BMJ Open

Use Pattern and Predictors of Use of Highly Caffeinated Energy Drinks among South Korean Adolescents

SCHOLARONE™
Manuscripts

Use Pattern and Predictors of Use of Highly Caffeinated Energy Drinks among South Korean Adolescents

Dongmun Ha[1], Inmyung Song[1], Gyeongil Jang[1], Eui-Kyung Lee[1], Ju-Young Shin[1]

[1]School of Pharmacy, Sungkyunkwan University, Suwon, Korea

Word count: 2,945

Corresponding author:

Ju-Young Shin, PhD.

School of Pharmacy, Sungkyunkwan University

2066 Seobu-ro, Jangan-gu, Suwon, Gyeong gi-do, South Korea

Tel: 82-31-290-7702; Fax: 82-31-292-8800

E-mail: shin.jy@skku.edu

1

Abstract

Objectives: There is growing concern about the abuse of highly caffeinated energy drinks among Korean adolescents. This study compared adolescents' perceptions regarding the use of these drinks to their use behaviours and identified factors associated with said use.

Design: A structured questionnaire was developed based on the Health Belief Model (HBM) and administered to 850 freshmen and sophomores at 3 high schools in Bucheon, South Korea. Descriptive analysis was used to quantify the relationship between their beliefs about highly caffeinated energy drinks and their current use behaviours. Internal consistency was estimated using Cronbach's alpha. Hierarchical logistic regression analysis was used to compute odds ratios (ORs) and 95% confidence intervals (CIs) for the following predictors of use: (1) demographic factors, (2) perceived health threat (susceptibility and severity), (3) likelihood of action (perceptions of benefits and harms), and (4) cues to act (media and recommendations of friends or family members).

Results: Altogether, 833 students responded to the questionnaire (effective response rate = 98.0%). About 63.0% reported use of highly caffeinated energy drinks and 35.2% had used them as needed and habitually. The more susceptible the respondents perceived themselves to be to the risk of using these drinks, the less likely they were to use them (OR: 0.73, 95% CI: 0.50–1.06). The more severe the perception of a health threat, the less that perception was associated with use (OR: 0.44, 95% CI: 0.29–0.67). Likelihood of action was the strongest predictor of use, explaining 12.5% of the variance in use. Benefits and harms (OR: 4.43, 95% CI: 2.77–7.09; OR: 1.86, 95% CI: 1.16–2.99) also were significant predictors of use.

Conclusions: Enhancing adolescents' perceptions of benefits and harms regarding the risks of using highly caffeinated energy drinks could be an effective way to influence the use of these drinks.

Keywords: adolescents, caffeine use, health belief model, highly caffeinated energy drink

2

Strengths and limitations of this study

- The factors associated with adolescents' use of highly caffeinated energy drinks were identified and recommendations for changing their behaviours were derived through a hierarchical logistic regression model.

- The relationship between adolescents' beliefs about highly caffeinated energy drinks, such as the perceived health threat, likelihood of action, cues to act, and current use was identified.

- The sample might not be representative of all Korean adolescents across regions and school types.

- Other sources of caffeine intake, such as colas, and measurements of caffeine intake, such as frequency, amount, and duration of use, were not considered.

INTRODUCTION

Adolescents consume highly caffeinated energy drinks anticipating that these drinks will quickly increase their alertness and replenish their levels of mental and physical energy.[1-5] Male students in North America tend to consume these drinks in conjunction with other substances while participating in sports.[6] High school students in Korea tend to consume these drinks to stay awake while studying for exams in an environment of fierce competition for admission to prestigious colleges. Students in Korea are under extraordinarily high pressure to academically achieve, and Korea has the highest suicide rate among the OECD countries.[7] It is particularly alarming regarding the high suicide rate among adolescents.[8]

