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 life-style 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).

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

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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 ($\geq$ 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 ($\geq 25\%$ 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/m ²)	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 (6.2)	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 ($\pm$ 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 func-

tional 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 non-validated 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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