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Original Article

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Lifestyle Habits Associated with Poor Defecation Habit among Pupils in Japan

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Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Purpose: Not enough attention has been paid to defecation habits in Japan. This study aimed to emphasize the importance of defecation habits on health and function in Japanese pupils.
Methods: Using multiple regression analysis, 2,722 questionnaires obtained from pupils in grades 5 to 12 were analyzed to determine lifestyle habits associated with defecation frequency.
Results: Significant regression formulae for defecation scores were obtained for all school types: elementary school (ES) (adjusted R^2=0.08, p<0.001), junior high school (JHS) (0.09, p<0.001), and senior high school (SHS) (0.15, p<0.001). The following factors were associated with poorer defecation scores, according to school type: female gender (all 3 school types), breakfast skipping (elementary and JHSs), lower physical activity (JHSs and SHSs), and longer school-day screen time (elementary and SHSs). In addition, poorer self-reported academic performance scores in ES, less standardized body mass index (BMI) in JHS, and shorter non-school- day screen time scores in SHS, were associated with poorer defecation scores.
Conclusion: Poor defecation frequency showed significant associations with various lifestyle habits, such as breakfast skipping, physical activity, and screen time, among pupils. Academic performance and standardized BMI were also associated with defecation frequency. More attention should be paid to defecation frequency to sustain health and function in pupils.

Keywords: Academic performance; Body mass index; Brain-gut axis; Breakfast; Exercise; Screen time

INTRODUCTION

The 2014 edition of the Annual Health, Labour and Welfare Report from the Japan Ministry of Health, Labor, and Welfare was titled “For the Realization of a Society of Health and Longevity: First Year of Health and Prevention” [1]. This report aimed to extend individuals' “healthy life expectancy at birth” through active health promotion, by improving exercise and dietary habits, as well as by encouraging people to consider their health and implement the recommendations. Although sleep, feeding, defecation, and exercise are fundamental human behaviors [2], the aims of this report excluded sleep and defecation habits. Indeed, in this report, the words "defecation," "constipation," and "diarrhoea" were missing. The Japan Ministry of Health, Labour, and Welfare might consider defecation habits negligible for the "realization of a society of health and longevity." It must be stated that not enough attention is paid to defecation habits in association with health issues in Japan. To the best of my knowledge, no study has investigated pediatricians' perceptions on constipation in Japan.

According to Liem et al. [3], an estimated 1.7 million US children (1.1%) reported constipation within a two-year period. Chronic constipation is a disorder that can negatively impact the quality of life [4]. Thus, Liem et al. [3] estimated that the children with constipation used more health services than those without, resulting in an additional cost of $3.9 billion/year for children with constipation. It should be noted that the health care burden of Japan in the 2018 financial year was $396 billion (1 yen=0.0093 USD). Functional constipation is common in children, with a prevalence ranging between 0.7% and 29.6%, and male dominancy depends on the criteria used [5]. Lewis [6] also reported that the prevalence of functional constipation was 12.9% among children and adolescents. According to Japan Toilet Labo [7], 16.6% of elementary school (ES) pupils suffer from constipation, defined according to the Rome III criteria. Fujitani et al. [8] reported the prevalence of functional constipation among 3- to 8-year-old children in Japan as 20.0%. A 2018 systematic review and meta-analysis reported the worldwide pooled prevalence of functional constipation in children as 9.5% (95% confidence interval, 7.5–12.1%), showing no statistically significant difference regarding sex [9]. The diagnosis of functional constipation is based on the Rome criteria for functional gastrointestinal disorders, currently the Rome IV criteria [10]. Regarding defecation frequency, the Rome criteria defined constipation as less than three spontaneous bowel movements per week. Although Liem et al. [3] reported no differences with respect to age, sex, race, and socioeconomic status, between children with constipation and those without constipation, Mugie et al. [5] investigated 19 articles and found that female gender, increasing age, socioeconomic status, and educational level, seemed to affect constipation prevalence. Associations with insufficient fruit and vegetable consumption and psychological problems were also reported [11].