Excessive caffeine ingestion could result in numerous physical and psychological symptoms, including irritability, anxiety, depression, nervousness, sleep deprivation, and headache.[9] It also could elevate blood pressure and cause dehydration and, even, heart attack.[10] Long-term overconsumption of caffeine could cause stomach ulcers, erosive esophagitis, or gastroesophageal reflux disease.[11] The use of caffeinated energy drinks has been associated with symptoms, such as headache,[12] gastrointestinal problems,[13] insomnia,[14] loss of appetite,[15] and anxiety.[16] Caffeine also can negatively influence adolescents' development because it can disturb sleep between 11 pm and 2 am when growth hormones are mostly secreted. Also, over-secretion of peptic acid caused by caffeine intake can cause nausea that might deter the growth and development of very selective eaters.[17]

Users of highly caffeinated energy drinks are likely to experience feelings of depression. Adolescents' use of highly caffeinated energy drinks has been strongly associated with their concurrent use of alcohol, tobacco, and narcotics.[18] Therefore, overuse of these drinks could negatively influence adolescents' health and behaviour. In 2011, based on the evidence of adverse health effects, the American Academy of Pediatrics recommended against adolescents' use of energy drinks.[19] However, little is known about Korean adolescents' patterns of use of highly caffeinated energy drinks or the factors associated with such use. This study analysed Korean adolescents' perceptions and behaviours regarding highly caffeinated energy drinks, including their awareness of the content, their patterns and reasons for use, and the factors associated with use.

METHODS

Study Participants

This study analysed survey data on 850 freshmen and sophomores at three high schools in Bucheon, Korea. The students anonymously responded to a structured questionnaire. The survey was conducted for eight days between April 5 and April 13, 2015. The Sungkyunkwan University Institutional Review Board approved the study protocol (IRB No. SKKU-2015-02-004).

Conceptual model and measurement

To identify the factors associated with using highly caffeinated energy drinks, a research framework was constructed based on the Health Belief Model (HBM),[20] which is a commonly employed theoretical model to explain the relationship between individuals' beliefs and their behaviours.[21] The HBM comprises three factors: perceived health threat, likelihood of action, and cues to act, and the survey was also constructed in these three parts.

Perceived health threat: susceptibility and severity

The measure of perceived health threat was based on the premise that individuals choose certain health behaviours when they believe that their health is threatened. Perceived health threat had two measurable dimensions: perceived susceptibility and perceived severity. In this study, perceived susceptibility measured the belief that one is susceptible to health problems, diseases, disabilities, and injuries as the result of using highly caffeinated energy drinks. Perceived severity measured whether the respondent regarded the ill effects of using these drinks as serious rather than trivial, such as death, disability, numerous pains, economic difficulty, and damage to family or social relationships.

Likelihood of action: benefits and harms

A measure of the likelihood of action was in the model based on the assumption that individuals choose to use drinks when they expect the benefits of these drinks to be greater than the drinks' harms. We employed two variables to measure this factor: benefits and harms. The questions were directed to

5

Cues to act: media and recommendations of family members or friends

Cues to act were defined as strategies to activate the respondent's 'readiness' to engage in certain behaviours.[22] The variables concerned cues from media or recommendations from family members or friends. Media cues are about exposure to mass media, such as television, magazines, and the Internet, which might influence adolescents' beliefs that using highly caffeinated energy drinks is useful for fatigue recovery and drowsiness prevention. Recommendations from family members or friends were included because these individuals influence adolescents' behaviours.

Demographic factors

Age, sex, grade (academic report), extent of stress regarding grades (perceived pressure to academically achieve), the respondent's parents' economic status, health, and educational levels, and the respondent's previous education on safe drug use were in the model. The respondents were categorized into three groups by grade, stress regarding grades, socioeconomic status, and health of parents as below average, average, or above average. Each parent's educational level was classified as high school degree or less, college degree, or graduate degree. Previous education on safe drug use was the number of times the respondent had attended those educational programs.

