Table 2 Multivariate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for functional constipation by quintiles of dietary fiber, water, and magnesium intake in 3825 Japanese women aged 18–20 years[a]

	Quintiles of dietary intake					
	1 (n = *765*)	*2* (n = *765*)	*3* (n = *765*)	*4* (n = *765*)	*5* (n = *765*)	*P for trend*
Total dietary fiber (g/4186 kJ)[b]	4.3 [1.9–4.9]	5.3 [4.9–5.7]	6.1 [5.7–6.6]	7.1 [6.6–7.7]	8.9 [7.7–28.5]	
n with/without functional constipation	203/562	199/566	197/568	203/562	200/565	
Multivariate adjusted OR (95% CI)[c]	1.0	0.94 (0.75, 1.19)	0.96 (0.76, 1.21)	0.97 (0.77, 1.22)	0.93 (0.74, 1.18)	0.66
Multivariate and nutrient adjusted OR (95% CI)[c,d]	1.0	1.07 (0.84, 1.37)	1.17 (0.90, 1.52)	1.21 (0.91, 1.61)	1.15 (0.83, 1.59)	0.28
Soluble dietary fiber (g/4186 kJ)[b]	1.1 [0.3–1.2]	1.4 [1.2–1.5]	1.6 [1.5–1.7]	1.9 [1.7–2.1]	2.4 [2.1–6.4]	
n with/without functional constipation	195/570	188/577	211/554	202/563	206/559	
Multivariate adjusted OR (95% CI)[c]	1.0	0.92 (0.72, 1.16)	1.08 (0.86, 1.37)	1.02 (0.80, 1.28)	1.01 (0.80, 1.28)	0.63
Multivariate and nutrient adjusted OR (95% CI)[c,d]	1.0	1.02 (0.80, 1.31)	1.26 (0.98, 1.62)	1.23 (0.94, 1.60)	1.23 (0.91, 1.65)	0.08
Insoluble dietary fiber (g/4186 kJ)[b]	3.2 [1.7–3.6]	3.9 [3.6–4.2]	4.4 [4.2–4.8]	5.1 [4.8–5.6]	6.5 [5.6–22.0]	
n with/without functional constipation	208/557	205/560	193/572	192/573	204/561	
Multivariate adjusted OR (95% CI)[c]	1.0	0.96 (0.76, 1.21)	0.92 (0.73, 1.16)	0.87 (0.69, 1.10)	0.94 (0.74, 1.18)	0.38
Multivariate and nutrient adjusted OR (95% CI)[c,d]	1.0	1.07 (0.84, 1.37)	1.09 (0.84, 1.42)	1.05 (0.78, 1.40)	1.11 (0.80, 1.55)	0.63
Total water (g/4186 kJ)[b]	656 [311–747]	823 [747–891]	959 [891–1037]	1125 [1037–1259]	1485 [1259–4340]	
n with/without functional constipation	218/547	197/568	179/586	193/572	215/550	
Multivariate adjusted OR (95% CI)[c]	1.0	0.89 (0.70, 1.11)	0.76 (0.60, 0.96)	0.81 (0.64, 1.02)	0.92 (0.73, 1.16)	0.33
Multivariate and nutrient adjusted OR (95% CI)[c,e]	1.0	0.94 (0.74, 1.19)	0.82 (0.64, 1.04)	0.88 (0.69, 1.13)	1.01 (0.78, 1.31)	0.89
Water from fluids (g/4186 kJ)[b]	316 [62–397]	461 [397–518]	580 [518–654]	746 [654–862]	1085 [862–4145]	
n with/without functional constipation	209/556	190/575	188/577	199/566	216/549	
Multivariate adjusted OR (95% CI)[c]	1.0	0.87 (0.69, 1.10)	0.84 (0.66, 1.06)	0.89 (0.71, 1.13)	0.97 (0.77, 1.22)	0.86
Multivariate and nutrient adjusted OR (95% CI)[c,e]	1.0	0.91 (0.72, 1.15)	0.89 (0.70, 1.12)	0.95 (0.75, 1.21)	1.05 (0.82, 1.34)	0.60
Water from foods (g/4186 kJ)[b]	279 [106–307]	327 [307–347]	364 [347–385]	406 [385–434]	478 [434–1282]	
n with/without functional constipation	240/525	184/581	196/569	184/581	198/567	
Multivariate adjusted OR (95% CI)[c]	1.0	0.72 (0.57, 0.90)	0.78 (0.62, 0.98)	0.71 (0.56, 0.89)	0.77 (0.61, 0.97)	0.04
Multivariate and nutrient adjusted OR (95% CI)[c,e]	1.0	0.74 (0.59, 0.94)	0.82 (0.64, 1.05)	0.74 (0.57, 0.96)	0.79 (0.58, 1.07)	0.12
Magnesium (mg/4186 kJ)[b]	87 [60–95]	102 [95–108]	114 [108–120]	127 [120–138]	155 [138–350]	
n with/without functional constipation	231/534	182/583	197/568	188/577	204/561	
Multivariate adjusted OR (95% CI)[c]	1.0	0.70 (0.56, 0.88)	0.75 (0.60, 0.95)	0.73 (0.58, 0.92)	0.79 (0.63, 0.996)	0.09
Multivariate and nutrient adjusted OR (95% CI)[c,f]	1.0	0.68 (0.53, 0.87)	0.71 (0.54, 0.93)	0.67 (0.50, 0.91)	0.73 (0.51, 1.02)	0.09

[a]Functional constipation was defined according to the Rome I criteria (Whitehead *et al.*, 1991).
[b]Values are median [range].
[c]Adjusted for body mass index (<18.5, 18.5–24.9, and ⩾25 kg/m^2), residential block (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyushu), size of residential area (city with a population ⩾1 million; city with a population <1 million; and town and village), current smoking (yes or no), current alcohol drinking (yes or no), oral medication usage (yes or no), physical activity level (quintiles) and energy intake (quintiles).
[d]Further adjusted for total water and magnesium intake (quintiles).
[e]Further adjusted for total dietary fiber and magnesium intake (quintiles).
[f]Further adjusted for total dietary fiber and total water intake (quintiles).

between the intake of water (as a nutrient) and constipation. In contrast, experimental studies have shown that low water intake may be an etiologic factor for constipation, although the potential beneficial effect of extra water intake is unclear (Klauser *et al.*, 1990; Anti *et al.*, 1998; Young *et al.*, 1998; Chung *et al.*, 1999; Arnaud, 2003).

Further, while we are unaware of previous studies examining the association between magnesium intake and constipation, we found that a low intake of magnesium was associated with an increasing prevalence of this condition. Magnesium might form sulfate or citrate salts that would promote fluid retention in the digestive tract and indirectly alter motility, and thereby act as a light laxative (Saez, 1991). The effect of magnesium on constipation warrants further examination.

Several limitations of our study can be identified. First, generally, given that increased intake of dietary fiber and fluid is a widely recommended treatment for constipation (Muller-Lissner *et al.*, 2005), subjects suffering from constipation might be expected to increase their intake of dietary fiber and water (from fluids). Such dietary change is particularly likely in our subjects, who were dietetic students and therefore may have been highly health conscious. In fact, a considerably large percentage of female Japanese dietetic students considered a high intake of dietary fiber and water beneficial for preventing constipation (81 and 42%, respectively) (Ohya and Yoneda, 1995). Thus, the null associations between dietary fiber, total water and water from fluids and constipation observed in the present study might have been due to a possible increase in intake of dietary fiber and water (from fluids) in subjects defined as having constipation. However, because water from foods and magnesium are generally unlikely to be recognized as having an effect on constipation, it is reasonable to consider that our subjects suffering from constipation neither increased nor decreased their intakes of water from foods and magnesium.

