CEP Clinical and Experimental Pediatrics [Epub ahead of print]
https://doi.org/10.3345/cep.2026.01347

Original article

Frequent energy drink consumption and associated factors among Japanese adolescents

Tomomi Miyoshi, PhD[1], Yuichiro Otsuka, MD, PhD[1], Yuki Tanaka, PhD[1], Suguru Nakajima, MD, PhD[2], Yoshitaka Kaneita, MD, PhD[1]

[1]Division of Public Health, Department of Social Medicine, Nihon University School of Medicine, Tokyo, Japan; [2]Department of Psychiatry, Division of Psychiatry, Nihon University School of Medicine, Tokyo, Japan

Background: Frequent energy drink consumption among adolescents is a public health concern; however, the associated factors and detailed consumption patterns among Japanese adolescents remain poorly characterized.
Purpose: We estimated the prevalence of frequent energy drink consumption and examined its associated factors and consumption patterns among Japanese high school students.
Methods: We conducted this school-based cross-sectional survey from April to June 2024 in 19 high schools in western Japan (n=6,764). Frequent consumption was defined as intake on ≥6 days during the past 30 days. In this study, the term "energy drink consumption" referred to the consumption of tonic drinks, energy drinks, or both. Multivariable logistic regression models were used to examine the associations with beverage-related perceptions, caffeine interest, advertising exposure, lifestyle habits, gaming disorder, and depressive symptoms. Among current consumers, defined as students reporting energy drink consumption on ≥1 day during the past 30 days, we analyzed age at first consumption, amount consumed per occasion, and usual consumption timing. Sex-stratified and sex-by-factor interaction analyses were exploratory.
Results: Overall, 79.3% of the students reported consuming energy drinks at least once, and 11.5% reported frequent consumption. In the primary model, frequent consumption was associated with male sex; energy drinks being perceived as making one feel energetic or relaxed; less frequent breakfast consumption; exercising ≥5 days/wk; supplement use; and presence of a gaming disorder. Perceiving energy drinks as unhealthy was inversely associated with frequent consumption. Exploratory interaction analyses suggested possible sex-related heterogeneity in the associations with caffeine interest and breakfast consumption and, among current consumers, consumption timing. Among current consumers, higher per-occasion intake and consumption upon waking or in the morning were associated with frequent consumption.
Conclusion: Among Japanese high school students, 79.3% had consumed energy drinks at least once, and 11.5% reported frequent consumption (≥6 days during the past 30 days). Frequent consumption was associated with beverage-related perceptions, lifestyle habits, and gaming disorder. Among current consumers, a higher per-occasion intake and consumption upon waking or in the morning were also associated with frequent consumption. These findings identified factors and consumption patterns that warrant attention in pediatric public health and school-based health education; however, their causal and clinical implications require confirmation.

Key words: Adolescent, Energy drinks, Caffeine, Internet addiction disorder, Japan

Key message

Question: What factors are associated with frequent energy drink consumption among Japanese adolescents?
Finding: Most students (79.3%) in this study reported consuming energy drinks at least once; 11.5% reported frequent consumption. Associated factors included beverage-related perceptions, infrequent breakfast consumption, supplement use, and gaming disorder. Among current consumers, greater per-occasion intake and morning consumption were associated with frequent consumption.
Meaning: School-based education may address caffeine effects, perceived benefits and harms, and morning use.

Introduction

Energy drinks are widely consumed by adolescents[1,2] and are associated with adverse physical, psychological, and behavioral outcomes.[1] A systematic review of 192

Corresponding author: Yuichiro Otsuka, MD, PhD. Division of Public Health, Department of Social Medicine, Nihon University School of Medicine, 1-6 Kanda Surugadai, Chiyoda-ku, Tokyo 101-8309, Japan
✉ Email: otsuka.yuichiro@nihon-u.ac.jp, https://orcid.org/0000-0001-8247-9235
Received: 22 May 2026, Revised: 10 October 2026, Accepted: 18 October 2026

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.
Copyright © 2026 by The Korean Pediatric Society

studies involving 1,120,613 participants reported prevalence estimates of 43.4%, 32.3%, and 21.6% over the past 12 months, 30 days, and 7 days, respectively.[2] These products commonly contain caffeine and are marketed or perceived as increasing alertness, improving concentration, and reducing fatigue.[1,3,4] Excessive caffeine intake is associated with adverse effects, including anxiety, insomnia, and headache.[5]

Energy drink consumption is more common among boys and is associated with short sleep duration and other health-risk behaviors.[6,7] Furthermore, frequent consumers are more likely to skip breakfast and report poorer self-rated health, multiple health complaints, psychological distress, and suicide-related indicators.[8-10] A longitudinal study reported that frequent energy drink consumption in early adolescence may be associated with greater alcohol consumption later in adolescence.[11] These findings link frequent energy drink consumption with unfavorable lifestyle and psychosocial characteristics.

Individual perceptions and the social environment may influence energy drink consumption. Among 2,613 seventh-grade students in Taiwan, approximately 75% reported exposure to online energy drink advertisements during the previous year. Excessive gaming and exposure to online energy drink advertising were positively associated with scores on a single-item energy drink consumption measure.[12]

Studies have reported associations between energy drink consumption and lifestyle habits, psychosocial factors, advertising exposure, and gaming-related behaviors [8,9,12]; however, these domains have been examined separately. Consequently, which factors remain independently associated with frequent consumption when considered simultaneously in the same adolescent population remains unclear. Beverage-related perceptions and caffeine interest may be relevant to health education because they reflect adolescents' expectations and understanding of energy drinks. Supplement use may indicate interest in physical performance or self-management, but its association with frequent consumption remains unclear. Consumption patterns, including age at first consumption, amount consumed per occasion, and timing, are poorly characterized among Japanese adolescents.

We aimed to estimate the prevalence of frequent energy drink consumption and identify associated factors, including beverage-related perceptions, caffeine interest, advertising exposure, lifestyle habits, gaming disorder, and depressive symptoms. Among consumers, we examined age at first consumption, amount consumed per occasion, and timing of consumption. Sex-stratified and sex-by-factor interaction analyses were exploratory. These findings may inform pediatric public health and school-based health education.

Methods

1. Study design and participants

Between April and June 2024, 7,187 students attending 19 participating high schools in a single prefecture in western Japan were eligible for our survey. This was a school-based cross-sectional study using nonprobability sampling. Of the 25 high schools invited through the researchers' network of collaborating schools, 19 agreed to participate. All students enrolled at the participating schools were invited to participate. After school principals approved participation, school nurses were asked to assist with study implementation. Students received an explanation of the study and voluntarily consented to complete the anonymous survey. Parents or guardians were informed and could decline their child's participation. The Ethics Committee of the Nihon University School of Medicine approved the study (Approval No. 2023-13; January 24, 2024), which was conducted in accordance with the Declaration of Helsinki.

A total of 6,951 questionnaires were returned, and 6,865 students consented to participate. Among the 6,845 students who answered the lifetime energy drink consumption question, 54 who selected "other" for sex and 7 with missing sex data were excluded, leaving 6,784 participants. A further 20 participants with missing consumption-frequency data were excluded, yielding 6,764 participants with available outcome data.

2. Questionnaire

The anonymous, self-administered questionnaire collected information on participant characteristics, energy drink consumption history and patterns, perceived effects and beliefs, caffeine interest, advertising exposure, lifestyle factors, gaming disorder, and depressive symptoms.

Before answering the consumption questions, participants were informed that the questions concerned "tonic drinks or energy drinks" and were shown representative products from both categories. We defined "energy drink consumption" as consuming either or both beverage categories.

3. Energy drink consumption

Lifetime consumption was assessed by asking whether participants had consumed a tonic drink or an energy drink at least once. Participants who answered "yes" were classified as ever consumers, regardless of missing responses to subsequent consumption-pattern items.

Accepted Article

Ever consumers were asked how many days they had consumed either type during the past 30 days. Response options were 0 days, 1–2 days, 3–5 days, 6–9 days, 10–19 days, and ≥20 days. For frequency analyses, participants who reported no lifetime consumption were assigned 0 days of consumption during the past 30 days.

Previous studies have reported thresholds such as at least once per week to define regular or frequent consumption,[7,8] whereas a European Food Safety Authority (EFSA)-commissioned survey defined high chronic consumption among adolescents as consumption on at least 4–5 days/wk.[13] We operationally defined frequent consumption as intake on ≥6 days during the past 30 days because this was the lowest response category representing consumption on at least 6 days. This cutoff distinguished frequent from less frequent consumption but was not intended to correspond to the EFSA definition of high chronic consumption.

Ever consumers were asked about their age at first consumption, amount consumed per occasion, and most common time of consumption. Age at first consumption was categorized as ≤10, 11–12, 13–14, or ≥15 years. Response options for amount consumed per occasion were "currently do not drink," less than 1 bottle/can, 1 bottle/can, and 2 or more bottles/cans. In analyses restricted to current consumers, amount consumed per occasion was categorized as less than 1 bottle/can, 1 bottle/can, or 2 or more bottles/cans. The most common time of consumption was categorized as upon waking, morning, daytime, evening, or night/late night.

