Correlates of highly caffeinated beverage consumption among Korean adolescents

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Abstract

Background : Adolescents in South Korea may be particularly vulnerable to highly caffeinated beverage consumption, which may lead to psychological and physiological problems. However, correlates of highly caffeinated beverage consumption have not been rigorously examined for Korean adolescents. This study investigated socio-demographic and behavioral factors related to highly caffeinated beverage consumption, using a nationally representative sample of Korean adolescents. Methods : We used 267,907 middle and high school students from the Korea Youth Risk Behavior Web-based Survey collected from year 2014 to 2017 for the present cross-sectional study. We employed multiple logistic regression to examine the associations between highly caffeinated beverage consumption and socio-demographic and behavioral factors. Results : Highly caffeinated beverage consumption was higher in 2017 than 2014 (23.9% vs. 12.0%) among Korean adolescents. Drinkers of highly caffeinated beverages were more likely to be boys, to be overweight or obese, to overestimate their body weight, to drink soda > 1 time per week, and to drink sweetened beverages > 1 time per week (p s < .05). Additionally, drinkers of highly caffeinated beverages were more likely to feel stressed, to feel sadness and depression, to seriously consider suicide, and to attempt suicide during last 12 months (p s < .05). Among male participants, drinkers of highly caffeinated beverages were less likely to meet the recommended 8 to 10 hours of sleep per night (p < .05). Conclusions : Highly caffeinated beverage consumption is a potential health concern, as drinkers of highly caffeinated beverages were more likely to report health and behavioral problems. New strategies are needed to effectively curb highly caffeinated beverage consumption in Korea.

Background

Consumption of highly caffeinated beverages (HCBs), often referred to as “energy drinks,” is of growing concern [1]. While HCBs may be advertised as products that provide a number of benefits such as improved energy and performance, they often have caffeine content that exceed daily recommendations [1]. Adults are recommended to consume less than 400 mg of caffeine per day, and children and adolescents are recommended to consume less than 2.5 mg per kilogram of their body weight per day [2–4]. Excess use of caffeine is associated with problems such as severe stress, increased suicidality, frequent sleep problems, and substance use [5–7]. Despite the potential health risks, caffeine remains one of the most widely used psychoactive substance in the world [8], including in South Korea (Korea) [9, 10].

Caffeine consumption has steadily grown in Korea [9, 10]. The majority of HCBs available today first entered the Korean market in 2010 [9, 10], and HCBs have since grown to an industry worth 102 billion Korean won (approximately 90 million USD) in 2013 [10]. Despite the size of the industry and the product’s apparent popularity, not much is known about HCB’s impact on public health. One study reported that the prevalence of coffee consumption is 52.3% in Korea [11], but prevalence of HCB consumption remains unclear. Another study found that Koreans consume an estimated 67.8-102.6 mg

of caffeine per day from all food sources [12], but the study used data before HCBs became popular in Korea.

Adolescents may be vulnerable to HCB abuse, as HCBs are relatively inexpensive, readily accessible, and have a sweet flavor that is more appealing to younger consumers than coffee [1, 3, 13]. Adolescents who consume HCBs may be at higher risk of caffeine intoxication than adults [13, 14]. Korean adolescents may be particularly vulnerable to HCB abuse and caffeine intoxication, as many rely on HCBs to stay awake or focus on studying [15, 16]. As such, the Korean government attempted to limit adolescent's caffeine intake by (i) requiring warning labels, (ii) restricting advertisement, and (iii) banning the sale of HCBs on school grounds [9, 10, 17–19]. However, the effectiveness of those policies remains unclear, as no studies to date have examined changes in the multi-year prevalence of HCB consumption. Moreover, only a few studies that reported the prevalence of highly caffeinated beverage consumption among Korean adolescents utilized representative samples [5, 6, 12], which limits the generalizability of most studies.

The correlates of highly caffeinated beverage consumption are not fully known for the Korean adolescent population. Previous studies have focused on sleep, stress, and psychological correlates of highly caffeinated beverage consumption among Korean adolescents [5, 6]. Relatively less attention was given to factors that may influence individuals' decision to use HCB, such as nutrition [20, 21], physical activity level [22], and body mass index (BMI) [23]. Few of the studies that considered such factors were not generalizable to the entire Korean adolescent population [21, 24]. For example, BMI, on one hand, may be positively associated with HCB consumption, as HCB often contain added sugar linked to adiposity and weight gain [25]. On the other hand, BMI may be negatively related to HCB consumption, as habitual use of caffeine can lead to weight loss [26].

More research on HCB consumption among Korean adolescents, particularly with regards to the multi-year prevalence and correlates, is needed to understand the extent of caffeine abuse. The purpose of this study was to investigate correlates of HCB consumption using a nationally representative sample of Korean adolescents.

Methods

Survey and study sample

The Korea Centers for Disease Control and Prevention has conducted the Korea Youth Risk Behavior Web-based Survey (KYRBS) every year since 2005. We have merged 4 data sets of KYRBS collected from year 2014 to 2017 because HCB was added to the questionnaire in 2014 [27]. All the responses to the survey are self-reported. For the first stage of the sampling, middle and high schools were chosen as Primary Sampling Units (PSU). For the second stage, one classroom of each grade within a PSU was selected with the systematic sampling method. The selection probability was 14% of all middle and high schools and 2% of all middle and high school students in Korea [28]. Online consent was obtained from all

participants. The current study was approved by the Touro University Institutional Review Board (IRB No. PH0219).