Second, all self-reported dietary assessment methods are subject to measurement error and selective underestimation and overestimation of dietary intake (Livingstone and Black, 2003). However, to minimize these possibilities, we used a previously validated DHQ (Sasaki *et al.*, 1998a, b, 2000), although the validity of total water and water from fluid was somewhat insufficient, which might explain the observed null association between these dietary variables and constipation. Additionally, the same tendency of associations between dietary variables and constipation was observed in a repeated analysis of 2717 subjects with a 'physiologically plausible' energy intake, namely those possessing a ratio of reported energy intake to estimated basal metabolic rate (standard value of basal metabolic rate for Japanese women aged 18–29 years (99 kJ/kg of body weight/day) multiplied by body weight of each subjects (kg) (Ministry of Health, Labour, and Welfare, 2005)) of 1.2–2.5 (Black *et al.*, 1996) (data not shown). Thus, although the effect of measurement error and selective underestimation or overestimation of dietary intake can never be excluded, data inaccuracy is unlikely to have had a major impact on our findings.

Third, given that our subjects were selected female dietetic students, our results might not be extrapolatable to general populations. Additionally, although we attempted to adjust for a wide range of potential confounding variables, we cannot rule out residual confounding owing to these or poorly measured variables such as physical activity level, which were assessed by a limited number of non-validated questions, as well as other unknown variables.

In conclusion, after adjustment for a variety of potential confounders, low intake of water from foods and of magnesium was independently associated with an increased prevalence of functional constipation among young women whose dietary fiber intake was relatively low. Because the cross-sectional nature of the present study precludes any causal inferences, however, further studies using prospective designs are required to clarify these relationships.

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Food Intake and Functional Constipation: A Cross-Sectional Study of 3,835 Japanese Women Aged 18–20 Years

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Summary Although we previously observed significant associations between intakes of several foods and constipation, definition of constipation was completely based on subjective perception assessed by a quite simple and single question: do you often have constipation? In this study, we examined the associations between food intake and functional constipation as defined according to symptom-based criteria (Rome I criteria: straining, hard stools, incomplete evacuation, and infrequency of bowel movement). Subjects were 3,835 female Japanese dietetic students aged 18–20 y from 53 institutions in Japan. Dietary intake was estimated with a validated, self-administered diet history questionnaire. The prevalence of functional constipation was 26.2%. Dietary intakes of several foods were significantly associated with functional constipation. A multivariate adjusted odds ratio (95% confidence interval; p for trend) for women in the highest quintile of dietary intake compared with those in the lowest was 0.59 (0.46–0.75; <0.0001) for rice, 0.77 (0.61–0.97; 0.003) for pulses, 1.64 (1.30–2.08; <0.0001) for confectioneries, and 1.41 (1.11–1.78; 0.01) for bread. In conclusion, intake of rice and pulse was negatively and that of confectioneries and bread was positively associated with functional constipation among a population of young Japanese women, which was generally consistent with our previous study where constipation was assessed by a quite simple question.

Key Words dietary fiber, food, rice, functional constipation, epidemiology

Constipation is a common health problem (*1–4*), and food intake is considered to be a major modifiable lifestyle factors associated with this condition (*5, 6*). Foods related to constipation in previous observational studies include dairy products (*7*), beans (*7*), meats (*7*), fruits (*7*), vegetables (*7*), rice (*3, 8, 9*), eggs (*9*), confectioneries (*8*), and several nonalcoholic beverages (*3, 7, 8, 10, 11*). However, while most previous studies have defined constipation according to the infrequency of bowel movement only (*10–13*) or the subjective perception of patients (*7, 8*), a consensus definition of constipation consists of straining, hard stools, and incomplete evacuation in addition to infrequency (Rome criteria) (*14*). Further, although Wong et al. (*3*) and Nakaji et al. (*9*) defined constipation using the Rome criteria and original subjective criteria, respectively, they assessed diet with a non-validated, relatively simple food frequency questionnaire. Moreover, although we previously observed associations between intakes of several foods and constipation (*11*), using a previously validated, self-administered, diet history questionnaire (DHQ) (*15–17*), the definition of constipation was completely based on subjective perception assessed by a quite simple and single question: do you often have constipation? Thus, to our knowledge, no study has so far investigated the relationship of food intake, as assessed with a validated assessment method, to functional constipation, as defined using symptom-based criteria. Here, we examined the associations between food intake, estimated using DHQ, and functional constipation as defined according to the Rome criteria (*14*).

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SUBJECTS AND METHODS

Subjects and survey procedure. The present study was based on a self-administered questionnaire survey among dietetic students (n=4,679) from 54 institutions in Japan. Staff at each institution distributed a dietary assessment questionnaire (i.e., DHQ) and another questionnaire on other lifestyle items during the preceding month to students during an orientation session or a first lecture designed for freshman students entering dietetic courses in April 2005; in most institutions, this was carried out within 2 wk after the course began to minimize the influence of new school year life on the answers. Students filled out the questionnaires during the session, lecture, or at home and then submitted the completed forms to staff at each institution. Questionnaires used in the present study included the explanation on how to answer questions. To standardize the survey procedure, when students asked how to answer questionnaires, staff at each institution did not provide any advice and only asked students to read the explanation on questionnaires carefully. In addition to the two questionnaires for the preceding month, a third questionnaire on lifestyle during the previous 6 y (i.e., junior high school and high school) was also distributed and answered in a similar fashion; in most institutions, this was carried out within 4 wk after the course began because it was considered burdensome for subjects to answer all three questionnaires at the same time and it was considered unlikely that new school year life would influence the answers for lifestyle during the previous 6 y.

The staff at each institution checked the responses according to the survey protocol. When missing answers or logical errors were identified, the student was asked to complete the questionnaire again. The staff at each institution mailed the questionnaires to the survey center. Staff at the survey center checked the answers again, and when necessary returned problematic questionnaires to staff at the respective institution, and the student was asked to complete the questionnaires again. All questionnaires were thus checked at least once by staff at each institution and by staff at the survey center. Most surveys were completed by May 2005. The protocol of the present study was approved by the Ethics Committee of the National Institute of Health and Nutrition.

In total, 4,286 students (4,066 women and 220 men) answered all three questionnaires (91.6%). For the current analysis, we selected female subjects aged 18–20 y (n=3,967) because of the small number of male subjects and women aged >20 y. We then excluded women who were in an institution where the survey had been conducted at the end of May (n=97) because the answers were likely influenced by the new school year life. We further excluded those with extremely low or high energy intake (<500 kcal/d or >4,000 kcal/d) (n=23) because their estimated dietary intake was likely unreliable. We finally excluded those with missing information on the variables used (n=24) for the purpose of multivariate analyses. As some subjects were in more than one exclusion category, the final analysis sample comprised 3,825 women. Although intentional dietary change or use of oral laxatives might have influence on dietary intake or constipation, further exclusion of subjects with intentional dietary change within the preceding year (n=649), those habitually using oral laxatives (n=231), or both did not materially alter the findings, and these subjects were therefore included in the analyses.

Dietary intake. Dietary habits during the previous month were assessed using a previously validated, self-administered DHQ (*15–17*). This is a 16-page structured questionnaire that consists of the following seven sections: general dietary behavior; major cooking methods; consumption frequency and amount of six alcoholic beverages; consumption frequency and semi-quantitative portion size of 121 selected food and non-alcoholic beverage items; dietary supplements; consumption frequency and semi-quantitative portion size of 19 staple foods (rice, bread, and noodles) and miso (fermented soybean paste) soup; and open-ended items for foods consumed regularly (≥once/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 (*18*) and several recipe books for Japanese dishes (*15*).

Estimates of dietary intake for 147 food and beverage items and energy were calculated using an ad hoc computer algorithm for the DHQ, which was based on the Standard Tables of Food Composition in Japan (*19*). Information on dietary supplements and data from the open-ended questionnaire items were not used in the calculation of dietary intake. The food and nonalcoholic beverage items were grouped into the 18 food groups (as shown in Table 2). Detailed descriptions of the methods used for calculating dietary intake and the validity of the DHQ have been published elsewhere (*15–17*). The Pearson correlation coefficient (*20*) between DHQ and 3-d estimated dietary records was 0.48 for energy among 47 women (*15*). In addition, the mean value of the Spearman correlation coefficients (*20*) for energy-adjusted intakes (g/1,000 kcal) of 16 food groups was 0.35 (range: 0.05–0.59) among 92 women (Sasaki S, unpublished observations, 2004).