4. Perceived effects/beliefs regarding energy drinks and interest in caffeine

Perceived effects and beliefs were assessed using 6 items: "feel mentally sharp," "feel more positive/motivated," "feel energetic," "feel relaxed," "believe it is nutritious," and "believe it is unhealthy." Each item was rated on a four-point scale. Responses of "somewhat agree" or "strongly agree" were categorized as "yes," and responses of "do not agree very much" or "do not agree at all" were categorized as "no."

The items were analyzed separately because they were not developed as a validated composite scale and represented distinct expected effects and health-related beliefs. Item-specific associations were considered potentially relevant to health education. Caffeine interest was assessed by asking, "Are you interested in caffeine?" with "yes" or "no" response options. This item captured general self-reported interest in caffeine; no specific aspect of caffeine interest was defined.

5. Advertising exposure

Participants selected all media through which they had seen energy drink advertisements during the past 30 days: websites or video-sharing platforms, television, in-store posters at convenience stores or supermarkets, and advertisements in stations, trains, or buses. They could select "I did not see any advertisements" or "I saw advertisements but do not remember where."

Advertising exposure was categorized according to the number of identifiable sources selected: 0, 1, or ≥2. Participants selecting at least one identifiable source were classified according to the number selected, even if they chose either additional response option. Participants selecting no identifiable source but choosing "I did not see any advertisements" or "I saw advertisements but do not remember where" were classified as having 0 identifiable sources. Participants who selected none of the response options were treated as having missing data.

6. Lifestyle factors

Breakfast consumption was categorized as almost daily, sometimes, or rarely. Exercise was categorized according to the number of days during the previous week on which participants engaged in sports or exercise for at least 1 h: 0–2, 3–4, or ≥5 days. Supplement use during the past 30 days was categorized as no use (0 days) or any use (≥1 day).

7. Gaming disorder

Gaming disorder was assessed using the nine-item Gaming Engagement Screener (GAMES) test, which was developed and validated for Japanese youth based on the concept of gaming disorder in the International Classification of Diseases, 11th Revision.[14] Item scores were summed; a total score of ≥5 indicated gaming disorder. Status was calculated only for participants who completed all 9 items; one or more missing responses resulted in missing gaming disorder status.

8. Depressive symptoms

Depressive symptoms were assessed using the nine-item Patient Health Questionnaire for Adolescents (PHQ-A)[15]. Total scores range from 0 to 27, with higher scores indicating greater symptom severity. A score of ≥10 indicated depressive symptoms, consistent with a validation study in a multiethnic Asian adolescent population.[16]

9. Statistical analysis

Participant characteristics were summarized as counts and percentages and compared according to frequent consumption status (<6 vs. ≥6 days during the past 30 days) using Pearson chi-square tests. Participants with missing data for a given variable were excluded from the

Accepted Article

corresponding comparison. Univariable and multivariable logistic regression models used frequent consumption as the dependent variable and estimated crude odds ratios (ORs), adjusted ORs (aORs), and 95% confidence intervals (CIs).

The primary multivariable model included sex, grade, the 6 perceived effects and beliefs, caffeine interest, advertising exposure, breakfast consumption, exercise, supplement use, gaming disorder, and depressive symptoms. School type (public vs. private) was included as an adjustment variable. Variance inflation factors were used to assess multicollinearity.

Participants with missing consumption-frequency data were excluded from all frequent-consumption analyses. Descriptive analyses included 6,764 participants. Univariable analyses excluded missing data separately for each explanatory variable, whereas the primary multivariable analysis included 4,996 complete cases. The primary model, excluding sex, was fitted separately for boys and girls, including 2,375 and 2,621 participants, respectively.

Sex-stratified and sex-by-factor interaction analyses were considered exploratory. Each factor was evaluated in a separate multivariable model containing sex, the factor, the corresponding sex-by-factor interaction term, and the remaining covariates from the primary model. For factors with more than 2 categories, all interaction terms were entered simultaneously. Overall interaction *P* values were obtained using likelihood-ratio tests, and category-specific interaction estimates and *P* values were obtained using Wald tests. Girls were the reference category; therefore, each interaction aOR represented the ratio of the corresponding category-specific OR among boys to that among girls.

To evaluate potential selection bias arising from complete-case analysis, we compared participants included in and excluded from the primary analysis among the 6,764 participants with available outcome data using Pearson chi-square tests.

As a sensitivity analysis addressing missing covariate data, multiple imputation by chained equations was performed among all 6,764 participants with outcome data. Missing values in ordinal and binary covariates were imputed using ordered logistic regression and logistic regression, respectively. Fifty imputed datasets were generated with a burn-in of 10 iterations. Before generating the imputed datasets, convergence was assessed by visually inspecting trace plots of the means and standard deviations of the imputed variables over 100 preliminary iterations; no systematic trends were observed. The imputation model included the outcome and all variables in the primary model, including school type, and estimates were pooled using Rubin rules. This analysis assumed that data were missing at random conditional on the variables included in the imputation model.

To assess the robustness of results to the operational outcome cutoff, the primary model was repeated using consumption on ≥10 and ≥20 days during the past 30 days as progressively stricter outcomes. Both analyses used the same 4,996 complete cases. Alternative frequency thresholds were used because the primary outcome measured frequency rather than amount consumed.

Consumption patterns were analyzed separately among current consumers, defined as participants reporting energy drink consumption on ≥1 day during the past 30 days. Within this sample, frequent consumers (≥6 days) were compared with participants who consumed energy drinks on 1–5 days. Models evaluating age at first consumption, amount consumed per occasion, and most common time of consumption were fitted in the total current-consumer sample and separately by sex. The total-sample model included sex, grade, the 3 consumption-pattern variables, and school type; sex-stratified models omitted sex. Among 3,001 current consumers, 54 with missing data for at least one variable in the consumption-pattern model were excluded, leaving 2,947 complete cases (1,645 boys and 1,302 girls). The primary and current-consumer complete-case samples were derived independently from the descriptive analytic sample using different sets of required variables; therefore, the current-consumer complete-case sample was not a subset of the primary complete-case sample. Exploratory sex-by-factor interaction analyses used the same sample and covariates.

All analyses, except the multiple-imputation analysis, were performed using IBM SPSS Statistics ver. 31.0 (IBM Corp., USA). The multiple-imputation analysis was performed using Stata 17 (StataCorp, USA). Statistical significance was set at $P<0.05$ (2-sided).

Accepted Article

Results

1. Participant characteristics

Participant selection and analytic samples are shown in Fig. 1. Table 1 summarizes the 6,764 participants (3,324 boys [49.1%] and 3,440 girls [50.9%]) with available consumption-frequency data. Overall, 5,365 participants (79.3%) had consumed energy drinks at least once, 779 (11.5%) reported frequent consumption, and 1,399 (20.7%) had never consumed energy drinks.

2. Factors associated with frequent consumption

Table 2 shows the univariable and multivariable results. In the adjusted model, frequent consumption was

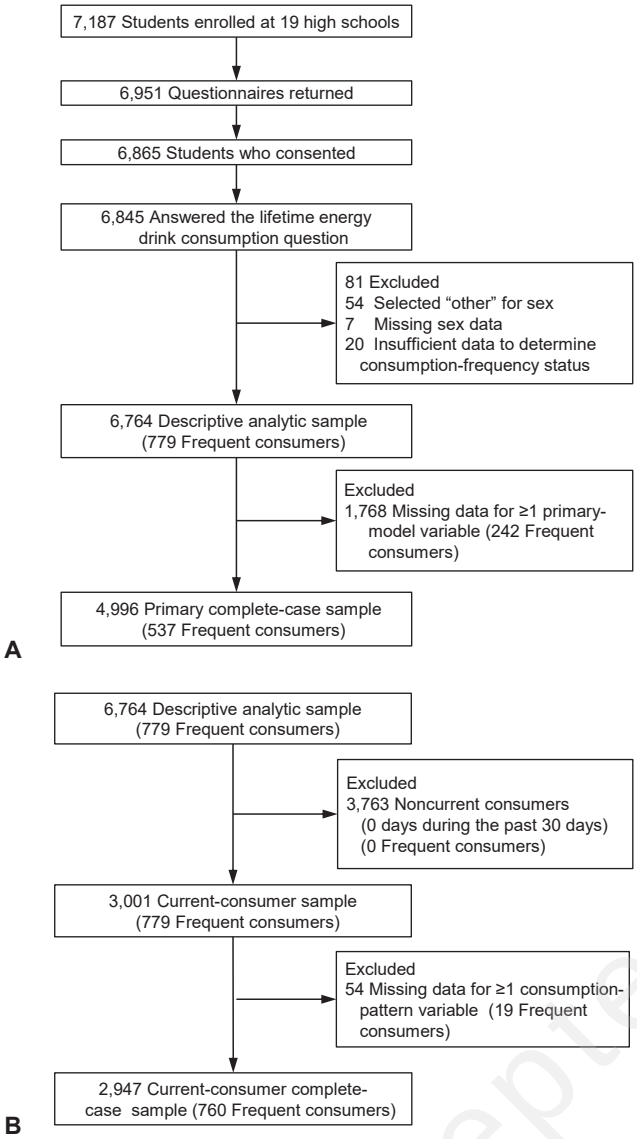


Fig. 1. Participant flow and derivation of the analytic samples. Panel A presents the primary descriptive analysis and derivation of the primary complete-case sample, whereas Panel B presents the derivation of the current-consumer complete-case sample. Both samples were independently derived from the same descriptive analytic sample. Because the primary and consumption-pattern models required different sets of variables, resulting in different missing-data exclusions, the current-consumer complete-case sample was not a subset of the primary complete-case sample. Energy drink consumption was defined as the consumption of tonic drinks, energy drinks, or both. Frequent consumers were defined as participants reporting energy drink consumption on ≥6 days during the past 30 days, current consumers as those reporting such consumption on ≥1 day, and noncurrent consumers as those reporting 0 days during the same period.

