The Relationship between Functional Constipation and Dietary Habits in School-Age Japanese Children

Masayuki OKUDA1, Ichiro KUNTSUGU2, Norikazu YOSHIKATE3 and Satoshi SASAKI1
1Graduate School of Sciences and Engineering for Innovation, Yamaguchi University, Ube 755–8505, Japan
2Graduate School of Medicine, Yamaguchi University, Ube 755–8505, Japan
3The School of Public Health, The University of Tokyo 113–0033, Tokyo, Japan

(Received June 27, 2018)

Summary Functional constipation negatively affects school-related quality of life for children and adolescents. We investigated the association between functional constipation, defined according to the Rome criteria version III, and dietary habits. The subjects of this cross-sectional study were 1,140 5th graders and 1,054 8th graders attending schools in Shunan City, Japan in 2012. Functional constipation was defined as having two or more symptoms of constipation. Dietary habits were assessed using a brief questionnaire. Self-reported biological, demographic and lifestyle information was obtained. Using multiple logistic models, dose-dependent associations among subgroups stratified with quintiles of nutrient and food intake were examined. The prevalence of functional constipation ranged from 3.7% to 8.3% across the grades. The most prevalent symptom was pain or hard stools. There was a link between higher rates of functional constipation and lower levels of dietary fiber intake, vegetables, and fruits (p<0.010–0.030). Associations with vegetables and fruits attenuated when controlling for dietary fiber intake (p=0.074–0.150). When 5th and 8th graders were separately analyzed, intake of dietary fiber, water from foods, and vegetables had beneficial effects on functional constipation in 8th graders (p=0.005–0.038), and fruit intake had a beneficial effect in 5th graders (p=0.012). Modification of dietary habits may have a positive effect in reducing functional constipation in school-age children. Diets rich in fiber, vegetables, and fruits, have the potential to improve functional constipation in Japanese children and adolescents.

Key Words cross-sectional study, dietary fiber, fruits, functional constipation, vegetables

Constipation is a common pediatric problem which deteriorates health-related quality of life (1–3), and increases school absenteeism (4, 5). The prevalence of constipation among children has been reported as ranging from 0.7% to 29.6% (mean=14%; median=12%) (6). Moreover, most children with constipation do not receive treatment (7).

Diet, physical activity levels, toilet behaviors, social environment factors, and family history have been considered as causes of child constipation (8–10). Several nutrients and foods have been examined as factors lowering constipation prevalence in school-age children (11–15), as well as in pre-school children and college students (16–20).

The wide range in the prevalence of constipation is partly due to the presence of a variety of definitions. Some studies used a single symptom as a definition, (e.g. defecation frequency or stool character) (11, 13, 14, 20), while others used a combination of these symptoms as functional constipation (e.g. Rome criteria) (12, 18, 19). The prevalence based on the Rome criteria version II and the Rome criteria version III (Rome III) is different (21–23). While version IV has just been released, Rome III, with the same items as version IV and its timeframe longer than that of version IV (2 mo vs. 1 mo), has been widely used in several studies that reported the prevalence of child constipation (6, 24, 25). Few studies have investigated the association between dietary habits and constipation based on the Rome III criteria; only one study of Korean toddlers used this measure and they found that dietary habits were related to functional constipation (19).

The purpose of the present study was to use the Rome III criteria to examine functional constipation and dietary habits in 5th and 8th graders in Shunan City, Japan. Specifically, in this study, we investigated the association between dietary nutrient/food intake and functional constipation, defined according to the Rome III criteria, in school-age children and adolescents.

