Original Article

Dietary intake, physical activity, and time management are associated with constipation in preschool children in Japan

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Background and Objectives: Constipation is a common complaint in children, which is not fatal but can affect quality of life. Several lifestyle-related risk factors for constipation have been reported, particularly dietary factors, but results have been inconsistent. Here, we examined the relationship of dietary and lifestyle factors with constipation in Japanese preschool children using data of a nationwide study. **Methods and Study Design**: Subjects were 5,309 children aged 5 to 6 years at 380 nursery schools in 44 of 47 prefectures in Japan. Children having three or fewer bowel movements per week were considered constipated. Dietary intake data was collected using a validated brief-type self-administered diet history questionnaire for Japanese preschool children, and information about general lifestyle was collected using a 4-page questionnaire designed for this study. Multivariate-adjusted odds ratios for constipation were calculated by logistic regression. **Results**: Higher dietary fiber intake was significantly associated with a lower prevalence of constipation (adjusted odds ratio: 0.62, *p* for trend: 0.005), but higher carbohydrate intake was marginally associated with a higher prevalence of constipation. Intake of potatoes, pulses, vegetables, and fruits intake decreased constipation prevalence, whereas higher rice intake was significantly and independently associated with higher prevalence of constipation. Regarding lifestyle factors, high physical activity and sufficient preparation time for breakfast and dinner for guardians were significantly associated with lower prevalence. Prevalence tended to be negatively associated with a higher educational background of the mother. **Conclusions**: Several lifestyle factors were associated with a lower prevalence of constipation among Japanese preschool children, including dietary fiber intake.

Key Words: constipation, diet, physical activity, time management, Japanese preschool children

INTRODUCTION

Constipation is common gastrointestinal complaint in childhood. Prevalence is defined as less than three defecations per week, and varies from 0.7% to 29.6% among children aged from birth to 18 years in Western and Asian countries.[1] In Japan, Kajiwara et al reported that 13.2% of boys and 24.1% girls aged 7 to 12 years have infrequent (≤3/week) bowel movements.[2] As infrequent bowel movement is often accompanied by abdominal pain, painful defecation or fecal incontinence,[3] it aggravates the quality of life of affected children and hinders efforts to build self-esteem.[4] Moreover, one-quarter of children with functional constipation suffer from symptoms of constipation into adulthood.[5]

A number of treatment options for constipation have been suggested. McClung et al stated that constipation treatment typically includes three phases: disimpaction (evacuation of the large fecal mass, days to weeks), laxative use (months), and a high-fiber diet (lifelong).[6] Given that constipation is usually a chronic condition, a good prognosis requires an improvement in lifestyle, particularly in dietary habits. Many studies have reported an association between dietary fiber intake and constipation,[6-8] and dietary fiber mixture has shown a comparable effect to lactulose, which is often prescribed as a laxative.[9] In addition, other lifestyle factors such as physical activity and family/school environment are also considered to be associated with the development of constipation.[10,11] To date, however, there is insufficient evidence to conclude that the effect of these lifestyle factors is causative.

Here, we conducted an epidemiological study to examine the relationship between constipation and lifestyle factors, including dietary intake, among preschool children in Japan. The study, part of the Japan Nursery School SHOKUIKU Study, particularly focused on die-

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tary fiber intake and lifestyle factors which can be modified in daily life. To our knowledge, this is the first large epidemiological study of constipation among Japanese preschool children.

MATERIALS AND METHODS

Study setting and participants

Participants in the Japan Nursery School SHOKUIKU Study were recruited from 44 of 47 prefectures in Japan. Representative dietitians of prefectural councils for dietitians (local branches of the Japan Dietetic Association) working at welfare facilities and staff dietitians in municipal child welfare facilities were initially invited to participate. Representative and staff dietitians or nursery governesses in 416 of 437 invited nurseries subsequently agreed to participate. These then recruited study subjects from guardians of children aged 5 or 6 years at their nursery school. Two questionnaires, one about the child's general lifestyle and the second assessing the child's dietary intake, were distributed to 9,762 guardians and collected between February and March in 2011. The number of respondents to the lifestyle questionnaire was 5637 (response rate: 57.7%) and that to the diet history questionnaire was 6,257 (64.1%). The two data sets for lifestyle and dietary intake were then merged. The number of subjects who answered both questionnaires was 5,515. We excluded children with missing values or outliers for key questions such as those whose energy intake was less than 500 kcal or 3,000 kcal and over. The final number of children analyzed was 5,309 in 380 facilities

Dietary assessment

Dietary intake data of the children during the preceding month was collected using a brief-type self-administered diet history questionnaire for Japanese preschool children (BDHQ3y).[12] The BDHQ3y is a four-page structured questionnaire that inquires about the consumption frequency of selected foods commonly consumed in Japan, general dietary behaviour, and usual cooking methods. It was developed based on comprehensive (16 pages)[13,14] and brief (4 pages)[15,16] versions of a validated self-administered diet history questionnaire for adults. Estimates of the daily intake of foods (66 items in total), energy, and selected nutrients were calculated using an ad hoc computer algorithm for the BDHQ3y based on the Standard Tables of Food Composition in Japan.[17] Although the BDHQ3y has been validated, the validation study was conducted in children aged 3 to 4 years.[12] Nearly all of our present subjects were 6 years old, and it is possible that adjustment for age in the nutritional value calculation did not fit the increase in actual dietary intake.