The KYRBS includes a nationally representative sample of middle and high school students (N = 267,907) [2014 (N = 72,060; 97.2% response rate), 2015 (N = 68,043; 96.7% response rate), 2016 (N = 65,528; 96.4% response rate), and 2017 (N = 62,276; 95.8% response rate)] [28]. Exclusion criteria included students receiving special education services or having reading difficulties.

Measures

Demographic and Socio-economic Characteristics

School type of the participants was categorized into middle and high school. Academic achievement was asked of students to which five responses were given, and we condensed the five responses into three options: (1) low (i.e., low or middle low), (2) middle, and (3) high (i.e., high or middle-high) [29]. The household income was coded into five levels, and we regrouped five levels into three as: (1) low (i.e., very low or low), (2) middle, and (3) high (i.e., very high or high) [29]. Weekly expenditure of the participants was originally categorized into sixteen groups from 0 – < 10,000 South Korea Won (SKW) (equivalent to 0 - < USD 8.92) to ≥ 150,000 SKW (USD 133.80) and recoded into three groups: (1) < 50,000 South Korea Won (SKW) (equivalent to < USD 44.66), (2) 50,000–99,999 SKW (USD 44.66–89.32), and (3) ≥ 100,000 SKW (≥ USD 89.33). Paternal and maternal education was grouped into three levels: (1) ≤ middle school, (2) high school, and (3) ≥ college. Living situation of the participants was categorized into four groups: (1) living with family, (2) living with relatives, (3) living alone or with friends, and (4) living in home for orphans. For work experience, we employed a dichotomous variable categorizing it as either “Yes” or “No”.

Health-related Characteristics

Both weight and height were self-reported by each participant. To calculate BMI, weight in kilograms was divided by height in meters squared. According to the 2017 Korean National Growth Chart, sex-specific BMI-for-age percentile cutoffs were used to categorize the participants in the following categories: (1) underweight (BMI < 5th percentile), (2) normal weight (5th ≤ BMI < 85th percentile), (3) overweight (85th ≤ BMI < 95th percentile), and (4) obese (BMI ≥ 95th percentile) [30]. Self-perceived body weight was assessed using the following question: “What do you think of your body weight?” The answer options included 1) “very underweight”, 2) “slightly underweight”, 3) “about the right weight”, 4) “slightly overweight”, and 5) “very overweight”. We regrouped these answers into 4 groups: 1) underweight (very or slightly underweight), 2) normal weight (about the right weight), 3) overweight (slightly overweight), and 4) obese (very overweight) [29]. Body weight perception was grouped into three categories based on differences between perceived weight and self-reported weight status [31]. The three possible option categories included: 1) underestimation (self-perceived body weight < self-reported weight status), 2)

accurate estimation (self-perceived body weight = self-reported weight status), and 3) overestimation (self-perceived body weight > self-reported weight status).

Weekly physical activity for ≥ 60 minutes was coded into eight levels from none to 7 days for the last 7 days, and we reclassified them into three levels: (1) none, (2) 1–2 days, and (3) ≥ 3 days based on prior research [32]. Weekly vigorous exercise for ≥ 20 minutes was categorized into six levels from none to ≥ 5 days for the last 7 days and we regrouped them into three levels: (1) none, (2) 1–2 days, and (3) ≥ 3 days. Tobacco use was dichotomized as “Never” vs. “Ever” during the participants’ lifetime. Sleeping time was assessed by asking the participants “During weekdays, what time do you usually go to bed and wake up for the last 7 days?” Sleep duration was calculated from time to go to bed from time to wake up. Based on sleep duration recommendations (8–10 hours per night) for adolescents from the National Sleep Foundation [33], meeting sleep duration recommendations was classified as a dichotomous variable with either “Not met” or “Met”. Feeling relief of fatigue after sleep was categorized into five groups from not enough at all to very enough and we regrouped them into three levels: (1) not enough/not enough at all, (2) fair, (3) very enough/enough. Feeling stressed was classified into five levels from never to very much and we reclassified them into three levels: (1) never/rarely, (2) a little, and (3) much/ very much. The following mental health-related variables were dichotomized as either “No” or “Yes”: (1) feeling sadness and depression during last 12 months, (2) seriously considered suicide during last 12 months, and (3) suicide attempt during last 12 months.

Dietary Behaviors

For alcohol use during the participants’ lifetime, a dichotomous variable was created, comparing users with nonusers. Weekly frequency of breakfast consumption was assigned into eight categories from 0 day to 7 days for the last 7 days and we regrouped them into three levels (1) 0 days, (2) 1–2 days, and (3) ≥ 3 days. Weekly frequency of soda and sweetened beverage (except soda and highly caffeinated beverages) consumption was grouped into seven levels from never to ≥ 3 times per day for the last 7 days and we regrouped them into three levels: (1) 0 times, (2) 1–2 times, and (3) ≥ 3 times per week. Highly caffeinated beverage consumption was evaluated by asking, “During the past 7 days, how frequent did you drink highly caffeinated beverages?” with 7 response options: (1) never, (2) 1–2 times per week, (3) 3–4 times per week, (4) 5–6 times per week, (5) 1 time per day, (6) 2 times per day, and (7) 3 times or more per day. The options were dichotomized as HCB drinkers and HCB nondrinkers.

Statistical Analysis

We employed the Cramer’s V test to find statistical differences in demographic, socio-economic, and health-related characteristics between the two groups (drinkers vs. nondrinkers of HCBs) [34]. We considered Cramer’s V effect sizes as: (1) negligible associations if the values were less than 0.1; (2) weak associations if the values were between 0.1 and less than 0.2; (3) moderate associations if the

values were between 0.2 and less than 0.4; and (4) strong associations if the values were equal to or greater than 0.4.