Regarding lifestyle habits, physical activity was reported to be negatively associated with constipation [3]. Tam et al. [12] reported that short sleep duration was associated with constipation; however, among elderly Chileans, those with constipation were reported to sleep significantly more than those with normal evacuation [13]. Body mass index (BMI) was reported to show no significant association with constipation in either adults [14] or children [9], although several studies have shown that child obesity is associated with constipation [15,16]. Skipping breakfast, early toilet training, and low intake of vegetables and fruits were also reported as significant factors leading to constipation in children [17]. Olaru et al. [4] reported associations of male gender, obesity/overweight, sedentary behaviors, and lower physical activity with constipation in children. In addition, unfavorable bowel activities, including constipation, were reported to be associated with breakfast skipping, slow eating, physical inactivity, long screen time, late wake time, late bedtime, and short sleep duration [18] In Taiwanese adolescents [19], female gender, being overweight/obese, and being sedentary for long periods were independently associated with increased risk of low defecation frequency.

Thus, defecation frequency might affect various aspects of lifestyle habits; however, no consistent results have been obtained. This may be partly because less attention has been paid to defecation frequency compared to eating or physical activity habits and media usage

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[1]. Indeed, there is often a lack of understanding between the physician and the patients' perception in terms of defining constipation [20]. The aim of the current study was to determine lifestyle factors associated with defecation frequency, to provide effective approaches to foster healthy lives in pupils. In addition, regarding academic performance, Sbahi and Cash [21] reported that constipation can potentially cause a reduction in school activities, but no concrete description of this issue was made. Kovacic et al. [22] compared the scores from five instruments (Pediatric Quality of Life Inventory; PedsQL-Family Impact Module; Functional Disability Inventory–Parent Version; Pediatric Inventory for Parents; and Pediatric Symptom Checklist–Parent Report) between children with and without functional constipation/fecal incontinence; however, academic performance was not assessed. An association between defecation frequency and academic performance, though self-reported, was also assessed.

MATERIALS AND METHODS

The current study was part of a survey conducted between October 2016 and November 2018 to determine the mutual associations among lifestyle factors, and to clarify the associations of lifestyle factors with pupils' health and academic performance. Details of the survey have been described in other studies [23,24]. The schoolteachers distributed the questionnaires to their students. Although pupils were asked to answer the questions independently, the involvement of parents is unknown. A letter was also delivered to assure students that their responses would be treated anonymously and confidentially, and that participation was voluntary. Written consent forms, signed by parents and completed questionnaires were collected by schoolteachers on a different day and sent to the author. Of the 4,208 questionnaires collected from 28 public schools (15 ESs, 8 junior high schools [JHSs], and 5 senior high schools [SHSs]) in the Kanto district, Japan, 2,722 indicated the students' agreement to participate in the study and had complete answers to all the required questions.

The queries on the questionnaire were original (**Table 1**), drawn up by considering queries used by the Japan Society of School Health [25]. The responses on defecation, breakfast, and sleepiness were expressed as defecation score, breakfast score, and sleepiness score, respectively. Defecation score showed the frequency of defecation: pupils with a defecation score of 1 (DF1) defecated every day, DF2 every other day, DF3 once every two to three days, and DF4 twice a week or less. Regarding dinner regularity, options 1 to 7 were categorized as regular dinner (dinner regularity score 1) and the last option (8) as irregular dinner (dinner regularity score 2). The hours of after-school activity per week (after-school activity score) were estimated as the product of the frequency and duration of activities. Regarding physical activity, the number of days per week engaged in physical activity (physical activity score) was considered. The responses on self-reported academic performance (1, very good; 2, good; 3, not good; 4, poor) were termed as self-reported academic performance score. Screen time on school days (school-day screen time score) and non-school days (non-school day screen time score), wake times on school days and non-school days, and bedtimes before school days and non-school days were asked separately. BMI was calculated by dividing body weight by height squared, varied by age and gender [25], and thus BMI values were standardized by grade and gender.

To determine the factors associated with defecation score, multiple regression analysis was conducted, using the defecation score as an objective variable. Grade, gender, breakfast intake score, sleepiness score, dinner regularity score, after-school activity score, physical activity score, self-reported academic performance score, screen time score of both school

