6 ± 2.1	<0.0001
Fat intake (% energy)	28.7 ± 6.6	30.6 ± 6.4	31.5 ± 5.2	31.1 ± 5.6	<0.0001
Dietary fiber intake (g/1000 kcal)	6.1 ± 1.6	6.3 ± 1.7	6.4 ± 1.6	6.5 ± 1.8	0.0045

* Values are mean ± standard deviation unless otherwise indicated.
† For continuous variables, tests for linear trend used the median value in each quartile as a continuous variable in linear regression; a Mantel-Haenszel chi-square test was used for categorical variables.

of American adolescents has also suggested a positive association between milk intake and body weight gain [22]. These inconsistent results may be explained at least in part by the different populations examined, different methods used to assess obesity and dietary intake, and number and type of variables used as confounding factors.

A possible reason for the null association we observed may be due to the narrow BMI range of our subjects, 78% of whom were of normal weight (BMI 18.5 to 24.9 kg/m^2) and only 6% were overweight (BMI ≥ 25 kg/m^2); thus, our population is relatively lean compared with populations in Western countries. Alternatively, it is possible that intakes of calcium and dairy products in our population were too low to have a beneficial effect on BMI; even intake levels of the highest quartile categories were relatively low for calcium (median 373 mg/1000 kcal) and dairy products (141 g/1000 kcal).

We do not believe that our null finding is due to any inaccuracy of our data for the following reasons. First, we used a validated DHQ to assess dietary intake. Second, although we used BMI computed from self-reported rather than measured weight and height, previous research has shown that BMI derived from the former is highly correlated with measured BMI [34,35], suggesting that BMI thus calculated is a reliable measurement for use in correlation analysis. Third, we previously observed a significant association of the self-reported rate of eating and dietary fiber intake with BMI in the same population [26], which may be some evidence of the quality of our data. Fourth, we conducted analyses with and without 481 women with implau-

Table 3
Adjusted mean ± SE of BMI according to quartiles of energy-adjusted intakes of calcium and dairy products with partial regression coefficients (β) and SE expressing changes in BMI for change in energy-adjusted intakes of calcium and dairy products ($n = 1905$)*

Variable	Quartiles of intakes of calcium or dairy products‡				P for trend†	β ± SE	P
	1 ($n = 476$)	2 ($n = 476$)	3 ($n = 477$)	4 ($n = 476$)			
Calcium intake (mg/1000 kcal)	170 (74–201)	227 (202–254)	282 (255–314)	373 (315–728)			
BMI (kg/m^2)	20.7 ± 0.1	20.7 ± 0.1	20.9 ± 0.1	20.8 ± 0.1	0.48	−0.0002 ± 0.0008	0.77
Dairy product intake (g/1000 kcal)	19 (0–32)	49 (33–65)	86 (66–108)	141 (109–458)			
BMI (kg/m^2)	20.6 ± 0.1	20.8 ± 0.1	21.1 ± 0.1	20.6 ± 0.1	0.81	−0.0004 ± 0.0001	0.71

BMI, body mass index; SE, standard error

* Adjusted for residential block (Kanto II, Hokkaido, and Tohoku; Kanto I; Tokai and Hokuriku; Kinki I; Kinki II; Chugoku; Shikoku; Kita-kyushu; and Minami-kyushu), size of residential area (city with population ≥ 1 million, city with population < 1 million, and town and village), current smoking (yes or no), alcohol drinking (yes or no), physical activity (sedentary or active), experience of dieting (yes or no), intentional dietary change (no, changed within 1 y, changed within 3 y, or changed >3 y ago), rate of eating (very slow, relatively slow, medium, relatively fast, or very fast), protein intake (percentage of energy, continuous), fat intake (percentage of energy, continuous), and dietary fiber intake (grams per 1000 kcal, continuous).

† Tests for linear trend used the median value in each quartile as a continuous variable in linear regression.

‡ Values are medians (ranges) or means ± SE.

sible energy intake, and these analyses provided similar results.

We could not include calcium intake from dietary supplements in the analysis because of the lack of a reliable composition table of dietary supplement in Japan. However, only 37 of 1905 women (2%) used calcium supplement in the present study. In addition, neither exclusion of calcium supplement users from analysis nor a further adjustment for calcium supplement usage as a dummy variable (yes or no) materially altered the results (data not shown). Thus, it is hardly likely that calcium supplement usage had a major effect on the findings in this study.

