Original Article

Lifestyle and bowel movements in school children: Results from the Toyama Birth Cohort Study

Masaaki Yamada, Michikazu Sekine and Takashi Tatsuse
Department of Epidemiology and Health Policy, Graduate School of Medicine and Pharmaceutical Sciences, University of Toyama, Toyama, Japan

Abstract  Background: Constipation is a prevalent health disorder. There have been few epidemiological surveys on constipation in Japanese children. The aim of this study was to evaluate the prevalence of non-daily bowel movements (BM) and irregular BM among children and to identify modifiable lifestyle factors relevant to bowel habits.

Methods: Subjects were from the Toyama Birth Cohort Study in Japan. A total of 7762 children aged 9–10 years were investigated via questionnaire in 1999. We evaluated bowel habit and the relationship between lifestyle and BM. Non-daily BM and totally irregular BM were defined as dependent variables in the present study.

Results: Non-daily BM were reported by 21.8% of boys and by 31.6% of girls, while 10.6% of boys and 18.3% of girls had totally irregular BM. Non-daily BM were significantly associated with skipping breakfast (OR, 1.23), slow eating (OR, 1.13), physical inactivity (OR, 1.50) and late wake up (OR, 1.29). Totally irregular BM were significantly correlated with skipping breakfast (OR, 1.30), slow eating (OR, 1.41), physical inactivity (OR, 1.27), long TV viewing (OR, 1.52), late bedtime (OR, 1.43), and short sleep duration (OR, 1.33). More girls had non-daily and totally irregular BM than boys, and these sex differences were not reduced after adjusting for lifestyle variables.

Conclusions: Non-daily and totally irregular BM are common in children, and there are many relevant lifestyle factors. Establishing regular lifestyle habits may lessen constipation.

Key words bowel habit, constipation, irregularity, sex difference, Toyama Birth Cohort Study.

Constipation occurs in adults and children worldwide, with a prevalence ranging from 0.7 to 29.6%.1,2 Only a few studies on constipation in children have been performed in Japan. Kawai et al.3 noted a prevalence of 5.7% in elementary school children, while another study reported a prevalence of 18.5% in primary school children.4 These studies, however, were limited by small sample numbers or the failure to include bowel movement (BM) as a primary outcome.

Despite the prevalence, constipation is not always addressed in a serious manner in clinical settings, but it is well known that constipation is a serious matter to the pediatricians, as well as for the patients and their parents, because symptoms of constipation can present as severe pain.5 Constipation is an important health problem that contributes to a high number of medical visits, and which generates health-care costs as a result of the medical procedures needed to diagnose it.2 In the USA, the number of patients with constipation who visited the emergency room increased by 41.5% from 2006 to 2011.6 Moreover, treatment of children with laxatives was not always associated with good prognosis.7,8 Bongers et al.7 reported that symptoms continued to the age of approximately 20 years in 25% of children with constipation, and that it decreased individuals’ quality of life.9,10

Previously identified risk factors of constipation are genetic predisposition, psychological stress, volitional withholding of stool, insufficient fiber intake, physical inactivity, low socioeconomic factors,1,2 and irregular BM.11 Although being female is an established risk factor in adult constipation, the sex difference in children is inconclusive.1,2 Considering the national financial burden and difficulties involved in the treatment of constipation, it is necessary to evaluate feasible, modifiable risk factors in daily life in a large population study.

In Japan, children’s unhealthy lifestyle habits, such as short sleep duration, skipping breakfast, and prolonged TV viewing, have been identified as a social issue, leading the Ministry of Education, Culture, Sports, Science and Technology to commence the health promotion campaign “Early to Bed, Early to Rise and Don’t Forget Your Breakfast” in 2006.12 The relationships between unhealthy lifestyle, low performance in academic achievement and physical fitness have been reported.13 In addition, several studies have shown that unhealthy lifestyle in children was related to an increase in health disorders such as obesity and poor quality of life.14–18

We hypothesized that an unhealthy lifestyle may be correlated with both irregular and less frequent BM. Childhood is
considered to be a critical period for adopting lifelong healthy lifestyles. The aim of this study was therefore to identify lifestyle factors associated with BM frequency and regularity in children’s daily lives. We also evaluated the sex differences in children’s bowel habits in this study. This is, to the best of our knowledge, the largest study of bowel habits ever conducted in Japanese children.

Methods

Participants and the Toyama Birth Cohort Study

Participants were those included in the Toyama Birth Cohort Study, a prospective, longitudinal survey of lifestyle and health among 10 438 children born between 2 April 1989 and 1 April 1990 in Toyama prefecture, Japan. Using a questionnaire, the cohort of schoolchildren had been evaluated every 3 years from phase 1 in 1992 to phase 5 in 2005. The purpose of the overall study was to clarify the effect of social and lifestyle factors on children’s health, and the details of this cohort study have been published elsewhere.\textsuperscript{14,15,18-20} In this study, data were used from phase 3, when the cohort children were in grade 4 of elementary school between June and July in 1999. This population was chosen because children are thought to be susceptible to actions that promote a healthy lifestyle from 7 to 9 years of age.\textsuperscript{21} The prefecture education authorities approved the content and ethics aspects of the study. The Toyama Birth Cohort Study was approved by the Institutional Review Board of Toyama Medical Pharmaceutical University. Written informed consent was obtained from the participants’ parents, and participation was voluntary.