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Table 1. Questionnaire

Please mark your grade.
Elementary school (grade 5, 6), junior high school (grade 1, 2, 3), senior high school (grade 1, 2, 3)
Please mark your gender.
Gender (male, female)
Please describe your height and weight.
Height (cm), weight (kg)
Please mark your bed time before school days.
1. <8 PM, 2. 8 PM–9 PM, 3. 9 PM–10 PM, 4. 10 PM–11 PM, 5. 11 PM–12 AM, 6. 12 AM–1 AM, 7. 1 AM–2 AM, 8. 2 AM–3 AM, 9. >3 AM
Please mark your bed time before non-school days.
1. <8 PM, 2. 8 PM–9 PM, 3. 9 PM–10 PM, 4. 10 PM–11 PM, 5. 11 PM–12 AM, 6. 12 AM–1 AM, 7. 1 AM–2 AM, 8. 2 AM–3 AM, 9. >3 AM
Please mark your wake time on school days.
1. <5 AM, 2. 5 AM–6 AM, 3. 6 AM–7 AM, 4. 7 AM–8 AM, 5. 8 AM–9 AM, 6. 9 AM–10 AM, 7. 10 AM–11 AM, 8. 11 AM–12 PM, 9. >12 PM
Please mark your wake time on non-school days.
1. <5 AM, 2. 5 AM–6 AM, 3. 6 AM–7 AM, 4. 7 AM–8 AM, 5. 8 AM–9 AM, 6. 9 AM–10 AM, 7. 10 AM–11 AM, 8. 11 AM–12 PM, 9. >12 PM
Please mark the frequency of sleepiness during class.
1. never, 2. sometimes, 3. often, 4. always
Please mark your frequency of breakfast intake.
1. always, 2. often, 3. sometimes, 4. never
Please mark your frequency of defecation.
1. every day, 2. every other day, 3. once every two to three days, 4. twice a week or less
Please mark your usual dinner time.
1. around 6 PM, 2. around 7 PM, 3. around 8 PM, 4. around 9 PM, 5. around 10 PM, 6. around 11 PM, 7. later than 11 PM, 8. not determined
Do you participate in any kind of after-school activity?
1. yes, 2. no
If yes, please mark the frequency of participation.
1. once a wk, 2. twice a wk, 3. three times a wk, 4. four times a wk, 5. five times a wk, 6. six times a wk, 7. every day
Please mark the average duration of a single after-school activity.
1. 1 hr 2. 2 hr 3. 3 hr 4. 4 hr 5. 5 hr or more
How many days a week do you perform habitual exercise, excluding school lessons?
0. none, 1. one day per wk, 2. two days per wk, 3. three days per wk, 4. four days per wk, 5. five days per wk, 6. six days per wk, 7. seven days per wk
How long do you use various media devices (television, video, video game, digital versatile disc, computer, tablet, mobile [cell]phone, smart phone) in a day? Please answer separately for school days and non-school days.
On school days
1. <2 hr, 2. 2–4 hr, 3. 4–6 hr, 4. 6–8 hr, 5. 8 hr or more
On non-school days
1. <2 hr, 2. 2–4 hr, 3. 4–6 hr, 4. 6–8 hr, 5. 8 hr or more
Please mark the best choice for your overall academic performance.
1. very good, 2. good, 3. not good, 4. poor

days and non-school days, bed time and waking time on both school days and non-school days, and standardized BMI were used as the variables.

The American Psychological Association [26] recommends describing effect sizes in studies. Since a Cohen's 'small' effect can produce substantial differences [27], we restricted our discussion to findings with $p<0.05$ and with more small effect sizes (adjusted R^2 >0.02 for multiple regression analysis and Cramer's V value >0.1 for chi-square test for independence) [28]. These analyses were conducted using BellCurve for Excel.

This study was approved by the Committee for Medical Research Ethics of our institute (no. 199).

RESULTS

The rate of pupils in each defecation score category is shown in **Table 2**. According to chi-square test for independence, school types and defecation score categories showed no significant association (chi-square=21.66, $p<0.01$, Cramer's V=0.06).

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Table 2. Number of pupils in each defecation score category in each school type

	DF1	DF2	DF3	DF4
School types; number (M/F)	Number (M/F) % in each school type (M/F)	Number (M/F) % in each school type (M/F)	Number (M/F) % in each school type (M/F)	Number (M/F) % in each school type (M/F)
ES; 956 (441/515)	585 (311/274) 61.2% (70.5%/53.2%)	217 (78/139) 22.7% (17.7%/27.0%)	124 (45/79) 13.0% (10.2%/15.3%)	30 (7/23) 3.1% (1.6%/4.5%)
JHS; 1,049 (541/508)	585 (344/241) 55.8% (63.6%/47.4%)	236 (109/127) 22.5% (20.1%/25.0%)	173 (70/103) 16.5% (12.9%/20.3%)	55 (18/37) 5.2% (3.3%/7.3%)
SHS; 717 (385/332)	460 (295/165) 64.2% (76.6%/49.7%)	141 (63/78) 19.7% (16.4%/23.5%)	82 (24/58) 11.4% (6.2%/17.5%)	34 (3/31) 4.7% (0.8%/9.3%)
Total; 2,722 (1,367/1,355)	1,630 (950/680) 59.9% (69.5%/50.2%)	594 (250/344) 21.8% (18.3%/25.4%)	379 (139/240) 13.9% (10.2%/17.7%)	119 (28/91) 4.4% (2.0%/6.7%)

DF: defecation score, M: male; F: female, ES: elementary school, JHS: junior high school; SHS: senior high school.
DF showed the frequency of defecation, and pupils with DF1 defecated every day, DF2 every other day, DF3 once every two to three days, DF4 twice a week or less.