The structured questionnaire and coding

A structured questionnaire was developed based on the HBM. All items except the demographic factors and dependent variable (current use of highly caffeinated energy drinks) were measured on five-point scales where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree (Table 1). The dependent variable measured the current use of highly caffeinated energy drinks where 1 = current use and 0 = current non-use. The independent variables were perceived health threat, likelihood of action, cues to act, and the demographic factors as described above.

6

Statistical Analysis

First, descriptive analysis was performed to identify the relationships between adolescents' beliefs, such as perceived health threat, likelihood of action, and cues to act, and their current use of highly caffeinated energy drinks. The means and standard deviations were calculated on the variables. Internal consistency was measured using Cronbach's alpha.

Second, a hierarchical logistic regression analysis was performed to test the relative effects of the independent variables on the use of highly caffeinated energy drinks and to explore the relationships among the independent variables. The parameters of the independent variables predicting use of highly caffeinated energy drinks were estimated using odds ratios (ORs) and 95% confidence intervals (CIs) by entering blocks of variables into the model in the following order: (1) demographic factors, (2) perceived health threat, (3) likelihood of action, and (4) cues to act. With this approach, the stronger the effect that a block of variables was expected to have on use, the later it was entered into the model. This order of entry allowed us to estimate the predictive power of each additional variable and block of variables controlling for the effects of the variables already entered. The explanatory power of the model was identified as Nagelkerke R^2. All of the statistical analyses were performed using SAS statistical application program (Version 9.4, SAS Institute Inc., Cary, NC, USA) and statistical significance was tested at the $p < 0.05$ level.

RESULTS

The sample comprised 836 students who responded to the questionnaire (response rate: 98.4%), and 833 cases were analysed after discarding three cases with missing data (effective response rate: 98.0%). The mean age was 16.5±0.8 years. The majority was male ($n = 463$, 55.6%). Of the 833 respondents, 792 (95.1%) reported that they were aware that the drinks they could buy in stores contained high amounts of caffeine. Five hundred twenty five (63.0%) reported that they had consumed these drinks and 293 (35.2%) reported consuming the drinks as needed or habitually. Most of the respondents' parents' had no more than high school degrees (fathers = 36.9%, mothers = 54.0%)

7

or college degrees (fathers = 54.5%, mothers = 40.9%). About 40.8% of the respondents reported no previous health education on safe drug use (Table 2). Cronbach's alpha values were 0.72, 0.76, and 0.71 on perceived health threat, likelihood of action, and cues to act, respectively (Table 3).

Beliefs and behaviours

The relationships between all of the independent variables (except media cues) and current use of highly caffeinated energy drinks were statistically significant. About 27.0% of the respondents who perceived a health threat were current users, whereas about 41.4% of the respondents who perceived no health threat were current users. About 28.5% of the respondents who perceived a severe health threat from use were current users, whereas about 54.2% of the respondents who did not perceive a severe health threat were current users ($p < 0.05$). More respondents reported perceptions of severity ($n = 615$) than of susceptibility ($n = 359$) ($p < 0.05$).

Respondents who reported positively about benefits and harms were more likely to be current users than to be non-users (62.8% and 65.1%, respectively) ($p < 0.05$). About 36.0% of the respondents who reported exposure to media were currently using these drinks compared to those who did not report such exposure (33.7%), and the coefficient was non-significant. Respondents with recommendations from family members or friends (48.5%) were more likely than those without such recommendations to be current users (33.3%, p < 0.05) (Table 4).

Factors associated with using highly caffeinated energy drinks

In the hierarchical logistic regression analysis, the four groups of factors all significantly contributed to the use of highly caffeinated energy drinks. The demographic factors (Model 1) explained about 1.5% of the variance in use ($p < 0.05$) (Table 5). Perceived health threat, which was added in Model 2, explained an additional 5.5% ($p < 0.05$) of the variance. The more severe the perceived health threat, the less it was associated with current use (OR: 0.44, 95% CI: 0.29–0.67). The more susceptible the respondent felt to a perceived health threat, the less it was associated with current use (OR: 0.73, 95% CI: 0.50–1.06). The likelihood of action had the strongest effect, adding

8

12.5% ($p < 0.05$) to the overall explanatory power of the model. The more cognizant respondents were of benefits (OR: 4.43, 95% CI: 2.77–7.09) and harms (OR = 1.86, 95% CI: 1.16–2.99), the more likely they were to currently use these drinks. Cues to act added 0.7% ($p < 0.05$) to the explanatory power and explained 20.2% of the variance. However, media and recommendations of family members or friends were not statistically significant (Table 5).