We used multiple logistic regression to identify the correlates of HCB consumption with adjustments for grade, family level household income [20], weekly expenditure [35], and academic achievement [22]. Prevalence of HCB consumption from 2014 to 2017 was calculated with 95% confidence intervals and was visualized by survey year and sex in graphical plots. We employed STATA version 14 (STATA Press, College Station, TX) to test statistical analyses with the significance level set at 0.05 (two-sided). We have taken into consideration sample weights from the complex survey design with the use of Svy commands in STATA.

Results

Demographic and Health-related Characteristics of Boys

The final sample consisted of 267,907 middle and high school students in Korea with a mean age of 15.0 (SD = 1.7) and 51.2% being boys. Among boys, 17.2% of them were drinkers of HCBs (Table 1). Boys consisted of 46.6% middle school students. The majority of boys (95.3%) lived with their family members. Only 24.1% of boys met 8–10 hours of recommended sleep duration. For the BMI weight status, the proportion of normal weight was highest (72.7%) in boys, followed by obese (10.2%), overweight (8.7%), and underweight (8.4%). Among boys, the degree of association between HCB consumption and all demographic and most health-related characteristics was negligible. However, HCB consumption was weakly associated with soda consumption (Cramer's V = 0.190) and sweetened beverage consumption (Cramer's V = 0.155).

Table 1

Characteristics of boys by highly caffeinated beverage consumption, KYRBS 2014–2017

	Total (N = 137,101)	Drinkers (N = 23,600)	Nondrinkers (N = 113,501)	Effect size[a]	p-value
	%	%	%		
School type					
Middle school	46.6	43.8	47.2	0.026	< .001
High school	53.4	56.2	52.8		
Academic achievement					
Low	34.0	38.6	33.1	0.045	< .001
Middle	27.3	26.2	27.5		
High	38.7	35.2	39.5		
Household income					
Low	16.0	17.3	15.7	0.026	< .001
Middle	44.6	41.9	45.2		
High	39.4	40.9	39.1		
Weekly expenditure					
< 50,000 won (< USD 44.66)	85.1	78.8	86.4	0.087	< .001
50,000–99,999 won (USD 44.66–89.32)	9.8	12.7	9.2		
≥ 100,000 won (≥ USD 89.33)	5.1	8.5	4.4		
Paternal education					
≤ Middle school	3.0	3.4	2.9	0.013	.001
High school	33.4	32.4	33.6		
≥ College	63.7	64.2	63.5		
Maternal education					
≤ Middle school	2.4	2.7	2.3	0.015	< .001
High school	41.1	39.7	41.4		
≥ College	56.5	57.6	56.3		

	Total (N = 137,101)	Drinkers (N = 23,600)	Nondrinkers (N = 113,501)	Effect size[a]	p-value
	%	%	%		
Living situation					
Living with family	95.3	93.4	95.7	0.059	< .001
Living with relatives	0.9	1.8	0.7		
Living alone or with friends	3.2	3.7	3.1		
Living in home for orphans	0.6	1.2	0.4		
Work experience in last 12 months					
No	86.0	81.0	87.1	0.066	< .001
Yes	14.0	19.0	12.9		
BMI[b]					
Underweight	8.4	8.0	8.5	0.019	< .001
Normal weight	72.7	72.1	72.8		
Overweight	8.7	8.8	8.6		
Obese	10.2	11,1	10.0		
Alcohol use					
Never	54.4	45.9	56.1	0.077	< .001
Ever	45.6	54.1	43.9		
Tobacco use					
Never	75.9	68.7	77.4	0.076	< .001
Ever	24.1	31.3	22.6		

Table 1
Continued

	Total (N = 137,101)	Drinkers (N = 23,600)	Nondrinkers (N = 113,501)	Effect size[a]	p-value
	%	%	%		
Weekly physical activity for ≥ 60 minutes					
None	27.4	24.5	28.0	0.030	< .001
1–2 days	30.1	31.6	29.8		
≥ 3 days	42.5	43.9	42.2		
Weekly vigorous exercise for ≥ 20 minutes					
None	14.0	12.5	14.3	0.021	< .001
1–2 days	36.4	36.3	36.4		
≥ 3 days	49.6	51.2	49.3		
Weekly frequency of breakfast consumption					
0 days	15.9	17.0	15.7	0.044	< .001
1–2 days	12.2	15.0	11.6		
≥ 3 days	71.9	68.1	72.7		
Weekly frequency of soda consumption					
0 times	18.4	8.3	20.5	0.190	< .001
1–2 times	46.7	38.0	48.5		
≥ 3 times	34.9	53.8	31.0		
Weekly frequency of sweetened beverage consumption					
0 times	14.4	6.0	16.2	0.155	< .001
1–2 times	40.8	33.7	42.3		
≥ 3 times	44.8	60.4	41.6		
Meeting sleep duration recommendations (8–10 hours)					

	Total (N = 137,101)	Drinkers (N = 23,600)	Nondrinkers (N = 113,501)	Effect size[a]	p-value
	%	%	%		
Not met	75.9	78.5	75.4	0.028	< .001
Met	24.1	21.5	24.7		
Feeling relief of fatigue after sleep					
Not enough/not enough at all	34.8	40.8	33.5	0.060	< .001
Fair	33.2	31.8	33.4		
Very enough/enough	32.1	27.5	33.1		
Degree of feeling stressed					
Never/rarely	25.3	20.6	26.3	0.075	< .001
A little	44.4	41.9	44.9		
Much/very much	30.3	37.5	28.8		