Table 1. Participant characteristics according to energy drink consumption frequency (N=6,764)

Characteristic	Total	<6 Days	≥6 Days	*P* value
Total	6,764 (100)	5,985 (100)	779 (100)	
Sex				<0.001
Boy	3,324 (49.1)	2,818 (47.1)	506 (65.0)	
Girl	3,440 (50.9)	3,167 (52.9)	273 (35.0)	
Age (yr)				0.006
15	2,542 (37.6)	2,215 (37.0)	327 (42.0)	
16	1,953 (28.9)	1,732 (28.9)	221 (28.4)	
17	1,934 (28.6)	1,747 (29.2)	187 (24.0)	
18	308 (4.6)	266 (4.4)	42 (5.4)	
Missing	27 (0.4)	25 (0.4)	2 (0.3)	
Grade				0.079
Grade 10	2,960 (43.8)	2,592 (43.3)	368 (47.2)	
Grade 11	1,881 (27.8)	1,678 (28.0)	203 (26.1)	
Grade 12	1,883 (27.8)	1,684 (28.1)	199 (25.5)	
Missing	40 (0.6)	31 (0.5)	9 (1.2)	
Energy drink consumption and consumption patterns				
Lifetime energy drink consumption				—
Ever	5,365 (79.3)	4,586 (76.6)	779 (100)	
Never	1,399 (20.7)	1,399 (23.4)	0 (0)	
Age (yr) at first consumption of energy drinks				—
Never consumed	1,399 (20.7)	1,399 (23.4)	0 (0.0)	
≤10	1,529 (22.6)	1,270 (21.2)	259 (33.2)	
11–12	1,722 (25.5)	1,451 (24.2)	271 (34.8)	
13–14	1,250 (18.5)	1,098 (18.3)	152 (19.5)	
≥15	855 (12.6)	759 (12.7)	96 (12.3)	
Missing	9 (0.1)	8 (0.1)	1 (0.1)	
Amount consumed per occasion				—
Never consumed	1,399 (20.7)	1,399 (23.4)	0 (0.0)	
Currently do not drink	334 (4.9)	334 (5.6)	0 (0.0)	
Less than 1 bottle/can	486 (7.2)	452 (7.6)	34 (4.4)	
1 bottle/can	4,341 (64.2)	3,677 (61.4)	664 (85.2)	
2 or more bottles/cans	189 (2.8)	113 (1.9)	76 (9.8)	
Missing	15 (0.2)	10 (0.2)	5 (0.6)	
Most common time of consumption				—
Never consumed	1,399 (20.7)	1,399 (23.4)	0 (0.0)	
Upon waking	166 (2.5)	133 (2.2)	33 (4.2)	
Morning	228 (3.4)	173 (2.9)	55 (7.1)	
Daytime	1,839 (27.2)	1,618 (27.0)	221 (28.4)	
Evening	1,164 (17.2)	989 (16.5)	175 (22.5)	
Night/late night	1,909 (28.2)	1,619 (27.1)	290 (37.2)	
Missing	59 (0.9)	54 (0.9)	5 (0.6)	
Lifestyle factors				
Breakfast consumption				<0.001
Almost daily	5,610 (82.9)	5,018 (83.8)	592 (76.0)	
Sometimes	668 (9.9)	566 (9.5)	102 (13.1)	
Rarely	467 (6.9)	385 (6.4)	82 (10.5)	
Missing	19 (0.3)	16 (0.3)	3 (0.4)	
Exercise habit (days/wk)				<0.001
0–2	2,167 (32.0)	1,965 (32.8)	202 (25.9)	
3–4	1,666 (24.6)	1,500 (25.1)	166 (21.3)	
5 or more	2,920 (43.2)	2,511 (42.0)	409 (52.5)	
Missing	11 (0.2)	9 (0.2)	2 (0.3)	

(continued)

Accepted Article

Table 1. Participant characteristics according to energy drink consumption frequency (N=6,764) (Continued)

Characteristic	Total	<6 Days	≥6 Days	*P* value
Perceived effects/beliefs about energy drinks				
Feel mentally sharp				0.643
No	3,159 (46.7)	2,801 (46.8)	358 (46.0)	
Yes	3,497 (51.7)	3,088 (51.6)	409 (52.5)	
Missing	108 (1.6)	96 (1.6)	12 (1.5)	
Feel more positive/motivated				<0.001
No	4,446 (65.7)	4,018 (67.1)	428 (54.9)	
Yes	2,199 (32.5)	1,863 (31.1)	336 (43.1)	
Missing	119 (1.8)	104 (1.7)	15 (1.9)	
Feel energetic				<0.001
No	3,141 (46.4)	2,865 (47.9)	276 (35.4)	
Yes	3,504 (51.8)	3,013 (50.3)	491 (63.0)	
Missing	119 (1.8)	107 (1.8)	12 (1.5)	
Feel relaxed				<0.001
No	5,621 (83.1)	5,051 (84.4)	570 (73.2)	
Yes	1,012 (15.0)	818 (13.7)	194 (24.9)	
Missing	131 (1.9)	116 (1.9)	15 (1.9)	
Believe it is nutritious				<0.001
No	4,579 (67.7)	4,097 (68.5)	482 (61.9)	
Yes	2,054 (30.4)	1,774 (29.6)	280 (35.9)	
Missing	131 (1.9)	114 (1.9)	17 (2.2)	
Believe it is unhealthy				<0.001
No	2,218 (32.8)	1,882 (31.4)	336 (43.1)	
Yes	4,435 (65.6)	4,004 (66.9)	431 (55.3)	
Missing	111 (1.6)	99 (1.7)	12 (1.5)	
Interest in caffeine				<0.001
No	5,074 (75.0)	4,546 (76.0)	528 (67.8)	
Yes	1,669 (24.7)	1,419 (23.7)	250 (32.1)	
Missing	21 (0.3)	20 (0.3)	1 (0.1)	
Other covariates				
Advertising exposure				0.047
0 identifiable sources	2,170 (32.1)	1,943 (32.5)	227 (29.1)	
1 identifiable source	2,601 (38.5)	2,306 (38.5)	295 (37.9)	
2 or more identifiable sources	1,970 (29.1)	1,716 (28.7)	254 (32.6)	
Missing	23 (0.3)	20 (0.3)	3 (0.4)	
Supplement use				<0.001
No	4,921 (72.8)	4,420 (73.9)	501 (64.3)	
Yes	1,753 (25.9)	1,489 (24.9)	264 (33.9)	
Missing	90 (1.3)	76 (1.3)	14 (1.8)	
Gaming disorder				<0.001
No	4,515 (66.8)	4,078 (68.1)	437 (56.1)	
Yes	762 (11.3)	617 (10.3)	145 (18.6)	
Missing	1,487 (22.0)	1,290 (21.6)	197 (25.3)	
Depressive symptoms				0.001
No	5,416 (80.1)	4,827 (80.7)	589 (75.6)	
Yes	1,223 (18.1)	1,050 (17.5)	173 (22.2)	
Missing	125 (1.8)	108 (1.8)	17 (2.2)	

Values are presented as number (%).
Participants for whom consumption frequency data were missing (n=20) were excluded.
P values were calculated using Pearson chi-square tests after the exclusion of participants for whom data were missing for the variable concerned. P values were not calculated for energy drink consumption or consumption-pattern variables because some categories were structurally determined by consumption status. Frequent consumption was defined as intake on ≥6 days during the past 30 days. "Currently do not drink" was a response option for amount consumed per occasion among ever consumers. Advertising exposure was categorized according to the number of identifiable sources. Gaming disorder was defined as a score of ≥5 on the nine-item Gaming Engagement Screener Test, and depressive symptoms were defined as a score of ≥10 on the Patient Health Questionnaire for Adolescents. Percentages may not total 100% because of rounding.

associated with male sex, feeling energetic or relaxed, less frequent breakfast consumption, exercising ≥5 days/wk, supplement use, and gaming disorder, and was inversely associated with perceiving energy drinks as unhealthy. Grade, caffeine interest, advertising exposure, and depressive symptoms showed no significant associations. Variance inflation factors ranged from 1.08 to 1.42 for the 6 perceived effects and beliefs, and the maximum value across all variables was 1.58, indicating no problematic multicollinearity.

The 4,996 participants included in the primary complete-case analysis differed from the 1,768 excluded participants with respect to sex, grade, frequent consumption, breakfast consumption, several beverage-related perceptions, advertising exposure, gaming disorder, and depressive symptoms (Supplementary Table 1). Accordingly, selection bias related to complete-case analysis cannot be excluded.

