Original Article

Relationships between body mass index and constipation, gastroesophageal reflux disease, stool forms based on the Bristol Stool Form Scale, and education level: results from an internet survey in Japan

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Detailed evaluations of body mass index (BMI) and stool form based on the Bristol Stool Form Scale (BSFS) in individuals with constipation, gastroesophageal reflux disease (GERD), and concomitant constipation and GERD have not been performed in Japan. This study was an internet survey conducted to examine the relationships between BMI and constipation, GERD, stool forms based on the BSFS, and education level. This internet-based survey recruited participants from general public survey panels. 10,000 individuals meeting the eligibility criteria were enrolled. Questions included demographics, medical data, and assessments based on validated measures for constipation and GERD. BMI was significantly lower in males with versus without constipation. BMI was significantly higher with GERD both males and females. Mean BMI increased from the BSFS-1/2 group through the BSFS-3/4/5 to the BSFS-6/7 groups in both sexes. BMI was highest in individuals with a maximum education level of junior high school and second highest in individuals completing high school. This is the first real-world survey that closely examines the relationship between BMI and stool forms of individuals in Japan. When the BMI increased, stool forms varied from hard to watery in Japanese people. BMI was related with education level in Japan. (Trial registration: UMIN000039688)

***Key Words*: education level, body mass index, Bristol Stool Form Scale, constipation, gastroesophageal reflux disease**

Chronic constipation is a common disease worldwide.[1,2] In Japan, the prevalence of constipation-related complaints was reported to be 2.5% in males and 4.4% in females.[3] However, a recent internet survey reported a higher prevalence of 19.1% in males and 37.5% in females.[4] The study group of the Japanese Society of Gastroenterology released evidence-based clinical practice guidelines for chronic constipation (CC) in 2017, and irritable bowel syndrome (IBS) was treated as one of the causes of CC. A study of a large number of subjects revealed the differences in characteristics between IBS and non-IBS subjects with CC who underwent a medical check-up in Japan.[5]

The prevalence of erosive GERD in Japan has been estimated as 10.0%.[6] The prevalence of GERD has recently increased according to increases in gastric acid secretion, decreases in *Helicobacter pylori* infection, and expanding eradication of *Helicobacter pylori*.

Outside of Japan, GERD and dyspepsia have been reported to be complicated with constipation, stating that constipation was present in 28% of patients with GERD and 30% with dyspepsia.[7] The combination of GERD and constipation has also been reported in children.[8,9] Recently, we performed an internet survey to investigate the frequency of overlapping constipation and GERD, and the health status of individuals experiencing these symptoms.[10] Of 10,000 Japanese participants, the number with constipation/GERD overlap was 693 (6.93%); individuals with overlapping constipation and GERD tended to have worse symptoms and quality of life.[10]

Although the potential effect of obesity in gastrointestinal (GI) symptoms is unclear, functional GI disorders are considered to be the result of an initial inflammatory damage to the GI tract that modifies visceral motility and/or sensitivity.[11] Epidemiologic results show that obesity is related with a wide range of chronic GI complaints, many of which overlap with functional GI disorders such as IBS or dyspepsia.[12–16] The association between constipation and lifestyle behaviors such as excessive alcohol consumption, an unhealthy diet, smoking, and lack of exercise has also been reported.[17,18] A few reports have shown an association between constipation and body mass index (BMI).[19,20] BMI and age have both been associated with rectosigmoid transit time in patients with constipation.[21] On the other hand, there have also been reports that constipation was not related to BMI.[22,23] A recent review of studies about constipation did not show the prevalence and related factors in obese individuals.[24–27]

High BMI and obesity have repeatedly been reported to be related to a high prevalence of GERD.[28–31] In addition, the Japanese criteria for diagnosing metabolic syndrome include visceral fat accumulation, dyslipidemia, hypertension, and hyperglycemia, and all 4 factors have been considered to associate with the occurrence of GERD.[30–32]

The current study used data from an internet questionnaire to investigate the relationship between BMI and constipation, GERD, the overlap of constipation and GERD (C + GERD), stool forms based on Bristol Stool Form Scale (BSFS), and level of education. We also evaluated the relationships among education level, BMI, and the prevalence of constipation and/or GERD.