DISCUSSION

This study analysed Korean adolescents' beliefs and behaviours regarding using highly caffeinated energy drinks and investigated the factors associated with their use of these drinks, such as perceived health threat, likelihood of action, and cues to act. The respondents' perceptions of benefits and harms regarding threats to health from using these drinks were the strongest predictors of current use, explaining 12.5% of the variance in current use and increased the likelihood that a respondent currently used these drinks 4.43 times for those who perceived benefits and 1.86 times for those who perceived harms. This finding implies that increasing adolescents' perceptions of benefits and harms regarding threats to health from using highly caffeinated energy drinks could be an effective way to lessen their use of these drinks.

Of the 833 respondents, 792 (95.1%) reported that they were aware that the highly caffeinated energy drinks sold in stores contained high amounts of caffeine. Five hundred and twenty-five (63.0%) reported that they had consumed these drinks and 293 (35.2%) consumed the drinks as needed or habitually. This finding is consistent with a study on Canadian high school students in 2012 that found that 62% of the students had consumed the drinks at least once during the previous year and 40% of them had done so at least once per month.[23] Similarly, 94% of German adolescents were aware of energy drinks and 53% of them had sampled these drinks.[19]

In the current study's analysis, users of highly caffeinated drinks were more likely than non-users to perceive the severity of risk as below average and more likely than non-users to perceive the likelihood of risk occurrence as below average. According to a 2011 online survey of adolescents conducted by the Centers for Disease Control and Prevention,[27] those who used highly caffeinated

energy drinks more than once per week were 7.7 times as likely as non-users to perceive these drinks as safe. These findings suggest that raising adolescents' awareness of the severity of risk and susceptibility to caffeine over-consumption might reduce the number of users.

This study found that, among respondents who currently used energy drinks, perceived knowledge of benefits and harms were significantly influenced use status. The odds of current use were greater in respondents with higher perceived benefits and harms. Perceptions of expected benefits or harms of using these drinks were the strongest predictors of current use.

Males were more likely than females to use highly caffeinated energy drinks. Consistently, the use of energy drinks is more common among male students in Canada.[28,29] Similarly, the number of boys who consumed these drinks every day has been found to be 2–2.3 times the number of girls who do so in North America and Europe,[24] Iceland,[25] and Finland.[26] This finding suggests that the gender distribution of users of highly caffeinated energy drinks is similar across countries and that health education programs should focus on raising awareness of perceived susceptibility among male students. However, except for gender, current use was not associated with sociodemographic factors, academic grades, pressure to academically perform, parents' educations, parents' socioeconomic and health status, or previous health education. Students who received recommendations from family members or friends tended to consume these drinks. However, exposure to media was not associated with current use.

The importance of health education regarding the judicious use of highly caffeinated energy drinks was highlighted by Sherwood (2010).[30] The current study also found that using these drinks was influenced by recommendations by family members and friends, suggesting the importance of guidance in school and family settings.

The US Poison Center collects information on the adverse health effects of highly caffeinated energy drinks.[31 32] However, Korea does not have a system of collecting and analysing such data to apply to health education and inform policymaking. Therefore, scientific evidence is lacking on the numbers of students experiencing health risks by using energy drinks or the long-term health effects. More research is needed to produce evidence on the effects of caffeine on adolescent health.