Constipation. A constipation questionnaire was developed based on a previous study (*2*) and incorporated into the 20-page questionnaire for lifestyle during the previous 6 y. We used the definition of functional constipation recommended by an international workshop on the management of constipation (Rome I criteria) (*14*). Although the Rome I criteria were modified in 1999 (Rome II criteria) (*21*), epidemiologic studies have consistently shown that the latter may be too restrictive for the diagnosis of constipation (*2, 4*); we therefore used the former. The Rome I criteria are a consensus definition of constipation consisting of various symptoms including bowel movement frequency (as shown below) (*14*), and have become the research standard for the definition of constipation (*1*). The following four questions were used to assess Rome I-defined functional constipation: 1) Do you strain during a bowel movement?; 2) Do you feel an incomplete emptying sensation after a bowel movement?; 3) How often are your stools hard?; and 4) How many bowel movements do you usually have each week? These questions referred to the last 12 mo. For questions 1–3, four answers were offered: never, sometimes (<25% of the time), often (≥25% of the time), and always. Functional constipation was defined as meeting two or more of the four criteria [an answer of *often* or *always* to questions 1–3 and <3 bowel movements per week (question 4)].

Confounding factors. In epidemiologic research, it is usual to divide the main dependent variables (food intake in the present study) and confounding factors (other lifestyle factors described below in the present study) based on previous studies (*1–13*). Thus, we assessed not only dietary intake but also several lifestyle factors described below in the present survey. In the questionnaires, subjects reported body weight and

Table 1. Characteristics of subjects.[a]

Variable	All (*n*=3,825)	Subjects with functional constipation[b] (*n*=1,002)	Subjects without functional constipation (*n*=2,823)	*p*[c]
Body mass index (kg/m²)	21.0±2.8	20.8±2.5	21.0±2.9	0.08
<18.5	557 (14.6)	139 (13.9)	418 (14.8)	0.19
18.5–24.9	2,976 (77.8)	798 (79.6)	2,178 (77.2)	
≧25	292 (7.6)	65 (6.5)	227 (8.0)	
Residential block				
Hokkaido and Tohoku	375 (9.8)	93 (9.3)	282 (10.0)	0.20
Kanto	1,310 (34.3)	351 (35.0)	959 (34.0)	
Hokuriku and Tokai	537 (14.0)	159 (15.9)	378 (13.4)	
Kinki	765 (20.0)	203 (20.3)	562 (19.9)	
Chugoku and Shikoku	421 (11.0)	99 (9.9)	322 (11.4)	
Kyushu	417 (10.9)	97 (9.7)	320 (11.3)	
Size of residential area				
City with a population ≧1 million	745 (19.5)	195 (19.5)	550 (19.5)	0.98
City with a population <1 million	2,495 (65.2)	652 (65.1)	1,843 (65.3)	
Town and village	585 (15.3)	155 (15.5)	430 (15.2)	
Current smoking				
No	3,769 (98.5)	980 (97.8)	2,789 (98.8)	0.02
Yes	56 (1.5)	22 (2.2)	34 (1.2)	
Current alcohol drinking				
No	3,097 (81.0)	770 (76.9)	2,327 (82.4)	0.0001
Yes	728 (19.0)	232 (23.2)	496 (17.6)	
Oral medication usage				
No	3,447 (90.1)	840 (83.8)	2,607 (92.4)	<0.0001
Yes	378 (9.9)	62 (16.2)	216 (7.7)	
Physical activity level	1.45±0.15	1.45±0.16	1.45±0.15	0.56
Quintile 1 (<1.36)	758 (19.8)	200 (20.0)	558 (19.8)	0.96
Quintile 2 (1.36–1.38)	772 (20.2)	205 (20.5)	567 (20.1)	
Quintile 3 (1.39–1.42)	765 (20.0)	206 (20.6)	559 (19.8)	
Quintile 4 (1.43–1.49)	765 (20.0)	196 (19.6)	569 (20.2)	
Quintile 5 (>1.49)	765 (20.0)	195 (19.5)	570 (20.2)	
Energy intake (kcal/d)	1,819±502	1,835±531	1,814±491	0.26
Quintile 1 (<1,407)	765 (20.0)	206 (20.6)	559 (19.8)	0.19
Quintile 2 (1,407–1,636)	765 (20.0)	195 (19.5)	570 (20.2)	
Quintile 3 (1,637–1,869)	765 (20.0)	191 (19.1)	574 (20.3)	
Quintile 4 (1,870–2,181)	765 (20.0)	186 (18.6)	579 (20.5)	
Quintile 5 (>2,182)	765 (20.0)	224 (22.4)	541 (19.2)	

[a] Values are mean±standard deviation or *n* (%).
[b] Defined according to the Rome I criteria (*14*).
[c] For continuous variables, independent *t*-test was used; for categorical variables, chi-square test was used.

height, residential area, current smoking (yes or no), and oral medication usage (yes or no). Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m). We classified BMI into three categories (<18.5, 18.5–24.9, and ≥25 kg/m²) according to the Japan Society for the Study of Obesity (*22*). The reported residential areas were grouped into six categories (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyushu) based on the regional blocks used in the National Nutrition Survey in Japan (*23*) (hereafter referred to as 'residential block'). The residential areas were also grouped into three categories according to population size (city with population ≥1 million; city with population <1 million; and town and village) (hereafter referred to as 'size of residential area').

Additionally, subjects reported the time when they usually went to bed and arose in the morning, which was used to calculate sleeping hours, and the frequency and duration of high- and moderate-intensity activities, walking, and sedentary activities. Each activity was assigned a metabolic equivalent (MET) value (*24, 25*). The 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. Physical activity level was then calculated by dividing total MET-hour score (kcal/kg of body weight/d) by the standard value of basal metabolic rate for Japanese women aged 18–29 y (23.6 kcal/kg of body weight/d) (*26*).

Statistical analysis. Associations between functional constipation (the dependent variable) and energy-

Table 2. Multivariate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for functional constipation[a] by quintiles of food intake[b] (n=3,825).