Our results may not be extrapolated to general Japanese populations because the subjects were selected female dietetic students who may have been highly health conscious. Other limitations regarding subject characteristics include the narrow range of age (18 to 20 y) and BMI (78% of subjects had a normal BMI, i.e., 18.5 to 24.9 kg/m^2) and the relatively low intakes of calcium and dairy products mentioned above. Possible seasonal changes in dietary habits were not taken into account in the present study because our DHQ assessed dietary habits during the previous month; however, seasonal variations in Japanese women seemed to be relatively minor, at least in calcium intake (7%) [36]. Although we attempted to adjust for a wide range of potential confounding variables, we can not rule out the possibility of residual confounding due to these or poorly measured variables such as physical activity, which was assessed quite roughly, and other unmeasured variables such as parental overweight or obesity, socioeconomic level, and unknown variables.

In conclusion, intakes of calcium and dairy products may not necessarily be associated with BMI among young Japanese women who not only are relatively lean but also have relatively low intakes of calcium and dairy products. However, better-designed cross-sectional studies and prospective and intervention studies should be conducted to confirm our present findings.

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ORIGINAL ARTICLE

Dietary intake in relation to self-reported constipation among Japanese women aged 18–20 years

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Objective: Information on modifiable lifestyle factors associated with constipation is limited, especially among non-Western populations. We examined associations between dietary intake and self-reported constipation in young Japanese women.
Design: Cross-sectional study.
Subjects: A total of 1705 female Japanese dietetic students aged 18–20 years and free of current disease and current dietary counseling.
Methods: Dietary intake was estimated over a 1-month period with a validated, self-administered, diet history questionnaire, and lifestyle variables including self-reported constipation were assessed by a second questionnaire designed for this survey.
Results: A total of 436 women (26%) reported themselves to be 'constipated'. A multivariate odds ratio (OR) for women in the highest quartile of rice intake was 0.47 (95% confidence interval (CI): 0.33, 0.68) compared with the lowest. Additionally, women in the highest category of coffee intake had a multivariate OR of 0.67 (0.47, 0.94) compared with women in the lowest. Conversely, women in the highest quartile of confectionery intake had a multivariate OR of 1.54 (1.12, 2.13) compared with women in the lowest. Moreover, a multivariate OR for constipation for women in the highest quartile of Japanese and Chinese tea intake was 1.49 (1.09, 2.05) compared with women in the lowest. Neither total dietary fiber intake nor other lifestyle factors examined were associated with constipation.
Conclusions: The consumption of rice and coffee was inversely associated with and that of confectioneries and Japanese and Chinese tea was positively associated with a prevalence of self-reported constipation.
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Keywords: dietary intake; constipation; Japanese women

Introduction

Constipation is a major health problem, although the criteria for constipation remain arbitrary (Thompson *et al.*, 1999), and symptoms of constipation vary from a relatively mild bowel habit disturbance to rare serious sequelae (Talley *et al.*, 2003). The reported prevalence of constipation ranges from 2 to 30% in Western countries, depending on the definition applied (Garrigues *et al.*, 2004; Higgins and Johanson, 2004). In Japan, the prevalence of constipation, defined as ≤3 bowel movements weekly, also seems to be relatively high (6–25%) (Hirai and Takezoe, 1997; Hirai *et al.*, 2001). As a result of its high prevalence, chronic nature and effect on quality of life (Talley, 2004), modifiable lifestyle factors associated with constipation need to be identified.

According to previous studies in the West, not only various factors including age (Everhart *et al.*, 1989; Sandler *et al.*, 1990; Campbell *et al.*, 1993; Dukas *et al.*, 2003), sex (Everhart *et al.*, 1989; Sandler *et al.*, 1990; Campbell *et al.*, 1993), smoking status (Dukas *et al.*, 2003), alcohol consumption (Dukas *et al.*, 2003; Sanjoaquin *et al.*, 2004), body mass index (BMI) (Sandler *et al.*, 1990; Dukas *et al.*, 2003; Sanjoaquin *et al.*, 2004), and physical activity (Everhart *et al.*, 1989;

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Sandler et al., 1990; Dukas et al., 2003; Sanjoaquin et al., 2004), but also several aspects of diet such as intakes of energy (Sandler et al., 1990; Towers et al., 1994), dietary fiber (Dukas et al., 2003; Sanjoaquin et al., 2004), and nonalcoholic beverages (Sandler et al., 1990; Sanjoaquin et al., 2004) have been associated with constipation. However, information on this issue is quite limited among people in Asian countries including Japan (Kunimoto et al., 1998; Wong et al., 1999; Nakaji et al., 2002; Fujiwara, 2003), where dietary habits and foods available differ considerably from those in Western countries. Moreover, quantitative assessment of diet was not performed in these Asian studies. Therefore, we investigated associations of dietary factors, which were assessed using a previously-validated self-administered diet history questionnaire (DHQ) (Sasaki et al., 1998a, b; 2000b), as well as other lifestyle factors with self-reported constipation in young Japanese women.