This study identified the relationship between adolescents' beliefs about highly caffeinated energy drinks, such as the perceived health threat, likelihood of action, cues to act, and current use. Through a hierarchical logistic regression model, factors associated with adolescents' use of highly caffeinated energy drinks were identified and recommendations for changing their behaviours were derived. Despite its strengths, the findings of this study might not be generalizable because of the following limitations. First, the sample might not be representative of all Korean adolescents. High school seniors (third graders in the South Korean high school system) were excluded from our study, but should have been included to investigate their patterns of use for enhancing academic performance because these students experience the heaviest pressure to academically achieve. However, only freshmen and sophomores were included in this survey because we expected a low response rate from seniors. Future research should survey all students to increase representativeness.

Another limitation arose by not including students across regions and school types. We surveyed students at three preparatory schools in one city. Generalizability would have improved if the study had included students in rural areas and all school types (preparatory, vocational, and special purpose schools). Furthermore, other sources of caffeine intake, such as colas, and measurements of caffeine intake, such as frequency, amount, and duration of use, were not considered in this study. This makes it difficult to compare our findings to those of other studies because of differences in definitions of caffeine use and evaluation criteria (e.g., daily consumption, once-a-week consumption, frequency of consumption in the last month).

CONCLUSIONS

This study analysed South Korean adolescents' beliefs and behaviours regarding the use of highly caffeinated energy drinks and the factors associated with their use. Despite the stated limitations, this study's findings can provide a reference for future research on adolescent health behaviours to generate scientific evidence for the preparation of behaviour modification plans. Future research is needed to investigate adolescents' behaviours in detail that considers caffeine intake and dietary habits as well as factors that influence adolescents' behavioural changes and motivations.

ACKNOWLEDGEMENTS

12

Table 1. Summary of scales, variables, measure values, and analysis values

Scale (composition)	Variable	Measure Value	Analysis Value
Demographic factors	Age	Years	Constant
	Sex	Male / female	Male = 0 and female = 1
	Grade / Stress about grades	3-point scale*	2 or 3 points = 1 and 1 points = 0
	Parents' education status (Father / mother)	High school degree or less / college degree / graduate degree	High school degree or less = 0, college degree and graduate degree = 1
	Socioeconomic and health statuses of parents (Economic / health)	3-point scale*	Above average=3 Average=2 Below average=1
	Previous health education on safe drug use	Frequencies	$\geq$ 2 times = 1 and < 2 times = 0
Perceived health threat	Perceived susceptibility Perceived severity	5-point scale†	4 or 5 points = 1 (Positive) and $\leq$ 3 points = 0 (Negative)
Likelihood of action	Benefits Harms	5-point scale†	4 or 5 points = 1 (Positive) and $\leq$ 3 points = 0 (Negative)
Cues to act	Media Recommendation of family members or friends	5-point scale†	4 or 5 points = 1 (Positive) and $\leq$ 3 points = 0 (Negative)
Caffeine use	Current use of highly caffeinated energy drinks	2-point scale‡	Current use = 0, Current nonuse = 1

*More than middle = 3, middle = 2, and less than middle = 1.

1

Table 2. Demographic characteristics of the sample

Variable	Participants, No. (%)
Age (in years), mean (SD)	16.5 (0.8)
Sex	
Female	370 (44.4)
Male	463 (55.6)
Awareness that energy drinks contain high amounts of caffeine	
Yes	792 (95.1)
No	41 (4.9)
Use of caffeinated energy drink	
Current use[a]	293 (35.2)
Past use	232 (27.8)
Non-use	308 (37.0)
Grade*	
Below average	233 (28.0)
Average	310 (37.2)
Above average	290 (34.8)
Stress regarding grades[†]	
Below average	218 (26.2)
Average	375 (45.0)
Above average	240 (28.8)
Father's education	
High school degree or less	307 (36.9)
College degree	454 (54.5)
Graduate degree	72 (8.6)
Mother's education	
High school degree or less	450 (54.0)
College degree	341 (40.9)
Graduate degree	42 (5.0)
Parents' socioeconomic status	
Below average	206 (24.7)
Average	419 (50.3)
Above average	208 (25.0)
Parents' health status	
Below average	377 (45.3)
Average	376 (45.1)
Above average	71 (9.6)
Previous health education on safe drug use	
More than three times	75 (9.0)
Two or three times	260 (31.2)
One time	158 (19.0)
None	340 (40.8)
Total	**833 (100.0)**

*Academic reports.