After multiple imputation of data from 6,764 participants, the directions and magnitudes of the principal associations were consistent with the complete-case results (Supplementary Table 2). Caffeine interest was associated with frequent consumption after imputation (aOR, 1.26; 95% CI, 1.06–1.50; P=0.008), whereas depressive symptoms remained unassociated (aOR, 1.15; 95% CI, 0.94–1.41; *P*= 0.178).

Among the 4,996 complete cases, 335 and 154 participants met the ≥10-day and ≥20-day thresholds, respectively (Supplementary Table 3). Eating breakfast sometimes or rarely, feeling relaxed, perceiving energy drinks as unhealthy, supplement use, and gaming disorder remained associated with both stricter outcomes. Male sex and feeling energetic remained associated with the ≥10-day but not the ≥20-day outcome, whereas exercising ≥5 days/wk was associated only with the primary ≥6-day outcome. Caffeine interest was positively associated with both stricter outcomes. Although the association at the ≥6-day threshold was not statistically significant, feeling mentally sharp showed progressively lower aORs across the ≥6-, ≥10-, and ≥20-day thresholds (0.84, 0.73, and 0.64, respectively), with statistically significant inverse associations at the 2 stricter thresholds. Thus, several principal associations were robust, although some varied according to the frequency threshold.

3. Sex-stratified analyses

Table 3 and Fig. 2 show the exploratory sex-stratified multivariable analyses. Among boys, feeling energetic or relaxed, rarely eating breakfast, exercising ≥5 days/wk, supplement use, and gaming disorder were associated with frequent consumption, whereas perceiving energy drinks as unhealthy was inversely associated. Among

Accepted Article

Table 2. Factors associated with frequent energy drink consumption (≥6 days during the past 30 days): univariable and multivariable logistic regression analyses

Variable	Participants (n)	Frequent consumers (n)	cOR	95% CI	*P* value	aOR	95% CI	*P* value
Sex								
Boy	3,324	506	2.08	1.78–2.43	<0.001	1.74	1.41–2.14	<0.001
Girl (ref.)	3,440	273	1.00			1.00		
Grade								
Grade 10 (ref.)	2,960	368	1.00			1.00		
Grade 11	1,881	203	0.85	0.71–1.02	0.085	0.90	0.72–1.12	0.347
Grade 12	1,883	199	0.83	0.69–1.00	0.049	0.92	0.73–1.16	0.482
Lifestyle factors								
Breakfast consumption								
Almost daily (ref.)	5,610	592	1.00			1.00		
Sometimes	668	102	1.53	1.22–1.92	<0.001	1.49	1.11–2.01	0.009
Rarely	467	82	1.81	1.40–2.33	<0.001	1.99	1.45–2.75	<0.001
Exercise habit (days/wk)								
0–2 days (ref.)	2,167	202	1.00			1.00		
3–4 days	1,666	166	1.08	0.87–1.34	0.503	1.01	0.77–1.32	0.972
5 days or more	2,920	409	1.58	1.33–1.89	<0.001	1.39	1.09–1.76	0.007
Perceived effects/beliefs about energy drinks								
Feel mentally sharp								
No (ref.)	3,159	358	1.00			1.00		
Yes	3,497	409	1.04	0.89–1.21	0.643	0.84	0.68–1.04	0.103
Feel more positive/motivated								
No (ref.)	4,446	428	1.00			1.00		
Yes	2,199	336	1.69	1.45–1.97	<0.001	1.17	0.94–1.47	0.164
Feel energetic								
No (ref.)	3,141	276	1.00			1.00		
Yes	3,504	491	1.69	1.45–1.98	<0.001	1.50	1.20–1.88	<0.001
Feel relaxed								
No (ref.)	5,621	570	1.00			1.00		
Yes	1,012	194	2.10	1.76–2.51	<0.001	1.49	1.15–1.92	0.002
Believe it is nutritious								
No (ref.)	4,579	482	1.00			1.00		
Yes	2,054	280	1.34	1.15–1.57	<0.001	0.92	0.74–1.13	0.405
Believe it is unhealthy								
No (ref.)	2,218	336	1.00			1.00		
Yes	4,435	431	0.60	0.52–0.70	<0.001	0.60	0.49–0.73	<0.001
Interest in caffeine								
No (ref.)	5,074	528	1.00			1.00		
Yes	1,669	250	1.52	1.29–1.78	<0.001	1.20	0.98–1.47	0.086
Other covariates								
Advertising exposure								
0 identifiable sources (ref.)	2,170	227	1.00			1.00		
1 identifiable source	2,601	295	1.10	0.91–1.32	0.332	1.10	0.88–1.38	0.398
2 or more identifiable sources	1,970	254	1.27	1.05–1.53	0.015	1.12	0.88–1.41	0.363
Supplement use								
No (ref.)	4,921	501	1.00			1.00		
Yes	1,753	264	1.56	1.33–1.84	<0.001	1.56	1.28–1.91	<0.001
Gaming disorder								
No (ref.)	4,515	437	1.00			1.00		
Yes	762	145	2.19	1.79–2.70	<0.001	1.99	1.57–2.52	<0.001
Depressive symptoms								
No (ref.)	5,416	589	1.00			1.00		
Yes	1,223	173	1.35	1.13–1.62	0.001	1.02	0.79–1.30	0.896

aOR, adjusted odds ratio; CI, confidence interval; cOR, crude odds ratio; ref., reference category; VIF, variance inflation factor.
The "Participants (n)" column reports participants with nonmissing consumption-frequency data and nonmissing data for the corresponding explanatory variable. The "Frequent consumers (n)" column reports participants in each category who consumed energy drinks on ≥6 days during the past 30 days.
cORs were estimated using univariable logistic regression models. aORs were estimated using a multivariable model containing all variables shown and school type (not shown). The multivariable analysis included 4,996 complete cases, including 537 frequent consumers.
VIFs ranged from 1.08 to 1.42 for the 6 perceived effects/beliefs and peaked at 1.58 across all model variables.
P values were based on Wald tests.

Accepted Article

Table 3. Exploratory sex-stratified analyses of factors associated with frequent energy drink consumption (≥6 days during the past 30 days)

Variable	Boys (N=2,375)					Girls (N=2,621)				
	Participants (n)	Frequent consumers (n)	aOR	95% CI	*P* value	Participants (n)	Frequent consumers (n)	aOR	95% CI	*P* value
Grade										
Grade 10 (ref.)	1,124	175	1.00			1,076	83	1.00		
Grade 11	652	88	0.87	0.65–1.15	0.326	779	57	0.91	0.63–1.32	0.627
Grade 12	599	82	0.94	0.70–1.26	0.673	766	52	0.89	0.61–1.30	0.558
Lifestyle factors										
Breakfast consumption										
Almost daily (ref.)	2,029	284	1.00			2,188	134	1.00		
Sometimes	196	28	1.02	0.66–1.57	0.943	256	33	2.29	1.49–3.51	<0.001
Rarely	150	33	1.81	1.17–2.80	0.007	177	25	2.27	1.40–3.69	<0.001
Exercise habit (days/wk)										
0–2 (ref.)	464	61	1.00			1,139	75	1.00		
3–4	464	52	0.85	0.56–1.27	0.417	779	62	1.18	0.82–1.70	0.378
≥5	1,447	232	1.41	1.02–1.95	0.037	703	55	1.28	0.88–1.87	0.198
Perceived effects/beliefs about energy drinks										
Feel mentally sharp										
No (ref.)	1,175	161	1.00			1,127	84	1.00		
Yes	1,200	184	0.88	0.67–1.15	0.354	1,494	108	0.78	0.55–1.11	0.169
Feel more positive/motivated										
No (ref.)	1,533	199	1.00			1,855	113	1.00		
Yes	842	146	1.03	0.77–1.37	0.848	766	79	1.45	1.00–2.12	0.053
Feel energetic										
No (ref.)	1,089	118	1.00			1,241	73	1.00		
Yes	1,286	227	1.66	1.25–2.21	<0.001	1,380	119	1.31	0.91–1.90	0.148
Feel relaxed										
No (ref.)	1,978	259	1.00			2,292	151	1.00		
Yes	397	86	1.45	1.06–1.99	0.021	329	41	1.49	0.97–2.30	0.069
Believe it is nutritious										
No (ref.)	1,652	222	1.00			1,784	124	1.00		
Yes	723	123	1.01	0.78–1.32	0.940	837	68	0.75	0.52–1.06	0.103
Believe it is unhealthy										
No (ref.)	730	131	1.00			867	97	1.00		
Yes	1,645	214	0.71	0.55–0.91	0.006	1,754	95	0.44	0.32–0.61	<0.001
Interest in caffeine										
No (ref.)	1,709	240	1.00			2,053	131	1.00		
Yes	666	105	0.99	0.76–1.29	0.945	568	61	1.66	1.18–2.34	0.004
Other covariates										
Advertising exposure										
0 identifiable sources (ref.)	777	93	1.00			862	68	1.00		
1 identifiable source	855	133	1.33	0.99–1.78	0.059	1,005	66	0.85	0.59–1.23	0.389
2 or more identifiable sources	743	119	1.26	0.93–1.71	0.132	754	58	0.98	0.67–1.43	0.905
Supplement use										
No (ref.)	1,625	214	1.00			2,075	132	1.00		
Yes	750	131	1.45	1.13–1.87	0.004	546	60	1.70	1.21–2.38	0.002
Gaming disorder										
No (ref.)	1,957	255	1.00			2,340	148	1.00		
Yes	418	90	1.75	1.30–2.35	<0.001	281	44	2.63	1.76–3.93	<0.001
Depressive symptoms										
No (ref.)	2,069	285	1.00			2,051	146	1.00		
Yes	306	60	1.25	0.89–1.74	0.197	570	46	0.75	0.51–1.10	0.142

aOR, adjusted odds ratio; CI, confidence interval; ref., reference category.
Separate multivariable logistic regression models were fitted for boys and girls; each included all variables shown and school type (not shown).
"Participants (n)" and "Frequent consumers (n)" report the numbers of participants and frequent consumers in each category.
The sex-stratified analyses were exploratory.
Differences in statistical significance between models were not interpreted as evidence of effect modification; formal sex-by-factor interaction tests are reported in the Results.
P values were based on Wald tests.