	Quintile category of food intake					p for trend
	1	2	3	4	5	
Rice (g/1,000 kcal)[c]	78 [0–101]	119 [101–135]	152 [135–169]	188 [169–214]	251 [214–448]	
n with/without functional constipation	247/518	206/559	191/574	197/568	161/604	
Multivariate adjusted OR (95% CI)[d]	1.00	0.81 (0.65–1.02)	0.73 (0.58–0.92)	0.76 (0.60–0.96)	0.59 (0.46–0.75)	<0.0001
Bread (g/1,000 kcal)[c]	4 [0–9]	14 [9–18]	23 [18–28]	34 [28–41]	53 [41–171]	
n with/without functional constipation	178/587	199/566	206/559	195/570	224/541	
Multivariate adjusted OR (95% CI)[d]	1.00	1.16 (0.92–1.47)	1.27 (1.00–1.61)	1.17 (0.92–1.49)	1.41 (1.11–1.78)	0.01
Noodles (g/1,000 kcal)[c]	0 [0–11]	16 [11–24]	31 [24–38]	47 [38–59]	79 [59–355]	
n with/without functional constipation	204/561	211/554	207/558	185/580	195/570	
Multivariate adjusted OR (95% CI)[d]	1.00	1.06 (0.84–1.33)	1.02 (0.81–1.29)	0.90 (0.71–1.14)	0.94 (0.75–1.19)	0.30
Potatoes (g/1,000 kcal)[c]	6 [0–8]	10 [8–11]	13 [11–15]	18 [15–22]	29 [22–165]	
n with/without functional constipation	199/566	169/596	206/559	218/547	210/555	
Multivariate adjusted OR (95% CI)[d]	1.00	0.80 (0.63–1.02)	1.03 (0.82–1.30)	1.10 (0.87–1.38)	1.04 (0.83–1.31)	0.15
Confectioneries[e] (g/1,000 kcal)[c]	18 [1–24]	29 [24–33]	37 [33–42]	47 [42–54]	63 [54–142]	
n with/without functional constipation	162/603	185/580	191/574	224/541	240/525	
Multivariate adjusted OR (95% CI)[d]	1.00	1.17 (0.92–1.50)	1.20 (0.94–1.53)	1.51 (1.19–1.92)	1.64 (1.30–2.08)	<0.0001
Fat and oil (g/1,000 kcal)[c]	7 [1–8]	10 [8–11]	12 [11–14]	15 [14–18]	21 [18–67]	
n with/without functional constipation	196/569	210/555	205/560	194/571	197/568	
Multivariate adjusted OR (95% CI)[d]	1.00	1.14 (0.91–1.44)	1.11 (0.88–1.40)	1.04 (0.82–1.32)	1.03 (0.81–1.31)	0.90
Pulses[f] (g/1,000 kcal)[c]	7 [0–10]	13 [10–17]	20 [17–25]	30 [25–37]	48 [37–174]	
n with/without functional constipation	234/531	216/549	174/591	181/584	197/568	
Multivariate adjusted OR (95% CI)[d]	1.00	0.90 (0.72–1.12)	0.64 (0.50–0.80)	0.68 (0.54–0.86)	0.77 (0.61–0.97)	0.003
Fish and shellfish (g/1,000 kcal)[c]	11 [0–16]	20 [16–24]	27 [24–31]	35 [31–41]	50 [41–164]	
n with/without functional constipation	209/556	208/557	194/571	184/581	207/558	
Multivariate adjusted OR (95% CI)[d]	1.00	1.00 (0.80–1.26)	0.92 (0.73–1.16)	0.88 (0.70–1.11)	0.98 (0.78–1.23)	0.54
Meats (g/1,000 kcal)[c]	15 [0–20]	23 [20–27]	31 [27–35]	39 [35–46]	55 [46–134]	
n with/without functional constipation	199/566	192/573	194/571	219/546	198/567	
Multivariate adjusted OR (95% CI)[d]	1.00	0.98 (0.78–1.24)	1.03 (0.81–1.29)	1.17 (0.93–1.47)	1.03 (0.81–1.30)	0.39
Eggs (g/1,000 kcal)[c]	3 [0–5]	8 [5–13]	15 [13–20]	25 [20–29]	36 [29–127]	
n with/without functional constipation	192/573	211/554	197/568	200/565	202/563	
Multivariate adjusted OR (95% CI)[d]	1.00	1.12 (0.89–1.42)	1.02 (0.80–1.29)	1.04 (0.82–1.31)	1.12 (0.89–1.42)	0.58
Dairy products (g/1,000 kcal)[c]	16 [0–26]	38 [26–52]	66 [52–82]	100 [82–123]	172 [123–596]	
n with/without functional constipation	212/553	200/565	198/567	193/572	199/566	
Multivariate adjusted OR (95% CI)[d]	1.00	0.90 (0.72–1.14)	0.88 (0.70–1.11)	0.87 (0.69–1.10)	0.91 (0.72–1.15)	0.39
Vegetables[g] (g/1,000 kcal)[c]	49 [2–67]	80 [67–95]	110 [95–126]	146 [126–173]	221 [173–1142]	
n with/without functional constipation	218/547	201/564	187/578	197/568	199/566	
Multivariate adjusted OR (95% CI)[d]	1.00	0.89 (0.71–1.12)	0.81 (0.64–1.02)	0.84 (0.67–1.06)	0.86 (0.68–1.09)	0.18
Fruits (g/1,000 kcal)[c]	8 [0–14]	20 [14–27]	36 [27–45]	57 [45–74]	104 [74–614]	
n with/without functional constipation	224/541	189/576	201/564	176/589	212/553	
Multivariate adjusted OR (95% CI)[d]	1.00	0.80 (0.64–1.01)	0.84 (0.67–1.06)	0.70 (0.55–0.89)	0.87 (0.69–1.09)	0.11
Water (g/1,000 kcal)[c]	0 [0]	11 [2–14]	34 [14–62]	96 [62–185]	319 [185–1649]	
n with/without functional constipation	319/950	62/199	205/560	203/562	213/552	
Multivariate adjusted OR (95% CI)[d]	1.00	0.93 (0.68–1.28)	1.05 (0.85–1.29)	1.04 (0.84–1.28)	1.10 (0.89–1.35)	0.36
Japanese and Chinese tea[h] (g/1,000 kcal)[c]	44 [0–80]	124 [80–189]	237 [189–288]	366 [288–459]	635 [459–1806]	
n with/without functional constipation	212/553	190/575	188/577	210/555	202/563	
Multivariate adjusted OR (95% CI)[d]	1.00	0.87 (0.69–1.09)	0.86 (0.68–1.09)	1.00 (0.79–1.26)	0.93 (0.74–1.17)	0.97
Black tea[i] (g/1,000 kcal)[c]	0 [0]	11 [2–14]	25 [14–40]	72 [40–1,069]		
n with/without functional constipation	482/1,351	108/354	206/559	206/559		
Multivariate adjusted OR (95% CI)[d]	1.00	1.02 (0.83–1.24)	0.83 (0.63–1.09)	1.02 (0.81–1.28)		0.99
Coffee (g/1,000 kcal)[c]	0 [0]	13 [4–29]	65 [29–1,282]			
n with/without functional constipation	638/1,800	171/451	193/572			
Multivariate adjusted OR (95% CI)[d]	1.00	1.10 (0.91–1.34)	1.11 (0.87–1.42)			0.41
Other nonalcoholic beverages (g/1,000 kcal)[c]	0 [0–0.002]	4 [0.002–10]	18 [10–29]	42 [29–61]	96 [61–860]	
n with/without functional constipation	197/568	212/553	178/587	198/567	217/548	
Multivariate adjusted OR (95% CI)[d]	1.00	1.11 (0.88–1.40)	0.87 (0.69–1.11)	1.02 (0.81–1.29)	1.11 (0.88–1.40)	0.60

[a] Defined according to the Rome I criteria (*14*).
[b] Except for water (5 categories), black tea (4 categories), and coffee (3 categories) because of more than one fifth nonconsumers.
[c] Values are median [range].
[d] Adjusted for body mass index (<18.5, 18.5–24.9, and ≧25 kg/m²), residential block (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyushu), size of residential area (city with a population ≧1 million; city with a population <1 million; and town and village), current smoking (yes or no), current alcohol drinking (yes or no), oral medication usage (yes or no), physical activity level (quintiles), and energy intake (quintiles).
[e] Including sugar and sweeteners.
[f] Including nuts.
[g] Including mushrooms and sea vegetables.
[h] Non- and semifermented tea.
[i] Fermented tea.

adjusted intakes (g/1,000 kcal) of the 18 food groups (as shown in Table 2) were examined. We calculated both crude and multivariate adjusted odds ratios (ORs) and 95% confidence intervals for functional constipation for each quintile category of dietary variables (except for several drinks because more than one-fifth of subjects were nonconsumers) using logistic regression analysis (*20*). Multivariate adjusted ORs were calculated by adjusting for BMI, residential block, size of residential area, current smoking, current alcohol drinking (yes or no, because of extremely low alcohol intake: mean=0.8 g/d), oral medication usage, physical activity level (quintiles), and energy intake (quintiles). As results for the crude and multivariate analyses were similar for all variables analyzed, we presented only those derived from the multivariate models. Trend of association was assessed by a logistic regression model assigning scores to the levels of the independent variable. All statistical analyses were performed using SAS statistical software, version 8.2 (SAS Institute Inc., Cary, NC, USA). All reported p values are 2-tailed, and a p value of <0.05 was considered statistically significant.