Questionnaire

Parents and children completed the distributed questionnaire, which consisted of children’s eating, physical activity, TV viewing, sleep and bowel habits, and anthropometry data. Eating habits (e.g. breakfast, daytime snacking, night snacks, and eating speed) were dichotomized into two groups as follows: “having breakfast every day” or “sometimes to usually skipping breakfast”; “having snacks several times a day” or “having snacks only once a day to none”; “usually having night snacks” or “sometimes to seldom having night snacks”; “and eating slow” or “not eating slow”. Physical activity was divided into three levels: very often; often; or rarely to almost never. The average hours of TV viewing on school days were divided into three groups: <1 h; 1–2 h; or >2 h. Sleep habits, including wake-up time, bedtime, and sleep duration, were categorized according to “waking before 7:00 a.m.” or “later”; “bedtime before 10:00 p.m.” or “later”, and “sleep duration <8 h”, referring to the research that indicating that the average times of waking and bedtime in Japanese elementary school children were 06:36 hours and 22:08 hours, respectively, with around 8.5 h of sleep.\textsuperscript{22} The validity of the lifestyle questionnaire was examined in our previous study.\textsuperscript{23} In that study, frequent physical activity was significantly correlated with increased energy expenditure in relation to physical activity, mean steps, and mean activity per day on the Actiwatch (\(P < 0.05\) for linear trend test). The correlation coefficient between subjective and objective records was 0.97 (\(P < 0.001\)) for assumed amount of sleep.\textsuperscript{24} Body mass index (BMI; weight in kg divided by square of height in m) was calculated from the questionnaire, which was measured by trained school nurses at their own school. The health check-up was performed on an annual basis in April according to the School Health Law. Age- and sex-specific cut-off points, equivalent to the adult overweight BMI of 25, were used to identify those children who were overweight.\textsuperscript{25} The specific cut-off points were developed by the Childhood Obesity Working Group of the International Obesity Task Force (IOTF). The cut-off points used in the present study were 19.46 kg/m\(^2\) for boys and 19.45 kg/m\(^2\) for girls, and BMI higher than this was defined as overweight.

BM frequency and regularity

The definition of constipation was vague, ranging from self-reported constipation to use of clinical criteria regarding BM frequency and symptoms.\textsuperscript{1,2} In the present study, BM frequency was divided into three groups: once (or more) per day; once every 2 days; and less than once every 2 days. In a review of child constipation by Loening-Baucke, daily BM was defined as one of the goals in the algorithm for education and treatment of childhood constipation.\textsuperscript{5} Hence, we defined non-daily BM (e.g. once every 2 days and less than once every 2 days) as a dependent variable. In addition, BM regularity was assessed and divided into three groups: regular to almost regular; somewhat irregular; and totally irregular. The review article also mentioned that regular bowel habits should be accomplished in childhood constipation management.\textsuperscript{5} Regularity was assessed according to subjective report by the children and their parents. Therefore, we defined “regular to almost regular” and “somewhat irregular” as regular BM, and used “totally irregular” as a dependent variable.

Statistical analysis

Statistical analysis of the questionnaires was based on the answered questions. Chi-squared test was used to compare the sex distributions of age; lifestyle factors such as eating, sleeping, physical activity, and TV viewing; and bowel habits. To assess reproducibility, kappa (\(k\)) statistical analysis was conducted between three categories of frequency and regularity in BM. Then, logistic regression analysis was conducted to evaluate the strength of the association between lifestyle factors and non-daily and totally irregular bowel habits. Following the overall analysis, boys and girls were analyzed separately, given the sex difference in lifestyle and bowel habits reported in previous studies in Japan.\textsuperscript{4,14,15,26} OR and 95% CI were calculated from binary logistic regression models adjusted for potential covariates such as age and lifestyle factors. These analyses were conducted using SPSS, version 20.0 J (SPSS, © 2016 The Authors. Pediatrics International published by John Wiley & Sons Australia, Ltd on behalf of Japan Pediatric Society.
Chicago, IL, USA). Two-tailed $P < 0.05$ was considered to indicate statistical significance.

**Results**

Of all the participants, 9378 returned their questionnaires, with a response rate of 89.8%. Then, a total of 7762 children (74.4%: 3855 boys and 3907 girls) who answered all the questionnaire items relevant to the present study were included in the analysis. The average age of participants was 9.76 years with an SD of 0.29 years. In the comparison between boys and girls, there was no significant difference in age, skipping breakfast, frequent daytime snacking, late waking, late bedtime, or sleep duration, although girls were more likely to get less sleep than boys (Table 1). Night-time snacking was more prevalent among boys than among girls, while eating speed was significantly lower in girls than in boys. The distributions of physical activity level and TV viewing hours differed significantly by sex. Girls were less active and watched TV longer, whereas more boys were significantly overweight compared with girls. There were notable sex differences for BM frequency and regularity. The percentage of daily BM was higher in boys than in girls (78.2 vs 68.4%, $P < 0.001$). Non-daily BM and less than one BM every 2 days were seen in 21.8% and in 2.7% of boys, and in 31.6% and in 5.1% of girls, respectively. Regarding BM regularity, more girls had totally irregular BM compared with boys (18.3% and 10.6%, respectively). Overall, girls appeared to have less healthy lifestyles such as less sleep, more physical inactivity, prolonged TV viewing, and non-daily and totally irregular BM. The kappa statistics were 0.21 in boys and 0.21 in girls.

In Table 2, analysis was performed on the overall participants to determine the lifestyle factors relevant to non-daily and totally irregular BM. Skipping breakfast, slow eating, physical inactivity, and long TV viewing, were associated with both non-daily and totally irregular BM. Late waking was associated with non-daily BM, while late bedtime and short sleep duration were associated with totally irregular BM. Slow eating and long TV viewing were significantly associated with totally irregular BM. Regarding the sex difference in prevalence, the OR for girls compared with boys were 1.65 (95% CI: 1.49–1.83) for non-daily BM, and 1.82 (95% CI: 1.61–2.07) for totally irregular BM on univariate analysis. After adjusting for lifestyle variables, age, and overweight, these sex differences were slightly attenuated to OR = 1.59 for non-daily BM and OR = 1.70 for totally irregular BM.

Table 3 lists the logistic analysis of the associations between non-daily BM and lifestyle factors by sex. Boys and girls had a similar trend. In boys, slow eating, physical inactivity, and late waking were associated with non-daily BM on univariate analysis. On multivariate analysis, physical inactivity (OR, 1.77) and late waking (OR, 1.30) remained significant. Slow eating in boys was marginally associated with non-daily BM (OR, 1.21). In girls, physical inactivity, prolonged TV viewing, and late waking were significantly correlated with non-daily BM, and slow eating had a marginal association on univariate analysis. On multivariate analysis, physical inactivity (OR, 1.31) and prolonged TV viewing (OR, 1.43 for 1–2 h of TV; and OR, 1.25 for >2 h of TV) remained significant, but there were two distinctive differences by sex. Although in both sexes, physical inactivity was associated with non-daily BM on multivariate analysis, a stronger and dose–response relationship was seen in boys. In contrast, prolonged TV viewing was significantly associated with non-daily BM in girls, whereas no relationship was seen in boys.