Table 1
Continued

	Total (N = 137,101)	Drinkers (N = 23,600)	Nondrinkers (N = 113,501)	Effect size[a]	p-value
	%	%	%		
Weekly physical activity for ≥ 60 minutes					
None	27.4	24.5	28.0	0.030	< .001
1–2 days	30.1	31.6	29.8		
≥ 3 days	42.5	43.9	42.2		
Weekly vigorous exercise for ≥ 20 minutes					
None	14.0	12.5	14.3	0.021	< .001
1–2 days	36.4	36.3	36.4		
≥ 3 days	49.6	51.2	49.3		
Weekly frequency of breakfast consumption					
0 days	15.9	17.0	15.7	0.044	< .001
1–2 days	12.2	15.0	11.6		
≥ 3 days	71.9	68.1	72.7		
Weekly frequency of soda consumption					
0 times	18.4	8.3	20.5	0.190	< .001
1–2 times	46.7	38.0	48.5		
≥ 3 times	34.9	53.8	31.0		
Weekly frequency of sweetened beverage consumption					
0 times	14.4	6.0	16.2	0.155	< .001
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	%	%	%		
Not met	75.9	78.5	75.4	0.028	< .001
Met	24.1	21.5	24.7		
Feeling relief of fatigue after sleep					
Not enough/not enough at all	34.8	40.8	33.5	0.060	< .001
Fair	33.2	31.8	33.4		
Very enough/enough	32.1	27.5	33.1		
Degree of feeling stressed					
Never/rarely	25.3	20.6	26.3	0.075	< .001
A little	44.4	41.9	44.9		
Much/very much	30.3	37.5	28.8		

[Insert Table 1 about here]

Demographic And Health-related Characteristics Of Girls

As shown in Table 2, 13.1% of girls were drinkers of HCBs. Among girls, there were 46.6% middle school students. The majority of girls (87.3%) did not meet the recommended sleep duration (8–10 hours per night). About 80% of girls were normal weight (78.8%), followed by overweight (8.5%), obese (6.4%), and underweight (6.3%). Among girls, the degree of association between HCB consumption and all demographic and health-related variables was negligible, except soda consumption (Cramer's V = 0.148, weak association) and sweetened beverage consumption (Cramer's V = 0.144, weak association).

Table 2

Characteristics of girls by highly caffeinated beverage consumption, KYRBS 2014–2017

	Total (N = 130,806)	Drinkers (N = 17,014)	Nondrinkers (N = 113,792)	Effect size[a]	p-value
	%	%	%		
School type					
Middle school	46.6	45.6	46.8	0.008	.090
High school	53.4	54.4	53.3		
Academic achievement					
Low	33.5	38.6	32.7	0.042	< .001
Middle	29.4	28.0	29.6		
High	37.1	33.4	37.7		
Household income					
Low	16.5	17.9	16.3	0.025	< .001
Middle	49.6	46.4	50.1		
High	33.9	35.7	33.6		
Weekly expenditure					
< 50,000 won (< USD 44.66)	86.5	82.2	87.2	0.053	< .001
50,000–99,999 won (USD 44.66–89.32)	10.0	12.4	9.6		
≥ 100,000 won (≥ USD 89.33)	3.5	5.5	3.2		
Paternal education					
≤ Middle school	2.7	3.2	2.7	0.012	.004
High school	35.3	34.6	35.3		
≥ College	62.0	62.1	62.0		
Maternal education					
≤ Middle school	2.5	3.0	2.5	0.018	< .001
High school	44.8	42.7	45.1		
≥ College	52.7	54.3	52.5		

	Total (N = 130,806)	Drinkers (N = 17,014)	Nondrinkers (N = 113,792)	Effect size[a]	p-value
	%	%	%		
Living situation					
Living with family	96.0	94.6	96.2	0.041	< .001
Living with relatives	0.7	1.3	0.6		
Living alone or with friends	3.0	3.3	2.9		
Living in home for orphans	0.4	0.8	0.3		
Work experience in last 12 months					
No	87.4	83.4	88.0	0.046	< .001
Yes	12.6	16.6	12.0		
BMI[b]					
Underweight	6.3	6.0	6.4	0.016	< .001
Normal weight	78.8	77.7	78.9		
Overweight	8.5	9.1	8.4		
Obese	6.4	7.3	6.3		
Alcohol use					
Never	64.6	56.4	65.8	0.066	< .001
Ever	35.4	43.6	34.2		
Tobacco use					
Never	91.6	86.9	92.2	0.064	< .001
Ever	8.4	13.1	7.8		

Table 2
Continued

	Total (N = 130,806)	Drinkers (N = 17,014)	Nondrinkers (N = 113,792)	Effect size[a]	p-value
	%	%	%		
Weekly physical activity for ≥ 60 minutes					
None	44.6	41.5	45.1	0.024	< .001
1–2 days	33.9	35.8	33.7		
≥ 3 days	21.5	22.7	21.3		
Weekly vigorous exercise for ≥ 20 minutes					
None	34.1	32.1	34.4	0.016	< .001
1–2 days	41.5	42.8	41.4		
≥ 3 days	24.3	25.1	24.2		
Weekly frequency of breakfast consumption					
0 days	15.0	16.3	14.8	0.036	< .001
1–2 days	15.0	17.8	14.6		
≥ 3 days	70.1	65.9	70.7		
Weekly frequency of soda consumption					
0 times	29.3	17.8	31.0	0.148	< .001
1–2 times	48.9	45.5	49.4		
≥ 3 times	21.8	36.7	19.6		
Weekly frequency of sweetened beverage consumption					
0 times	16.1	7.7	17.4	0.144	< .001
1–2 times	45.0	36.1	46.3		
≥ 3 times	38.9	56.3	36.3		
Meeting sleep duration recommendations (8–10 hours)					