Accepted Article

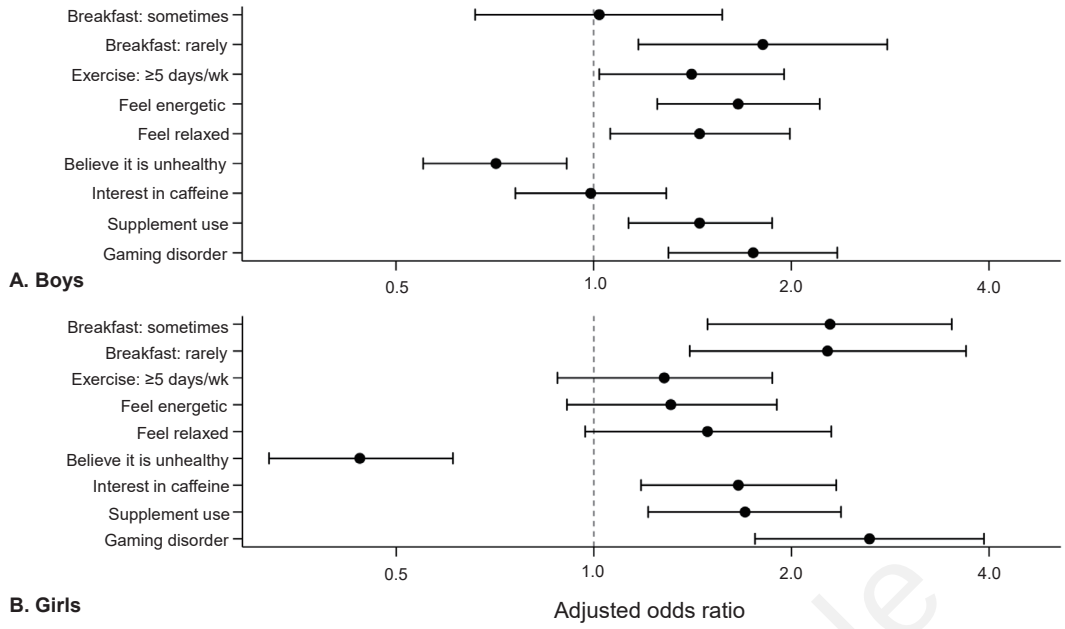


Fig. 2. Adjusted odds ratios for selected factors associated with frequent energy drink consumption in exploratory sex-stratified analyses. Panels A and B present the results for boys and girls, respectively. Points indicate adjusted odds ratios, while horizontal lines indicate 95% confidence intervals. The vertical reference line denotes an adjusted odds ratio of 1.00. The sex-stratified multivariable logistic regression models included the variables listed in Table 3 and school type. The analysis included 2,375 boys and 2,621 girls. For visual clarity, the figure displays factors that were associated with frequent consumption in at least one sex-stratified model; the complete results are provided in Table 3. The selection for display does not indicate statistically significant effect modification by sex.

girls, caffeine interest, eating breakfast sometimes or rarely, supplement use, and gaming disorder were associated with frequent consumption, whereas perceiving energy drinks as unhealthy was inversely associated. Grade and advertising exposure were not associated with frequent consumption in either sex.

Exploratory interaction analyses identified an interaction between sex and caffeine interest (interaction aOR, 0.62; 95% CI, 0.41–0.94; *P* for interaction=0.024). Breakfast consumption showed an overall interaction with sex (*P* for interaction=0.015); for eating breakfast sometimes versus almost daily, the interaction aOR was 0.42 (95% CI, 0.23–0.76; *P*=0.004). However, interactions of sex with feeling energetic (*P* for interaction=0.318) and exercise (overall P for interaction=0.163) were not significant. No other examined factor showed a significant interaction with sex.

4. Consumption patterns among current energy drink consumers

Among 3,001 current energy drink consumers, 54 were excluded because of missing data for at least one variable in the consumption-pattern model, leaving 2,947 complete cases. Of these, 760 were frequent consumers (489 boys and 271 girls; Table 4). In the total current-consumer sample, male sex was associated with frequent consumption (aOR, 1.53; 95% CI, 1.29–1.83), whereas age at first consumption was not. Compared with consuming <1 bottle/can per occasion, consuming 1 bottle/can (aOR, 1.75; 95% CI, 1.19–2.57) or ≥2 bottles/cans (aOR, 4.44; 95% CI, 2.70–7.30) was associated with frequent consumption. Relative to daytime consumption, consumption upon waking (aOR, 1.64; 95% CI, 1.04–2.58) or in the morning (aOR, 1.88; 95% CI, 1.29–2.74) was also associated.

In the exploratory sex-stratified models, consuming 1 bottle/can or ≥2 bottles/cans per occasion was associated with frequent consumption among boys, whereas only the estimate for ≥2 bottles/cans was significant among girls. Morning consumption was associated with frequent consumption in both sexes, whereas consumption upon waking was associated with frequent consumption among girls but not boys. These subgroup patterns were interpreted together with the formal interaction tests rather than as independent evidence of sex differences.

Exploratory interaction analyses identified an overall interaction between sex and the most common time of consumption (*P* for interaction=0.043). For consumption upon waking versus daytime consumption, the interaction aOR was 0.26 (95% CI, 0.10–0.66; *P*=0.005), suggesting a stronger association among girls than boys. No significant interactions were observed for age at first consumption (overall *P* for interaction=0.720) or amount consumed per occasion (overall *P* for interaction=0.331).

Accepted Article

Table 4. Associations between energy drink consumption patterns and frequent energy drink consumption (≥6 days during the past 30 days) among current consumers: total-sample and exploratory sex-stratified analyses

Variable	Total (N=2,947)					Boys (N=1,645)					Girls (N=1,302)				
	Participants (n)	Frequent consumers (n)	aOR	95% CI	*P* value	Participants (n)	Frequent consumers (n)	aOR	95% CI	*P* value	Participants (n)	Frequent consumers (n)	aOR	95% CI	*P* value
Sex															
Boys	1,645	489	1.53	1.29–1.83	<0.001	-	-	-	-	-	-	-	-	-	-
Girls (ref.)	1,302	271	1.00			-	-	-	-	-	-	-	-	-	-
Grade															
Grade 10 (ref.)	1,320	364	1.00			784	248	1.00			536	116	1.00		
Grade 11	835	200	0.86	0.70–1.05	0.137	460	126	0.83	0.64–1.08	0.157	375	74	0.87	0.62–1.22	0.426
Grade 12	792	196	0.92	0.74–1.14	0.421	401	115	0.92	0.70–1.22	0.573	391	81	0.91	0.64–1.28	0.582
Age (yr) at first consumption of energy drinks															
≤10	922	258	1.32	0.98–1.76	0.064	465	157	1.40	0.95–2.05	0.087	457	101	1.18	0.75–1.87	0.468
11–12	977	264	1.21	0.91–1.61	0.196	569	178	1.25	0.86–1.81	0.243	408	86	1.12	0.71–1.78	0.621
13–14	636	147	0.98	0.72–1.34	0.918	392	99	0.94	0.63–1.40	0.756	244	48	1.06	0.64–1.75	0.829
≥15 (ref.)	412	91	1.00			219	55	1.00			193	36	1.00		
Amount consumed per occasion (bottles/cans)															
<1 (ref.)	220	33	1.00			77	12	1.00			143	21	1.00		
1	2,573	653	1.75	1.19–2.57	0.005	1,463	425	2.28	1.21–4.29	0.011	1,110	228	1.45	0.89–2.37	0.141
≥2	154	74	4.44	2.70–7.30	<0.001	105	52	5.17	2.48–10.76	<0.001	49	22	4.94	2.34–10.41	<0.001
Most common time of consumption															
Upon waking	100	33	1.64	1.04–2.58	0.034	49	12	0.83	0.41–1.66	0.595	51	21	3.03	1.63–5.64	<0.001
Morning	149	55	1.88	1.29–2.74	<0.001	93	37	1.74	1.09–2.78	0.019	56	18	2.17	1.17–4.05	0.015
Daytime (ref.)	900	217	1.00			502	141	1.00			398	76	1.00		
Evening	638	168	1.17	0.92–1.48	0.201	335	105	1.20	0.88–1.63	0.245	303	63	1.13	0.77–1.64	0.543
Night/late night	1,160	287	1.04	0.84–1.29	0.703	666	194	1.07	0.82–1.39	0.613	494	93	0.97	0.68–1.38	0.852

aOR, adjusted odds ratio; CI, confidence interval; ref., reference category.
Current consumers were participants who reported consumption on ≥1 day during the past 30 days. Frequent consumers (≥6 days) were compared with those who consumed energy drinks on 1–5 days.
Analyses were restricted to 2,947 current consumers with complete data. The total-sample model included sex, grade, age at first consumption, amount consumed per occasion, most common time of consumption, and school type (not shown); sex-stratified models included the same variables except sex and were exploratory. Differences in statistical significance between sex-stratified models were not interpreted as evidence of effect modification; formal sex-by-factor interaction tests are reported in the Results.
P values were based on Wald tests.