RESULTS

Basic characteristics of the subjects are shown in Table 1. Mean (±standard deviation) age, body height, and body weight was 18.1±0.3 y, 157.9±5.3 cm, and 52.3±7.7 kg, respectively. A total of 1,002 women (26.2%) were classified as having constipation. There were more current smokers, alcohol drinkers, and oral medication users among subjects with constipation. Table 2 shows the association between food intake and constipation. There was a clear dose-response relationship between an increased intake of rice and a decreased prevalence of constipation. In comparison with women in the 1st (lowest) quintile of rice consumption, the multivariate adjusted OR for women in the 2nd, 3rd, 4th, and 5th quintiles were 0.81, 0.73, 0.76, and 0.59, respectively (p for trend <0.0001). Pulse intake was also inversely associated with constipation. Multivariate OR in the 2nd, 3rd, 4th, and 5th quintiles compared with the 1st quintile were 0.90, 0.64, 0.68, and 0.77, respectively (p for trend$=0.003$). In contrast, the prevalence of constipation clearly increased with increasing intake of confectioneries. In comparison with women in the 1st quintile, the multivariate adjusted OR for women in the 2nd, 3rd, 4th, and 5th quintiles were 1.17, 1.20, 1.51, and 1.64, respectively (p for trend <0.0001). A positive relationship was also seen between bread intake and constipation. Multivariate OR in the highest quintile was 1.41 compared with those in the lowest quintile (p for trend$=0.01$). No clear associations were observed between constipation and the intake of other foods examined.

DISCUSSION

To our knowledge, this study is the first to examine food intake as assessed by a validated assessment method (DHQ in the present study) in relation to functional constipation, as defined according to the Rome I criteria. We found that after controlling for a series of potential confounding factors, the consumption of rice and pulses and of confectioneries and bread were negatively and positively associated with functional constipation, respectively, among this group of young women.

The prevalence of Rome I-defined functional constipation in the present group was 26.2%. A similar prevalence by these criteria has been observed in Canadian (21.0%) (*4*) and Spanish (28.6%) (*2*) women, whereas a somewhat smaller ratio was seen in elderly Singaporean women (10.5%) (*3*).

We found clear dose-response relationships between increased intake of rice with a decreased prevalence of constipation (Table 2). The favorable effect of rice on constipation has been consistently reported in previous studies conducted in Asian countries, where rice is the main staple food (*3, 8, 9*). The reason for the association is unknown. Nakaji et al. (*9*) hypothesized that the effect of rice is due to its dietary fiber, given that rice is the largest source of dietary fiber for Japanese people (*27*). In contrast, Wong et al. (*3*) hypothesized that the effect is explained by the increased energy intake because rice is the largest source of energy. These hypotheses could not be investigated further, however, because the authors used a simple diet questionnaire which did not allow the estimation of dietary intake (*3, 9*). Our previous results (*8*) do not support these hypotheses because the association between rice and constipation was not dependent on either energy or dietary fiber intake. Additionally, in the present study, the association between rice and constipation was independent of energy intake; mean dietary fiber intake (11.8 g/d) was much lower than the Dietary Goal of dietary fiber of the Dietary Reference Intakes for Japanese, 2005 for this age range (17 g/d) (*26*), and the contribution of rice to dietary fiber was only 10% (the top contributor was vegetables (37%)). These findings suggest that the effect of rice on constipation is unlikely due to its energy or dietary fiber. Relation of dietary fiber to functional constipation in this population is published elsewhere (*28*). Rice is a staple food in Japan and a major contributor of many nutrients; some constituents of rice may, either alone or combination, 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.

An inverse association between pulse intake and constipation was observed (Table 2). A similar finding has been reported in a study of the US (*7*). We also found an adverse effect of confectionery intake (Table 2), which is in agreement with our previous study of young Japanese women (*8*). Additionally, a positive association of bread intake to constipation was found (Table 2), although we are not aware of any previous report of this association. It is unclear why these foods had such effects on constipation. Given the large number of statistical analyses conducted in the present study, our findings regarding these foods may have been due to chance alone. Alternatively, their intake may be a marker of other unknown lifestyle factors that were not addressed in the present study.

In contrast to previous studies (*3, 7–11*), we found no association between constipation and the intake of dairy products, meats, fruits, vegetables, eggs, Japanese and Chinese tea, black tea, coffee, and other nonalcoholic beverages (Table 2). These discrepancies may be at least partly explained by the different populations investigated, different dietary assessment methods used, different definitions of constipation, and differences in the number and type of variables used as confounding factors.

Because it is possible that subjects suffering from constipation might change their diet, our findings, particularly those regarding foods significantly associated with the presence or absence of constipation (rice, pulses, confectioneries, and bread), should be interpreted with caution. We cannot deny the possibility that the associations merely reflect dietary behaviors changed after, not before, the development of constipation, although these foods are not generally considered to influence constipation. As mentioned above, however, previous studies have shown similar findings for rice (*3, 8, 9*), pulses (*7*), and confectioneries (*8*), but not bread.

All self-reported dietary assessment methods are subject to measurement error and selective under- and overestimation of dietary intake (*29*). To minimize these possibilities, we used a previously validated DHQ (*15–17*). Additionally, the same tendency of associations between food intakes and constipation was observed in a repeated analysis of 2,717 subjects with a 'physiologically plausible' energy intake, namely those possessing a ratio of reported energy intake to estimated basal metabolic rate [standard value of basal metabolic rate for Japanese women aged 18–29 y (23.6 kcal/kg of body weight/d) multiplied by body weight of each subjects (kg) (*26*)] of 1.2 to 2.5 (*30*) (data not shown). Thus, although the possibility of measurement error and selective under- or overestimation of dietary intake can never be excluded, data inaccuracy is unlikely to have had a major impact on the findings in the present study.

Given that our subjects were selected female dietetic students who may be highly health conscious, our results are likely not extrapolatable to general populations. Additionally, although we attempted to adjust for a wide range of potential confounding variables, we cannot rule out residual confounding due to these or poorly measured variables such as physical activity level, which was assessed by a limited number of nonvalidated questions, or other unknown variables.

In conclusion, after adjustment for a variety of potential confounders, the intake of rice and pulses and that of confectioneries and bread were negatively and positively associated with functional constipation, respectively, among young women. However, owing to the cross-sectional nature of the present study, which precludes any causal inferences, and the lack of biological explanation for these relationships, further observational and experimental studies are required to clarify these relationships.

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Dietary Patterns Associated with Functional Constipation among Japanese Women Aged 18 to 20 Years: A Cross-Sectional Study

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Summary Although several nutrients and foods have been suggested to be preventive for constipation, all previous studies have examined a single nutrient or food in each analysis. In contrast, analysis of dietary patterns may provide new insights into the influence of diet on functional constipation. We conducted a cross-sectional examination of the association between dietary pattern and functional constipation in 3,770 Japanese female dietetic course students aged 18–20 y from 53 institutions in Japan. Diet was assessed with a validated self-administered diet history questionnaire with 148 food items, from which 30 food groups were created and entered into a factor analysis. Functional constipation was defined using the Rome I criteria, which has previously been used in several epidemiologic studies on constipation. The prevalence of functional constipation was 26.0% (n=979). Four dietary patterns were identified: 1) "Healthy," 2) "Japanese traditional," 3) "Western," and 4) "Coffee and dairy products." After adjustment for several confounding factors, the "Japanese traditional" pattern, characterized by a high intake of rice, miso soup, and soy products and a low intake of bread and confectionaries, was associated with a significantly lower prevalence of functional constipation. In comparison with the lowest quintile, the multivariate adjusted odds ratio (95% confidence interval) was 0.52 (0.41–0.66) in the highest quintile (p for trend $<$0.0001). Other dietary patterns were not associated with functional constipation. The Japanese traditional dietary pattern, characterized by a high intake of rice and a low intake of bread and confectionaries, may be beneficial in preventing functional constipation in young Japanese women.