	Total (N = 130,806)	Drinkers (N = 17,014)	Nondrinkers (N = 113,792)	Effect size[a]	p-value
	%	%	%		
Not met	87.3	88.1	87.1	0.010	.004
Met	12.7	11.9	12.9		
Feeling relief of fatigue after sleep					
Not enough/not enough at all	48.2	55.6	47.1	0.059	< .001
Fair	31.6	28.6	32.1		
Very enough/enough	20.1	15.9	20.8		
Degree of feeling stressed					
Never/rarely	14.4	10.6	15.0	0.077	< .001
A little	41.9	36.0	42.8		
Much/very much	43.7	53.4	42.3		

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[Insert Table 2 about here]

Correlates Of Highly Caffeinated Beverage Consumption

Among all drinkers, higher odds of HCB consumption were associated with (1) being boys, (2) living with relatives, (3) having work experience in the last 12 months, (4) being overweight or obese, (5) overestimation of their body weight, (6) alcohol drinking, and (7) tobacco use (ps < .05). Additionally, drinkers were more likely (1) to have ≥ 60 minutes of physical activity 1–2 days per week, (2) to consume breakfast 1–2 days per week, (3) to consume soda ≥ 1 time per week, and (4) to consume sweetened beverages ≥ 1 time per week (ps < .05). Drinkers were more likely (1) to feel less than enough relief of fatigue after sleep, (2) to feel stressed a little or more, (3) to feel sadness and depression during last 12 months, (4) to seriously consider suicide during last 12 months, and (5) to attempt suicide during last 12 months (ps < .05). Significantly lower odds of HCB consumption were associated with high school educated mothers and underweight participants (ps < .05).

Among male drinkers, significantly higher odds of HCB consumption were associated with (1) living with relatives and (2) having work experience in the last 12 months (ps < .05). Boys drinking HCBs were more likely (1) to be obese, (2) to drink alcohol, and (3) to use tobacco (ps < .05). In addition, they were more likely (1) to have ≥ 60 minutes of physical activity 1–2 days per week, (2) to have ≥ 20 minutes of vigorous exercise ≥ 3 days per week, (3) to consume breakfast 1–2 days per week, (4) to consume soda

≥ 1 time per week, and (5) to consume sweetened beverage ≥ 1 time per week (ps < .05). Furthermore, they were more likely (1) not to meet recommended sleep duration (8–10 hours per night), (2) to feel not enough relief of fatigue after sleep, (3) to feel stressed a little or more, (4) to feel sadness and depression during last 12 months, (5) to seriously consider suicide during last 12 months, and (6) to attempt suicide during the last 12 months (ps < .05). Significantly lower odds of HCB consumption were associated with underweight participants and body weight underestimation (ps < .05).

Among female drinkers, significantly higher odds of HCB consumption were associated with (1) obesity, (2) body weight overestimation, (3) alcohol use, and (4) tobacco use (ps < .05). Girls drinking HCBs were more likely (1) to have ≥ 60 minutes of physical activity 1–2 days per week, (2) to consume soda ≥ 1 time per week and (3) to consume sweetened beverage ≥ 1 time per week (ps < .05). Moreover, HCB consumption was significantly associated with (1) feeling less than enough relief of fatigue after sleep, (2) feeling stressed a little or more, (3) feeling sadness and depression during last 12 months, (4) serious consideration of suicide during last 12 months, and (5) suicide attempt during last 12 months (ps < .05). In addition, significanlty lower odds of HCB consumption were associated with high school educated mothers (ps < .05).

[Insert Table 3 about here]

Table 3
Multiple logistic regression of highly caffeinated beverage consumption, KYRBS 2014–2017

	All (N = 267,907)	**Boys (N = 137,101)**	**Girls (N = 130,806)**
	AOR (95% CI)[a]	AOR (95% CI)[a]	AOR (95% CI)[a]
Gender			
Boys	1.25 (1.20, 1.31)***	-	-
Girls	Reference	-	-
Paternal education			
≤ Middle school	Reference	Reference	Reference
High school	0.92 (0.83, 1.02)	0.92 (0.80, 1.06)	0.91 (0.78, 1.06)
≥ College	0.95 (0.85, 1.05)	0.96 (0.84, 1.10)	0.93 (0.79, 1.09)
Maternal education			
≤ Middle school	Reference	Reference	Reference
High school	0.88 (0.79, 0.98)*	0.91 (0.79, 1.06)	0.84 (0.72, 0.98)*
≥ College	0.99(0.88, 1.10)	1.00 (0.86, 1.16)	0.97 (0.83, 1.13)
Living situation			
Living with family	Reference	Reference	Reference
Living with relatives	1.46 (1.18, 1.80)***	1.66 (1.28, 2.17)***	1.19 (0.83, 1.71)
Living alone or with friends	1.02 (0.93, 1.12)	0.97 (0.85, 1.10)	1.08 (0.96, 1.22)
Living in home for orphans	1.03 (0.65, 1.63)	0.92 (0.54, 1.56)	1.31 (0.51, 3.41)
Work experience in last 12 months			
No	Reference	Reference	Reference
Yes	1.05 (1.00, 1.11)*	1.09 (1.02, 1.16)*	1.01 (0.94, 1.09)
BMI[b]			
Under	0.90 (0.84, 0.96)**	0.90 (0.82, 0.98)*	0.91 (0.82, 1.00)
Normal	Reference	Reference	Reference