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Materials and methods

Survey design. This internet-based survey was registered with the University Hospital Medical Information Network in Japan (Trial registration: UMIN000039688). The Ethics Review Committee of Aichi Medical University approved the study's implementation (Approval No. 2019-179). The study was conducted in accordance with the Declaration of Helsinki by the World Medical Association and the Ethical Guidelines for Medical Research (established on December 22, 2014) by the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labor, and Welfare of Japan.

The survey took place between 16–18 March, 2020. Participants were recruited from panels of the general public held by a survey company (Rakuten Insight Inc., Tokyo, Japan). Inclusion and exclusion criteria were applied, and 10,000 individuals meeting the eligibility criteria were enrolled after adjustments to reflect the general Japanese population's location, gender, and age composition.[33] The survey was closed to further participation when 10,000 participants matching the required Japanese population characteristics were enrolled.

Participants. The inclusion criteria required participants to be males or females aged 20 to 69 years (inclusive), who provided informed consent for survey participation. Exclusion criteria were previous open surgery of the abdomen (excluding appendicitis); intestinal conditions such as inflammatory bowel disease, ulcerative colitis, and Crohn's disease; cancer of the gastrointestinal tract; pregnancy; and inability to follow the study instructions.

Diagnostic criteria. Constipation was diagnosed according to the Japanese Society of Gastroenterology guidelines. GERD was diagnosed according to the GERD questionnaire [GerdQ],[34] with participants scoring ≥8 diagnosed as GERD.[35]

Investigated items. We investigated the following associations: between BMI and constipation; between BMI and GERD; between BMI and C + GERD; BMI and the Bristol Stool Form Scale (BSFS) score; between BMI and education level; between education level and the prevalence of constipation and/or GERD.

Statistical methods. The sample size of 10,000 participants was set to ensure that sufficient individuals with constipation and GERD were enrolled; no formal sample size calculations were employed. The 2-sided significance level was set at 5.0% for all analyses and calculated using the chi-square test or the Mann–Whitney U test. Statistical analyses were conducted using SAS ver. 9.4 (SAS Institute Inc., Cary, NC) by SRL Medisearch Co., Ltd. (Tokyo, Japan).

Results

Participants. A total of 10,000 survey responses were enrolled; 5,023 from males and 4,977 from females. Eight hundred four males and 762 females were in their 20s; 952 and 927 were in their 30s; 1,197 and 1,168 were in their 40s; 988 and 983 were in their 50s; 1,082 and 1,137 were in their 60s. The most frequently reported health conditions were hypertension (n = 1,187), hyperlipidemia (n = 702), gastroduodenal ulcer (n = 597), hemorrhoidal disease (n = 455), and diabetes mellitus (n = 435). On the other hand, 7,182 participants had no reported health conditions.

Prevalence of constipation, GERD, C + GERD. Constipation was diagnosed in 3,804 participants (Table 1). GERD was identified in 1,223 participants (Table 1). There was C + GERD in 693 (group A), constipation only in 3,111 (group B), GERD only in 530 (group C), and neither constipation nor GERD in 5,666 (group D) (Table 1).

BSFS. The stool classifications were considered abnormal (BSFS 1, 2, 6, and 7) and normal (BSFS 3, 4, and 5), and compared by group (Table 2). Abnormal stools were more common in groups B and C than in group D (chi-square test for B vs D and C vs D, both p<0.001). In turn, abnormal stools were more common in group A than in groups B or C (chi-square test for A vs B and A vs C, both p<0.001) (Table 2).