Key Words food-based dietary pattern, factor analysis, functional constipation, Japanese traditional dietary pattern, young Japanese women

Constipation is a common public health problem (*1–4*) with a well-recognized propensity to cause considerable discomfort and affect quality of life (*1*). Regarding nutritional approaches, although much attention has been focused on the benefit of dietary fiber (*5–10*), results to date have been inconsistent. Magnesium (*10*) and water from foods (*10*) have recently been postulated as preventive factors. For foods, various studies have observed associations between the prevalence of constipation and dairy products (*11*), beans (*11, 12*), meats (*11*), fruits (*11*), vegetables (*11*), rice (*3, 9, 12, 13*), eggs (*13*), confectionaries (*9, 12*), and some nonalcoholic beverages (*3, 5, 9, 11*). Nevertheless, the dominant approach of examining single nutrients or foods might not adequately account for complicated interactions and cumulative effects, which might in turn result in the drawing of erroneous associations between dietary factors and disease.

To overcome this limitation, the dietary pattern approach, or the measurement of overall diet, is now widely used to elucidate the relationship between diet and disease (*14, 15*). To our knowledge, however, no previous study has investigated the relationship between dietary pattern and prevalence of constipation. In addition, although the research standard or the definition of functional constipation includes various symptoms such as infrequency, straining, hard stools, and incomplete evacuation (Roma I criteria) (*16*), most previous studies have defined constipation according to the infrequency of bowel movement only (*5–8*) or the subjective perception of the patient (*9, 11*).

Here, we attempted to identify dietary patterns using factor analysis, and examined the relationships between dietary pattern and the prevalence of functional constipation as defined according to the Rome I criteria (*16*) among Japanese women aged 18 to 20 y.

SUBJECTS AND METHODS

Subjects and study design. The subjects were students newly enrolled in the dietetic course at 54 universities, colleges, and technical schools in Japan in April

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2005 (n=4,679). The study design, data-collection method, and study member list have been described in detail elsewhere (*10, 12*). In brief, two kinds of questionnaire on dietary habits and other lifestyle items during the preceding month were completed during an orientation session or first lecture given to freshman, in most institutions within 2 wk after the course began. A third questionnaire on lifestyle during the previous 6 y (i.e., junior and senior high school) was answered in similar fashion, in most institutions within 4 wk after the course began. A total of 4,286 students (4,066 women and 220 men) answered all three questionnaires (response rate=91.6%).

All questionnaires were checked at least once each by staff at the respective institution and at the survey center. Most surveys were completed by May 2005. The study protocol was approved by the Ethics Committee of the National Institute of Health and Nutrition.

Dietary assessment and food grouping. We used a self-administered diet history questionnaire (DHQ), a validated 16-page questionnaire which assesses dietary habits in the preceding 1-mo period (*17, 18*). A detailed description of the questionnaire, calculation of food and nutrient intakes, and validity is given elsewhere (*17, 18*). Measures of dietary intake for 148 food and beverage items and energy were calculated using an ad hoc computer algorithm for the DHQ, which was based on the Standard Tables of Food Composition in Japan (*19*). Information on dietary supplements and data from the open-ended questionnaire items were not used in the calculation of dietary intake.

To reduce the complexity of the data, food items were grouped together (*20*). The grouping scheme was generally based on the principles of similarity of nutrient profiles or culinary usage of the foods, mainly according to the Food Composition Tables of Japanese foods, 5th Revised Edition (*19*), and the classification of food groups used by the National Nutrition Survey (*21*). Finally, 30 separate food groups were established and used in analyses of dietary patterns (*20*).

Definition of constipation. A constipation questionnaire developed for a previous study (*2*) was incorporated into the 20-page questionnaire for lifestyle during the preceding 6 y. We used the definition of functional constipation recommended by an international workshop on the management of constipation (Rome I criteria) (*16*). Although the Rome I criteria were modified in 1999 (Rome II criteria) (*22*), epidemiologic studies have consistently shown that the latter may be too restrictive for the diagnosis of constipation (*2, 4*), and we therefore used the former. The following four questions were used to assess Rome I-defined functional constipation: 1) Do you strain during a bowel movement?; 2) Do you feel a sensation of incomplete emptying after a bowel movement?; 3) How often are your stools hard?; and 4) How many bowel movements do you usually have each week? These questions referred to the last 12 mo. For questions 1–3, four answers were offered: never, sometimes (<25% of the time), often (>25% of the time), and always. Functional constipation was defined as meeting two or more of the four criteria [an answer of often or always to questions 1–3 and less than three bowel movements per week for question 4].

Measurement of confounding factors. In the questionnaires, subjects reported body weight and height, residential area, current smoking (yes/no), and oral medication usage (yes/no). Body mass index (BMI) was calculated as body weight (kg) divided by the square of body height (m^2). Reported residential areas were grouped into six categories (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyushu) based on the regional blocks used in the National Nutrition Survey in Japan (*21*). Residential areas were also grouped into three categories according to population size (city with population ≥1 million; city with population <1 million; and town and village). Physical activity level was calculated by dividing total energy expenditure by basal metabolic rate calculated using the FAO/WHO/UNU formula (*23*). The calculation method has been described in detail elsewhere (*10, 12*).

Statistical analysis. For the current analysis, we selected female subjects aged 18–20 y (n=3,967). Of these, 197 women were excluded for the following reasons: attendance at an institution which conducted the survey at the end of May (n=97); reported daily energy intake outside the range of 3.7–4.7 MJ (725–3,235 kcal) (*24*) (n=78); or missing information on the variables used (n=24). Thus, 3,770 women underwent final analysis. Further exclusion of subjects with intentional dietary change during the preceding year (n=615) or those habitually using oral laxatives (n=367) did not materially alter the findings, and these subjects were therefore included in the analysis.

Factor analysis (principal component) was conducted to derive the food pattern based on the 30 food groups from the DHQ using the FACTOR PROCEDURE of the SAS software (*25*). Intake of these food groups was adjusted for total energy intake using the residual method (*26*). The factors were rotated by orthogonal transformation (Varimax rotation function in SAS) to achieve a simpler structure with greater interpretability. To identify the number of factors to be retained, we used the eigenvalue >1.0 criterion, the most widely used in factor analysis, as a first step. However, this procedure created 11 independent factors, a number too large for further analyses. The scree plot showed small breaks in the eigenvalues after factor five, suggesting that retaining three or four factors would be optimal. Post-rotated factor loadings revealed that four factors well described distinctive dietary patterns of the study population. After Varimax rotation, factor scores were saved from the principal component analysis for each individual. The factor scores for each pattern and for each individual were determined by summing the intake of each food group weighted by the factor loading (*27*).

The scores were divided into quintiles, and used for comparison with nutrient intake and other lifestyle factors and to estimate associations with the prevalence of

Table 1. Subject characteristics (n=3,770).[a]

Variable	
Age (y)	18.1±0.33
Body height (cm)	157.9±5.3
Body weight (kg)	52.3±7.6
Body mass index (kg/m²)	21.0±2.8
<18.5	550 (15)
18.5–24.9	2,937 (78)
≥25	283 (8)
Residential block	
Hokkaido and Tohoku	372 (10)
Kanto	1,290 (34)
Hokuriku and Tokai	526 (14)
Kinki	756 (20)
Chugoku and Shikoku	416 (11)
Kyushu	410 (11)
Size of residential area	
City with population ≥1 million	736 (20)
City with population <1 million	2,458 (65)
Town and village	576 (15)
Current smoking	
No	3,716 (99)
Yes	54 (1)
Oral medication usage	
No	3,403 (90)
Yes	367 (10)
Energy intake (MJ/d)	7.6±2.0
Physical activity level	1.40±0.17
Functional constipation[b]	
No	2,791 (74)
Yes	979 (26)

[a] Values are expressed as means±SD or numbers of subjects (%).
[b] Defined according to the Rome I criteria (14).

functional constipation. Correlation coefficients for each factor and energy-adjusted nutrient intake were calculated. In logistic regression analysis, we calculated both crude and multivariate-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for functional constipation for each quintile category of dietary pattern using logistic regression analysis. Multivariate-adjusted ORs were calculated by adjusting for BMI (three categories), residential block (six categories), size of residential area (three categories), current smoking (two categories), oral medication usage (two categories), physical activity level (quintiles), and energy intake (quintiles). We tested for linear trends across categories of dietary patterns by assigning scores to the levels of the independent variables.