MATERIALS AND METHODS

Subjects. This study plan, in accordance with the Declaration of Helsinki, was approved by the Institutional Review Board, Yamaguchi University Hospital (H22-158), and we obtained written informed assent from the students and informed consent from the guardians. This cross-sectional study was conducted in all 51 schools in Shunan City, Japan. Overall, 2,706 5th and 8th grade students (1,368 5th graders, and 1,338 8th graders) were enrolled in these schools in 2012. We distributed questionnaires to students in each school between May and June 2012, and asked students to complete them at home. The completed questionnaires were collected at school, and we obtained anonymized

E-mail: okuda@yamaguchi-u.ac.jp
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Table 1. Characteristics of the subjects.

|                      | 5th graders |           | 8th graders |           |
|----------------------|-------------|-----------|-------------|-----------|
|                      | Boys, n=599 | Girls, n=541 | Boys, n=538 | Girls, n=516 |
| Age, y               | 10.6±0.3 | 10.6±0.3 | 13.6±0.3 | 13.6±0.3 |
| BMI, kg/m²           | 17.4±2.5 | 17.0±2.3 | 18.8±2.4 | 19.3±2.5 |
| Secondary maturation | 22        | 3.7%      | 36         | 6.7%      |
| Siblings, One        | 72        | 12.0%     | 61         | 11.3%     |
| Two                  | 287       | 47.9%     | 274        | 50.6%     |
| More than 2          | 240       | 40.1%     | 206        | 38.1%     |
| Exercise frequency   | 313       | 52.3%     | 387        | 71.5%     |
| Single parent        | 76        | 12.7%     | 88         | 16.3%     |
| Waking up after 6:30 AM | 399   | 66.6%     | 389        | 71.9%     |
| TV watching ≥2 h on weekdays | 368 | 61.4% | 357 | 66.0% |
| Energy intake        | 1,912±435  | 1,682±432 | 2,520±748  | 2,016±673 |
| Functional constipation | 39  | 6.5%      | 43         | 7.9%      |
| Infrequency          | 17        | 2.8%      | 25         | 4.6%      |
| Soiling of underwear | 4         | 0.7%      | 10         | 1.8%      |
| Retentive posturing  | 40        | 6.7%      | 48         | 8.9%      |
| Pain or hard stools  | 113       | 18.9%     | 129        | 23.8%     |
| Presence of large stools | 13  | 2.2%      | 12         | 2.2%      |
| Obstructive stools   | 29        | 4.8%      | 21         | 3.9%      |

Mean±standard deviation, or counts and percentage.

Data of 2,403 students from the Shunan City Education Board (See Fig. S1, Supplemental Online Material). Out of 2,403, 22 students received medical treatment for diabetes, dyslipidemia, hypertension, heart disease, or kidney disease. The data for analysis did not include students who received diet advice from doctors or nurses according to their self-report.

Questionnaires. Functional constipation was defined as two or more of the following symptoms for 2 mo based on Rome III: low defecation frequency (≤2 per week), soiling of underwear (at least 1 per week), retentive posturing (at least 1 per week), pain or hard stools, presence of a large fecal mass, large stool obstructing toilet (26). Options of each question were taken from the self-reported Rome III Diagnostic Questionnaire for the Pediatric Functional Gastrointestinal (GI) Disorders (27).

Dietary intake was assessed using the Brief-Type Self-Administered Diet History Questionnaire for children and adolescents (28–30). This questionnaire contains 90 items that assess frequency of food intake in addition to dietary-related items such as frequency, habits, and preparation of foods consumed in a previous month. The version for children and adolescents was validated using biomarkers (28–30). Based on this information and the Japanese food composition table, we estimated daily intake of nutrients and foods in the subjects.

Protein, fat, and carbohydrate were indicated as percentage of energy (%E); other nutrients were indicated as g/1,000 kcal, or mg/1,000 kcal (energy density method; total, insoluble, and water-soluble dietary fiber, water, water from foods and beverages, magnesium, iron, and zinc). Foods were indicated as g/1,000 kcal (rice, breads, noodles, confectionaries, pulses, vegetables, fruits, green tea, sweetened beverages, dairy products, meats, and fish). Since there is no means by which to identify over- or under-reporters, the subjects with energy intake less than 600 kcal or more than 5,000 kcal were excluded from the analysis as outliers, and the final population for analysis consisted of 1,140 5th graders (599 boys, and 541 girls), and 1,054 8th graders (538 boys, and 516 girls; See Fig. S1, Supplemental Online Material). The subjects were stratified by sex and grade, and classified into five categories by quintiles based on each nutrient or food intake datum (Q1, Q2, Q3, Q4, and Q5 in increasing order).