The associations between lifestyle factors and totally irregular BM by sex are given in Table 4. In boys, skipping breakfast, physical inactivity, prolonged TV viewing, late waking, and late bedtime were associated with totally irregular BM on univariate analysis. The associations that remained significant on multivariate analysis were skipping breakfast (OR, 1.50), physical inactivity (OR, 1.70), TV viewing >2 h (OR, 1.33), and late bedtime (OR, 1.64). In girls, skipping breakfast, frequent daytime snacking, slow eating, prolonged TV viewing, late bedtime, and short sleep duration were associated with totally irregular BM on univariate analysis. On multivariate

---

**Table 1** Participant characteristics vs sex

| Characteristics          | Boys % (n = 3855) | Girls % (n = 3907) | P-value + |
|--------------------------|-------------------|--------------------|-----------|
| Age (years)              |                   |                    |           |
| 9                        | 21.9              | 23.8               | 0.052     |
| 10                       | 78.1              | 76.2               |           |
| Skipping breakfast       | 6.6               | 7.1                | 0.418     |
| Daytime snacking         | 11.1              | 11.4               | 0.590     |
| Twice or more per day    |                   |                    |           |
| Night snacking           | 13.5              | 11.2               | <0.001    |
| Slow eating              | 19.1              | 30.0               | <0.001    |
| Physical activity        |                   |                    | <0.001    |
| Rarely or almost never   | 22.4              | 23.5               |           |
| Often                    | 46.5              | 52.0               |           |
| Very often               | 31.1              | 24.5               |           |
| TV viewing (h)           |                   |                    | <0.001    |
| <1                       | 23.1              | 18.6               |           |
| 1–2                      | 42.8              | 40.0               |           |
| >2                       | 34.2              | 41.4               |           |
| Overweight or obesity    | 18.2              | 13.6               | <0.001    |
| Waking after 7 a.m.      | 12.0              | 10.7               | 0.086     |
| Bedtime after 10:30 p.m. | 7.3               | 8.1                | 0.250     |
| Sleep duration <8 h      | 5.3               | 6.1                | 0.157     |
| Bowel movement frequency |                   |                    | <0.001    |
| Once (or more) per day   | 78.2              | 68.4               |           |
| Once every 2 days        | 19.1              | 26.5               |           |
| Less than once every 2 days | 2.7            | 5.1                |           |
| Bowel movement regularity|                   |                    |           |
| Regular – almost regular | 65.3              | 48.8               |           |
| Somewhat irregular       | 23.7              | 32.9               |           |
| Totally irregular        | 10.6              | 18.3               |           |

+Pearson chi-squared test.
|                          | Non-daily BM |               |               |                   |   | Irregular BM |               |               |                   |   |
|--------------------------|-------------|---------------|---------------|-------------------|---|---------------|---------------|---------------|-------------------|---|
|                          | %           | Univariate    | Multivariate  | %                 |   | Univariate    | Multivariate  | %                 |                   |   |
|                          |             | OR (95%CI)    | P-value       | OR (95%CI)        | P-value | OR (95%CI)    | P-value       | OR (95%CI)        | P-value             |   |
| Boys                     | 21.8        | 1             | <0.001        | 1.59 (1.43–1.76)  | <0.001 | 10.6          | 1             | 1.82 (1.61–2.07)  | <0.001             |   |
| Girls                    | 31.6        | 1.65 (1.49–1.83) | <0.001        | 1.23 (1.01–1.51)  | 0.040 | 18.3          | 1             | 1.52 (1.22–1.90)  | <0.001             |   |
| Age (years)              |             |               |               |                   |   |               |               |                   |                   |   |
| 9                        | 27.9        | 0.93 (0.82–1.04) | 0.205        | 0.95 (0.84–1.08)  | 0.427 | 14.5          | 1             | 1.02 (0.88–1.18)  | 0.827              |   |
| 10                       | 26.4        | 1.26 (1.04–1.53) | 0.018        | 1.05 (0.90–1.23)  | 0.538 | 18.1          | 1             | 1.11 (0.92–1.34)  | 0.278              |   |
| Skipping breakfast       | Yes         | 27.0          | 0.97 (0.82–1.14) | 0.713            | 14.2 | 18.1          | 1             | 1.33 (1.11–1.65)  | 0.002              |   |
|                          | No          | 31.1          | 1.00 (0.85–1.17) | 0.976            | 14.2 | 18.1          | 1             | 1.02 (0.88–1.18)  | 0.827              |   |
| Daytime snacking twice or more | Yes   | 27.0          | 1.02 (0.87–1.18) | 0.833            | 14.2 | 18.1          | 1             | 1.11 (0.92–1.34)  | 0.278              |   |
|                          | No          | 30.8          | 1.31 (1.17–1.46) | <0.001           | 0.048 | 19.2          | 1             | 1.57 (1.37–1.80)  | <0.001             |   |
| Slow eating              | Yes         | 26.9          | 1.23 (1.08–1.39) | 0.001            | 13.9 | 18.1          | 1             | 1.37 (1.16–1.63)  | <0.001             |   |
|                          | No          | 23.1          | 1.18 (1.04–1.34) | <0.001           | 0.008 | 13.5          | 1             | 0.97 (0.83–1.13)  | 0.667              |   |
| Physical activity        | Rarely or almost never | 31.1 | 1.48 (1.28–1.70) | <0.001 | 1.50 (1.30–1.74) | <0.001 | 18.1 | 1.37 (1.16–1.63) | <0.001 | 1.27 (1.06–1.52) | 0.008 |
|                          | Often       | 26.9          | 1.23 (1.08–1.39) | <0.001           | 0.008 | 13.5          | 1             | 0.97 (0.83–1.13)  | 0.667              |   |
| TV viewing (h)           | <1          | 28.1          | 1.19 (1.04–1.36) | 0.015            | 0.017 | 13.2          | 1             | 1.16 (0.97–1.40)  | 0.112              | 1.15 (0.95–1.39) | 0.145 |
|                          | 1–2         | 27.4          | 1.17 (1.02–1.35) | 0.025            | 0.136 | 18.0          | 1             | 1.68 (1.40–2.01)  | <0.001             | 1.52 (1.26–1.82) | <0.001 |
| Overweight or obese      | Yes         | 19.5          | 0.62 (0.53–0.72) | <0.001           | 0.001 | 13.3          | 1             | 0.87 (0.73–1.04)  | 0.131              | 0.84 (0.70–1.02) | 0.073 |
|                          | No          | 28.1          | 1.19 (1.03–1.37) | 0.017            | 0.132 | 13.2          | 1             | 1.16 (0.97–1.40)  | 0.112              | 1.15 (0.95–1.39) | 0.145 |
| Waking after 7 a.m.      | No          | 30.9          | 1.26 (1.08–1.47) | 0.003            | 0.010 | 18.0          | 1             | 1.32 (1.10–1.59)  | 0.003              | 1.15 (0.94–1.40) | 0.186 |
| Bedtime after 10:30 p.m. | Yes        | 29.8          | 1.18 (0.98–1.41) | 0.081            | 0.764 | 23.1          | 1             | 1.85 (1.51–2.27)  | <0.001             | 1.43 (1.12–1.81) | 0.004 |
|                          | No          | 26.5          | 1.23 (0.97–1.54) | 0.033            | 0.083 | 21.6          | 1             | 1.66 (1.32–2.11)  | <0.001             | 1.33 (1.02–1.73) | 0.036 |
| Sleep duration <8 h      | Yes         | 31.1          | 1.25 (1.02–1.54) | 0.033            | 0.083 | 21.6          | 1             | 1.66 (1.32–2.11)  | <0.001             | 1.33 (1.02–1.73) | 0.036 |
|                          | No          | 26.5          | 1.23 (0.97–1.54) | 0.033            | 0.083 | 21.6          | 1             | 1.66 (1.32–2.11)  | <0.001             | 1.33 (1.02–1.73) | 0.036 |