Values of nutrient intake were energy-adjusted using the density method (that is, percentage of energy for energy-providing nutrients and amount per 4,184 kJ (1,000 kcal) of energy for other nutrients). The BDHQ3y also elicited the child's weight and height. Body mass index (BMI) was calculated by dividing the guardian-reported body weight (kg) by the square of height (m^2).

Other variables

Information about the general lifestyle of children was collected using a 4-page questionnaire designed for this study. This questionnaire enquired about the frequency of bowel movements per week. Children with three or fewer bowel movements per week were considered constipated. The Rome III criteria[3] and other studies[18,19] stated that constipation in childhood was diagnosed if a child had fewer than three stools per week. However, as we had no information on any other symptoms relating with constipation such as fecal incontinence, pain on bowel movements or characteristics of stools, we used the definition described above in order to avoid misclassifying children who had three stools per week but also some difficulties on defecation.

Statistical analysis

Associations between constipation and a number of lifestyle factors, including dietary intake, were initially examined by comparing basic characteristics between children with and without constipation using the *t* test, chi-square test, and Cochran-Armitage test (for trends). We then categorized dietary intakes into quintiles based on distribution, and calculated crude and multivariable-adjusted odds ratios and 95% confidence intervals for constipation for each quintile category of dietary variable using logistic regression analyses, with the lowest quintile category used as a reference. Multivariate-adjusted odds ratios were calculated by adjusting for potential confounding factors including residential area, physical activity level, preparation time for breakfast, educational background of the mother. These covariates were included in the model because they had a significant association with presence or absence of constipation. Trends of association were examined using a logistic regression model which assigned scores at the level of the independent variable (dietary intake). In addition to the multivariate-adjusted model, we also examined whether fiber intake confounded the relationship between dietary intake and constipation using a fiber-adjusted model in which fiber intake (continuous variable) was adjusted with the same set of covariates as in the multivariate-adjusted model. The association between constipation and general lifestyle factors other than dietary intake was examined using a multivariate logistic regression model which included the same set of covariates as the multivariate-adjusted model for dietary intake, except for quintiles of any dietary intake. The fiber-adjusted model for lifestyle factors was the same as that for the multivariate-adjusted model for dietary fiber intake. By using the same model, constipation risks were predicted in different conditions defined by physical activity (three categories) and dietary fiber intake (quintiles). Adjusted odds ratios of constipation for each condition were also calculated.

All statistical analyses were performed using SAS statistical software (version 9.3, SAS Institute Inc, Cary, NC, USA). A two-sided p value of <0.05 was considered statistically significant.

Ethical considerations

The study protocol was approved by the Ethics Committee of the Japanese Society of Nutrition and Dietetics (approved Oct 21 2010; approval number, 2010_09_01). Response to the questionnaire was regarded as an agreement to participate, in accordance with Ethical Guidelines

for Epidemiological Research published by the Ministry of Health, Labor and Welfare.

RESULTS

Characteristics of the analyzed children (n=5,309) are shown in Table 1. Age and sex distribution did not statistically differ between children with and without constipation.

Multivariate-adjusted odds ratios for constipation by quintiles of nutrient intake are shown in Table 2. Higher dietary fiber intake was significantly associated with a lower prevalence of constipation (total dietary fiber; *p* for trend: 0.005). Further, intake of total dietary fiber from vegetables, fruits, potatoes, and pulses was negatively associated with the prevalence of constipation. In contrast, higher dietary fiber intake from cereals was associated with a significantly increased prevalence (p=0.05). Higher energy percent from fat was also associated with a lower prevalence of constipation even after adjusting for fiber intake (*p* for trend: 0.03). Higher intake of magnesium and zinc were associated with a lower prevalence of constipation in the multivariate-adjusted model, but the relationship was lost after adjustment for total fiber intake. The relationship between food intake and the prevalence of constipation is shown in Table 3. Among staple foods which are rich in carbohydrate, higher rice intake was significantly associated with a higher prevalence of constipation (p=0.01). Potato, pulse, vegetable, and fruit intakes were associated with a lower prevalence chiefly owing to the high fiber contents in these foods. However,

Table 1. Characteristics of subjects.