Covariates. Body height and weight were self-reported in the questionnaire, which were validated elsewhere (31), and body mass index (BMI) was calculated as body weight (kg)/square of body height (m²). Sexual maturation at puberty was determined based on self-report. It was defined as the grade at which the voice cracked for boys and the grade at which menarche appeared for girls. Number of siblings (one, two, and three or more), the presence of a single parent as a social factor, and weekly frequency of exercise (less than 3 times, and 3 or more times), TV watching time on a weekday (less than 2 h, and 2 or more hours), and typical morning awakening time (before, and after 6:30 AM) were also asked.

Statistical analysis. Measured variables were expressed as mean±standard deviation, median, or percentage. Odds ratios were obtained from logistic regression models to examine the association between functional constipation and dietary nutrient and food intake. In the models, grade, sex, BMI, sexual maturation, number of siblings, single parent status, exercise frequency, TV watching, and morning awakening time were adjusted. A linear trend along with 5 categories of each intake was also examined to obtain p for trend ($p_{trend}$). Post-hoc analysis was conducted with additional
Table 3. Prevalence of functional constipation among nutrient intake subgroups based on the quintiles.

| Nutrient                                | Q1     | Q2     | Q3     | Q4     | Q5     | p     |
|-----------------------------------------|--------|--------|--------|--------|--------|-------|
| Total dietary fiber, g/1,000 kcal       | 4.8    | 5.5    | 6.1    | 6.7    | 7.7    | 3.7   |
| Insoluble dietary fiber, g/1,000 kcal   | 3.5    | 4.0    | 4.4    | 4.8    | 5.5    | 2.7   |
| Soluble dietary fiber, g/1,000 kcal     | 1.1    | 1.4    | 1.5    | 1.7    | 2.0    | 0.8   |
| Water, g/1,000 kcal                     | 786.2  | 886.2  | 962.9  | 1,044.2| 1,177.8| 670.1 |
| Water from foods, g/1,000 kcal          | 569.9  | 635.4  | 682.8  | 730.9  | 813.1  | 466.3 |
| Water from beverages, g/1,000 kcal      | 109.4  | 224.0  | 281.6  | 340.3  | 460.8  | 96.9  |
| Protein, %Energy                        | 12     | 14     | 14     | 15     | 17     | 12    |
| Fat, %Energy                            | 23     | 26     | 29     | 30     | 34     | 23    |
| Carbohydrate, %Energy                   | 50     | 53     | 56     | 58     | 63     | 45    |
| Magnesium, mg/1,000 kcal                | 100.0  | 112.3  | 120.9  | 130.0  | 143.7  | 95.9  |
| Iron, mg/1,000 kcal                     | 3.0    | 3.5    | 3.8    | 4.2    | 4.6    | 2.8   |
| Zinc, mg/1,000 kcal                     | 4.0    | 4.2    | 4.4    | 4.6    | 5.0    | 3.7   |
| Rice, g/1,000 kcal                      | 102.1  | 127.9  | 159.5  | 187.6  | 234.0  | 80.1  |
| Bread, g/1,000 kcal                     | 13.7   | 19.9   | 26.2   | 33.9   | 44.4   | 4.6   |
| Noodles, g/1,000 kcal                   | 18.2   | 24.2   | 28.8   | 35.4   | 52.2   | 9.9   |
| Confectionaries, g/1,000 kcal           | 13.6   | 26.3   | 36.4   | 51.1   | 73.2   | 16.1  |
| Pulses, g/1,000 kcal                    | 15.8   | 24.3   | 31.4   | 39.6   | 53.0   | 5.4   |
| Vegetables, g/1,000 kcal                | 83.9   | 111.1  | 131.5  | 153.5  | 191.6  | 42.8  |
| Fruits, g/1,000 kcal                    | 13.3   | 22.7   | 32.2   | 50.4   | 80.1   | 4.4   |
| Green tea, g/1,000 kcal                 | 53.7   | 176.5  | 218.2  | 272.5  | 359.1  | 32.5  |
| Sweetened beverages, g/1,000 kcal       | 0.0    | 12.5   | 33.0   | 52.2   | 111.4  | 0.0   |
| Dairy products, g/1,000 kcal            | 103.7  | 135.5  | 159.5  | 188.4  | 236.9  | 49.5  |
| Meat, g/1,000 kcal                      | 24.8   | 32.2   | 37.3   | 43.1   | 53.4   | 19.0  |
| Fish, g/1,000 kcal                      | 16.0   | 21.7   | 26.3   | 32.7   | 44.6   | 12.1  |