BM, bowel movement.
Table 3  Correlates of non-daily BM vs sex

| Variable                        | Boys (n = 3855) | Girls (n = 3907) |
|--------------------------------|----------------|------------------|
|                                | Univariate     | Multivariate     |
|                                | OR (95%CI)      | P-value          | OR (95%CI)      | P-value |
|                                |                |                  |                |         |
| Age (years)                    |                |                  |                |         |
| 9                              | 22.5 1         | OR (95%CI)       | 32.8           | 1       |
| 10                             | 21.6 0.95 (0.79–1.14) 0.594 0.96 (0.83–1.21) 0.963 | 31.2 0.93 (0.79–1.09) 0.349 0.93 (0.79–1.09) 0.282 | 1       |
| Skipping breakfast             | Yes            | 25.2 1.22 (0.91–1.64) 0.178 1.23 (0.90–1.67) 0.194 | 36.6 1.27 (0.99–1.64) 0.064 1.23 (0.94–1.60) 0.132 | 1       |
|                                | No             | 21.6 1           | 31.2 1         | 1       |
| Daytime snacking twice or more | Yes            | 20.2 0.90 (0.70–1.15) 0.389 0.87 (0.67–1.12) 0.278 | 32.9 1.07 (0.87–1.32) 0.529 1.05 (0.84–1.30) 0.687 | 1       |
|                                | No             | 22.0 1           | 31.4 1         | 1       |
| Night snacking                 | Yes            | 22.5 1.05 (0.84–1.31) 0.666 1.09 (0.86–1.36) 0.482 | 32.3 1.04 (0.84–1.29) 0.719 1.03 (0.82–1.28) 0.823 | 1       |
|                                | No             | 21.7 1           | 31.5 1         | 1       |
| Slow eating                    | Yes            | 26.2 1.35 (1.12–1.62) 0.002 1.21 (1.00–1.46) 0.051 | 33.7 1.15 (1.00–1.33) 0.059 1.08 (0.93–1.26) 0.291 | 1       |
|                                | No             | 20.8 1           | 30.7 1         | 1       |
| Physical activity              | Rarely or almost never | 27.3 1.71 (1.38–2.10) 0.001 1.77 (1.43–2.19) <0.001 | 33.9 1.23 (1.01–1.50) 0.035 1.31 (1.08–1.75) 0.007 | 1       |
|                                | Often          | 21.7 1.25 (1.04–1.51) 0.017 1.26 (1.05–1.52) 0.015 | 31.6 1.11 (0.94–1.31) 0.232 1.12 (0.95–1.33) 0.192 | 1       |
|                                | Very often     | 18.1 1           | 29.4 1         | 1       |
| TV viewing (h)                 | <1             | 22.3 1           | 26.8 1         | 1       |
|                                | 1–2            | 21.3 0.95 (0.78–1.15) 0.582 0.97 (0.79–1.18) 0.727 | 34.2 1.42 (1.17–1.73) <0.001 1.43 (1.18–1.76) <0.001 | 1       |
|                                | >2             | 22.3 1.00 (0.81–1.23) 0.993 1.01 (0.82–1.24) 0.963 | 31.5 1.26 (1.04–1.53) 0.021 1.25 (1.03–1.60) 0.027 | 1       |
| Overweight or obese            | Yes            | 16.6 0.67 (0.54–0.83) 0.001 0.62 (0.49–0.77) 0.001 | 23.4 0.62 (0.50–0.77) <0.001 0.59 (0.47–0.73) <0.001 | 1       |
|                                | No             | 23.0 1           | 32.9 1         | 1       |
| Waking after 7 a.m.            | Yes            | 26.2 1.32 (1.06–1.65) 0.014 1.30 (1.03–1.65) 0.027 | 36.1 1.26 (1.02–1.55) 0.035 1.19 (0.95–1.50) 0.126 | 1       |
|                                | No             | 21.2 1           | 31.0 1         | 1       |
| Bedtime after 10:30 p.m.       | Yes            | 23.3 1.10 (0.82–1.46) 0.524 0.92 (0.66–1.27) 0.598 | 31.2 1.22 (0.95–1.55) 0.114 1.10 (0.84–1.45) 0.486 | 1       |
|                                | No             | 21.7 1           | 35.6 1         | 1       |
| Sleep duration <8 h            | Yes            | 25.2 1.22 (0.89–1.70) 0.222 1.22 (0.85–1.74) 0.280 | 36.1 1.24 (0.95–1.63) 0.120 1.22 (0.91–1.65) 0.190 | 1       |
|                                | No             | 21.6 1           | 31.3 1         | 1       |