Characteristic	n (%) or mean±SD			*p* value[§]
	Total (n=5,309)	Children with constipation[†] (n=448)	Children without constipation[†] (n=4,861)	
Age (days)	2,349±105	2,354±104	2,348±105	0.29
5 years old	391 (7.4)	29 (6.5)	362 (7.5)	0.45
6 years old	4,918 (92.6)	419 (93.5)	4,499 (92.6)	
Sex				
Boy	2,805 (52.8)	219 (48.9)	2,586 (53.2)	0.08
Girl	2,504 (47.2)	229 (51.1)	2,275 (46.8)	
Height (cm)	115±5.4	115±5.5	115±5.4	0.45
Weight (kg)	20.6±3.2	20.7±3.1	20.6±3.2	0.78
Body mass index (kg/m^2)	15.5±1.8	15.5±1.7	15.5±1.8	0.84
Residential block				
Hokkaido and Tohoku	698 (13.2)	64 (14.3)	634 (13.0)	0.04
Kanto	1,448 (27.3)	104 (23.2)	1,344 (27.7)	
Hokuriku and Tokai	935 (17.6)	89 (19.9)	846 (17.4)	
Kinki	625 (11.8)	41 (9.2)	584 (12.0)	
Chugoku and Shikoku	797 (15.0)	66 (14.7)	731 (15.0)	
Kyushu and Okinawa	806 (15.2)	84 (18.8)	722 (14.9)	
Constipation				
No	4,861 (91.6)	-	-	-
Yes	448 (8.4)	-	-	
Physical activity level				
Low	234 (4.4)	30 (6.7)	204 (4.2)	0.009
Middle	1,108 (20.9)	106 (23.7)	1,002 (20.6)	
High	3,967 (74.7)	312 (69.6)	3,655 (75.2)	
Sleeping hours (minutes)	568±36	565±41	568±36	0.08
Preparation time for breakfast				
Not enough	1,569 (29.6)	158 (35.3)	1,411 (29.0)	0.01
Enough	1,702 (32.1)	142 (31.7)	1,560 (32.1)	
Plenty	2,038 (38.4)	148 (33.0)	1,890 (38.9)	
Appetite				
Poor	875 (16.5)	85 (19.0)	790 (16.3)	0.33
Middle	2,613 (49.2)	216 (48.2)	2,397 (49.3)	
Good	1,819 (34.3)	147 (32.8)	1,672 (34.4)	
Educational background of the mother				
Junior or senior high school	2,284 (43.0)	215 (48.0)	2,069 (42.6)	0.03
Junior college, technical school or university	3,025 (57.0)	233 (52.0)	2,792 (57.4)	
Energy intake (kcal/day)	1,133±308	1,113±316	1,135±307	0.14
Quintile 1 (509-884)[‡]	1,061	113 (10.7)	948 (89.4)	0.11 (trend)
Quintile 2 (884-1,023)	1,062	83 (7.8)	979 (92.2)	
Quintile 3 (1,024-1,163)	1,062	74 (7.0)	988 (93.0)	
Quintile 4 (1,163-1,349)	1,062	92 (8.7)	970 (91.3)	
Quintile 5 (1,349-2,949)	1,062	86 (8.1)	976 (91.9)	

[†]Constipation was defined as three or fewer bowel movements per week.
[‡]Range of each quintile
[§]Differences between children with and without constipation were compared using the *t*-test and chi-square test for continuous variables and categorical variables, respectively. The Cochran-Armitage test was used as a test for trend.

Table 2. Multivariate-adjusted odds ratios and 95% confidence intervals for constipation by quintiles of nutrient intake in 5,309 Japanese preschool children

Variable	Quintile category of nutrient intake[†]					*p* for trend
	1 (lowest, n=1,061)	2 (n=1,062)	3 (n=1,062)	4 (n=1,062)	5 (highest, n=1,062)	
Total dietary fiber (g/1,000 kcal)	4.0 [1.3-4.4]	4.7 [4.4-4.9]	5.2 [4.9-5.4]	5.7 [5.4-6.1]	6.8 [6.1-13.4]	
n with/without constipation	117/944	81/981	100/962	79/983	71/991	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.69 (0.51, 0.93)	0.86 (0.65, 1.15)	0.67 (0.50, 0.91)	0.62 (0.46, 0.85)	0.005
Soluble dietary fiber (g/1,000 kcal)	0.9 [0.2-1.0]	1.1 [1.0-1.1]	1.2 [1.1-1.3]	1.4 [1.3-1.5]	1.7 [1.5-3.4]	
n with/without constipation	123/938	92/970	86/976	85/977	62/1000	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.75 (0.56, 0.99)	0.69 (0.52, 0.92)	0.69 (0.51, 0.92)	0.50 (0.37, 0.69)	<0.001
Insoluble dietary fiber (g/1,000 kcal)	3.0 [1.1-3.3]	3.5 [3.3-3.7]	3.9 [3.7-4.1]	4.3 [4.1-4.6]	5.0 [4.6-10.0]	
n with/without constipation	116/945	84/978	96/966	78/984	74/988	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.71 (0.53, 0.96)	0.83 (0.62, 1.10)	0.67 (0.50, 0.91)	0.65 (0.48, 0.89)	0.008
Total dietary fiber (TDF) by source						
TDF from cereals (g/1,000 kcal)	1.0 [0.27-1.2]	1.3 [1.2-1.4]	1.5 [1.4-1.6]	1.8 [1.6-1.9]	2.1 [1.9-4.5]	
n with/without constipation	75/986	86/976	92/970	96/966	99/963	
Multivariate-adjusted OR (95% CI)[‡]	ref	1.17 (0.85, 1.62)	1.25 (0.91, 1.72)	1.31 (0.95, 1.79)	1.35 (0.99, 1.86)	0.05
TDF from vegetables (g/1,000 kcal)	0.6 [0.0-0.8]	0.9 [0.8-1.0]	1.2 [1.0-1.3]	1.5 [1.3-1.8]	2.2 [1.8-8.2]	
n with/without constipation	115/946	95/967	87/975	77/985	74/988	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.83 (0.62, 1.10)	0.76 (0.56, 1.01)	0.67 (0.49, 0.91)	0.66 (0.48, 0.90)	0.003
TDF from fruits (g/1000 kcal)	0.2 [0.0-0.3]	0.3 [0.3-0.4]	0.5 [0.4-0.6]	0.8 [0.6-0.9]	1.2 [0.9-4.0]	
n with/without constipation	97/964	104/958	87/975	85/977	75/987	
Multivariate-adjusted OR (95% CI)[‡]	ref	1.10 (0.82, 1.47)	0.93 (0.68, 1.26)	0.90 (0.66, 1.23)	0.81 (0.59, 1.12)	0.09
TDF from potatoes (g/1,000 kcal)	0.2 [0.0-0.2]	0.3 [0.2-0.4]	0.4 [0.4-0.5]	0.5 [0.5-0.6]	0.8 [0.6-2.0]	
n with/without constipation	104/957	98/964	76/986	88/974	82/980	
Multivariate-adjusted OR (95% CI)[†]	ref	0.93 (0.69, 1.24)	0.71 (0.52, 0.97)	0.81 (0.60, 1.09)	0.74 (0.55, 1.01)	0.03
TDF from pulses (g/1,000 kcal)	0.03 [0.00-0.11]	0.2 [0.1-0.2]	0.3 [0.2-0.4]	0.6 [0.4-0.7]	1.1 [0.7-4.4]	
n with/without constipation	102/959	97/965	92/970	69/993	88/974	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.94 (0.70, 1.26)	0.90 (0.67, 1.22)	0.67 (0.48, 0.92)	0.85 (0.63, 1.16)	0.07
Carbohydrate (% energy/day)	50.6 [32.0-52.9]	54.6 [52.9-56.0]	57.3 [56.0-58.7]	60.2 [58.7-61.9]	64.5 [61.9-79.1]	
n with/without constipation	92/969	77/985	82/980	83/979	114/948	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.83 (0.60, 1.14)	0.90 (0.66, 1.24)	0.91 (0.67, 1.24)	1.27 (0.95, 1.70)	0.08
Fiber-adjusted OR (95%CI)[§]	ref	0.84 (0.61, 1.16)	0.93 (0.68, 1.27)	0.93 (0.68, 1.27)	1.29 (0.96, 1.73)	0.06
Protein (% energy/day)	10.9 [7.9-11.6]	12.1 [11.6-12.5]	13.0 [12.5-13.4]	14.0 [13.4-14.5]	15.4 [14.5-23.1]	
n with/without constipation	117/944	81/981	83/979	97/965	70/992	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.68 (0.50, 0.92)	0.72 (0.53, 0.97)	0.85 (0.64, 1.13)	0.62 (0.45, 0.84)	0.03
Fiber-adjusted OR (95%CI)[§]	ref	0.71 (0.52, 0.95)	0.75 (0.56, 1.02)	0.91 (0.68, 1.21)	0.67 (0.49, 0.93)	0.13