Figures in upper rows are counts of functional constipation/subgroup from the lowest Q1 to the highest Q5. Figures in lower rows are odds ratios (95% confidence intervals). Odds ratios were adjusted for grade, sex, BMI, sexual maturation, number of siblings, single parent status, exercise frequency, TV watching, and wake-up time.
adjustment for total dietary fiber that had significant odds ratios (ORs) in the subject with the highest intake, and significant \( \text{p} \). For sensitivity analysis, the data were analyzed separately on the basis of grade or sex. Considering modification by social environment, we analyzed models without TV watching and awakening time, without single parent status and number of siblings and with bread intake. SAS 9.4 (SAS Institute Japan Ltd., Tokyo, Japan) was used for statistical analyses and a \( \text{p} \) value <0.05 was considered significant.

**RESULTS**

The characteristics of the subjects (5th graders aged 10.6±0.3 y, and 8th graders aged 13.6±0.3 y) are shown in Table 1. The most prevalent symptom was pain or hard stools (13.9% to 23.8%), followed by retentive posturing (5.8% to 8.9%). Defecation frequency was reported as being less than three times per week in 2.8% to 8.3% of the subjects. The prevalence of functional constipation in the subjects was 6.5% and 7.9% in 5th grade boys and girls, respectively, and 3.7% and 8.3% in 8th grade boys and girls.

Median energy intake of 5th and 8th graders was 1,772 and 2,229 kcal/d, respectively. When dietary intake amounts were described as energy density, the daily intake of nutrients and foods was higher in 5th graders than in 8th graders (Table 2). Median intake of total dietary fiber was 6.1 g/1,000 kcal in 5th graders, and 5.2 g/1,000 kcal in 8th graders, corresponding to 10.7 and 11.9 g/d in 5th and 8th graders, respectively. Median intake of water was 962.9 g/1,000 kcal and 10.7 and 11.9 g/d in 5th and 8th graders, respectively.

| Food Category | Q1 | Q2 | Q3 | Q4 | Q5 | \( \text{p}_{\text{rend}} \) |
|---------------|----|----|----|----|----|----------------|
| Rice          | 33/437 | 25/439 | 22/441 | 26/439 | 39/438 | 0.443 |
| Bread         | 27/437 | 27/439 | 31/441 | 31/439 | 29/438 | 0.150 |
| Noodles       | 25/437 | 28/439 | 39/441 | 27/439 | 26/438 | 0.150 |
| Confectionaries | 30/437 | 29/439 | 21/441 | 30/439 | 25/438 | 0.650 |
| Pulses        | 32/437 | 35/439 | 35/441 | 20/439 | 23/438 | 0.599 |
| Vegetables    | 35/437 | 42/439 | 27/441 | 18/439 | 23/438 | 0.087 |
| Fruits        | 42/437 | 27/439 | 31/441 | 25/439 | 20/438 | 0.014 |
| Green tea     | 27/437 | 29/439 | 33/441 | 23/439 | 33/438 | 0.684 |
| Sweetened beverages | 29/437 | 27/439 | 26/441 | 31/439 | 32/438 | 0.495 |