Subjects and methods

Subjects and data collection

The subjects were students who entered dietetic courses at 22 colleges and technical schools in Japan in April 1997 (n = 2069) (Sasaki et al., 2002; 2000a; 2003a). A total of 2063 students (2017 women and 46 men) participated in the survey (response rate: 99.7%). The staff of each school checked the submitted questionnaires according to the survey protocol. When missing values and/or logical errors were detected, the subjects were asked to complete the questions again. The questionnaires were checked at least once by the staff at each school and by the staff at the survey center. Most surveys were completed by the end of May 1997.

Questionnaires

Data were collected using the following two questionnaires: DHQ and a questionnaire on general lifestyle. The DHQ is a previously validated, structured 16-page questionnaire for assessing dietary habits in the previous month, consisting of the following seven sections: overall dietary behaviors; major cooking methods; consumption frequency and amount of six alcoholic beverages; consumption frequency and semi-quantitative portion size of selected 121 food and nonalcoholic beverage items; dietary supplement; consumption frequency and amount of 19 staple foods (rice, bread and noodles) and miso-soup; and open-ended sections for foods consumed regularly ($\geqslant$once/week) but not appearing in the DHQ (Sasaki et al., 1998a, b; 2000b). The food and beverage items and their portion sizes in the DHQ were derived mainly from the data of the National Nutrition Survey of Japan (Ministry of Health and Welfare, 1994). Dietary intake, including 147 food and beverage items, energy and dietary fiber, was calculated using an *ad hoc* algorithm for the DHQ, which was based on the food composition table in Japan (Science and Technology Agency, 2000); information on dietary supplement and from the open-ended section is not used in the calculation. Dietary fiber intake was estimated by the modified Prosky method (Science and Technology Agency, 2000) from the intake of 86 fiber-containing foods in the DHQ. The food and nonalcoholic beverage items were grouped into the following 18 food groups: rice; bread; noodles; potatoes; confectioneries (including sugar and sweeteners); fat and oil; pulses (including nuts); fish and shellfish; meat; eggs; dairy products; vegetables (including mushrooms and sea vegetables); fruits; water; Japanese and Chinese tea (nonfermented type of tea (green tea) and semi-fermented type of tea (oolong tea)); black tea (fermented type of tea); coffee; other nonalcoholic beverages. A detailed description and methods of calculating dietary intake and the validity of the DHQ have been published elsewhere (Sasaki et al., 1998a). The Pearson correlation coefficient between the DHQ and 3-d dietary records was 0.48 for energy intake among 47 women (Sasaki et al., 1998a). For dietary fiber intake (g/1000 kcal), the Pearson correlation coefficient between DHQ and 16-d dietary records was 0.69 among 92 women; the mean value of the Spearman correlation coefficients for intakes of 16 food groups (g/1000 kcal) was 0.35 (range: 0.05–0.59) (unpublished observations, Sasaki, 2004).

Body weight and height were self-reported as part of the DHQ. BMI was computed as weight (kg) divided by square of height (m). We classified BMI into three categories ($<$18.5, 18.5–24.9, and $\geqslant$25) according to the Japan Society for the Study of Obesity (Matsuzawa et al., 2000). The subjects were also asked in the DHQ whether they currently received dietary counseling.

The questionnaire on general lifestyle during the previous month is a 4-page questionnaire designed for this survey. In this questionnaire, subjects reported residential area (a place where the subject mainly lived during the previous month), participation in sports club activities (times/months), without inquiring into the types of sports, their intensity or duration, and smoking status ('never,' 'past' or 'current'). They were also asked whether or not they were currently suffering from some diseases. Residential areas were categorized into 12 blocks according to the National Nutrition Survey in Japan (Ministry of Health and Welfare, 2004). Since relatively few subjects were categorized into three of these blocks, they were included in their neighboring blocks. The residential areas were also divided into three categories according to population size (cities with population $\geqslant$1 million, cities with population $<$1 million, and towns and villages). The subjects who participated in sport club activities at least once per week were regarded as 'active' and all others as 'sedentary'.

Constipation was assessed by the following question in the questionnaire: do you often have constipation? The possible answers were 'yes', 'sometimes', or 'no'. The subjects with an answer of *yes* to the question were considered to be 'constipated'. We examined the validity of this question in

145 female Japanese dietetic students (mean age: 21.2 years) using 14-d bowel movement diaries as the standard; 33 subjects with an answer of *yes* had significantly ($P<0.001$) fewer bowel movements (mean ± s.d.: 3.4 ± 1.1 day/week) than did 60 subjects with an answer of *sometimes* (4.5 ± 1.3 day/week) or 52 subjects with an answer of *no* (6.2 ± 1.0 day/week).