OR: odds ratio; CI: confidence interval

[†]Median [range]

[‡]In the multivariate-adjusted model, residential area, physical activity level, preparation time for breakfast, and educational background of the mother were used as covariates.

[§]In the fiber-adjusted model, fiber intake was included as a covariate in addition to the same set of variables in the multivariate-adjusted model.

Table 2. Multivariate-adjusted odds ratios and 95% confidence intervals for constipation by quintiles of nutrient intake in 5,309 Japanese preschool children (cont.)

Variable	Quintile category of nutrient intake[†]					*p* for trend
	1 (lowest, n=1,061)	2 (n=1,062)	3 (n=1,062)	4 (n=1,062)	5 (highest, n=1,062)	
Fat (% energy/day)[#]	21.9 [10.6-24.2]	25.7 [24.2-27.0]	28.2 [27.0-29.3]	30.6 [29.3-31.9]	34.0 [31.9-50.7]	
n with/without constipation	113/948	86/976	78/984	81/981	90/972	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.74 (0.55, 0.99)	0.66 (0.49, 0.90)	0.69 (0.51, 0.93)	0.75 (0.56, 1.00)	0.04
Fiber-adjusted OR (95%CI)[§]	ref	0.74 (0.55, 1.00)	0.67 (0.49, 0.91)	0.68 (0.50, 0.92)	0.73 (0.54, 0.98)	0.03
Magnesium (mg/1,000 kcal)	96.3 [64.4-103]	108 [103-112]	116 [112-120]	125 [120-131]	140 [131-204]	
n with/without constipation	109/952	95/967	81/981	85/977	78/984	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.88 (0.66, 1.18)	0.75 (0.56, 1.02)	0.81 (0.60, 1.09)	0.75 (0.55, 1.03)	0.05
Fiber-adjusted OR (95%CI) [§]	ref	0.96 (0.71, 1.29)	0.86 (0.63, 1.18)	0.97 (0.70, 1.35)	1.05 (0.72, 1.53)	0.91
Zinc (mg/1,000 kcal)	3.7 [2.8-3.9]	4.0 [3.9-4.1]	4.2 [4.1-4.3]	4.4 [4.3-4.6]	4.8 [4.6-6.4]	
n with/without constipation	103/958	89/973	107/955	71/991	78/984	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.87 (0.65, 1.18)	1.10 (0.82, 1.47)	0.70 (0.51, 0.96)	0.79 (0.58, 1.08)	0.06
Fiber-adjusted OR (95%CI) [§]	ref	0.88 (0.65, 1.19)	1.13 (0.85, 1.51)	0.73 (0.53, 1.01)	0.85 (0.62, 1.17)	0.17
Total water (g/1,000 kcal)	643 [316-711]	757 [711-802]	847 [802-894]	945 [894-1,001]	1,091 [1,002-1,843]	
n with/without constipation	108/953	85/977	87/975	78/984	90/972	
Multivariate-adjusted OR (95% CI)[‡]	ref	0.79 (0.58, 1.06)	0.83 (0.61, 1.11)	0.72 (0.53, 0.98)	0.85 (0.63, 1.15)	0.23
Fiber-adjusted OR (95%CI)[§]	ref	0.81 (0.60, 1.10)	0.87 (0.64, 1.17)	0.77 (0.57, 1.06)	0.98 (0.72, 1.33)	0.71

OR: odds ratio; CI: confidence interval

[†]Median [range]

[‡]In the multivariate-adjusted model, residential area, physical activity level, preparation time for breakfast, and educational background of the mother were used as covariates.