A significant regression formula for defecation score was obtained considering all data (adjusted R^2=0.07, p<0.001). The factors significantly associated with an increase in defecation score included female gender, lower grades, higher breakfast skipping rate, lower after-school activity, lower physical activity score, poorer self-reported academic performance, later bedtime before non-school days, and lower standardized BMI values (**Table 3**). Since grade was found to be a significant factor associated with defecation score, further multiple regression analyses were performed separately in each school type.

Significant regression formulae for defecation score were obtained for all school types: ES (adjusted R2=0.08, p<0.001), JHS (0.09, p<0.001), and SHS (0.15, p<0.001). The following

Table 3. Significant factors associated with defecation score on multilinear regression analysis

Significant factors	Regression coefficient (95% confidence interval)	β	*p*-value
Total (R^2=0.07)			
Constant	0.75 (0.47–1.03)	0.75	<0.001
Gender (male 1; female 2)	0.33 (0.26–0.40)	0.19	<0.001
Grade	−0.03 (−0.05–−0.01)	−0.07	<0.01
Breakfast intake score	0.10 (0.04–0.16)	0.06	<0.01
After-school activity score	−0.01 (−0.01–0.00)	−0.05	<0.05
Physical activity score	−0.02 (−0.03–−0.01)	−0.07	<0.001
Self-reported academic performance score	0.05 (0.01–0.10)	0.05	<0.05
Bed time before non-school day	0.05 (0.00–0.10)	0.08	<0.05
Standardized BMI	−0.04 (−0.08–−0.01)	−0.05	<0.01
ES (R^2=0.08)			
Constant	1.09 (0.30–1.88)	1.09	<0.01
Gender (male 1; female 2)	0.25 (0.14–0.37)	0.15	<0.001
Breakfast score	0.20 (0.05–0.36)	0.08	<0.01
Self-reported academic performance score	0.10 (0.02–0.18)	0.08	<0.05
School-day screen time score	0.12 (0.01–0.23)	0.10	<0.05
JHS (R^2=0.09)			
Constant	0.80 (0.06–1.53)	0.80	<0.05
Gender (male 1; female 2)	0.28 (0.17–0.39)	0.15	<0.001
Breakfast intake score	0.22 (0.12–0.32)	0.14	<0.001
Physical activity score	−0.03 (−0.05–−0.01)	−0.10	<0.01
Standardized BMI	−0.07 (−0.12–−0.01)	−0.07	<0.05
SHS (R^2=0.15)			
Constant	1.24 (0.27–2.21)	1.24	<0.05
Gender (male 1; female 2)	0.51 (0.38–0.64)	0.29	<0.001
Physical activity score	−0.03 (−0.05–−0.01)	−0.10	<0.05
School-day screen time score	0.17 (0.06–0.28)	0.19	<0.01
Non-school-day screen time score	−0.14 (−0.23–−0.05)	−0.19	<0.01

BMI: body mass index, ES: elementary school, JHS: junior high school, SHS: senior high school.

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factors were significantly associated with poorer defecation, according to school type: female gender was (all 3 school types), breakfast skipping (ES and JHS), lower physical activity score (JHS and SHS), and longer school-day screen time (ES and SHS) (**Table 3**). In addition, poorer self-reported academic performance score in ES, less standardized BMI in JHS, and shorter non-school- day screen time score in SHS were associated with poorer defecation score (**Table 3**).