All statistical analyses were performed using version 8.2 of the SAS software package (SAS Institute, Inc., Cary, North Carolina, USA). A two-sided p value of <0.05 was considered significant, except in correlation analyses between dietary patterns and nutrient intakes because these were not necessarily independent of each other. A Pearson correlation coefficient of >0.2 or <−0.2 was considered significant.

Table 2. Factor-loading matrix for the four dietary patterns (n=3,770).[a,b]

	Factor 1 Healthy	Factor 2 Japanese traditional	Factor 3 Western	Factor 4 Coffee and dairy products
Green and dark yellow vegetables	0.73	—	—	—
White vegetables	0.71	—	—	—
Mushrooms	0.62	—	—	—
Seaweeds	0.55	—	—	—
Soy products	0.50	0.36	—	—
Fish and shellfish	0.49	—	—	—
Potatoes	0.49	—	—	—
Processed fish	0.44	—	—	—
Fruit	0.41	—	—	—
Salted vegetables	0.31	—	—	—
Tea	—	—	—	—
Nuts	—	—	—	—
Rice	—	0.77	—	—
Miso soup	—	0.47	—	—
Fruit and vegetable juices	—	—	—	—
Alcohol	—	—	—	—
Noodles	—	—	—	—
Breads	—	−0.60	—	—
Confectionaries	—	−0.70	−0.33	—
Fats and oils	—	—	0.60	—
Meats	—	—	0.58	—
Seasonings	—	—	0.51	—
Processed meats	—	—	0.46	—
Eggs	—	—	0.33	—
Butter	—	—	—	—
Sugary foods	—	—	—	0.70
Coffee	—	—	—	0.69
Dairy products	—	—	—	0.41
Soup	—	—	—	—
Soft drinks	—	—	—	—
Percentage of variance	10.8%	6.9%	6.1%	5.3%

[a] Data from the self-administered diet history questionnaire (DHQ).
[b] Absolute values <0.27 were excluded from the table for simplicity.

RESULTS

Subject characteristics are shown in Table 1. A total of 979 women (26%) were classified with functional constipation.

The factor loading matrix is shown in Table 2. High positive loadings indicate strong associations between given food groups and patterns, whereas negative loadings indicate negative associations. Patterns were labeled according to those food groups with high loadings. Factor 1, which loaded heavily on green and white vegetables, mushrooms, seaweeds, soy products, fish and shellfish, potatoes, and fruit, was labeled the "Healthy" pattern. Factor 2, with high loadings for rice, miso soup and soy products was labeled the "Japanese traditional" pattern. Factor 3, with high loadings for fats and oils, meat, processed meat, eggs, and seasoning was labeled the "Western" pattern. Factor 4, with high loadings for sugary foods, coffee, and dairy products was labeled the "Coffee and dairy products" pattern. The four dietary patterns overall accounted for 29.1%

Table 3. Sample characteristics for the lowest (Q1) and highest (Q5) quintiles of four dietary patterns (n=3,770).[a,b]

	Factor 1 Healthy		Factor 2 Japanese traditional		Factor 3 Western		Factor 4 Coffee and dairy products	
	Q1 (n=754)	Q5 (n=754)	Q1 (n=754)	Q5 (n=754)	Q1 (n=754)	Q5 (n=754)	Q1 (n=754)	Q5 (n=754)
Age (y)[c]	18.1±0.3	18.1±0.3	18.1±0.4	18.1±0.4	18.1±0.3	18.1±0.3	18.1±0.3	18.1±0.4*
Body height (cm)	157.9±5.4	158.0±5.4	158.2±5.3	157.7±5.2	158.4±5.2	157.7±5.4	157.9±5.3	157.8±5.1
Body weight (kg)	52.8±7.9	52.1±7.5	52.1±7.4	52.8±7.8	52.0±7.3	52.6±7.9	52.5±7.8	52.1±7.2
Size of residential area								
City with population ≥1 million	144 (19)	162 (22)	176 (23)	145 (19)	152 (20)	161 (21)	148 (20)	174 (23)
City with population <1 million	484 (64)	465 (62)	497 (66)	475 (63)	496 (66)	476 (63)	487 (65)	470 (62)
Town and village	126 (17)	127 (17)	81 (11)	134 (18)	106 (14)	117 (16)	119 (16)	110 (15)
Current smoker	19 (3)	2 (0)	18 (2)	6 (1)	9 (1)	16 (2)	14 (2)	10 (1)
Oral medication usage	47 (6)	107 (14)	85 (11)	82 (11)	99 (13)	72 (10)	65 (9)	95 (13)
Energy intake (MJ/d)[c]	8.0±2.0	8.2±2.00	8.2±2.2	7.8±2.0**	8.1±2.1	8.3±2.1*	8.1±2.1	8.2±2.1
Physical activity level[c]	1.40±0.18	1.43±0.19**	1.42±0.19	1.41±0.17	1.42±0.20	1.41±0.18	1.41±0.19	1.40±0.15

[a] The factors were standardized continuous variables, and each subject had a score for each factor.
[b] Values are expressed as means±SD or numbers of subjects (%).
[c] Significantly different from the first quintile (Q1) of each dietary pattern, *$p<0.05$, **$p<0.001$ (Dunnett's t-test).

of variance in food intake.

The subjects were divided into quintiles by the factor score of each dietary pattern. Sample means and frequencies were calculated across quintiles. Sample characteristics of young women in the lowest and highest quintiles of each food pattern are presented in Table 3. Subjects with a high intake of the Healthy pattern were physically active, while those with a high intake of the Japanese traditional pattern had a high BMI, low energy intake, and were more likely to live in a small town. Subjects with a high intake of the Western pattern had a high BMI and high energy intake.

Correlation coefficients between each of the four dietary patterns and energy-adjusted nutrient intakes are presented in Table 4. For energy-adjusted nutrient intake, the Healthy pattern was correlated with protein, vitamin A, vitamin C, calcium, potassium, magnesium, soluble dietary fiber, insoluble dietary fiber, total dietary fiber, water from foods, water from fluid, and water from all foods (Pearson correlation coefficient (r)=0.22–0.82). The Japanese traditional pattern was positively correlated with carbohydrate, magnesium, and water from foods (r=0.21–0.37), and negatively with fat (r=−0.34). The Western pattern was positively correlated with fat and protein (r=0.31–0.64), and negatively with carbohydrate, and soluble and total dietary fibers (r=−0.68–−0.21). The Coffee and dairy products pattern was positively correlated with calcium, potassium, and magnesium (r=0.27–0.44).

Multivariate-adjusted odds ratios for functional constipation across quintiles of all four dietary patterns are presented in Table 5. There was a clear dose-response relationship between a high intake of the Japanese traditional pattern and a decreased prevalence of constipation. In comparison with the first quintile of the Japanese traditional pattern, multivariate-adjusted odds ratios for women in the second, third, fourth and fifth quintiles were 0.77 (95% CI: 0.62–0.96), 0.74 (95% CI: 0.59–0.92), 0.66 (95% CI: 0.52–0.83), and 0.52 (95% CI: 0.41–0.66), respectively (p for trend <0.0001). No association with prevalence of functional constipation was seen for the other dietary patterns.

DISCUSSION

To our knowledge, this is the first study on the association between dietary pattern and the prevalence of functional constipation. The Japanese traditional pattern showed a strongly negative correlation with the prevalence of functional constipation.