Relationships between BMI and constipation, GERD, and C + GERD. Male BMI was significantly lower with constipation than without (p<0.0001) (Table 3). However, female BMI did not differ with and without constipation (Table 3). For both males and females, BMI was higher in GERD than without (p<0.0001) (Table 3). On comparison of all 4 groups, in the males, BMI in group C (GERD only) was significantly higher than in the other 3 groups (chi-square test for C vs A, p<0.0001; C vs B, p<0.01; C vs D, p<0.01; B vs D, p<0.01) (Table 3). BMI did not differ between groups A and B, or between groups A and D (Table 3). In the females, BMI in group C was also highest among the 4 groups. BMI was significantly higher in group C than in groups B and D (chi-square test for C vs B, p<0.0001; C vs D, p<0.01), but there was no significant difference between groups C and A (Table 3).

Relationships between BMI and BSFS. Stool type BSFS-4 was most common in both males and females (Table 4). BMI was highest in male participants with BSFS-6 and in females with BSFS-6. There were 3 participant groups: BSFS-1/2 (abnormal: hard or lumpy stool), BSFS-3/4/5 (normal stool), and BSFS-6/7 (abnormal: mushy or watery stool). The BMI of the male BSFS-6/7 group was the highest compared with that of the BSFS-1/2 and BSFS-3/4/5groups (chi-square test for BSFS-1/2 vs BSFS-6/7, p<0.001; BSFS-3/4/5 vs BSFS-6/7, p<0.05) (Table 5). The BMI of the female BSFS-6/7 group was also the highest compared with that of the BSFS-1/2 and BSFS-3/4/5 groups (chi-square test for BSFS-1/2 vs BSFS-6/7, p<0.0001; BSFS-3/4/5 vs BSFS-6/7, p<0.05) (Table 5). The BMI of the male BSFS-3/4/5 group was significantly higher than that of the BSFS-1/2 group (chi-square test for BSFS-1/2 vs BSFS-3/4/5, p<0.01) (Table 5). The BMI of the BSFS-3/4/5 group in the females was also significantly higher than that of BSFS-1/2 group (chi-square test for BSFS-1/2 vs BSFS-3/4/5, p<0.05) (Table 5). Thus, BMI showed an increasing spectrum from the BSFS-1/2 through BSFS-3/4/5 and then BSFS-6/7 groups in both males and females (Table 5).

Table 1. Numbers of participants with constipation and gastroesophageal reflux disease

	GERD*		Total
	With GERD	Without GERD	
Chronic constipation according to Japanese guidelines			
With constipation	693 (56.7%)	3,111 (35.4%)	3,804
Without constipation	530 (43.3%)	5,666 (64.6%)	6,196
Total	1,223	8,777	10,000

*GERD was diagnosed according to the GERD questionnaire [GerdQ]. Participants scoring 8 and more on the GerdQ were diagnosed as GERD. GERD, gastroesophageal reflux disease.

Table 2. Bristol Stool Form Scale according to the presence of chronic constipation and/or the presence of gastroesophageal reflux disease

	Chronic constipation/GERD				
	Group A: constipation and GERD (*n* = 693)	Group B: constipation only (*n* = 3,111)	Group C: GERD only (*n* = 530)	Group D: no constipation, no GERD (*n* = 5,666)	Total (*n* = 10,000)
BSFS score					
BSFS-1	74 (10.7)	286 (9.2)	15 (2.8)	65 (1.2)	440
BSFS-2	121 (17.5)	359 (11.5)	11 (2.1)	75 (1.3)	566
BSFS-3	184 (26.6)	832 (26.7)	32 (6.0)	378 (6.7)	1,426
BSFS-4	181 (26.1)	1,160 (37.3)	319 (60.2)	4,198 (74.1)	5,858
BSFS-5	73 (10.5)	335 (10.8)	99 (18.7)	693 (12.2)	1,200
BSFS-6	54 (7.8)	107 (3.4)	47 (8.9)	211 (3.7)	419
BSFS-7	6 (0.9)	32 (1.0)	7 (1.3)	46 (0.8)	91
BSFS-3/4/5	438 (63.2)	2,327 (74.8)	450 (84.9)	5,269 (93.0)	8,484
BSFS-1/2/6/7	255 (36.8)	784 (25.2)	80 (15.1)	397 (7.0)	1,516

GERD, gastroesophageal reflux disease; BSFS, Bristol Stool Form Scale.