Statistical analysis
For statistical analysis, we selected female subjects aged 18–20 years ($n=1960$). We excluded one woman whose residential area was not in Japan, 154 women currently having some diseases, and 33 women currently receiving dietary counseling. Also excluded were 43 women with a reported energy intake less than half the energy requirement for the lowest physical activity category (<775 (1550 × 0.5) kcal/day) or a reported energy intake more than 1.5 times the energy requirement of the highest physical activity category (>3450 (2300 × 1.5) kcal/day) according to the Recommended Dietary Allowance for Japanese (Ministry of Health and Welfare, 1999). We further excluded 47 women with missing values in the variables used. A total of 1705 women remained for the present analysis; some women were in more than one exclusion category.

The association between self-reported constipation (the dependent variable) and a number of variables was examined. The variables examined were six nondietary variables, that is, residential blocks (nine categories), size of residential area (three categories), physical activity (two categories), smoking status (three categories), alcohol drinking habits (two categories ('yes' or 'no') because of extremely low alcohol intake (mean: 0.7 g/day)), and BMI (three categories) and 22 dietary variables, that is, intakes of energy (kcal/day), 18 food groups mentioned above (g/1000 kcal), and total, soluble, and insoluble dietary fiber (g/1000 kcal) (quartiles except for water (four categories), black tea (four categories), and coffee (three categories) because of more than one quarter nonconsumers). We calculated both crude and multivariate odds ratios (ORs) and 95% CIs for self-reported constipation for each category of variables included using the logistic regression analysis; multivariate ORs were calculated by adjusting for six nondietary variables and energy intake. As results for the crude and multivariate analyses were similar for all variables considered, we presented only the results derived from the multivariate models. Trend of association (for only dietary variables) was assessed by a logistic regression model assigning scores to the levels of the independent variable. All statistical analyses were performed using the SPSS for Windows software program, version 11.5, (SPSS Japan Inc.) and the SAS statistical software, version 8.2 (SAS Institute Inc.). A two-sided P value of <0.05 was considered statistically significant.

Results

The mean (± s.d.) of selected physical characteristics was as follows: 18.1 ± 0.4 years for age, 157.9 ± 5.2 cm for height, 51.8 ± 7.3 kg for weight, and 20.8 ± 2.6 kg/m^2 for BMI. A total of 436 (26%) out of 1705 women reported themselves to be 'constipated'. Table 1 presents the multivariate ORs (95% CIs) for constipation in each category of selected demographic and lifestyle factors. Living in town or village was associated with a decreased prevalence of constipation compared with living in city with population ≥1 million (OR: 0.64; 95% CI: 0.43, 0.97). Residential block, physical activity, smoking status, alcohol drinking habits, and BMI were not significantly associated with constipation.

Table 1 Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for self-reported constipation in relation to selected demographic and lifestyle factors among 1705 Japanese women aged 18–20 years

	n with/without constipation	*Adjusted OR[a] (95% CI)*
Residential block[b]		
Kanto II, Hokkaido, Tohoku	21/56	1.00
Kanto I	97/282	0.75 (0.41, 1.34)
Tokai, Hokuriku	74/173	1.06 (0.60, 1.89)
Kinki I	32/103	0.71 (0.36, 1.37)
Kinki II	31/73	1.07 (0.55, 2.06)
Chugoku	52/219	0.61 (0.33, 1.10)
Shikoku	27/115	0.59 (0.31, 1.15)
Kita-kyushu	58/127	1.16 (0.64, 2.10)
Minami-kyushu	44/121	0.95 (0.51, 1.76)
Size of residential area		
City with population ≥1 million	81/202	1.00
City with population <1 million	258/723	0.83 (0.59, 1.17)
Town and village	97/344	0.64 (0.43, 0.97)
Physical activity[c]		
Sedentary	385/1113	1.00
Active	51/156	0.94 (0.66, 1.32)
Smoking status		
Nonsmoker	402/1197	1.00
Past smoker	15/39	1.18 (0.63, 2.21)
Currrent smoker	19/33	1.79 (0.98, 3.26)
Alcoholdrinking habits		
Nondrinker	345/991	1.00
Drinker	91/278	0.87 (0.66, 1.15)
Body mass index (kg/m^2)		
<18.5	69/215	1.00
18.5–24.9	351/971	1.15 (0.85, 1.55)
≥25	16/83	0.62 (0.34, 1.13)

[a]OR adjusted for residential block, size of residential area, physical activity, smoking status, alcohol drinking habits, body mass index, and energy intake.
[b]The residential blocks were categorized into 12 blocks according to the National Nutrition Survey of Japan (Ministry of Health and Welfare, 2004). As the subjects categorized into three of these blocks (Hokkaido, Tohoku, and Hokuriku) were relatively few, they were included in their neighboring regions.
[c]The subjects who took part in sports club activity at least once per week were defined as 'active' and others as 'sedentary'.