BM, bowel movement.
Table 4  Correlates of totally irregular BM vs sex

| Variable                          | Boys (n = 3855) |       |       | Girls (n = 3907) |       |       |
|-----------------------------------|----------------|-------|-------|------------------|-------|-------|
|                                  | %              | Univariate | Multivariate | %              | Univariate | Multivariate |
|                                  | OR (95%CI)     | P-value | OR (95%CI)     | P-value | OR (95%CI)     | P-value |
| Age (years)                      |                |         |         |                  |         |         |
| 9                                 | 10.7           | 1       | 1       |                  | 18.0   | 1       |
| 10                                | 11.0           | 1.04 (0.81–1.33) | 0.755 | 1.04 (0.81–1.34) | 0.741  | 1.03 (0.85–1.25) | 0.770  | 1.02 (0.84–1.24) | 0.847  |
| Skipping breakfast                | Yes            | 16.9   | 1.73 (1.23–2.45) | 0.002 | 1.50 (1.01–2.09) | 0.048  | 23.2   | 1.38 (1.03–1.85) | 0.030  | 1.19 (0.88–1.62) | 0.258  |
|                                  | No             | 10.5   | 1       |      |                  | 17.9   | 1       |
| Daytime snacking twice or more    | Yes            | 13.1   | 1.27 (0.94–1.71) | 0.124 | 1.14 (0.84–1.56) | 0.408  | 17.7   | 1.37 (1.08–1.74) | 0.009  | 1.24 (0.97–1.58) | 0.094  |
|                                  | No             | 10.7   | 1       |      |                  | 22.8   | 1       |
| Night snacking                   | Yes            | 13.1   | 1.27 (0.96–1.68) | 0.092 | 1.18 (0.89–1.40) | 0.254  | 19.0   | 1.06 (0.82–1.36) | 0.673  | 0.98 (0.76–1.28) | 0.900  |
|                                  | No             | 10.6   | 1       |      |                  | 18.2   | 1       |
| Physical activity                | Rarely or almost never | 15.2   | 1.67 (1.28–2.18) | <0.001 | 1.70 (1.30–2.24) | <0.001 | 19.1   | 1.11 (0.89–1.40) | 0.350  | 1.03 (0.82–1.30) | 0.791  |
|                                  | Often          | 9.8    | 1.01 (0.79–1.30) | 0.929 | 1.00 (0.78–1.28) | 0.992  | 16.7   | 0.85 (0.70–1.04) | 0.107  | 0.83 (0.67–1.01) | 0.064  |
|                                  | Very often     | 9.7    | 1       |      |                  | 20.9   | 1       |
| TV viewing (h)                   | <1             | 10.0   | 1       |      |                  | 13.5   | 1       |
|                                  | 1–2            | 9.6    | 0.95 (0.72–1.25) | 0.951 | 0.95 (0.72–1.26) | 0.738  | 17.0   | 1.32 (1.02–1.69) | 0.033  | 1.34 (1.04–1.73) | 0.024  |
|                                  | >2             | 13.4   | 1.40 (1.06–1.83) | 0.016 | 1.33 (1.01–1.75) | 0.044  | 21.6   | 1.77 (1.39–2.27) | <0.001 | 1.71 (1.34–2.20) | <0.001 |
| Overweight or obese              | Yes            | 9.1    | 0.79 (0.59–1.04) | 0.092 | 0.66 (0.49–0.89) | 0.006  | 18.7   | 1.03 (0.81–1.30) | 0.808  | 0.99 (0.77–1.27) | 0.944  |
|                                  | No             | 11.3   | 1       |      |                  | 18.2   | 1       |
| Waking after 7 a.m.              | Yes            | 15.8   | 1.64 (1.25–2.16) | <0.001 | 1.34 (0.99–1.80) | 0.054  | 20.3   | 1.16 (0.90–1.49) | 0.255  | 1.00 (0.77–1.31) | 0.983  |
|                                  | No             | 10.3   | 1       |      |                  | 18.1   | 1       |
| Bedtime after 10:30 p.m.         | Yes            | 18.7   | 2.00 (1.46–2.75) | <0.001 | 1.64 (1.13–2.39) | 0.010  | 27.0   | 1.74 (1.34–2.26) | <0.001 | 1.27 (0.93–1.73) | 0.128  |
|                                  | No             | 10.3   | 1       |      |                  | 17.5   | 1       |
| Sleep duration <8 h              | Yes            | 12.6   | 1.19 (0.78–1.82) | 0.429 | 0.87 (0.55–1.40) | 0.573  | 29.4   | 1.95 (1.46–2.62) | <0.001 | 1.67 (1.20–2.31) | 0.002  |
|                                  | No             | 10.9   | 1       |      |                  | 17.6   | 1       |

BM, bowel movement.
analysis, the habits that remained significantly associated with totally irregular BM were slow eating (OR, 1.61), prolonged TV viewing (OR, 1.34 for 1–2 h of TV; and OR, 1.71 for >2 h of TV), and short sleep duration (OR, 1.67). Generally, boys and girls had a similar trend, but there were a few differences by sex. Prolonged TV viewing was related to totally irregular BM, although girls had a stronger and dose–response relationship between TV viewing and totally irregular BM. Girls also had a significant relationship between slow eating and totally irregular BM. Physical activity was weakly correlated with totally irregular BM in girls, whereas boys had a significant association between physical activity and totally irregular BM.