Table 3. The relationship between body mass index and constipation, gastroesophageal reflux disease, or overlap of constipation and gastroesophageal reflux disease

n = 3,804		With constipation	Without constipation	*p* value
BMI (mean ± SD)	Male (*n* = 1,594)	23.34 ± 3.81	23.88 ± 3.54	<0.0001
	Female (*n* = 2,210)	21.2 ± 3.4	21.37 ± 3.53	ns
n = 1,223		With GERD	Without GERD	*p* value
BMI (mean ± SD)	Male (*n* = 663)	24.03 ± 3.84	23.31 ± 3.59	<0.0001
	Female (*n* = 560)	21.95 ± 4.09	20.9 ± 3.38	<0.0001

n = 10,000		Group A: constipation and GERD (*n* = 693)	Group B: constipation only (*n* = 3,111)	Group C: GERD only (*n* = 530)	Group D: no constipation, no GERD (*n* = 5,666)
BMI (mean ± SD)	Male	23.48 ± 3.76	23.57 ± 3.82	24.63 ± 3.84	23.89 ± 3.49
	Female	21.6 ± 3.9	20.75 ± 3.3	22.47 ± 4.34	21.38 ± 3.44
Number	Male	348 (50.2%)	1,246 (40.0%)	315 (59.4%)	3,114 (55.0%)
	Female	345 (49.8%)	1,865 (60.0%)	215 (40.6%)	2,552 (45.0%)

Participants were diagnosed as chronic constipation according to the Japanese guidelines. Participants were diagnosed as GERD based on GerdQ questionnaire (individuals who scored a total of 8 or more on the GerdQ questionnaire). *P* value was calculated using the Mann–Whitney *U* test. Male: group C vs group A, *p*<0.0001; group C vs group B, *p*<0.01; group C vs group D, *p*<0.01; group A vs group B, not significant; group A vs group D, not significant; group B vs group D, *p*<0.01. Female: group C vs group A, not significant; group C vs group B, *p*<0.0001; group C vs group D, *p*<0.01; group A vs group B, *p*<0.01; group A vs group D, not significant; group B vs group D, not significant. BMI, body mass index; GERD, gastroesophageal reflux disease; ns, not significant.

Table 4. The relationship between body mass index and Bristol Stool Form Scale

	BSFS-1	BSFS-2	BSFS-3	BSFS-4	BSFS-5	BSFS-6	BSFS-7
BMI (mean ± SD)							
Male	22.22 ± 3.47	22.78 ± 3.83	23.05 ± 3.55	23.55 ± 3.64	23.57 ± 3.38	23.97 ± 3.83	23.4 ± 4.10
Female	20.5 ± 2.77	20.96 ± 3.14	21.02 ± 3.21	21.41 ± 3.48	21.6 ± 3.97	22.02 ± 4.31	20.47 ± 2.87
Male and female	21.11 ± 3.14	21.63 ± 3.52	21.81 ± 3.49	22.52 ± 3.72	22.81 ± 3.74	23.2 ± 4.13	22.55 ± 4.00
Number							
Male	156	208	558	3,044	739	253	65
Female	284	358	868	2,814	461	166	26
Total	440	566	1,426	5,858	1,200	419	91

BMI, body mass index; BSFS, Bristol Stool Form Scale.

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Table 5. The relationship between body mass index and integrated Bristol Stool Form Scale

	BSFS-1/2	BSFS-3/4/5	BSFS-6/7
BMI (mean ± SD)			
Male	22.54 ± 3.69	23.49 ± 3.59	23.72 ± 3.99
Female	20.76 ± 2.99	21.35 ± 3.49	21.69 ± 4.41
Male and Female	21.4 ± 3.37	21.88 ± 3.7	23.0 ± 4.26
Number			
Male	364	4,341	318
Female	642	4,143	192
Total	1,006	8,484	510

Male: BSFS-1/2 vs BSFS-3/4/5, $p<0.01$; BSFS-1/2 vs BSFS-6/7, $p<0.001$; BSFS-3/4/5 vs BSFS-6/7, $p<0.05$. Female: BSFS-1/2 vs BSFS-3/4/5, $p<0.05$; BSFS-1/2 vs BSFS-6/7, $p<0.0001$; BSFS-3/4/5 vs BSFS-6/7, $p<0.05$. Male and female: BSFS-1/2 vs BSFS-3/4/5, $p<0.01$; BSFS-1/2 vs BSFS-6/7, $p<0.0001$; BSFS-3/4/5 vs BSFS-6/7, $p<0.0001$. *P* value was calculated using the Mann–Whitney *U* test. BMI, body mass index; BSFS, Bristol Stool Form Scale.