Accepted Article

Discussion

Among 6,764 Japanese high school students, 79.3% had consumed energy drinks. Frequent consumption (≥6 days during the past 30 days) was reported by 537 of the 4,996 participants (10.7%) in the primary complete-case sample, compared with 779 of the 6,764 participants (11.5%) in the full descriptive analytic sample. In the primary complete-case analysis, frequent consumption was associated with male sex, perceptions of feeling energetic or relaxed, less frequent breakfast consumption, exercise on ≥5 days/wk, supplement use, and gaming disorder; perceiving energy drinks as unhealthy was inversely associated. In the current-consumer complete-case analysis of 2,947 participants, greater per-occasion intake and consumption upon waking or in the morning were also associated with frequent consumption. Sensitivity analyses using stricter frequency thresholds supported several principal associations, although some differed by cutoff.

Comparisons with previous prevalence estimates require caution because recall periods, frequency thresholds, and age groups vary. Beverage definitions and regulatory classifications differ across settings.[17-19] Lifetime energy drink consumption was 79.3% in this study. A systematic review and meta-analysis including children, adolescents, young adults, and adults estimated a pooled lifetime prevalence of energy drink consumption of 54.7% (95% CI, 48.8%–60.6%), with substantial between-study heterogeneity.[2] In Western Australian and Canadian studies, ever consumption was defined by an affirmative response to the question, "Have you ever tried an energy drink, even a few sips?"[20,21] Using this criterion, a school-based survey of 3,688 Western Australian students in grades 7–12 reported a prevalence of 51.2%.[20] A national web-based survey of Canadian youth and young adults reported a weighted prevalence of 69.4% among 620 participants aged 15–17 years.[21] Although these studies assessed energy drinks only, the present study assessed tonic drinks, energy drinks, or both; therefore, their prevalence estimates are not directly comparable with

ours. Frequent consumption (≥6 days during the past 30 days) was 11.5% in the present study. By comparison, a global meta-analysis estimated any consumption at 32.3% during the past 30 days and 21.6% during the past 7 days.[2] Weekly consumption was reported by 8% of Australian adolescents,[7] whereas consumption ≥3 times during the previous 7 days increased from 3.2% to 12.2% among Korean adolescents.[22] These estimates should be interpreted within their respective definitions and populations.

Observed associations with male sex and less frequent breakfast consumption were consistent with those of previous studies.[6,8,23] Positive perceptions and gaming-related factors have been linked to energy drink consumption,[3,12] alongside broader behavioral problems.[24] Frequent consumption was inversely associated with perceiving energy drinks as unhealthy and positively associated with perceiving them as producing energy or relaxation. Greater perceived harm may discourage frequent consumption; conversely, frequent consumers may perceive or report energy drinks as less harmful. Because the study was cross-sectional, the temporal direction of these associations cannot be determined. Young people expect caffeinated beverages to improve alertness, concentration, or mood despite limited understanding of caffeine content, appropriate intake levels, and potential health risks.[3,4,25]

Among current consumers, greater per-occasion intake and consumption upon waking or in the morning were associated with frequent consumption. Greater per-occasion intake may reflect stronger expectations of alertness or mood effects. Repeated caffeine intake may cause tolerance, withdrawal, and dependence-like symptoms in adolescents,[5,26,27] although caffeine dose and consumption reasons were not assessed.

The exploratory sex-stratified and interaction analyses suggested possible sex-related heterogeneity for only a limited number of factors. Interactions were observed for caffeine interest and breakfast consumption. By contrast, although feeling energetic and exercising ≥5 days/wk were associated with frequent consumption only among boys in the stratified models, the corresponding interaction tests were not significant; these differences in subgroup significance were not interpreted as evidence of sex differences. Given the exploratory analyses and number of comparisons, these findings require cautious interpretation and independent confirmation.

Supplement use was associated with frequent consumption and may reflect interest in physical performance or condition management, consistent with reports of energy drink consumption among adolescent athletes.[28] However, supplement types and purposes were not assessed.

Less frequent breakfast consumption and morning energy drink consumption may reflect disrupted routines or attempts to compensate for insufficient sleep, which has been linked to energy drink consumption in adolescents and young adults.[7-9,29] Caffeine can temporarily increase alertness by reducing sleep pressure through adenosine-receptor antagonism,[30] although sleep duration was not analyzed. In exploratory analyses among current consumers, the association between consumption upon waking and frequent consumption appeared stronger among girls than boys, but the underlying reasons remain unclear. Because caffeine and energy drink consumption may affect sleep and acute cardiovascular measures in youth,[5,31] accounting for sleep, caffeine dose, and physical condition should be considered in future studies.

This study's strengths include the large school-based sample, validated measures,[14-16] Japanese PHQ-A reference data,[32] simultaneous consideration of multiple factors, and separate examination of consumption patterns among current consumers.

This study has some limitations. First, its cross-sectional design precludes conclusions about causality or temporal sequence. Second, the survey was conducted in a single prefecture in western Japan, which limits generalizability. Third, the primary multivariable analysis excluded 1,768 of 6,764 participants because at least one model variable was missing. Missingness was common for gaming disorder because scores could be calculated only when all 9 GAMES items were completed. Among the 281 excluded participants with available gaming-disorder data, the prevalence of gaming disorder was 22.4% compared with 14.0% among included participants, suggesting a greater tendency toward item nonresponse among students with gaming disorder and raising uncertainty about the missing-at-random assumption. Included and excluded participants differed in several characteristics, and selection bias cannot be excluded. Although multiple-imputation results were consistent with complete-case results, imputation assumed that data were missing at random conditional on observed variables; bias related to unobserved determinants may remain. Fourth, self-reported measures were susceptible to recall and reporting bias. Fifth, caffeine, sugar, and other product ingredients were not assessed, precluding analyses of actual caffeine intake or product composition. Finally, frequent consumption was defined using an operational cutoff of ≥6 days during the past 30 days rather than a clinically validated threshold. Although several associations persisted at thresholds of ≥10 and ≥20 days, others varied with the outcome definition.

In conclusion, 79.3% of students had consumed energy drinks at least once, and 11.5% reported frequent con-

Accepted Article

sumption. Frequent consumption was associated with beverage-related perceptions, lifestyle habits, and gaming disorder. These findings identify potential targets for pediatric public health and school-based education concerning caffeine effects, appropriate intake, healthier beverage choices, and morning energy drink consumption. Longitudinal and clinically oriented studies are needed to determine the direction and health implications of these associations.

Footnotes

Supplementary materials: Supplementary Tables 1–3 are available at https://doi.org/10.3345/cep.2026.01347.

Conflicts of interest: No potential conflict of interest relevant to this article was reported.

Funding: This work was supported by JSPS KAKENHI Grant Number JP23K09750. The funding source had no role in the study design, data collection, analysis, interpretation of data, writing of the manuscript, or the decision to submit the article for publication.

Acknowledgments: The authors thank the participating students and the school principals, teachers, and school nurses who supported this study.

Author contribution: Conceptualization: TM, YO, SN, YK; Data curation: TM, YO, YT, SN; Formal analysis: TM, YO; Funding acquisition: YK; Methodology: TM, YO, YK; Project administration: YO, YK; Writing–original draft: TM; Writing–review & editing: YO, YT, SN, YK.