Discussion

In the present study, lifestyle factors such as skipping breakfast, slow eating, physical inactivity, and long TV viewing were associated with both non-daily and totally irregular BM. Late waking was associated with non-daily BM, while late bedtime and short sleep duration were associated with totally irregular BM. Physical inactivity in boys, and prolonged TV viewing in girls were significantly associated with both non-daily and totally irregular BM. In addition, boys had a higher prevalence of frequent and regular BM than did girls. The sex differences in BM were only slightly explained by the lifestyle factors.

The association between several lifestyle factors, such as skipping breakfast, insufficient physical exercise, sedentary time, and short sleep duration, and constipation has been reported in previous studies,11,27,28 which analyzed boys and girls together. In a study that surveyed children aged 7–12 in Taiwan, 56.9% of boys and 48.4% of girls had daily BM.11 In another study conducted in children aged 10–16 years in Sri Lanka, 84.4% of all boys and 83.2% of all girls had daily defecation.29 The present results fall between those of these two studies. Cultural, dietary, genetic, and environmental differences may contribute to the variance of BM frequency, particularly at early life stages.

Eating habits and BM

There have been many reports on dietary intake and constipation, but, to date, the literature on eating habits and constipation in children is limited. In Japanese adults and high school girls, a relationship was found between skipping breakfast and constipation.30,31 and Mori et al.26 also reported this relationship in schoolchildren. Similarly, the present study showed that not only skipping breakfast but also slow eating was associated with non-daily and totally irregular BM, in which eating speed was evaluated subjectively. There have been several reports on the relationship between child obesity and fast eating in Japan.32,33 In contrast, children who eat slowly may be small eaters or do several things at once, such as talking or watching TV while eating. The small amount of food in the stomach at any one time would not significantly dilate the gastric wall, and possibly lead to lessened brain–gut axis.34 As a result, absorption and bowel motility may be impaired.

Sleep habits and BM

The association between sleeping habits and constipation in children has not been widely investigated. As far as we are aware, there has been only one large study conducted in Hong Kong that showed that children sleeping <7 h at night were more likely to have constipation compared with those who had >7 h sleep.28 In the present study, late waking was associated with non-daily BM, and sleep duration <8 h at night was marginally associated with non-daily BM. Late bedtime and short sleep duration were significantly associated with totally irregular BM. Although the kappa statistics between the three categories of frequency and regularity were low, similar lifestyle factors were associated with the two. Sufficient sleep duration and early waking may be effective in the prevention of non-daily and of totally irregular BM.

The gastrointestinal tract is subject to a circadian rhythm created by clock genes.35 Clock genes are functional in the liver, gastrointestinal epithelial cells, and neurons of the enteric nervous system. In a previous biological study conducted in healthy adults using manometry to investigate motor activity in the colon, pressure waves in the colon were inactive during the night, but waking induced a threefold increase in motility, and meals induced a twofold increase.36 That study proved the existence of a well-established circadian rhythm in the colon, and the ideal time for defecation may be in the morning. Alterations in the circadian rhythm have also been associated with gastrointestinal disease. For example, shift-workers were more likely to have abdominal pain, constipation, and diarrhea.37,38 We assume that children have the same circadian rhythm in their colons, and the associations between unhealthy sleep habits and non-daily and totally irregular BM were confirmed in the present large-scale study.

Physical activity and TV viewing

Studies focusing on physical activity and constipation in children and adolescents are few, and the results are inconsistent. Some reported that there was no association between physical activity and constipation in children,27,39 while others noted that insufficient physical activity was related to constipation in children.40,41 In adults, there have been many reports showing physical inactivity to be associated with constipation.42,43 De Schryver et al.44 reported that physical activity intervention improved defecation and total colonic transit time in middle-aged adults. Sedentary time, including TV viewing, has also been studied in adults, but only a few studies were carried out on childhood constipation. According to the previous data, long sedentary time was associated with constipation in children.41 Consistent with the literature, in the present study physical inactivity was associated with non-daily BM, but it differed according to sex. In boys, the association between
physical activity and both non-daily and totally irregular BM was stronger than in girls. In contrast, the correlation between TV viewing and non-daily and totally irregular BM was stronger in girls than in boys. There are three possible reasons for these sex differences. First, boys’ physical activity levels are much higher compared with girls’, therefore boys’ TV viewing time may not be relevant to their BM. Second, girls’ perception of activity level may differ from that of boys, thus it may not represent girls’ real activity level. As a result, a questionnaire about physical activity in girls may not be useful in comparison with boys. Third, the intestine’s biological response to exercise may differ. Gut motility in boys may be more sensitive to exercise than in girls, although further biological studies are needed. This study is, to the best of our knowledge, the first large-scale analysis of BM in children with regard to sex. It sheds new light on the relationship between physical activity, TV viewing, and BM in boys and girls.

**Sex difference in BM**

Although constipation is more common in girls in Japan, the sex difference is inconsistent worldwide. There have been reports from Taiwan and the USA showing female dominance. Several studies, however, noted no significant sex difference. This sex disparity may be caused by the different criteria used. The criteria for constipation, exclusively applied in clinical use, were the Roma III criteria, and the North American Society of Gastroenterology and Nutrition (NASPGHAN) definition. Those criteria include not only defecation frequency but also fecal incontinence and subjective appraisal, such as painful bowel opening, hard stool, and stool size. Fecal incontinence is more prevalent in boys. These factors may affect the sex difference in constipation. In this study, we used a simple definition: daily BM or not. Girls had a higher prevalence of infrequent and irregular BM. Furthermore, even after adjusting for lifestyle factors, the sex difference was not reduced. This means that gender-related lifestyle differences had only a small effect on children’s BM. Instead, unknown biological factors, such as sex hormones or the differences in body structure and gut motility, may be responsible for the sex difference in BM.