Table 2 shows the associations between dietary intake and constipation. Energy intake was not associated with a prevalence of constipation. There was a clear dose-response relationship between increased intake of rice and a decreased

Table 2 Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for self-reported constipation in relation to intakes of energy, dietary fiber, and food groups among 1705 Japanese women aged 18–20 years

	n with/without constipation	Adjusted OR[a] (95% CI)
Energy intake (kcal/day)		
1365 (777–1554)[b]	113/313	1.00
1703 (1555–1833)	105/321	0.94 (0.68, 1.28)
1977 (1834–2154)	100/327	0.87 (0.63, 1.19)
2447 (2155–3339)	118/308	1.12 (0.82, 1.53)
P for trend		0.58
Food intake (g/1000 kcal)		
Rice		
82.9 (0–104.9)	131/295	1.00
124.3 (105.0–144.3)	129/297	0.98 (0.72, 1.32)
164.3 (144.4–186.4)	97/330	0.65 (0.47, 0.90)
221.0 (186.5–441.8)	79/347	0.46 (0.32, 0.66)
P for trend		<0.0001
Bread		
8.5 (0–15.0)	95/331	1.00
21.8 (15.1–27.6)	111/315	1.20 (0.87, 1.65)
35.3 (27.7–43.5)	113/314	1.23 (0.89, 1.69)
59.5 (43.6–180.5)	117/309	1.27 (0.93, 1.75)
P for trend		0.15
Noodles		
0 (0–13.4)	117/309	1.00
22.0 (13.5–29.5)	110/316	0.91 (0.67, 1.23)
38.4 (29.6–50.3)	108/319	0.87 (0.63, 1.18)
67.4 (50.4–208.0)	101/325	0.81 (0.59, 1.11)
P for trend		0.19
Potatoes		
7.7 (0–10.1)	97/329	1.00
12.3 (10.2–14.4)	112/315	1.19 (0.87, 1.64)
17.0 (14.5–21.2)	111/315	1.18 (0.86, 1.63)
28.1 (21.3–99.0)	116/310	1.23 (0.90, 1.69)
P for trend		0.24
Confectioneries[c]		
16.9 (0.6–23.3)	95/331	1.00
29.5 (23.4–35.6)	84/342	0.86 (0.61, 1.20)
41.9 (35.7–49.3)	127/300	1.47 (1.07, 2.02)
60.6 (49.4–159.6)	130/296	1.56 (1.13, 2.14)
P for trend		<0.001
Fat and oil		
6.3 (0.8–8.4)	124/302	1.00
10.2 (8.5–11.8)	109/317	0.83 (0.61, 1.13)
13.8 (11.9–15.9)	93/334	0.72 (0.52, 0.98)
19.6 (16.0–68.4)	110/316	0.86 (0.63, 1.17)
P for trend		0.23
Pulses[d]		
8.8 (0–12.8)	114/312	1.00
16.9 (12.9–21.1)	95/331	0.76 (0.55, 1.05)
26.2 (21.2–33.5)	119/308	1.02 (0.74, 1.39)
43.9 (33.6–119.6)	108/318	0.93 (0.68, 1.27)
P for trend		0.94