Figures in upper rows are counts of functional constipation/subgroup from the lowest Q1 to the highest Q5. Figures in lower rows are odds ratios (95% confidence intervals). Odds ratios were adjusted for grade, sex, BMI, sexual maturation, number of siblings, single parent status, exercise frequency, TV watching, and wake-up time.
For 8th graders, significant negative associations emerged between increased functional constipation and lower intake of several nutrients or foods including total dietary fiber, water from foods, total and animal protein, magnesium, zinc, and vegetables (Table S3, Supplemental Online Material). The highest intake groups in terms of total dietary fiber, water from foods, protein, and zinc had significant negative ORs (0.31–0.45) compared to the lowest intake groups. In contrast, the students who ate more bread had higher rates of functional constipation \( (p_{\text{trend}}=0.020) \).

When boys’ and girls’ data were analyzed separately, intakes of total dietary fiber and of fruits showed significant association only in girls \( (p_{\text{trend}}=0.029 \) or 0.005, respectively). For models without TV watching and awakening time, or without single parent status and number of siblings, these social environments scarcely affected the associations of total dietary fiber, vegetables, and fruits. Significant associations of water intake from foods appeared \( (p_{\text{trend}}=0.035 \) and 0.048, respectively). Additional adjustment for bread intake did not change the results.

**DISCUSSION**

The prevalence of functional constipation in the subjects of this study ranged from 3.7% to 8.3%. The prevalence of functional constipation in the current study is less than what has been found in previous reports \( (6) \). However, high frequency complaints of pain and hard stools and retention were similar to other reports \( (19) \). Defecation frequency has often been used as a functional definition of constipation in studies examining the association between lifestyle factors and constipation \( (12, 14, 20) \). Although the prevalence of infrequent defecation was similar to that of functional constipation, when infrequent defecation was used as an objective variable instead of functional constipation, more nutrients and foods showed significant associations (from 3 to 13 items; Model 2 in Table S1, Supplemental Online Material). More research will need to be conducted to examine which measure is more helpful and appropriate.

Dietary fiber has been studied in adults and increased intake is related to lower rates of constipation \( (32, 33) \), and it can lead to improvement for those suffering from constipation \( (34) \). Children with clinically diagnosed constipation tend to have lower dietary fiber intakes than the non-constipated \( (35, 36) \). In studies using defeation frequency as the measure of constipation, dietary fiber has desirable effects among infants \( (18, 20) \). Previous studies of school-age children did not show significant negative associations between dietary fiber and constipation \( (11, 12) \), but these associations have been found in college students \( (17) \). This is the first report that shows the significant association between functional constipation and dietary fiber intake among primary and secondary school students. The highest intake groups, who consumed 14.2 g/d and 13.4 g/d of total dietary fiber for 5th grade boys and girls (10–11 y old), respectively, and 15.8 g/d and 14.8 g/d for 8th grade boys and girls (13–14 y old), respectively, had lower prevalence of constipation than the lowest intake group (9.3, 9.0, 8.2, and 7.4 g/d, respectively). These intake amounts are slightly higher than the recommended value for both 10–11 y old boys and girls (13 g/d), and are less than the value for 12–14 y old boys and girls (17 g/d and 16 g/d, respectively) \( (37) \).

The results of this study revealed that 8th grade students who reported greater intake of total dietary fiber, vegetables, and fruits had lower rates of functional constipation. In 5th graders, odds ratios for total and water-soluble dietary fiber, water from foods, and fruits were less than 1, but only fruit intake showed a dose-dependent association (lower prevalence of functional constipation for higher intake). The reason why we found few significant relationships in 5th graders may be their early-stage developmental facility to recognize symptoms and habits; for example, low correlations between gold standard and estimates from questionnaires were found in physical dietary intake and physical activity of 5th graders \( (28, 38) \). These measuring errors and possible biases could take results of the subpopulation in unexpected directions.