**Limitations**

First, the study design was cross-sectional, therefore causation was unable to be inferred. Second, the questionnaire used did not reflect the actual lifestyle and BM. The data on frequency and regularity in BM were based on subjective responses. In addition, an explicit definition of regularity in BM was not provided to participants. Third, the questionnaire items on BM were not the criteria used internationally to assess constipation. Thus, the prevalence of constipation in other studies using Roma criteria is not comparable to the present one. The main objective, however, was to clarify the relationship between daily lifestyle in children and bowel habits. The categorization of BM was sufficient to analyze the associations. Finally, the present research did not include dietary intake, such as fiber and vegetables. Children who skip breakfast and have short sleep, however, tend to have a less healthy diet involving low fiber and low micronutrients, therefore the lack of data on dietary intake may not influence the present results or damage the validity of the study. A longitudinal study should be conducted to investigate the effect of unhealthy lifestyle on child BM.

In conclusion, the present study provides data on lifestyle factors and BM in Japanese children. Non-daily and totally irregular BM were prevalent among children, especially girls. Several lifestyle factors were associated with non-daily and totally irregular BM, and there was a sex difference in the strength of the relationship with lifestyle factors. The results of the present large-scale study provide support for the national health promotion campaign, raised by the Japanese government, to encourage children to have daily and regular bowel habits. Policy makers, clinical doctors and parents should be aware of the potential risk factors linked to non-daily and totally irregular bowel habits in childhood, and educate children about the importance of a healthy lifestyle.

**Acknowledgments**

We express our great appreciation to all children and their parents participating in this study. We are indebted to the principals and school nurses in Toyama Prefecture for their help and cooperation. We also acknowledge the contribution of Ms Yasuko Yamazaki to data collection and general management of this study. The Toyama Birth Cohort study has been supported by grants from the Ministry of Health and Welfare (H10-Child-020), the Ministry of Health, Labour and Welfare (H13-Health-022), Toyama Medical Association, and the Japan Heart Foundation. The granting sources had no role in the design or conduct of the study; management, analysis, or interpretation of the data; or the preparation, review, or approval of manuscript.

**Disclosure**

The authors declare no conflict of interest.

**Author contributions**

M.S. designed and performed the Toyama Birth Cohort study. M.Y. collected, analyzed the data and wrote the manuscript. M.S. and T.T. gave technical support and conceptual advice. All authors read and approved the final manuscript.

**References**

1 van den Berg MM, Benninga MA, Di Lorenzo C. Epidemiology of childhood constipation: a systematic review. *Am. J. Gastroenterol.* 2006; 101: 2401–9.
2 Mugie SM, Benninga MA, Di Lorenzo C. Epidemiology of constipation in children and adults: a systematic review. *Best Pract. Res. Clin. Gastroenterol.* 2011; 25: 3–18.
3 Kawai S, Kubo T, Nakamura S et al. The bowel habit in children with nocturnal enuresis. Yonousyou Kenkyu 2011; 16: 51–6. (in Japanese).

4 Kajiwara M, Inoue K, Usui A et al. The micturition habits and prevalence of daytime urinary incontinence in Japanese primary school children. J. Urol. 2004; 171: 403–7.

5 Loeving-Baucke V. Chronic constipation in children. Gastroenterology 1993; 105: 1557–64.

6 Sommers T, Corban C, Sengupta N et al. Emergency department burden of constipation in the United States from 2006 to 2011. Am. J. Gastroenterol. 2015; 110: 572–9.

7 Bongers ME, van Wijk MP, Reitsma JB, Benninga MA. Long-term prognosis for childhood constipation: clinical outcomes in adulthood. Pediatrics 2010; 126: e156–62.

8 Pijpers MA, Bongers ME, Benninga MA, Berger MY. Functional constipation in children: a systemic review on prognosis and predictive factors. J. Pediatr. Gastroenterol. Nutr. 2010; 50: 256–68.

9 Belsey J, Greenfield S, Candy D, Geraint M. Systematic review: impact of constipation on quality of life in adults and children. Aliment. Pharmacol. Ther. 2010; 31: 938–49.

10 Faleiros FT, Machado NC. Assessment of health-related quality of life in children with functional defecation disorders. J. Pediatr. 2006; 82: 421–5.

11 Wu TC, Chen LK, Pan WH et al. Constipation in Taiwan elementary school students: a nationwide survey. J. Chin. Med. Assoc. 2011; 74: 57–61.

12 Ministry of Education, Culture, Sports, Science and Technology in Japan. The National “Early to Bed, Early to Rise and Don’t Forget Your Breakfast” Campaign. [Cited 11 December 2015.] Available from URL: http://www.mext.go.jp/a_menu/shougai/asagohan/index.htm (in Japanese).

13 National Congress, National Congress of “Early to Bed, Early to Rise and Don’t Forget Your Breakfast”. [Cited 11 June 2015.] Available from URL: http://www.hayanehayaoki.jp/ab.out.html (in Japanese).

14 Sekine M, Yamagami T, Handa K et al. A dose–response relationship between short sleeping hours and childhood obesity: result of the Toyama Birth Cohort Study. Child Care Health Dev. 2002; 28: 163–70.

15 Chen Xi, Sekine M, Hamanishi S et al. Lifestyles and health-related quality of life in Japanese school children: a cross-sectional study. Prev. Med. 2005; 40: 668–78.

16 Janssen I, Katzmarzyk PT, Boyce WF, King MA, Pickett W. Overweight and obesity in Canadian adolescents and their associations with dietary habits and physical activity patterns. J. Adolesc. Health 2004; 35: 360–7.

17 Al-Hazzaa HM, Musagur AQ, Ahahussain NA, Al-Sobayel HI, Qahwaji DM. Prevalence of short sleep duration and its association with obesity among adolescents 15- to 19-year-olds: a cross-sectional study from three major cities in Saudi Arabia. Ann. Thorac. Med. 2012; 7: 133–9.

18 Sekine M, Yamagami T, Hamanishi S et al. Parental obesity, lifestyle factors and obesity in preschool children: results of the Toyama Birth Cohort study. J. Epidemiol. 2002; 12: 33–9.

19 Liu J, Sekine M, Tatsuse T et al. Family history of hypertension and risk of overweight in Japanese children: results from the Toyama Birth Cohort study. J. Epidemiol. 2014; 24: 304–11.