ORCID
Tomomi Miyoshi https://orcid.org/0000-0003-4547-363X
Yuichiro Otsuka https://orcid.org/0000-0001-8247-9235
Yuki Tanaka https://orcid.org/0009-0004-1587-4103
Suguru Nakajima https://orcid.org/0009-0000-6917-4058
Yoshitaka Kaneita https://orcid.org/0000-0003-1287-7590

References

1. Khouja C, Kneale D, Brunton G, Raine G, Stansfield C, Sowden A, et al. Consumption and effects of caffeinated energy drinks in young people: an overview of systematic reviews and secondary analysis of UK data to inform policy. BMJ Open 2022;12:e047746.
2. Aonso-Diego G, Krotter A, García-Pérez Á. Prevalence of energy drink consumption world-wide: a systematic review and meta-analysis. Addiction 2024;119:438-63.
3. Turton P, Piché L, Battram DS. Adolescent attitudes and beliefs regarding caffeine and the consumption of caffeinated beverages. J Nutr Educ Behav 2016;48:181-9.e1.
4. Visram S, Crossley SJ, Cheetham M, Lake A. Children and young people's perceptions of energy drinks: a qualitative study. PLoS One 2017;12:e0188668.
5. Temple JL. Review: trends, safety, and recommendations for caffeine use in children and adolescents. J Am Acad Child Adolesc Psychiatry 2019;58:36-45.
6. Ajibo C, Van Griethuysen A, Visram S, Lake AA. Consumption of energy drinks by children and young people: a systematic review examining evidence of physical effects and consumer attitudes. Public Health 2024;227:274-81.
7. Nuss T, Morley B, Scully M, Wakefield M. Energy drink consumption among Australian adolescents associated with a cluster of unhealthy dietary behaviours and short sleep duration. Nutr J 2021;20:64.
8. Puupponen M, Tynjälä J, Välimaa R, Paakkari L. Associations between adolescents' energy drink consumption frequency and several negative health indicators. BMC Public Health 2023;23:258.
9. Park S, Lee Y, Lee JH. Association between energy drink intake, sleep, stress, and suicidality in Korean adolescents: energy drink use in isolation or in combination with junk food consumption. Nutr J 2016;15:87.
10. Kim SY, Sim S, Choi HG. High stress, lack of sleep, low school performance, and suicide attempts are associated with high energy drink intake in adolescents. PLoS One 2017;12:e0187759.
11. Brunborg GS, Raninen J, Burdzovic Andreas J. Energy drinks and alcohol use among adolescents: a longitudinal study. Drug Alcohol Depend 2022;241:109666.
12. Yang CY, Chang FC, Rutherford R, Chen WY, Chiu CH, Chen PH, et al. Excessive gaming and online energy-drink marketing exposure associated with energy-drink consumption among adolescents. Int J Environ Res Public Health 2022;19:10661.
13. Zucconi S, Volpato C, Adinolfi F, Gandini E, Gentile E, Loi A, et al. Gathering consumption data on specific consumer groups of energy drinks. Support Publ 2013;10:EN-394.
14. Higuchi S, Osaki Y, Kinjo A, Mihara S, Maezono M, Kitayuguchi T, et al. Development and validation of a nine-item short screening test for ICD-11 gaming disorder (GAMES test) and estimation of the prevalence in the general young population. J Behav Addict 2021;10:263-80.
15. Johnson JG, Harris ES, Spitzer RL, Williams JB. The Patient Health Questionnaire for Adolescents: validation of an instrument for the assessment of mental disorders among adolescent primary care patients. J Adolesc Health 2002;30:196-204.
16. Sung SC, Ang FJL, Liu X, Chakraborty B, Wong JCM, Fung DSS, et al. Screening for depressive disorders: validation of the Patient Health Questionnaire for Adolescents (PHQ-A) in a population-based multi-ethnic Asian sample. Psychiatry Res 2025;348:116487.
17. Striley CW, Khan SR. Review of the energy drink literature from 2013: findings continue to support most risk from mixing with alcohol. Curr Opin Psychiatry 2014;27:263-8.
18. Bailey RL, Saldanha LG, Dwyer JT. Estimating caffeine

Accepted article

intake from energy drinks and dietary supplements in the United States. Nutr Rev 2014;72 Suppl 1:9-13.
19. Japan Soft Drink Association. Guidelines on labeling of soft drinks with high added caffeine content, including so-called energy drinks [Internet]. Tokyo (Japan): Japan Soft Drink Association; 2017 Nov 16 [cited 2026 Mar 1]. Available from: https://www.j-sda.or.jp/guideline/regulations_and_guidelines/caffeine-guideline.php. Japanese.
20. Trapp G, Hurworth M, Christian H, Bromberg M, Howard J, McStay C, et al. Prevalence and pattern of energy drink intake among Australian adolescents. J Hum Nutr Diet 2021;34:300-4.
21. Reid JL, McCrory C, White CM, Martineau C, Vanderkooy P, Fenton N, et al. Consumption of caffeinated energy drinks among youth and young adults in Canada. Prev Med Rep 2016;5:65-70.
22. Shim JS, Lee JM. Energy drink consumption among Korean adolescents: prevalence and associated factors. Clin Exp Pediatr 2024;67:531-9.
23. Veselska ZD, Husarova D, Kosticova M. Energy drinks consumption associated with emotional and behavioural problems via lack of sleep and skipped breakfast among adolescents. Int J Environ Res Public Health 2021;18:6055.
24. Holubcikova J, Kolarcik P, Madarasova Geckova A, Reijneveld SA, van Dijk JP. Regular energy drink consumption is associated with the risk of health and behavioural problems in adolescents. Eur J Pediatr 2017;176:599-605.
25. Cormier B, Reid JL, Hammond D. At-a-glance - perceptions of caffeinated drinks among youth and young adults in Canada. Health Promot Chronic Dis Prev Can 2018;38:214-8.
26. Bernstein GA, Carroll ME, Thuras PD, Cosgrove KP, Roth ME. Caffeine dependence in teenagers. Drug Alcohol Depend 2002;66:1-6.
27. Oberstar JV, Bernstein GA, Thuras PD. Caffeine use and dependence in adolescents: one-year follow-up. J Child Adolesc Psychopharmacol 2002;12:127-35.
28. Nowak D, Jasionowski A. Analysis of consumption of energy drinks by a group of adolescent athletes. Int J Environ Res Public Health 2016;13:768.
29. Kaldenbach S, Hysing M, Strand TA, Sivertsen B. Energy drink consumption and sleep parameters in college and university students: a national cross-sectional study. BMJ Open 2024;14:e072951.
30. Ribeiro JA, Sebastião AM. Caffeine and adenosine. J Alzheimers Dis 2010;20 Suppl 1:S3-15.
31. Oberhoffer FS, Li P, Jakob A, Dalla-Pozza R, Haas NA, Mandilaras G. Energy drinks: effects on blood pressure and heart rate in children and teenagers: a randomized trial. Front Cardiovasc Med 2022;9:862041.
32. Adachi M, Takahashi M, Hirota T, Shinkawa H, Mori H, Saito T, et al. Distributional patterns of item responses and total scores of the Patient Health Questionnaire for Adolescents in a general population sample of adolescents in Japan. Psychiatry Clin Neurosci 2020;74:628-9.

How to cite this article: Miyoshi T, Otsuka Y, Tanaka Y, Nakajima S, Kaneita Y. Frequent energy drink consumption and associated factors among Japanese adolescents. Clin Exp Pediatr [Epub ahead of print] https://doi.org/10.3345/cep.2026.01347.

Accepted Article

Supplementary Table 1. Comparison of participant characteristics between the complete-case and excluded groups

Variable	Included (N=4,996)	Excluded (N=1,768)		*P* value
		Available n	No. (%)	
Sex		1,768		<0.001
Boy	2,375 (47.5)		949 (53.7)	
Girl	2,621 (52.5)		819 (46.3)	
Grade		1,728		0.042
Grade 10	2,200 (44.0)		760 (44.0)	
Grade 11	1,431 (28.6)		450 (26.0)	
Grade 12	1,365 (27.3)		518 (30.0)	
Energy drink consumption				
Frequent energy drink consumption		1,768		<0.001
<6 Days	4,459 (89.3)		1,526 (86.3)	
≥6 Days	537 (10.7)		242 (13.7)	
Lifestyle factors				
Breakfast consumption		1,749		<0.001
Almost daily	4,217 (84.4)		1,393 (79.6)	
Sometimes	452 (9.0)		216 (12.3)	
Rarely	327 (6.5)		140 (8.0)	
Exercise habit (days/week)		1,757		0.768
0–2	1,603 (32.1)		564 (32.1)	
3–4	1,243 (24.9)		423 (24.1)	
≥5	2,150 (43.0)		770 (43.8)	
Perceived effects/beliefs about energy drinks				
Feel mentally sharp		1,660		<0.001
No	2,302 (46.1)		857 (51.6)	
Yes	2,694 (53.9)		803 (48.4)	
Feel more positive/motivated		1,649		0.006
No	3,388 (67.8)		1,058 (64.2)	
Yes	1,608 (32.2)		591 (35.8)	
Feel energetic		1,649		0.073
No	2,330 (46.6)		811 (49.2)	
Yes	2,666 (53.4)		838 (50.8)	
Feel relaxed		1,637		0.004
No	4,270 (85.5)		1,351 (82.5)	
Yes	726 (14.5)		286 (17.5)	
Believe it is nutritious		1,637		0.426
No	3,436 (68.8)		1,143 (69.8)	
Yes	1,560 (31.2)		494 (30.2)	
Believe it is unhealthy		1,657		<0.001
No	1,597 (32.0)		621 (37.5)	
Yes	3,399 (68.0)		1,036 (62.5)	
Interest in caffeine		1,747		0.868
No	3,762 (75.3)		1,312 (75.1)	
Yes	1,234 (24.7)		435 (24.9)	
Other covariates				
Advertising exposure		1,745		<0.001
0 Identifiable sources	1,639 (32.8)		531 (30.4)	
1 Identifiable source	1,860 (37.2)		741 (42.5)	
2 or more identifiable sources	1,497 (30.0)		473 (27.1)	
Supplement use		1,678		0.297
No	3,700 (74.1)		1,221 (72.8)	
Yes	1,296 (25.9)		457 (27.2)	
Gaming disorder		281		<0.001
No	4,297 (86.0)		218 (77.6)	
Yes	699 (14.0)		63 (22.4)	
Depressive symptoms		1,643		0.001
No	4,120 (82.5)		1,296 (78.9)	
Yes	876 (17.5)		347 (21.1)	

Values are presented as number (%).
Included participants had complete data for all variables in the primary multivariable logistic regression model. Excluded participants had complete data on energy drink consumption frequency but had missing data for at least one variable included in the model. Available n denotes the number of participants with complete data for each characteristic. For gaming disorder, data were available for 281 of the 1,768 excluded participants; the remaining 1,487 participants had missing gaming-disorder data.
P values were obtained using Pearson chi-square tests after excluding missing values for the characteristic concerned.