Table 6. The relationship between body mass index and educational level, and between educational level and the prevalence of constipation and/or gastroesophageal reflux disease

Final education	Junior high school	High school	Vocational college or junior college	4-year university (college)	Graduate education	Unknown (no declaration)
Number	187	2,743	2,306	4,153	540	71
BMI (mean ± SD)	23.30 ± 4.57	22.62 ± 3.82	21.98 ± 3.78	22.36 ± 3.45	22.51 ± 3.66	23.47 ± 5.26
With/without constipation (constipation rate)	82/105 (43.9%)	1,043/1,700 (38.0%)	954/1,352 (41.4%)	1,524/2,629 (36.7%)	163/377 (30.2%)	38/33 (53.5%)
With/without GERD (GERD rate)	27/160 (14.4%)	337/2,406 (12.3%)	281/2,025 (12.2%)	518/3,635 (12.5%)	53/487 (9.8%)	7/64 (9.9%)
Overlap of constipation and GERD	15 (8%)	190 (6.9%)	167 (7.2%)	286 (6.9%)	30 (5.6%)	5 (7%)
Constipation only	67 (35.8%)	853 (31.1%)	787 (34.1%)	1,238 (29.8%)	133 (24.6%)	33 (46.5%)
GERD only	12 (6.4%)	147 (5.36%)	114 (4.9%)	232 (5.6%)	23 (4.3%)	2 (2.8%)
Neither constipation or GERD	93 (49.7%)	1,553 (56.6%)	1,238 (53.7%)	2,397 (57.7%)	354 (65.6%)	31 (43.7%)

BMI; junior high school vs high school, vocational college or junior college, 4-year university (college), or graduate education, $p<0.0001$; high school vs vocational college or junior college, $p<0.001$; high school vs 4-year university (college) or graduate education, $p<0.0001$; vocational college or junior college vs 4-year university (college) or graduate education, $p<0.0001$; 4-year university (college) vs graduate education, $p<0.0001$. *P* value was calculated using the Mann–Whitney *U* test. With/without constipation; junior high school or high school vs graduate education, $p<0.01$; high school vs vocational college or junior college, $p<0.05$; junior college vs 4-year university (college) or graduate education, $p<0.01$; 4-year university (college) vs graduate education, $p<0.01$. *P* value was calculated using the chi-square test. Constipation only; graduate education vs junior high school, $p<0.01$; graduate education vs high school, $p<0.01$; graduate education vs vocational college or junior college, $p<0.001$; graduate education vs 4-year university (college), $p<0.05$. BMI, body mass index; BSFS, Bristol Stool Form Scale; GERD, gastroesophageal reflux disease.

Relationships among education level, BMI, constipation, and GERD. BMI was the highest in individuals finishing education at the junior high school (JHS) level and the second highest in those finishing at high school (HS) (Table 6). BMI was lowest in those completing education at the vocational or junior college (VJC) levels ($p<0.0001$) (Table 6). Significant associations included: JHS vs HS, VJC, 4-year university/college (4YU), and graduate/post-graduate education (PGE) ($p<0.0001$); HS vs VJC ($p<0.001$); HS vs 4YU and PGE ($p<0.0001$); VJC vs 4YU and PGE ($p<0.0001$); 4YU vs PGE ($p<0.0001$) (Table 6).

Constipation rate was highest in JHS, but there was no significant difference among JHS, HS, VJC, and 4YU. Constipation rate was lowest in PGE compared with JHS, HS, VJC, and 4YU ($p<0.01$) (Table 6).