The main source of dietary fiber in Japan is vegetables (37.3% of total dietary fiber), followed by grains (21.1%), and other foods \( (<1.0%): \) fruits, potatoes, or pulses \( (39) \). Vegetable intake was negatively associated with functional constipation in this study and this aligns with many previous studies \( (14, 15, 20) \), even though some studies found conflicting evidence \( (16, 40) \).

The results of previous studies about the effect of water intake have been inconsistent \( (12–14, 18, 19) \). In 8th graders in the present study, water intake from foods had a beneficial effect on functional constipation defined based on Rome III, and this is similar to past findings \( (19) \). A previous study of Japanese preschool children showed that the association attenuated after adjustment for dietary fiber \( (20) \), and Anti et al. reported that water intake enhanced the effect of dietary fiber intake on stool frequency \( (41) \). It is difficult to discriminate the effects among vegetables, dietary fiber, and water in the observational study.

Magnesium salts, such as magnesium sulfate, modulate water transfer in the intestinal tract \( (42) \) and accelerate intestine transit time \( (43) \), and therefore they are expected as a constipation remedy. The association between increased magnesium intake and reduced constipation was shown in the 8th grade population of this study, which was similar to findings in other age groups like infants (aged 3–5 y) \( (40) \) and adult women (aged 18–20 y) \( (16) \). In the combined population of 5th and 8th grades, however, the dose-dependent association was not significant, even though the odds ratios of Q3–Q5 were less than 1.

Some existing studies have examined the association between increased bread intake and increased constipation \( (16, 20, 44) \), and only one study found a significant association. In the present study, we found that increased bread intake is related to higher prevalence of functional constipation in 8th graders. Some reasons for this association may be due to the gluten from wheat, which produces allergic reactions, and constipation, in
some people (45). While celiac disease is rare in Japanese (0.05%; 46), increase of bowel symptoms in Canadian immigrant children at a younger age suggests that diet habitual change affects child symptoms (47). Additionally, families eating bread as the main staple food may be especially busy in the mornings and this may affect toileting habits (48).

This study has many strengths, including a relatively large sample size and statistical control of possible confounding variables, but there are several limitations. First, variables used in this study were obtained using self-reported questionnaires. Although the Brief-Type Self-Reported Diet History Questionnaire used for assessing dietary intake was validated in the population from the same areas, correlations of estimated nutrition intake with biomarkers were lower in 5th graders than in 8th graders (28). The Rome III Diagnostic Questionnaire for Pediatric Functional Gastrointestinal (GI) Disorders has reasonable test-retest reliability, but only fair validity when using physician diagnosis (49). Second, the cross-sectional design of this study could incompletely explain causality between dietary intake and functional constipation. Intake of dietary fiber and fluid is a first-line treatment in clinical settings, and a recommendation to prevent constipation at the community level. Knowledge about preferable foods is likely to make students with constipation eat more vegetables and fluids, but this might decrease the observational effects in comparison to the true effects. We did not ask the students about habitual use of laxatives, which might attenuate the effect. Third, the participants in this study were 5th and 8th graders in Shunan City. Generalizability of the obtained results to all Japanese school-age children is unknown. In addition to this, we cannot explain the relationship between intake of protein or zinc and the prevalence of functional constipation, although this result for protein is supported by previous studies among preschool children aged 5–6 y (20) and adults (44), and that for zinc is reported in a study of children aged 7–10 y (12).

In conclusion, functional constipation may distress Japanese school-age children and adolescents, and at the same time, dietary habits could reduce the prevalence of functional constipation. Diets rich in fiber, water, and vegetables and fruits have the potential to improve functional constipation, especially in 8th graders. Social environment that influences dietary intake of children may be a target for public health intervention to mitigate children’s functional constipation.

Acknowledgments
We thank the staff at the Shunan Healthy Diet Project for their help in acquiring data.

Supporting Information
Supplemental Online Material is available on J-STAGE.

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