[§]In the fiber-adjusted model, fiber intake was included as a covariate in addition to the same set of variables in the multivariate-adjusted model.

Table 3. Multivariate-adjusted odds ratios and 95% confidence intervals for constipation by quintiles of food intake in 5,309 Japanese preschool children

Variable	Quintile category of food intake[†]					*p* for trend
	1 (lowest, n=1,061)[‡]	2 (n=1,062)	3 (n=1,062)	4 (n=1,062)	5 (highest, n=1,062)	
Rice (g/1,000 kcal)	112 [33-136]	154 [136-172]	187 [172-203]	219 [203-241]	275 [242-442]	
n with/without constipation	77/984	86/976	89/973	79/983	117/945	
Multivariate-adjusted OR (95% CI)[††]	ref	1.13 (0.82, 1.55)	1.17 (0.85, 1.61)	1.03 (0.74, 1.42)	1.57 (1.16, 2.13)	0.01
Fiber-adjusted OR (95% CI)[#]	ref	1.10 (0.80, 1.52)	1.14 (0.83, 1.57)	0.99 (0.71, 1.38)	1.48 (1.09, 2.01)	0.04
Bread (g/1,000 kcal)	4.3 [0.0-6.3]	10.3 [6.3-12.9]	15.6 [12.9-20.3]	25.5 [20.3-31.0]	37.8 [31.0-123.1]	
n with/without constipation	88/973	87/975	97/965	92/970	84/978	
Multivariate-adjusted OR (95% CI)[††]	ref	1.00 (0.73, 1.36)	1.12 (0.83, 1.52)	1.07 (0.78, 1.45)	0.96 (0.70, 1.32)	0.98
Fiber-adjusted OR (95% CI)[#]	ref	1.00 (0.73, 1.37)	1.13 (0.83, 1.53)	1.08 (0.80, 1.48)	0.99 (0.72, 1.36)	0.87
Noodles (g/1,000 kcal)	11.1 [0.0-14.2]	16.8 [14.2-19.2]	21.8 [19.2-24.7]	28.2 [24.7-33.2]	43.5 [33.2-166.8]	
n with/without constipation	94/967	92/970	79/983	97/965	86/976	
Multivariate-adjusted OR (95% CI)[††]	ref	0.98 (0.72, 1.33)	0.83 (0.60, 1.13)	1.03 (0.76, 1.39)	0.89 (0.66, 1.21)	0.62
Fiber-adjusted OR (95% CI)[#]	ref	0.99 (0.73, 1.35)	0.85 (0.62, 1.17)	1.06 (0.79, 1.44)	0.94 (0.69, 1.28)	0.89
Potatoes (g/1,000 kcal)	8.0 [0.0-10.6]	13.3 [10.6-16.6]	19.7 [16.6-22.4]	25.5 [22.4-30.1]	38.2 [30.2-111.8]	
n with/without constipation	107/954	92/970	95/967	74/988	80/982	
Multivariate-adjusted OR (95% CI)[††]	ref	0.84 (0.62, 1.12)	0.89 (0.66, 1.19)	0.66 (0.48, 0.90)	0.70 (0.52, 0.96)	0.008
Fiber-adjusted OR (95% CI)[#]	ref	0.86 (0.64, 1.16)	0.94 (0.70, 1.26)	0.72 (0.52, 0.99)	0.81 (0.58, 1.12)	0.10
Pulses (g/1,000 kcal)	4.8 [0.0-7.3]	9.4 [7.3-11.6]	13.8 [11.6-16.3]	19.3 [16.4-23.2]	29.2 [23.2-119.1]	
n with/without constipation	123/938	92/970	82/980	69/993	82/980	
Multivariate-adjusted OR (95% CI)[††]	ref	0.73 (0.55, 0.97)	0.64 (0.48, 0.86)	0.54 (0.39, 0.73)	0.64 (0.47, 0.86)	<0.001
Fiber-adjusted OR (95% CI)[#]	ref	0.76 (0.57, 1.02)	0.69 (0.51, 0.93)	0.59 (0.43, 0.81)	0.75 (0.54, 1.05)	0.02
Vegetables (g/1,000 kcal)[§]	12.5 [0.0-17.9]	21.6 [17.9-25.4]	29.3 [25.4-33.8]	39.3 [33.8-46.4]	58.8 [46.4-201.8]	
n with/without constipation	123/938	88/974	80/982	86/976	71/991	
Multivariate-adjusted OR (95% CI)[††]	ref	0.71 (0.53, 0.95)	0.65 (0.48, 0.88)	0.71 (0.53, 0.95)	0.59 (0.43, 0.80)	0.002
Fiber-adjusted OR (95% CI)[#]	ref	0.71 (0.53, 0.95)	0.71 (0.52, 0.96)	0.72 (0.51, 1.00)	0.70 (0.47, 1.04)	0.08
Fruits (g/1,000 kcal)[¶]	10.7 [0.0-16.6]	23.2 [16.7-30.0]	36.8 [30.0-45.1]	54.7 [45.1-67.1]	89.2 [67.2-297.5]	
n with/without constipation	108/953	96/966	89/973	74/988	81/981	
Multivariate-adjusted OR (95% CI)[††]	ref	0.89 (0.67, 1.19)	0.85 (0.63, 1.15)	0.70 (0.51, 0.95)	0.79 (0.58, 1.07)	0.04
Fiber-adjusted OR (95% CI)[#]	ref	0.92 (0.69, 1.24)	0.92 (0.68, 1.24)	0.78 (0.57, 1.07)	0.96 (0.69, 1.35)	0.46
Meats (g/1,000 kcal)	17.4 [0.0-21.6]	24.7 [21.6-27.3]	29.9 [27.3-32.5]	35.7 [32.5-39.8]	46.7 [39.8-154.9]	
n with/without constipation	122/940	97/964	69/993	74/988	86/976	
Multivariate-adjusted OR (95% CI)[††]	ref	0.77 (0.58, 1.02)	0.54 (0.39, 0.73)	0.58 (0.43, 0.78)	0.66 (0.50, 0.89)	<0.001
Fiber-adjusted OR (95% CI)[#]	ref	0.77 (0.58, 1.03)	0.54 (0.39, 0.73)	0.58 (0.43, 0.78)	0.66 (0.50, 0.89)	<0.001

OR: odds ratio; CI: confidence interval.