GERD rate was highest in JHS and lowest in PGE, but there was no significant difference among JHS, HS, VJC, 4YU, and PGE (Table 6).

The rate of C + GERD was highest in JHS and lowest in PGE. However, there was no significant difference among JHS, HS, VJC + 4YU, and PGE. The rate of constipation only was highest in JHS, and the rate of constipation only was significantly lowest in PGE compared with JHS, HS, VJC, and 4YU (PGE vs JHS, $p<0.01$; PGE vs HS, $p<0.01$; PGE vs VJC, $p<0.001$; PGE vs 4YU, $p<0.05$) (Table 6). The rate of GERD only was highest in JHS and lowest in PGE. However, there was no significant difference in GERD only among JHS, HS, VJC, 4YU, and PGE (Table 6).

Discussion

This study was an internet survey in Japan conducted to examine the prevalence of constipation, GERD, and the overlapping combination of the 2, and to relate those conditions to BMI and stool form status according to the BSFS. Moreover, various relationships among BMI, constipation, GERD, stool forms, and education level in Japan were evaluated. The relationship between BMI and detailed stool forms with the BSFS and the relationships among education level, BMI, constipation, and

GERD have not been previously reported, and this is the first real-world survey to investigate these in Japan.

Of 10,000 participants, 3,804 (38.04%) were constipated; this result was similar to a previous report in Japan.[4] GERD was identified in 1,223 (12.23%) participants, and this result was also similar to a previous report in Japan.[6] Concomitant constipation and GERD were identified in 693 (6.93%) individuals. Of 1,223 participants with GERD, 693 (56.7%) participants had constipation. A previous study in the United States found that 28.3% of patients with GERD had constipation.[7] Our study found twice as many, and this might reflect differences in race and ethnicity.

In our current study, BMI was significantly lower in the males with versus without constipation. This difference was not evident in females. Although the relationship between constipation and lifestyle behaviors like excessive alcohol consumption, an unhealthy diet, smoking, and insufficient exercise has also been reported,[17,18] a recent review and many previous reports have disputed the association between constipation and obesity or high BMI.[22–27] Our findings in females are similar to those conclusions. However, our male BMI was related to constipation. There could be a constitutional sex-related difference in Japan compared with other countries, or this outcome might be demonstrated by the cytokines theory. According to this theory, obesity is considered to be a chronic inflammatory condition in which several cytokines regulate important roles in the pathogenesis of GI sensitivity and motility.[36]

BMI was significantly correlated with GERD in both males and females in our study. Obesity and high BMI have consistently been related to a high prevalence of GERD.[28–31] Our results correspond to those reports. This condition could be caused by a pressure difference between the lower esophageal sphincter and the abdomen. An increase in intra-abdominal pressure might lead to gastric acid flowing back into the esophagus.[37]

On comparison of the 4 groups C + GERD, constipation alone, GERD alone, and neither constipation nor GERD, BMI was highest in the group with GERD alone. To our knowledge, there have been no reports to date about the relationship between BMI and C + GERD, nor have there been comparisons of BMI among groups of individuals with C + GERD, constipation alone, GERD alone, and neither constipation or GERD. BMI was lower in the C + GERD versus GERD alone groups, and the additional constipation might be a factor in decreasing BMI. The clinical significance of our results may require further investigation.

The stool forms BSFS-3/4/5 were defined generally as normal, and forms BSFS-1/2/6/7 as abnormal. The stool forms of BSFS-1/2 were hard or lumpy, and those of BSFS-6/7 were mushy or watery. In our results, the BMI was significantly highest in both males and females of the BSFS-6/7 group compared with the BSFS-1/2 and BSFS-3/4/5 groups. The BMI was significantly lowest in the males and females of the BSFS-1/2 group compared with the BSFS-3/4/5 and BSFS-6/7 groups. Thus, BMI followed an increasing curve from the BSFS-1/2 through BSFS-3/4/5 and on to BSFS-6/7 groups for both males and females. Several studies have shown a significant correlation between higher BMI and diarrhea and a negative correlation with constipation.[13,38–40] Alkhowaiter, *et al.*[23] reported an association of increased BMI with diarrhea, and no association with constipation.[13,38–40] Our results on BMI and diarrhea were similar to those of previous reports. The pathophysiology of diarrhea in individuals with obesity could be related with several potential mechanisms such as dietary habits, dairy activities, and lifestyle behaviors, which may accelerate colonic transit time,[21] intestinal inflammation, and changes in bile acids.[41]