Table 2 *Continued*

	n with/without constipation	Adjusted OR[a] (95% CI)
Fish and shellfish		
15.8 (0–21.7)	111/314	1.00
27.2 (21.8–31.6)	103/324	0.93 (0.68, 1.28)
26.5 (31.7–43.0)	107/320	0.97 (0.71, 1.33)
55.1 (43.1–229.1)	115/311	1.12 (0.81, 1.53)
P for trend		0.48
Meats		
17.2 (0–22.2)	114/311	1.00
26.9 (22.3–31.4)	108/320	0.94 (0.69, 1.28)
36.6 (31.5–42.7)	108/318	0.92 (0.67, 1.26)
52.9 (42.8–117.5)	106/320	0.91 (0.66, 1.25)
P for trend		0.55
Eggs		
3.1 (0–8.0)	106/320	1.00
12.9 (8.1–17.3)	99/327	0.92 (0.67, 1.27)
22.9 (17.4–27.3)	113/313	1.10 (0.80, 1.52)
33.3 (27.4–114.3)	118/309	1.24 (0.90, 1.70)
P for trend		0.11
Dairy products		
18.6 (0–32.3)	98/328	1.00
48.7 (32.4–65.6)	123/303	1.37 (1.00, 1.88)
85.3 (65.7–109.1)	111/316	1.23 (0.89, 1.70)
140.6 (109.2–457.7)	104/322	1.05 (0.76, 1.45)
P for trend		0.99
Vegetables[e]		
52.0 (2.1–69.9)	117/309	1.00
84.9 (70.0–100.4)	100/326	0.86 (0.63, 1.18)
117.6 (100.5–139.9)	109/318	0.96 (0.70, 1.31)
176.8 (140.0–457.9)	110/316	0.97 (0.71, 1.33)
P for trend		0.95
Fruits		
14.3 (0–24.5)	118/308	1.00
34.5 (24.6–44.6)	101/325	0.80 (0.58, 1.09)
56.8 (44.7–72.6)	105/322	0.85 (0.62, 1.17)
99.5 (72.7–695.7)	112/314	0.95 (0.69, 1.29)
P for trend		0.84
Water		
0 (0)	160/504	1.00
11.5 (2.6–17.2)	56/132	1.31 (0.91, 1.89)
45.4 (17.3–83.0)	109/318	1.11 (0.83, 1.49)
181.2 (83.1–1836.0)	111/315	1.12 (0.84, 1.50)
P for trend		0.45
Japanese and Chinese tea[f]		
47.8 (0–86.2)	100/326	1.00
141.6 (86.3–201.1)	96/330	0.92 (0.66, 1.27)
248.1 (201.2–313.3)	105/322	1.09 (0.79, 1.50)
432.9 (313.4–1471.1)	135/291	1.54 (1.12, 2.11)
P for trend		0.004
Black tea[g]		
0 (0)	115/379	1.00
12.3 (5.4–18.9)	83/275	0.98 (0.71, 1.36)
31.2 (19.0–49.2)	120/307	1.37 (1.01, 1.85)
78.2 (49.3–871.7)	112/314	1.17 (0.86, 1.61)
P for trend		0.11

Table 2 *Continued*

	n with/without constipation	Adjusted OR[a] (95% CI)
Coffee		
0 (0)	240/748	1.00
13.1 (4.7–27.3)	66/225	0.74 (0.58, 0.96)
66.0 (27.4–604.7)	130/296	0.66 (0.47, 0.94)
P for trend		0.045
Other nonalcoholic beverages		
0 (0–4.3)	108/318	1.00
14.3 (4.4–25.3)	118/308	1.11 (0.81, 1.51)
38.6 (25.4–55.9)	102/325	0.92 (0.67, 1.27)
92.7 (56.0–698.0)	108/318	1.03 (0.75, 1.41)
P for trend		0.83
Total dietary fiber intake (g/1000 kcal)		
4.6 (2.6–5.1)	97/326	1.00
5.7 (5.2–6.1)	110/321	1.14 (0.83, 1.57)
6.6 (6.2–7.2)	109/317	1.17 (0.85, 1.62)
8.1 (7.3–14.3)	120/305	1.36 (0.98, 1.87)
P for trend		0.07
Soluble dietary fiber intake (g/1000 kcal)		
1.1 (0.5–1.2)	94/332	1.00
1.5 (1.3–1.5)	110/316	1.22 (0.89, 1.68)
1.7 (1.6–1.8)	102/325	1.10 (0.79, 1.52)
2.1 (1.9–4.5)	130/296	1.60 (1.16, 2.21)
P for trend		0.01
Insoluble dietary fiber intake (g/1000 kcal)		
3.4 (1.8–3.7)	101/325	1.00
4.1 (3.8–4.3)	112/314	1.12 (0.82, 1.53)
4.8 (4.4–5.2)	105/322	1.05 (0.76, 1.45)
5.9 (5.3–10.9)	118/308	1.27 (0.92, 1.75)
P for trend		0.21

[a]OR adjusted for residential block, size of residential area, physical activity, smoking status, alcohol drinking habits, and body mass index. For intakes of dietary fiber and food groups, further adjusted for energy intake.
[b]Median (range).
[c]Including sugar and sweeteners.
[d]Including nuts.
[e]Including mushrooms and sea vegetables.
[f]Non- and semifermented tea.
[g]Fermented tea.

prevalence of constipation (*P* for trend <0.0001). Women in the highest quartile had a multivariate OR of 0.46 (95% CI: 0.32, 0.66) compared with women in the lowest. Other staple foods including bread and noodles were not associated with prevalence of constipation. Because only staple foods were assessed for each meal separately in DHQ, we further assessed the relationships of intakes of rice from each meal with constipation. Increased intakes of rice at breakfast, lunch, and dinner were all associated with a decreased prevalence of constipation (multivariate OR (95% CI) in the highest quartile compared with the lowest: 0.62 (0.44, 0.86) for breakfast (*P* for trend = 0.002); 0.65 (0.46, 0.91) for lunch (*P* for trend = 0.001); 0.55 (0.39, 0.78) for dinner (*P* for trend = 0.001)).