[†]Median [range].

[‡]The number of subjects included in each quintile category differed for meat (n=1,062, 1,061, 1,062, 1,062, 1,062) and fats and oils (n=1,052, 1,069, 1,065, 1,063, 1,060) due to skewness of the distributions.

[§]Vegetables include all kinds of vegetables except vegetable juice.

[¶]Fruits includes all kinds of fruits except fruit juice.

[††]In the multivariate-adjusted model, residential area, physical activity level, preparation time for breakfast, and educational background of the mother were used as covariates.

[#]In the fiber-adjusted model, fiber intake was included as a covariate in addition to the same set of variables in the multivariate-adjusted model.

[$]Fats and oils includes butter, margarine, mayonnaise, and cooking oils.

Table 3. Multivariate-adjusted odds ratios and 95% confidence intervals for constipation by quintiles of food intake in 5,309 Japanese preschool children (cont.)

Variable	Quintile category of food intake[†]					*p* for trend
	1 (lowest, n=1,061)[‡]	2 (n=1,062)	3 (n=1,062)	4 (n=1,062)	5 (highest, n=1,062)	
Fish (g/1,000 kcal)	10.0 [0.0-12.8]	15.2 [12.8-17.5]	19.7 [17.5-22.3]	25.5 [22.3-29.5]	36.8 [29.5-137.2]	
n with/without constipation	101/960	86/976	81/981	92/970	88/974	
Multivariate-adjusted OR (95% CI)[††]	ref	0.87 (0.64, 1.17)	0.81 (0.60, 1.10)	0.96 (0.71, 1.29)	0.91 (0.67, 1.23)	0.76
Fiber-adjusted OR (95% CI)[#]	ref	0.90 (0.66, 1.22)	0.85 (0.63, 1.16)	1.03 (0.76, 1.39)	1.00 (0.74, 1.37)	0.71
Fats and oils (g/1,000 kcal)[$]	4.5 [0.4-5.6]	6.4 [5.6-7.2]	7.9 [7.2-8.7]	9.6 [8.7-10.7]	12.5 [10.7-26.5]	
n with/without constipation	100/952	88/981	81/984	88/975	91/969	
Multivariate-adjusted OR (95% CI)[††]	ref	0.84 (0.62, 1.14)	0.76 (0.56-1.03)	0.83 (0.62-1.13)	0.84 (0.62-1.13)	0.28
Fiber-adjusted OR (95% CI)[#]	ref	0.82 (0.61, 1.12)	0.74 (0.54, 1.01)	0.82 (0.60, 1.11)	0.81 (0.60, 1.10)	0.21

OR: odds ratio; CI: confidence interval.

[†]Median [range].

[‡]The number of subjects included in each quintile category differed for meat (n=1062, 1061, 1062, 1062, 1062) and fats and oils (n=1052, 1069, 1065, 1063, 1060) due to skewness of the distributions.

[$]Vegetables include all kinds of vegetables except vegetable juice.

[¶]Fruits includes all kinds of fruits except fruit juice.

[††]In the multivariate-adjusted model, residential area, physical activity level, preparation time for breakfast, and educational background of the mother were used as covariates.

[#]In the fiber-adjusted model, fiber intake was included as a covariate in addition to the same set of variables in the multivariate-adjusted model.

[$]Fats and oils includes butter, margarine, mayonnaise, and cooking oils.

even after adjusting for fiber intake, intake of pulses was significantly related with the prevalence. Although prevalence of constipation decreased with meat intake, no association was observed with fish intake.

The relationship between lifestyle factors other than dietary intake and constipation is shown in Table 4. A high level of physical activity was significantly associated with a lower prevalence of constipation. Also, the prevalence of constipation among children was significantly lower if the guardians had a sufficiently long preparation time for breakfast and dinner. These relationships were stable even after adjustment for dietary fiber intake. Mothers with a higher educational background tended to have children without constipation, but this relationship was confounded by other variables such as fiber intake and residential area.

Lastly, constipation risk was predicted by the same logistic regression model in different conditions defined by physical activity level and dietary fiber intake. The results were shown in Table 5. When a subject consumed very high amount of dietary fiber and had high physical activity, the risk of constipation was 6.5%. On the other hand, when another subject consumed very low amount of dietary fiber and had low physical activity, the risk was 15.5%. Adjusted odds ratio of constipation for the subjects with the highest constipation risk was 2.63 compared with the reference subjects who consumed very high amount of dietary fiber and had high physical activity.