The Japan Society for the Study of Obesity defined a BMI of 22 as normal, 25 and more as obese, and less than 18.5 as underweight in Japan. In our study, the mean BMI in the BSFS-1/2, BSFS-3/4/5, BSFS-6/7 groups was around 22 for both males and females. Thus, the mean was normal as a whole, but there was a wide individual BMI range from 13.5 to 46.8 in males and 12.3 to 46.4 in females. In our real-world survey in Japan, 10,000 eligible participants were enrolled after adjustments were made reflecting the general Japanese population's location, gender, and age composition.[33] However, individual characteristics other than gender and age were not adjusted. If a person with low BMI regained his/her body weight, for example, his/her stool may become normalized. Similarly, if a person with high BMI loses significant body weight, his/her stool may also become normalized.

BMI was significantly highest in individuals with an education level of JHS and significantly second highest in individuals of HS education. BMI decreased from JHS through HS, PGE, 4YU, and was lowest in those educated to the VJC level. There have been reports from other countries that associate lower education with higher BMI.[42,43] Our results in Japan were similar. Education level is thought to affect BMI not only in Japan but also worldwide.

Constipation rate was also highest in the JHS group and was significantly lowest in the PGE group compared with that of the JHS, HS, VJC, and 4YU groups. However, GERD rates did not significantly differ among JHS, HS, VJC, 4YU, and PGE. Education level has been considered related to constipation as well as high BMI but not GERD in Japan. It is known to be related both with leisure-time physical activity (LTPA) and sitting time,[44,45] and individuals with higher education achieve more LTPA compared to those with lower education.[46] Lower LTPA is thought to cause body weight gain and fewer bowel movements, resulting in higher BMI and higher frequency of constipation.

Limitations of this study include the reliance on self-reported information without confirmation from medical records. Additionally, individuals over 70 years of age may not have been appropriately represented in the study population because participants required internet access to participate. Finally, this survey in our study was conducted within Japan and further validation of survey data in non-Japanese individuals is warranted.

This is the first real-world survey to examine, in detail, the relationship between BMI and stool forms in individuals in Japan. In Japan, higher BMI resulted in watery stool forms, and lower BMI resulted in hard stool forms.

Statement of Ethics

This internet-based survey was registered with the University Hospital Medical Information Network in Japan (Trial registration: UMIN000039688). The Ethics Review Committee of Aichi Medical University approved the study's implementation (Approval No. 2019-179). The study was conducted in accordance with the Declaration of Helsinki by the World Medical Association and the Ethical Guidelines for Medical Research (established on December 22, 2014) by the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labor, and Welfare of Japan. All participants in this study provided informed consent for survey participation.

Author Contributions

Conceptualization: NO, KK, YF, and ME; methodology, formal analysis, and investigation: NO, YF, SI, YT, AK, YY, KA, and TS; writing – original draft preparation: NO; writing – review and editing: NO, YF, KK, and MS; and funding acquisition, resources, and supervision: KK.

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Abbreviations

BMI	body mass index
BSFS	Bristol Stool Form Scale
C + GERD	constipation and gastroesophageal reflux disease
GERD	gastroesophageal reflux disease
GI	gastrointestinal
HS	high school
IBS	irritable bowel syndrome
JHS	junior high school
PGE	graduate/post-graduate education
VJC	vocational or junior college
4YU	4-year university/college

Conflict of Interest

NO received expenses reimbursement related to this study from EA Pharma Co., Ltd. KK received expenses reimbursement related to this study from EA Pharma Co., Ltd.; research funding from EA Pharma Co., Ltd.; and scholarship donations from AstraZeneca and Daiichi Sankyo Co., Ltd.

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