The prevalence of constipation increased with increasing intake of confectioneries (*P* for trend <0.001). In comparison with women in the lowest quartile, the multivariate OR for women in the highest was 1.56 (95% CI: 1.13, 2.14). There was also a positive association between intake of Japanese and Chinese tea and a prevalence of constipation (*P* for trend = 0.004). Women in the highest quartile of the intake had a multivariate OR of 1.54 (95% CI: 1.12, 2.11) compared with those in the lowest. On the other hand, there was an inverse association between coffee intake and a prevalence of constipation (*P* for trend = 0.045). Women in the highest category of the intake had a multivariate OR of 0.66 (95% CI: 0.47, 0.94) compared with those in the lowest. No clear associations were observed between constipation and the intake of other food groups examined. As shown in

Table 3 Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for self-reported constipation in relation to intakes of selected food groups (further adjusted for intake of total dietary fiber) and total dietary fiber (further adjusted for intake of rice) among 1705 Japanese women aged 18–20 years

	n with/without constipation	Adjusted OR[a] (95% CI)
Food intake (g/1000 kcal)		
Rice[b]		
82.7 (0–104.6)[c]	131/295	1.00
123.9 (104.7–144.1)	129/297	0.99 (0.73, 1.33)
163.7 (144.2–185.8)	97/330	0.66 (0.48, 0.91)
220.3 (185.9–440.5)	79/347	0.47 (0.33, 0.68)
P for trend		<0.0001
Confectioneries[b]		
16.7 (0.6–23.1)	95/331	1.00
29.1 (23.2–35.1)	84/342	0.86 (0.61, 1.21)
41.2 (35.2–48.6)	127/300	1.47 (1.07, 2.03)
59.9 (48.7–157.6)	130/296	1.54 (1.12, 2.13)
P for trend		0.0005
Japanese and Chinese tea[d]		
47.8 (0–86.2)	100/326	1.00
141.6 (86.3–201.1)	96/330	0.89 (0.64, 1.23)
248.1 (201.2–313.3)	105/322	1.05 (0.76, 1.45)
432.9 (313.4–1471.1)	135/291	1.49 (1.09, 2.05)
P for trend		0.0067
Coffee		
0 (0)	240/748	1.00
13.1 (4.7–27.3)	66/225	0.75 (0.58, 0.97)
66.0 (27.4–604.7)	130/296	0.67 (0.47, 0.94)
P for trend		0.0563
Total dietary fiber intake (g/1000 kcal)		
4.6 (2.6–5.1)	97/326	1.00
5.7 (5.2–6.1)	110/321	1.03 (0.75, 1.43)
6.6 (6.2–7.2)	109/317	1.01 (0.72, 1.40)
8.1 (7.3–14.3)	120/305	1.16 (0.84, 1.62)
P for trend		0.41

[a]OR adjusted for residential block, size of residential area, physical activity, smoking status, alcohol drinking habits, body mass index, and energy intake. For intakes of food groups, further adjusted for total dietary fiber intake and for total dietary fiber intake, further adjusted for intake of rice (excluding dietary fiber content).
[b]Excluding dietary fiber content.
[c]Median (range).
[d]Non- and semifermented tea.

Table 3, further adjustment for total dietary fiber, as well as soluble and insoluble dietary fiber (data not shown), did not change the results of rice (excluding dietary fiber content) (P for trend <0.0001), confectioneries (excluding dietary fiber content) (P for trend $= 0.0005$), Japanese and Chinese tea (P for trend $= 0.0067$), and coffee (P for trend $= 0.0563$) materially, indicating that these observed associations are independent of dietary fiber intake.