Although constipation is a common condition in several communities, a precise determination of prevalence is not always easy owing to inconsistency among symptoms (*2*, *28*, *29*). In the present study, we used the standard definition of functional constipation recommended by an international workshop on the management of constipation (Rome I criteria) (*16*) to assess functional constipation from various symptoms. The prevalence of functional constipation defined by the Roma I criteria in this population was 26%. A similar

Table 4. Pearson correlation coefficients between each of the four dietary patterns and daily nutrient intakes (n=3,770).[a,b]

	Factor 1 Healthy	Factor 2 Japanese traditional	Factor 3 Western	Factor 4 Coffee and dairy products
Protein (g/d)	0.56	0.12	0.31	0.09
Fat (g/d)	0.09	−0.34	0.64	0.15
Carbohydrate (g/d)	−0.19	0.23	−0.68	−0.12
Vitamin A (mg/d)	0.49	0.08	0.06	0.17
Vitamin C (mg/d)	0.68	−0.01	−0.01	0.07
Calcium (mg/d)	0.42	0.09	−0.16	0.44
Potassium (mg/d)	0.77	0.10	0.00	0.33
Magnesium (mg/d)	0.67	0.21	−0.08	0.27
Soluble dietary fiber (g/d)	0.71	−0.20	−0.20	0.19
Insoluble dietary fiber (g/d)	0.82	0.04	−0.20	0.18
Total dietary fiber (g/d)	0.82	−0.03	−0.21	0.18
Water from foods (g/d)	0.79	0.37	0.04	0.07
Water from fluid (g/d)	0.22	−0.02	0.01	0.08
Total water (g/d)	0.41	0.08	0.02	0.11
Alcohol (g/d)	−0.05	−0.08	0.02	−0.02

[a] All nutrients were energy-adjusted using the residual method.
[b] Pearson correlation coefficients of >0.2 or <−0.2 were considered significant.

Table 5. Multivariate adjusted odds ratios and 95% confidence intervals for functional constipation by quintile (n=754 for each quintile) of each dietary pattern (n=3,770).[a]

	Quintile category of dietary pattern					p for trend
	1 (lowest) (referent)	2	3	4	5 (highest)	
Factor 1 (Healthy)						
n with functional constipation	214	177	186	190	212	
Non-adjusted OR (95% CI)	1.00	0.77 (0.61–0.98)	0.83 (0.66–1.04)	0.85 (0.68–1.07)	0.99 (0.79–1.24)	0.81
Multivariable adjusted OR (95% CI)[b]	1.00	0.75 (0.59–0.95)	0.81 (0.64–1.02)	0.83 (0.66–1.05)	0.93 (0.74–1.17)	0.79
Factor 2 (Japanese traditional)						
n with functional constipation	246	203	197	180	153	
Non-adjusted OR (95% CI)	1.00	0.76 (0.61–0.95)	0.73 (0.59–0.91)	0.65 (0.52–0.81)	0.53 (0.42–0.66)	<0.0001
Multivariable adjusted OR (95% CI)[b]	1.00	0.77 (0.62–0.96)	0.74 (0.59–0.92)	0.66 (0.52–0.83)	0.52 (0.41–0.66)	<0.0001
Factor 3 (Western)						
n with functional constipation	206	183	198	183	209	
Non-adjusted OR (95% CI)	1.00	0.85 (0.68–1.07)	0.95 (0.75–1.19)	0.85 (0.68–1.07)	1.02 (0.81–1.28)	0.87
Multivariable adjusted OR (95% CI)[b]	1.00	0.87 (0.69–1.10)	0.98 (0.78–1.24)	0.90 (0.71–1.14)	1.06 (0.84–1.33)	0.59
Factor 4 (Coffee and dairy products)						
n with functional constipation	201	166	216	200	196	
Non-adjusted OR (95% CI)	1.00	0.77 (0.61–0.98)	1.11 (0.89–1.38)	0.99 (0.79–1.25)	0.97 (0.77–1.22)	0.53
Multivariable adjusted OR (95% CI)[b]	1.00	0.76 (0.60–0.97)	1.09 (0.87–1.37)	0.98 (0.78–1.24)	0.92 (0.73–1.16)	0.80

[a] Functional constipation was defined according to the Rome I criteria (*14*).
[b] Adjusted for body mass index (<18.5, 18.5–24.9, and ≥25 kg/m²), residential block (Hokkaido and Tohoku; Kanto; Hokuriku and Tokai; Kinki; Chugoku and Shikoku; and Kyushu), size of residential area (city with population ≥1 million; city with population <1 million; and town and village), current smoking (yes or no), oral medication usage (yes or no), physical activity level (quintile), and energy intake (quintile).

prevalence according to these criteria has been observed in Canadian women, at 21% (*4*), and in Spanish women, at 29% (*2*). In contrast, the lower ratio of 15% was reported for elderly Singaporean women (*3*).

At the food level, beneficial effects on constipation have been reported for dairy products such as cheese and milk (*11*), beans (*11, 12*), fruits and vegetables (*11*), meats (*11*), rice (*3, 9, 12, 13*), eggs (*13*), coffee (*11*), Chinese tea (*3, 9*), and Japanese tea (*9*), although the results have not always been consistent. Among these results, however, the favorable effect of rice on constipation has been consistently reported in those studies conducted in Asian countries, where rice is a staple food (*3, 9, 12, 13*). In the previous studies, the prevalence of constipation significantly negatively and positively associated with the intakes of rice and confectionaries, respectively (*9, 12*). The highest loadings in the Japanese traditional pattern were given to rice and confectionaries, positively and negatively, respectively (Table 2). Therefore, the observed strong association between the Japanese traditional dietary pattern and prevalence of constipation is probably explained mainly by these two foods.

With regard to individual nutrients, a protective effect has been seen for a high intake of dietary fiber in some studies (*5, 6*), but not in others, including ours (*7–10*). In contrast, the Healthy pattern, which was highly and positively associated with soluble, insoluble, and total dietary fibers, was not correlated with the prevalence of constipation. Our previous study using the same database showed a weak but significant negative association between the intake of magnesium and water from food and the prevalence of constipation (*10*). The Japanese traditional dietary pattern showed a positive association with the intakes of magnesium and water from foods (Table 4). These variables may therefore at least partly contribute to the lower prevalence of constipation. However, these two nutrients were associated with the Healthy dietary pattern much more strongly than with the Japanese traditional dietary pattern (Table 4). It may indicate the existence of unidentified nutrients or bioactive substances related to the prevalence of constipation in the Japanese traditional dietary pattern.

Our study has several limitations. First, the subjects were not randomly sampled from the general Japanese population, but were rather selected female students aged 18–20 y who might be highly health-conscious. To minimize the possible bias induced by nutritional education, we finished the survey within 1 mo of entrance to the course. Second, our findings came from a cross-sectional study. Because we could not exclude the possibility that the subjects changed their dietary behavior or food choices because of their condition of constipation, it was not possible to evaluate the causal association between dietary pattern and constipation. Third, Rome I criteria do not completely differentiate constipation-predominant irritable bowel syndrome from functional constipation (*28*). This might make the results obscure. Fourth, dietary habits and constipation were evaluated in different time periods, namely in the previous month for the former and in the previous year for the latter. However, the results did not materially change when analysis was limited to subjects reporting a stable diet within the previous year (n=3,155). Fifth, the validity and reproducibility of the dietary pattern identified in this study are unknown. However, the four patterns may be representative of Japanese populations because the same patterns were identified in our previous study among premenopausal Japanese farmwomen aged 40 to 55 y (*20*).

In conclusion, dietary pattern was associated with the prevalence of functional constipation among Japanese women aged 18 to 20 y. The Japanese traditional dietary pattern, characterized by a high intake of rice, miso soup, and soy products and a low intake of breads and confectionaries, may contribute to the prevention of functional constipation. Confirmation requires further studies using various populations with different dietary patterns.

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