Accepted Article

Supplementary Table 2. Sensitivity analysis of factors associated with frequent energy drink consumption using multiple imputation

Variable	Complete-case analysis (N=4,996)			Multiple-imputation analysis (N=6,764)		
	aOR	95% CI	*P* value	aOR	95% CI	*P* value
Sex						
Boy	1.74	1.41–2.14	<0.001	1.69	1.42–2.01	<0.001
Girl (ref.)	1.00			1.00		
Grade						
Grade 10 (ref.)	1.00			1.00		
Grade 11	0.90	0.72–1.12	0.347	0.91	0.75–1.10	0.324
Grade 12	0.92	0.73–1.16	0.482	0.92	0.76–1.11	0.390
Lifestyle factors						
Breakfast consumption						
Almost daily (ref.)	1.00			1.00		
Sometimes	1.49	1.11–2.01	0.009	1.57	1.24–1.99	<0.001
Rarely	1.99	1.45–2.75	<0.001	1.79	1.37–2.35	<0.001
Exercise habit (days/wk)						
0–2 (ref.)	1.00			1.00		
3–4	1.01	0.77–1.32	0.972	0.99	0.79–1.24	0.950
≥5	1.39	1.09–1.76	0.007	1.34	1.10–1.63	0.004
Perceived effects/beliefs about energy drinks						
Feel mentally sharp						
No (ref.)	1.00			1.00		
Yes	0.84	0.68–1.04	0.103	0.85	0.71–1.01	0.068
Feel more positive/motivated						
No (ref.)	1.00			1.00		
Yes	1.17	0.94–1.47	0.164	1.20	0.99–1.46	0.057
Feel energetic						
No (ref.)	1.00			1.00		
Yes	1.50	1.20–1.88	<0.001	1.43	1.18–1.73	<0.001
Feel relaxed						
No (ref.)	1.00			1.00		
Yes	1.49	1.15–1.92	0.002	1.51	1.22–1.87	<0.001
Believe it is nutritious						
No (ref.)	1.00			1.00		
Yes	0.92	0.74–1.13	0.405	0.99	0.83–1.18	0.933
Believe it is unhealthy						
No (ref.)	1.00			1.00		
Yes	0.60	0.49–0.73	<0.001	0.60	0.51–0.71	<0.001
Interest in caffeine						
No (ref.)	1.00			1.00		
Yes	1.20	0.98–1.47	0.086	1.26	1.06–1.50	0.008
Other covariates						
Advertising exposure						
0 identifiable sources (ref.)	1.00			1.00		
1 identifiable source	1.10	0.88–1.38	0.398	1.08	0.89–1.31	0.421
2 or more identifiable sources	1.12	0.88–1.41	0.363	1.14	0.94–1.40	0.184
Supplement use						
No (ref.)	1.00			1.00		
Yes	1.56	1.28–1.91	<0.001	1.43	1.21–1.70	<0.001
Gaming disorder						
No (ref.)	1.00			1.00		
Yes	1.99	1.57–2.52	<0.001	1.89	1.50–2.37	<0.001
Depressive symptoms						
No (ref.)	1.00			1.00		
Yes	1.02	0.79–1.30	0.896	1.15	0.94–1.41	0.178

aOR, adjusted odds ratio; CI, confidence interval; ref., reference category.
aORs were estimated using multivariable logistic regression models containing all variables shown and adjusted for school type. The complete-case analysis included 4,996 participants. Multiple imputation by chained equations addressed missing covariate data among 6,764 participants with nonmissing consumption-frequency data; 50 imputed datasets were generated. The imputation model included the outcome and all variables in the analytic model, and estimates were pooled using Rubin rules.
P values were based on Wald tests.

Accepted Article

Supplementary Table 3. Sensitivity analyses of factors associated with frequent energy drink consumption using alternative frequency thresholds

Variable	≥6 Days (537 events)			≥10 Days (335 events)			≥20 Days (154 events)		
	aOR	95% CI	*P* value	aOR	95% CI	*P* value	aOR	95% CI	*P* value
Sex									
Boy	1.74	1.41–2.14	<0.001	1.49	1.16–1.92	0.002	1.29	0.90–1.84	0.171
Girl (ref.)	1.00			1.00			1.00		
Grade									
Grade 10 (ref.)	1.00			1.00			1.00		
Grade 11	0.90	0.72–1.12	0.347	0.76	0.57–1.00	0.052	0.67	0.45–1.01	0.058
Grade 12	0.92	0.73–1.16	0.482	0.77	0.58–1.03	0.075	0.73	0.48–1.09	0.125
Lifestyle factors									
Breakfast consumption									
Almost daily (ref.)	1.00			1.00			1.00		
Sometimes	1.49	1.11–2.01	0.009	1.61	1.13–2.30	0.009	1.87	1.17–2.99	0.009
Rarely	1.99	1.45–2.75	<0.001	2.28	1.57–3.31	<0.001	2.00	1.17–3.40	0.011
Exercise habit (days/wk)									
0–2 (ref.)	1.00			1.00			1.00		
3–4	1.01	0.77–1.32	0.972	1.00	0.72–1.38	0.991	0.88	0.56–1.37	0.569
≥5	1.39	1.09–1.76	0.007	1.21	0.90–1.61	0.209	0.92	0.61–1.39	0.693
Perceived effects/beliefs about energy drinks									
Feel mentally sharp									
No (ref.)	1.00			1.00			1.00		
Yes	0.84	0.68–1.04	0.103	0.73	0.56–0.94	0.016	0.64	0.44–0.93	0.020
Feel more positive/motivated									
No (ref.)	1.00			1.00			1.00		
Yes	1.17	0.94–1.47	0.164	1.17	0.89–1.55	0.264	1.12	0.74–1.69	0.608
Feel energetic									
No (ref.)	1.00			1.00			1.00		
Yes	1.50	1.20–1.88	<0.001	1.49	1.13–1.96	0.005	1.13	0.76–1.67	0.557
Feel relaxed									
No (ref.)	1.00			1.00			1.00		
Yes	1.49	1.15–1.92	0.002	1.53	1.13–2.08	0.007	1.87	1.20–2.91	0.006
Believe it is nutritious									
No (ref.)	1.00			1.00			1.00		
Yes	0.92	0.74–1.13	0.405	0.95	0.74–1.23	0.722	0.87	0.60–1.27	0.479
Believe it is unhealthy									
No (ref.)	1.00			1.00			1.00		
Yes	0.60	0.49–0.73	<0.001	0.62	0.49–0.78	<0.001	0.68	0.49–0.96	0.028
Interest in caffeine									
No (ref.)	1.00			1.00			1.00		
Yes	1.20	0.98–1.47	0.086	1.32	1.03–1.70	0.030	1.46	1.02–2.09	0.040
Other covariates									
Advertising exposure									
0 Identifiable sources (ref.)	1.00			1.00			1.00		
1 Identifiable source	1.10	0.88–1.38	0.398	1.04	0.79–1.37	0.796	0.92	0.63–1.34	0.656
2 or more identifiable sources	1.12	0.88–1.41	0.363	1.08	0.81–1.44	0.611	0.71	0.46–1.08	0.111
Supplement use									
No (ref.)	1.00			1.00			1.00		
Yes	1.56	1.28–1.91	<0.001	1.67	1.31–2.13	<0.001	1.56	1.10–2.22	0.013
Gaming disorder									
No (ref.)	1.00			1.00			1.00		
Yes	1.99	1.57–2.52	<0.001	1.73	1.30–2.31	<0.001	2.10	1.42–3.11	<0.001
Depressive symptoms									
No (ref.)	1.00			1.00			1.00		
Yes	1.02	0.79–1.30	0.896	0.98	0.72–1.32	0.885	0.68	0.43–1.08	0.098

aOR, adjusted odds ratio; CI, confidence interval; ref., reference category.
Outcomes were defined as energy drink consumption on ≥6, ≥10, or ≥20 days during the past 30 days.
All models used the same complete-case sample of 4,996 participants and included all variables shown and school type (not shown). The ≥6-day model was the primary analysis; the ≥10-day and ≥20-day models were sensitivity analyses using progressively stricter frequency criteria.
P values were based on Wald tests.

Accepted Article