	All (N = 267,907)	Boys (N = 137,101)	Girls (N = 130,806)
Overweight	1.07 (1.01, 1.13)*	1.06 (0.98, 1.14)	1.09 (1.00, 1.18)*
Obese	1.22 (1.15, 1.29)***	1.21 (1.12, 1.30)***	1.24 (1.13, 1.37)***
Body weight perception			
Underestimation	0.95 (0.92, 0.99)*	0.95 (0.90, 1.00)*	0.95 (0.89, 1.02)
Accurate estimation	Reference	Reference	Reference
Overestimation	1.03 (0.99, 1.07)	0.99 (0.93, 1.05)	1.06 (1.00, 1.12)*
Alcohol use			
Never	Reference	Reference	Reference
Ever	1.17 (1.13, 1.22)***	1.16 (1.10, 1.22)***	1.19 (1.13, 1.26)***
Tobacco use			
Never	Reference	Reference	Reference
Ever	1.11 (1.06, 1.16)***	1.10 (1.04, 1.16)**	1.11 (1.02, 1.21)*
Weekly physical activity for ≥ 60 minutes			
None	Reference	Reference	Reference
1–2 days	1.10 (1.06, 1.15)***	1.14 (1.07, 1.21)***	1.08 (1.02, 1.14)**
≥ 3 days	1.04 (1.00, 1.09)	1.06 (1.00, 1.12)	1.03 (0.96, 1.11)
Weekly vigorous exercise for ≥ 20 minutes			
None	Reference	Reference	Reference
1–2 days	1.04 (0.99, 1.09)	1.05 (0.97, 1.13)	1.04 (0.98, 1.10)
≥ 3 days	1.05 (1.00, 1.11)	1.08 (1.01, 1.16)*	1.02 (0.94, 1.09)

Table 3
Continued

	All (N = 267,907)	Boys (N = 137,101)	Girls (N = 130,806)
	AOR (95% CI)[a]	AOR (95% CI)[a]	AOR (95% CI)[a]
Weekly frequency of breakfast consumption			
0 days	Reference	Reference	Reference
1–2 days	1.07 (1.01, 1.14)*	1.12 (1.03, 1.21)**	1.02 (0.94, 1.11)
≥ 3 days	0.96 (0.92, 1.00)	0.96(0.90, 1.02)	0.96 (0.90, 1.03)
Weekly frequency of soda consumption			
0 times	Reference	Reference	Reference
1–2 times	1.41 (1.35, 1.48)***	1.55 (1.44, 1.67)***	1.33 (1.25, 1.42)***
≥ 3 times	2.32 (2.20, 2.44)***	2.71 (2.51, 2.92)***	1.99 (1.85, 2.13)***
Weekly frequency of sweetened beverage consumption			
0 time	Reference	Reference	Reference
1–2 times	1.61 (1.52, 1.71)***	1.78 (1.63, 1.95)***	1.45 (1.33, 1.57)***
≥ 3 times	2.35 (2.21, 2.49)***	2.37 (2.17, 2.59)***	2.33 (2.14, 2.54)***
Meeting sleep duration recommendations (8–10 hours)			
Not met	1.04 (0.99, 1.09)	1.06 (1.00, 1.13)*	1.01 (0.94, 1.09)
Met	Reference	Reference	Reference
Feeling relief of fatigue after sleep			
Not enough/not enough at all	1.22 (1.17, 1.28)***	1.18 (1.12, 1.25)***	1.29 (1.20, 1.38)***
Fair	1.07 (1.02, 1.12)**	1.05 (0.99, 1.11)	1.11 (1.03, 1.19)**

	All (N = 267,907)	Boys (N = 137,101)	Girls (N = 130,806)
Very enough/enough	Reference	Reference	Reference
Degree of feeling stressed			
Never/rarely	Reference	Reference	Reference
A little	1.12 (1.07, 1.17)***	1.10 (1.04, 1.17)***	1.15 (1.06, 1.25)***
Much/very much	1.33 (1.27, 1.40)***	1.32 (1.24, 1.40)***	1.37 (1.27, 1.49)***
Feeling sadness and depression during last 12 months			
No	Reference	Reference	Reference
Yes	1.25 (1.20, 1.29)***	1.20 (1.14, 1.27)***	1.29 (1.22, 1.36)***
Seriously considered suicide during last 12 months			
No	Reference	Reference	Reference
Yes	1.11 (1.05, 1.16)***	1.08 (1.00, 1.16)*	1.13 (1.06, 1.20)***
Suicide attempt during last 12 months			
No	Reference	Reference	Reference
Yes	1.44 (1.31, 1.58)***	1.62 (1.39, 1.87)***	1.31 (1.16, 1.49)***
Use of weighted data with adjustment for the complex survey design.			
AOR = adjusted odds ratio; CI = confidence interval.			
[a]Odds ratio adjusted for grade, family level household income, weekly expenditure, and academic achievement.			
[b]Underweight (BMI < 5th percentile), normal weight (5th percentile ≤ BMI < 85th percentile), overweight (85th percentile ≤ BMI < 95th percentile), and obese (BMI ≥ 95th percentile).			
*p < 0.05; **p < 0.01; ***p < 0.001.			
Figure 1 Prevalence (%) of highly caffeinated drink consumption by survey year among all participants (N = 267,907).			
Solid line, all participants			

	All (N = 267,907)	Boys (N = 137,101)	Girls (N = 130,806)
Dashed line, boys			
Dotted line, girls			
Error bars, 95% Confidence Interval			
Figure 1 Prevalence (%) of highly caffeinated beverage consumption by survey year among all participants (N = 267,907)			

Prevalence Of Highly Caffeinated Beverages Consumption

Among all participants, the prevalence of HCB consumption was higher by 1.8% points from 12.0% in 2014 compared to 13.8% in 2016. Then the prevalence was higher by 10.1% points from 13.8% in 2016 compared to 23.9% in 2017, and this difference was much higher for boys (11.7% points) than for girls (8.5% points) in the short time period. HCB consumption was more prevalent in boys (26.7%) than in girls (20.9%) in 2017.