DISCUSSION

Pupils in the DF4 category in the current study met the Rome IV diagnostic criteria for constipation, based on defecation frequency. Of course, diagnosis of constipation needs to meet one of the other five criteria (straining, lumpy or hard stools, sensation of incomplete evacuation, sensation of anorectal obstruction/blockage, and manual manoeuvres to facilitate defecation). The proportion of DF4 category pupils in the present study was 3.1%, 5.2%, 4.7% in ES, JHS, and SHS, respectively. These figures were lower than those in prior reports on child constipation [5,9], although Chu et al. [29] reported that, more than half of the studies had prevalence rates ranging from 3 to 10%. According to a report from Sri Lanka, when compared to adolescents, the prevalence of constipation was higher among children younger than 12 years of age [30]. In general, pupils in grade 6 or higher were aged 12 years or older in the current study. This observation [30] might have a psychological explanation, as some adolescent pupils (aged 12 or older) with constipation might avoid answering this question due to shame or unrecognized ignorance on bowel habits, despite their responses being anonymous.

Regarding gender difference, the present study revealed more females than males in the poorer defecation frequency category in all school types. This female dominancy was consistent with the results of the survey conducted by the Japan Society of School Health [25], where female dominancy was reported in the first and second grades of ES. A 2011 meta-analysis reported a 14% prevalence of functional constipation in adults, and it was more common in women than in men [31]. In addition to psychological factors such as concerns of smell or noise in the bathroom [32], hormonal circumstances [32,33], and muscle issues such as injuries with delivery and lower power to strain, are suggested to be associated with the higher constipation rate in the adult females. The factors involved in female dominancy on poorer defecation frequency among pupils in Japan remain unknown.

Consistent with previous reports, the current study demonstrated significant associations of poor defecation frequency with breakfast skipping (ES and JHS) [17,18], less physical activity (JHS and SHS) [3,12], and longer school-day screen time (ES and SHS) [3,18,19]. In addition, although only in ES, poorer self-reported academic performance score was significantly associated with poorer defecation score. In children and adults with functional constipation, sensations such as pain and abdominal distention arising from the colon are processed via afferent pathways from the enteric nervous system to the cerebral cortex [34]. This brain–gut axis [35] might eventually affect brain processing and lead to the alteration of its functioning.

In turn, brain processing and functioning might modulate colonic and rectal function via efferent pathways of the brain–gut axis, resulting in gastrointestinal dysfunction [36]. To support this theory, studies using functional MRI reported that, compared with healthy individuals as control subjects, pediatric and adult patients with functional constipation showed different patterns of brain processing in response to rectal distention, and a distinct baseline brain activity pattern [37,38]. Constipation could affect one aspect of brain functioning—academic performance—through the brain–gut axis, although the reason why no association was found in JHS and SHS is yet to be clarified. Interestingly, bacterial diversity increase steadily from birth until around 12 years of age, then remain relatively stable throughout adulthood [39]. Moreover, in obese children, prebiotic supplementation significantly reduced energy intake in 11- and 12-year-olds, but not in 7- to 10-year-olds [40]. Gut microbacterial condition might differ around ages 10–12 years, which may cause functional alterations in the brain–gut axis and may explain the school-type difference in the association between defecation frequency and academic performance.

Inconsistent with previous reports [12,13], sleep factors showed no association with defecation frequency in pupils of all three school types in this study. In addition, contrary to former articles [4,14-16,18,19], shorter non-school-day screen time among SHS pupils and less standardized BMI values in JHS pupils revealed significant associations with poorer defecation frequency. Therefore, further studies should be conducted to clarify the association of sleep, screen time, and BMI with defecation frequency.

The survey that used the questionnaire being referenced in this study was conducted over 25 years ago, with several revisions by experts, and the results have been used as the fundamental data for policy making as well as compiling manuals on the proper lifestyle of children in Japan [25]. The questionnaire is assumed to be generalized and established.

The current study relied on self-reports from pupils and thus lacked direct measurements of height, weight, and other evaluated factors. This design was one of the biggest limitations of this study. However, the mean BMI values and the rate of female dominancy in the poor defecation frequency category are similar to the results for schoolchildren in Japan [25]. These similarities could support the external validity of this study to some extent. Self-reported academic performance has generally been considered accurate [41], and it is widely used as a measure of student performance [42], although limitations have been noted [43]. Additionally, the present study did not measure demographic factors such as family composition, socioeconomic status, and parents' educational background. Finally, this study was cross-sectional, and thus the current findings failed to identify a causal relationship. However, the study revealed that poor defecation frequency had significant associations with various lifestyle habits, such as breakfast, physical activity, and screen time. Academic performance and BMI were also associated with defecation frequency, although not in all school types. More attention should be paid to defecation frequency in terms of sustaining the health and function of pupils. Recently, the term "gut-heart axis" has also been proposed [44]. Gut conditions must be one of key issues for the realization of a society of health and longevity [1].

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