DISCUSSION

In this study, we showed that higher dietary fiber intake was significantly associated with a lower prevalence of constipation. Although several previous studies have shown a protective effect of dietary fiber on constipation among children,[6-9,20] others have shown no relationship between dietary fiber intake and constipation.[21,22] Accordingly, the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition has not yet recommended the use of fiber supplements in the treatment of functional constipation.[23]

Our results support the positive health effect of dietary fiber on constipation. Higher dietary fiber intake from vegetables, fruits, potatoes, and pulses lowered prevalence of constipation. Wu et al also reported in their study that less frequent consumption of vegetables, fruits, soybean products, and eggs was associated with constipation in Taiwanese school-aged children.[24] In contrast, although cereals are an important source of dietary fiber, dietary fiber from cereals were not associated with a decrease in constipation. Our results also showed that a higher intake of rice, a staple food in Japan, might actually cause a higher prevalence of constipation. Rice is a main source of carbohydrate in Japan; therefore, the marginal association between higher carbohydrate intake and higher prevalence of constipation was observed for the same reason in this study. Since higher rice intake was associated with a lower intake of vegetables, fruits, potatoes, and pulses in our population (data not shown), decreased intakes of these fiber-rich foods confounded the relationship between rice intake and constipation. In addition, although the “rice” intake shown in this study includes all types of rice, it was nearly equal to intake of well-milled rice which includes less than one-twentieth the amount of dietary fiber of wheat bran.[17,25] Actually, 86.0% of our present children consumed only well-milled rice, and even in the children who consumed other types of rice such as brown rice or half-milled rice (n=746, those who consumed other rice solely or together with white rice), average intake of well-milled rice was 189.8 g/day, and that of other rice was 92.5 g/day. This undesirable effect of rice intake might be due to the difference in dietary fiber content between well-milled rice and other cereals. On the other hand, higher intakes of fat as a nutrient and meat were also associated with a low risk of constipation, and these associations were not lost after adjustment for fiber intake. Sandler et al. also found in their study that constipated subjects reported lower consumption of meat and poultry,[26] but mechanism of this relationship is unknown. Macronutrient balance, i.e. balance among protein, fat, and carbohydrate intake as energy source, might affect constipation risk irrespective of fiber intake, but we were unable to locate any studies of this relationship. Given that other studies have reported that higher rice intake reduced constipation risk in Japanese adults,[27,28] this point requires further consideration. Higher intakes of magnesium and zinc were also associated with a lower prevalence of constipation, but the fiber-adjusted analysis suggested that these relationships might have resulted from confounding by dietary fiber intake.

Further, several lifestyle factors were found as risk factors of constipation. Higher physical activity was associated with a lower prevalence of constipation. Adjustment for fiber intake did not change the significance of this relationship. The predicted risks shown in Table 5 suggested that both of physical activity and dietary fiber intake might be important to the same degree to reduce the constipation risk. Another independent risk factor of constipation was lower educational background of the mother. These findings are compatible with the results of many previous studies,[10,29-31] albeit that one study reported no relationship between constipation and physical activity.[32] Interestingly, we also found a relationship between the busyness of daily life in guardians and constipation in children. In apparent contrast, the time children got up in the morning or went to bed were not associated with constipation, nor was the length of sleeping hours. When guardians are busy, children might be rushed, and feel that they do not have enough time to go to the bathroom. Other lifestyle factors assessed in our study had no significant relationship with constipation.

The strength of our study is its large number of subjects from almost all prefectures in Japan (44 of 47). The large population size allowed us to account for a number of possible confounding factors in the multivariate model. Also, our detailed quantitative dietary assessment allowed us to examine the relationship between constipation and dietary intake quantitatively. To our knowledge, this is the first epidemiological study among Japanese preschool children with a detailed, quantitative assessment of dietary intake and constipation.

Several limitations also warrant mention. First, the generalizability of our results might be limited. All the children in the study attended nursery schools. Nursery

Table 4. Multivariate-adjusted odds ratios and 95% confidence intervals for constipation in relation to selected lifestyle factors among 5,309 Japanese preschool children

Variable	Value (median [range])	n with/without constipation	Crude OR (95% CI)	Multivariate-adjusted OR (95% CI)†	Fiber-adjusted OR (95% CI)‡
Body mass index (kg/m^2)					
Low	14.0 [7.7-14.7]	156/1,618	ref		
Middle	15.3 [14.7-15.9]	135/1,629	0.86 (0.68, 1.09)	-	-
High	16.8 [15.9-26.4]	157/1,614	1.01 (0.80, 1.27)		
Physical activity level					
Low		30/204	ref	ref	ref
Middle		106/1,002	0.72 (0.47, 1.11)	0.74 (0.48, 1.15)	0.76 (0.49, 1.17)
High		312/3,655	0.58 (0.39, 0.87)*	0.60 (0.40, 0.90)*	0.62 (0.41, 0.93)*
Getting up time					
Before 6:30		52/516	ref		
6:30-8:00		370/4,097	0.90 (0.66, 1.22)	-	-
After 8:00		26/248	1.04 (0.63, 1.71)		
Going to bed time					
Before 21:00		39/381	ref		
21:00-22:00		247/2,946	0.82 (0.58, 1.17)	-	-
After 22:00		162/1,534	1.03 (0.72, 1.49)		
Sleeping hours (minutes)					
Short	540 [290-550]	172/1,661	ref		
Middle	570 [555-580]	146/1,629	0.87 (0.69, 1.09)	-	-
Long	600 [585-840]	130/1,571	0.80 (0.63, 1.01)		
Preparation time for breakfast (for guardian)					
Not enough		158/1,411	ref	ref	ref
Ordinary		142/1,560	0.81 (0.64, 1.03)	0.80 (0.63, 1.01)	0.80 (0.63, 1.02)
Sufficient		148/1,890	0.70 (0.55, 0.88)*	0.69 (0.54, 0.87)*	0.71 (0.56, 0.91)*
Preparation time for dinner (for guardian)					
Not enough		126/1,161	ref		
Ordinary		125/1,368	0.84 (0.65, 1.09)	-	-
Sufficient		197/2,332	0.78 (0.62, 0.98)*		
Appetite					
Poor		85/790	ref		
Middle		216/2,397	0.84 (0.64, 1.09)	-	-
Good		147/1,672	0.82 (0.62, 1.08)		
Eating rate					
Slow		188/2,079	ref		
Middle		184/2,038	1.00 (0.81, 1.23)	-	-
Fast		71/663	1.18 (0.89, 1.58)		

OR: odds ratio; CI: confidence interval.