[Insert Fig. 1 about here]

Discussion

This study examined the prevalence and recent trends of HCB consumption among Korean adolescents. This study also investigated socio-demographic and behavioral factors related to HCB consumption in a nationally representative sample of Korean adolescents. To the best of our knowledge, this is the first study to comprehensively examine HCB consumption using multiple years of KYRBS data.

In this study, boys were more likely to consume HCBs, consistent with findings in previous studies [6, 7]. However, correlates of HCB consumption were generally similar for boys and girls. For both sexes, adolescents who consumed HCB were more likely to be obese, to drink soda at least once a week, and to drink sweetened beverage at least once a week. This not only confirms previous findings that the sugar content and the subsequent sweet flavor are reasons why adolescent consume HCBs [36, 37], but it also suggests that for adolescents consuming HCBs, the sugar content and its subsequent impact on weight may mask any weight-loss effect expected from the caffeine content [23, 26]. Hence, HCB abuse should be considered a concern for obesity as well as caffeine abuse.

Both boys and girls who consumed HCBs were more likely to engage in risky behaviors (alcohol and tobacco use) than nondrinkers, although the effect sizes were negligible. This is generally consistent with previous findings that adolescents with risky behaviors are more likely to consume HCBs [5, 6, 20, 38]. Similarly, adolescents who consumed HCBs were more likely to feel stressed, sad and depressed, feel unrested after sleep, and have suicidal thoughts and suicide attempts. Adolescents who feel stressed and

unrested may choose to consume HCB for temporary relief, though it may lead to the development of long-term sleep problems [5, 6, 13, 24].

Some sex differences were observed in the present study. Our regression analyses showed that among boys, HCB drinkers were more likely to have ≥ 20 minutes of vigorous exercise ≥ 3 days per week than nondrinkers. This phenomenon can be explained by how boys are more likely than girls to perceive higher energy and athletic performance after acute administration of caffeine [39]. Because boys perceive higher energy and athletic performance from caffeine [39], they may also expect HCBs to improve their workout, which leads to HCB consumption when engaged in vigorous-intensity exercise. Such association was not observed in girls, as girls were less likely to associate caffeine with athletic performance [39].

Another characteristic unique for boys was how HCB consumption was higher for boys who ate breakfast for low number of days. This may be attributed to how adolescents sometimes consume HCBs as snack supplements when skipping breakfast [40]. However, it is unclear why this phenomenon was observed in boys only. It may be that, in girls, the phenomenon was masked by other characteristics unique to girls, such as maternal education. Our results indicate that girls with mothers having high school education were less likely to consume HCBs than those with mothers having middle school education or less. It may be that mothers who received high school education were aware of potential harms of HCBs, and at the same time, managed intimate mother-daughter relationship. Previous studies have suggested that mother-daughter relationship may be inversely associated with body image and health behavior [41, 42], as mothers with intimate relationship with their daughters are able to function as effective advisors or role models. Similarly, in our study, mothers with intimate relationship with their daughters may have been more effective at discouraging their daughter's HCB consumption, even when the daughters were tempted to consume HCBs as snack supplements after skipping breakfast. Future strategies to curb HCB use among Korean adolescents should consider such possible sex differences.

The prevalence of HCB consumption was 26.7% for boys and 20.9% for girls in 2017. This is higher than 11.9–14.1% reported in earlier studies [6, 7]. One of our unique findings was the change in prevalence by year, most notable between years 2016 and 2017. We observed a sharp (13.8–23.9%) increase in HCB consumption between years 2016 and 2017, despite Korean government's policies intended to reduce adolescent's access to HCBs [17, 18]. This suggests that Korea's HCB policies may be ineffective, as asserted by a number of critics. For example, one of the existing policies that restrict television advertisements has been criticized for not understanding adolescent's media consumption, as it only prohibits advertisements between 5–7 pm in which many Korean adolescents are attending Hagwon learning academies and are away from television [43, 44]. A different policy that prohibits the sale of HCBs in school grounds has been criticized for its loopholes, as numerous venues outside school grounds remain free to sell HCBs [44, 45]. Although longitudinal analysis comparing HCB use before and after policy implementation is needed to evaluate the extent of effectiveness of each specific policy, this study shows that overall, existing policies intended to curb adolescent's HCB use are not as effective as initially envisioned. New strategies are needed to address HCB use, before HCB becomes even more popular among Korean adolescents.

Limitations

This study is not without limitations. First, although efforts were made to include and control for known confounders, there are unmeasured confounders such as the type of HCB, nutrient content of HCB, and access to HCB that could potentially influence the association between independent variables and HCB consumption. Second, this study relied on self-reported data, and given how adolescents have shown to under-report their body weight and over-report their height [46], BMI percentiles computed in this study may have differed slightly from those using direct anthropometric measurements. Third, this study used BMI percentiles to assign weight categories. While BMI percentile is commonly used to predict adiposity in children and adolescents, they cannot account for individuals' body composition (e.g., amount of fat mass vs. fat-free mass) or fat distribution (e.g., abdominal vs. non-abdominal fat). Lastly, though this study used multiple years of data to best identify factors associated with HCB consumption, this study was not a longitudinal analysis. Numbers reported reflect correlation, but not necessarily causation.