There was a positive association of intake of total and soluble dietary fiber with a prevalence of constipation (P for trend $= 0.07$ and 0.01, respectively). The association between total dietary fiber and constipation, however, disappeared when further adjusted for rice (excluding dietary fiber content) (P for trend $= 0.41$; Table 3), confectioneries (excluding dietary fiber content) (P for trend $= 0.16$), Japanese and Chinese tea (P for trend $= 0.09$), or coffee (P for trend $= 0.09$). Additionally, although the positive association between soluble dietary fiber and constipation remained when further adjusted for Japanese and Chinese tea (P for trend $= 0.01$) or coffee (P for trend $= 0.02$), the association disappeared when further adjusted for rice (excluding dietary fiber content) (P for trend $= 0.37$) or confectioneries (excluding dietary fiber content) (P for trend $= 0.08$). Thus, the positive association between dietary fiber and constipation seemed to be largely dependent on rice intake.

Discussion

We found that increased intakes of rice and coffee were associated with a decreased risk of constipation in young Japanese women. We also found that lower intakes of confectioneries and Japanese and Chinese tea were associated with a decreased risk of constipation. While a limited number of studies on this issue conducted in Asian countries used non-validated, relatively simple questionnaires for the assessment of dietary factors (Kunimoto *et al.*, 1998; Wong *et al.*, 1999; Nakaji *et al.*, 2002; Fujiwara, 2003), we used a previously validated DHQ for quantitative assessment of dietary intake.

We found dose–response relationships of increased intake of rice with a decreased risk of constipation. Furthermore, increased intakes of rice from breakfast, lunch, and dinner were all associated with decreased risk of constipation. The protective effect of rice on constipation has also been indicated in two previous studies conducted in Asian communities (Wong *et al.*, 1999; Nakaji *et al.*, 2002) where rice is the main staple food. The reason for the association is not well known. Nakaji *et al.* (2002) hypothesized that the effect of rice is due to dietary fiber in rice because rice is the largest source of dietary fiber in Japanese people (Sasaki *et al.*, 2003b). Conversely, Wong *et al.* (1999) hypothesized that the effect of rice is explained by the increased energy intake because rice is high in energy but low in fiber. In these studies, however, quantitative assessment of dietary intake was not available because of the use of relatively simple questionnaire. Our data do not support their hypotheses since the association between rice and constipation was independent of both energy and dietary fiber intake. Rice is a staple food in Japan and a major contributor of many vitamins and minerals; some of constituents in rice and/or combinations of these constituents might exert a preventive effect on constipation. Alternatively, rice intake might merely reflect an overall healthier lifestyle that may not have been accurately captured and controlled in our analysis.

Several studies have suggested the association of breakfast-skipping and constipation (Kunimoto *et al.*, 1998; Fujiwara, 2003), but we did not assess this association because of a quite small number of women with the habit of breakfast-skipping ($n = 30$). In the present study, however, 65% of the staple food intake at breakfast was derived from rice, while a decreased intake of rice at breakfast was associated with increased risk of constipation. This might suggest breakfast-skipping as a risk factor of constipation.

A positive association between confectionery intake and constipation was observed, although we are not aware of any research reporting this association. We also found an adverse effect of Japanese and Chinese tea, which is in agreement with a study of Singapore (Wong *et al.*, 1999), and a preventive effect of coffee, generally consistent with a study of the US (Dukas *et al.*, 2003). It is unclear why these foods had such effects on constipation. Although our finding regarding these foods may have been due to chance alone given the large number of statistical analyses conducted in the present study and intake of these foods may be a marker of other lifestyle factors that were not addressed, further studies examining the association between constipation and these foods would be some of interest.

Constipation seemed to be associated with intake of energy (Sandler *et al.*, 1990; Towers *et al.*, 1994), fluids (water and pure fruit juices) (Sanjoaquin *et al.*, 2004), beverages (sweetened, carbonated, and noncarbonated) (Sandler *et al.*, 1990), tea (Sandler *et al.*, 1990), meats (Sandler *et al.*, 1990; Sanjoaquin *et al.*, 2004), eggs (Nakaji *et al.*, 2002), dairy products (Sandler *et al.*, 1990), and fish (Sandler *et al.*, 1990; Sanjoaquin *et al.*, 2004) in previous studies. We, however, did not find any association of constipation with these dietary factors in the present study. These discrepancies may be, at least partially, explained by the differences in the characteristics, dietary habits, and lifestyle of the subjects examined, dietary assessment methods used, and definitions of constipation applied among studies.

The effect of dietary fiber on constipation is widely accepted, but only a few studies have found an inverse association between dietary fiber and constipation (Dukas *et al.*, 2003; Sanjoaquin *et al.*, 2004), and many other studies have failed to find this association (Everhart *et al.*, 1989; Whitehead *et al.*, 1989; Campbell *et al.*, 1993; Towers *et al.*, 1994). Unexpectedly, there seemed to be a positive association between dietary fiber intake and constipation in the