*$p<0.05$.

†Multivariate-adjusted OR: adjusted for residential area, physical activity level, preparation time for breakfast, and educational background of the mother.

‡Fiber-adjusted OR: adjusted for the same set of covariates with the multivariate adjusted model and dietary fiber intake (continuous).

Table 4. Multivariate-adjusted odds ratios and 95% confidence intervals for constipation in relation to selected lifestyle factors among 5,309 Japanese preschool children (cont.)

Variable	Value (median [range])	n with/without constipation	Crude OR (95% CI)	Multivariate-adjusted OR (95% CI)†	Fiber-adjusted OR (95% CI)‡
Mastication					
Not enough		112/1,045	ref		
Enough		274/3,106	0.82 (0.65, 1.04)	-	-
Plenty		59/679	0.81 (0.58, 1.13)		
Educational background of mother					
Junior or senior high school		215/2,069	ref	ref	ref
Junior college, technical school or university		233/2,792	0.80 (0.66, 0.98)*	0.82 (0.68, 1.00)	0.84 (0.69, 1.03)
Educational background of father					
Junior or senior high school		202/2,193	ref		
Junior college, technical school or university		181/2,102	0.94 (0.76, 1.15)	-	-

OR: odds ratio; CI: confidence interval.
*$p<0.05$
†Multivariate-adjusted OR: adjusted for residential area, physical activity level, preparation time for breakfast, and educational background of the mother.
‡Fiber-adjusted OR: adjusted for the same set of covariates with the multivariate adjusted model and dietary fiber intake (continuous).

Table 5. Predicted risk and adjusted odds ratio of constipation in different conditions defined by physical activity and dietary fiber intake

		Predicted constipation risk (%) and adjusted odds ratio*				
		Total dietary fiber intake group				
	Intake quintile	Very low	Low	Middle	High	Very high
	Intake range (g/1,000kcal)	[1.3-4.4]	[4.4-4.9]	[4.9-5.4]	[5.4-6.1]	[6.1-13.4]
Physical activity level	Low	15.5 (2.63)	11.2 (1.80)	13.7 (2.27)	11.0 (1.77)	10.2 (1.63)
	Middle	12.2 (1.98)	8.7 (1.36)	10.7 (1.71)	8.5 (1.33)	7.9 (1.23)
	High	10.1 (1.61)	7.2 (1.11)	8.9 (1.39)	7.1 (1.09)	6.5 (ref)

*The logistic regression model to predict constipation risk and calculate adjusted odds ratios included total dietary fiber (quintiles), physical activity level (three categories), residential area, preparation time for breakfast, and educational background of the mother as covariates. The odds ratios were given in parenthesis.

schools in Japan are established based on the Child Welfare Act and the standard length of child care per day is 8 hours. In contrast, kindergartens are established based on the School Education Act and offer classes for approximately 4 hours. Most guardians who let their children attend nursery schools are employed, whereas most of those whose children are in kindergartens are housewives or workers with short working hours. Family environment might therefore differ between children in nursery schools and kindergartens. The number of children in nursery schools in 2013 was 2,185,166 (Social Welfare Facility Survey, reported by the Ministry of Health, Labour and Welfare) while the number in kindergartners was 1,583,610 (School Basic Survey, reported by the Ministry of Education, Culture, Sports, Science and Technology). Presently, nursery school enrolments are slightly increasing while kindergarten enrolments are decreasing, suggesting that our findings might be applicable to more children in the future. Second, our definition of constipation was not a typical one. Information about the frequency of bowel movements was collected by questionnaire from the guardians, and we had no other information about defecation such as pain, hardness of stool, or fecal incontinence. We therefore defined "constipation" as three or fewer bowel movements per week to include subjects who had three stools per week but with some difficulty. Third, we suspect that there was considerable underestimation of dietary intake, on the basis that mean energy intake in the subjects was 1132 kcal/day, versus estimated energy requirements for 6- to 7-year-old children with a middle physical level activity of 1550 kcal/day for boys and 1450 kcal/day for girls.[33] Although the BDHQ3y has been validated, the validation study was conducted in children aged 3 to 4 years.[12] Nearly all of our present subjects were 6 years old, and it is possible that adjustment for age in the nutritional value calculation did not fit the increase in actual dietary intake. Therefore, it is difficult to discuss absolute values of approximate dietary intake based on the present study only, but the direction of the relationships should be stable even if the method of age-adjustment is modified.

In conclusion, we found that higher intake of dietary fiber was associated with lower prevalence of constipation among Japanese preschool children. While macronutrient balance might have been associated with constipation risk, confirmation of this will require careful consideration for both food and nutrient intake. We also found that low physical activity, low maternal educational background, and busyness of the guardian were also associated with constipation. Preventing constipation in preschool children requires lifestyle improvement in not only children but also guardians.

AUTHOR DISCLOSURES

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