Conclusions

Despite the limitations, this study provides important information on HCB consumption and some of its correlates among Korean adolescents. This study found various factors associated HCB consumption, such as obesity, alcohol/tobacco use, stress, and sleep problems. This study found sex differences in HCB consumption, including differences by frequency of vigorous-intensity exercise, frequency of breakfast consumption, and maternal education. This study also found a significant growth in HCB consumption between 2016 and 2017, despite Korean government's efforts to curb adolescent's caffeine abuse. New strategies are needed to effectively curb HCB consumption among Korean adolescents. Future studies may utilize longitudinal and qualitative methods to further investigate sex differences in HCB consumption.

Declarations

Ethics approval and consent to participate

Ethics approval was given by the Institutional Review Board of Touro University, CA, USA (IRB No. PH0219). All participants provided online consent to participate in the survey. This study also obtained consent from their school principals and homeroom teachers.

Consent for publication

All participants have provided online consent for their personal data to be utilized.

Availability of data and material

Data can be made available through the authors.

Competing interests

The authors declare that they have no conflict of interest.

Funding

The authors have no financial sources to disclose.

Authors' contributions

HK and JS conceived the idea for the paper. HK, JS, and JL analyzed the data. HK, JS, JL, SC, and JC drafted the original manuscript. JPC and GC revised the original manuscript. All authors read and approved the manuscript.

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Abbreviations

BMI: body mass index; HCB: highly caffeinated beverage; KYRBS: Korea Youth Risk Behavior Web-based Survey; PSU: Primary Sampling Units; SKW: South Korea Won; USD: United States Dollar

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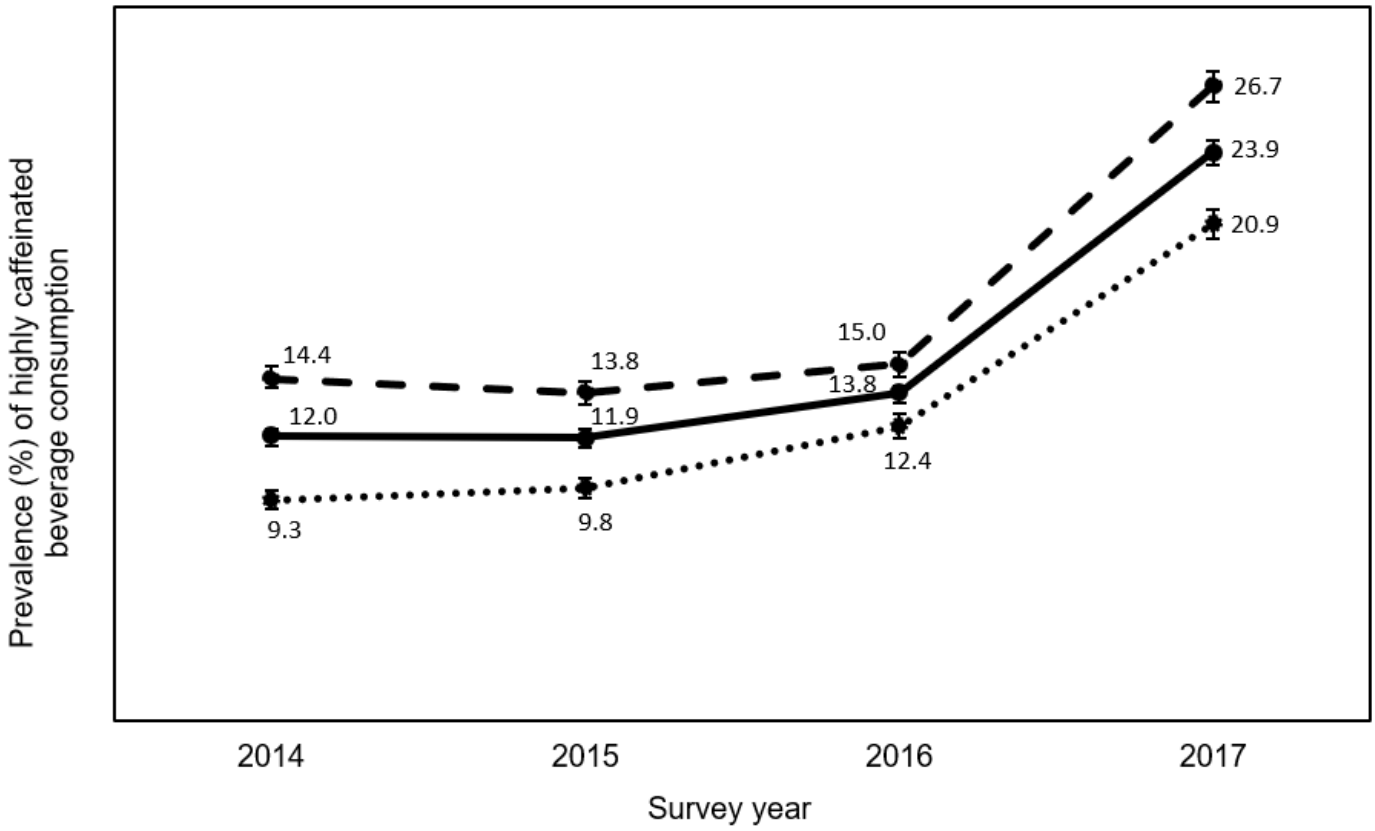
Figures

Fig. 1 Prevalence (%) of highly caffeinated beverage consumption by survey year among all participants ($N = 267,907$)



Note. Use of weighted data for the complex survey design.

Figure 1

Prevalence (%) of highly caffeinated drink consumption by survey year among all participants (N = 267,907). Solid line, all participants Dashed line, boys Dotted line, girls Error bars, 95% Confidence Interval

Supplementary Files

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- completedSTROBEcrosssectionalchecklist1023.docx