20 Sun Y, Sekine M, Kagamimori S et al. Lifestyle and overweight among Japanese adolescents: the Toyama Birth Cohort Study. J. Epidemiol. 2009; 19: 303–10.

21 Moraeus L, Lissner L, Olsson L, Sjoberg A. Age and time effects on children’s lifestyle and overweight in Sweden. BMC Public Health 2015; 15: 355.

22 Nihon Kodomo Katei Sougoukensyuusyo. Almanac of Data on Japanese Children 2016. KTC chuushappan, Tokyo, 2016. (in Japanese).

23 Chen X, Sekine M, Hamanishi S et al. Validation of a self-reported physical activity questionnaire for schoolchildren. J. Epidemiol. 2003; 13: 278–87.

24 Gaina A, Michikazu S, Chen X, Shimako H, Sadanobu K. Sleep parameters recorded by Actiwatch in elementary school children and junior high school adolescents: schooldays vs weekends. Sleep Hypnosis 2004; 6: 65–76.

25 Cole TJ, Bellizzi MC, Flegel KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000; 320: 1240–3.

26 Mori E, Yamashita H, Inutsuka H et al. Relationship between dietary intake and defecation habits among school children. Eiyougaazashi 2001; 59: 183–90. (in Japanese).

27 Chien LY, Liou YM, Chang P. Low defaecation frequency in Taiwanese adolescents: association with dietary intake, physical activity and sedentary behaviour. J. Paediatr. Child Health 2011; 47: 381–6.

28 Tam YH, Li AM, So HK et al. Socioenvironmental factors associated with constipation in Hong Kong children and Roma III criteria. J. Pediatr. Gastroenterol. Nutr. 2012; 55: 56–61.

29 Devanarayana NM, Rajindrajith S. Bowel habits and behaviors related to defecation in 10 to 16 year-olds: impact of socioeconomic characteristics and emotional stress. J. Pediatr. Gastroenterol. Nutr. 2011; 52: 569–73.

30 Kunimoto M, Nishi M, Sasaki K. The relation between irregular bowel movement and the lifestyle of working women. Hepatogastroenterology 1998; 45: 956–60.

31 Nishi M, Miyake K, Kunimoto M. Factors affecting constipation in female high school students. Syoni Hoken Kenkyu 2002; 61: 520–4.

32 Ochiai H, Shirasawa T, Ohtsu T et al. Eating behaviors and overweight among adolescents: a population-based survey in Japan. J. Obes. 2013; 2013: 717942.

33 Murakami K, Miyake Y, Sasaki S, Tanaka K, Arakawa M. Self-reported rate of eating and risk of overweight in Japanese children: Ryukyu Child Health Study. J. Nutr. Sci. Vitaminol. (Tokyo) 2012; 58: 247–52.

34 Aziz Q, Thompson DG. Brain–gut axis in health and disease. Gastroenterology 1998; 114: 559–78.

35 Hoogerwerf WA. Role of biological rhythms in gastrointestinal health. Rev. Endocr. Metab. Disord. 2009; 10: 293–300.

36 Rao SS, Sadeghi P, Beaty J, Kavlock R, Ackerson K. Ambulatory 24-h colonic manometry in healthy humans. Am. J. Gastroenterol. 2001; 96: G629–39.

37 Costa G. The impact of shift and night work on health. Appl. Ergon. 1996; 27: 9–16.

38 Caruso CC, Lusk SL, Gillespie BW. Relationship of work schedules to gastrointestinal diagnosis, symptoms, and medication use in auto factory workers. Am. J. Ind. Med. 2004; 46: 586–96.

39 Inan M, Aydiner CY, Aksoy B et al. Factors associated with childhood constipation. J. Paediatr. Child Health 2007; 43: 700–6.

40 Driessen LM, Kiefe-de Jong JC, Wijtzes A et al. Preschool physical activity and functional constipation: the generation R study. J. Pediatr. Gastroenterol. Nutr. 2013; 57: 768–74.

41 Huang R, Ho SY, Lo WS, Lam TH. Physical activity and constipation in Hong Kong adolescents. PLoS ONE 2014; 9: e90193.

42 Everhart JE, Go VL, Johannes RS, Fitzsimmons SC, Roth HP, White LR. A longitudinal survey of self-reported bowel habits in the United States. Dig. Dis. Sci. 1989; 34: 1153–62.

43 Dukas L, Willett WC, Giovannucci EL. Association between physical activity, fiber intake, and other lifestyle variables and constipation in a study of women. Am. J. Gastroenterol. 2003; 98: 1760–6.
44 De Schryver AM, Keulemans YC, Peters HP et al. Effects of regular physical activity on defecation pattern in middle-aged patients complaining of chronic constipation. Scand. J. Gastroenterol. 2005; 40: 422–9.
45 Uc A, Hyman PE, Walker LS. Functional gastrointestinal disorders in African American children in primary care. J. Pediatr. Gastroenterol. Nutr. 2006; 42: 270–4.
46 Rasquin A, Di Lorenzo C, Forbes D et al. Childhood functional gastrointestinal disorder: child/adolescent. Gastroenterology 2006; 130: 1527–37.
47 van der Wal MF, Benninga MA, Hirasing RA. The prevalence of encopresis in a multicultural population. J. Pediatr. Gastroenterol. Nutr. 2005; 40: 345–8.
48 Levine MD. Children with encopresis: a descriptive analysis. Pediatrics 1975; 56: 412–6.
49 Haghighatdoost F, Karimi G, Esmailzadeh A, Azadbakht L. Sleep deprivation is associated with lower diet quality indices and higher rates of general and central obesity among young female students in Iran. Nutrition 2012; 28: 1146–50.
50 Deshmukh PR, Nicklas TA, O’Neil CE, Keast DR, Radcliffe JD, Cho SL. The relationship of breakfast skipping and type of breakfast consumption with nutrient intake and weight status in children and adolescents: the National Health and Nutrition Examination Survey 1999–2006. J. Am. Diet. Assoc. 2010; 110: 869–78.