†Pressure felt to academically achieve

[a] Current use of caffeinated energy drinks as needed or habitually

1

Table 3. Descriptive statistics of perceived health threat, likelihood of action, and cues to act with Cronbach's alphas

Variable	Mean	Standard deviation	Cronbach's alpha
Perceived health threat [a]			
Susceptibility	3.96	0.84	0.72
Severity	3.24	1.02	
Likelihood of action [b]			
Benefits	3.75	0.43	0.76
Harms	1.20	0.43	
Cues to act [c]			
Media	3.63	0.96	0.71
Recommendations of family members or friends	2.23	1.03	

[a] Adolescents' perception of susceptibility and that health threat is serious
[b] Adolescents' perception about expected benefits or harms of using highly caffeinated energy drinks
[c] Adolescents' motivation that put their perceptions from media or recommendations of family members or friends regarding consumption of highly caffeinated energy drinks into action

2

Table 4. Positive and negative responses to questions on perceived health threat, likelihood of action, and cues to act for current use and non-use of highly caffeinated energy drinks

Category	Variables	Response	Current use No. (%)	Non-use No. (%)	Total No. (%)	*p*-value
Perceived health threat [a]	Susceptibility*	Positive	97 (27.0)	262 (73.0)	359 (100.0)	
		Negative	196 (41.4)	278 (58.6)	474 (100.0)	<0.001†
		Total	293 (35.2)	540 (64.8)	833 (100.0)	
	Severity*	Positive	175 (28.5)	440 (71.5)	615 (100.0)	
		Negative	117 (54.2)	99 (45.8)	216 (100.0)	<0.001†
		Total	292 (35.1)	539 (64.9)	831 (100.0)	
Likelihood of action [b]	Benefits*	Positive	251 (62.8)	149 (37.3)	400 (100.0)	
		Negative	41(31.3)	90 (68.7)	131 (100.0)	<0.001†
		Total	292 (55.0)	239 (45.0)	531 (100.0)	
	Harms*	Positive	82 (65.1)	44 (34.9)	126 (100.0)	
		Negative	211 (51.8)	196 (48.2)	407 (100.0)	0.010†
		Total	293 (55.0)	240 (45.0)	533 (100.0)	
Cues to action [c]	Media*	Positive	193 (36.0)	343 (64.0)	536 (100.0)	
		Negative	100 (33.7)	197 (66.3)	297 (100.0)	0.496
		Total	293 (35.2)	540 (64.8)	833 (100.0)	
	Recommendations of family members or friends*	Positive	49 (48.5)	52 (51.5)	101 (100.0)	
		Negative	244 (33.3)	488 (66.7)	732 (100.0)	0.004†
		Total	293 (35.2)	540 (64.8)	833 (100.0)	

*Positive: agree or strongly agree, negative: neither agree nor disagree, disagree, or strongly disagree.
†Statistically significant.
[a] Perceptions of susceptibility and that health threat is serious
[b] Perceptions about expected benefits or harms of using highly caffeinated energy drinks
[c] Motivation that put their perceptions from media or recommendations of family members or friends regarding consumption of highly caffeinated energy drinks into action

3

Table 5. Results of hierarchical logistic regression analysis

Variables	Step1 OR (95% CI)	Step2 OR (95% CI)	Step3 OR (95% CI)	Step4 OR (95% CI)
Demographic characteristics				
►Age	1.01 (0.81, 1.26)	1.01 (0.81, 1.27)	0.96 (0.76, 1.21)	0.97 (0.76, 1.22)
►Sex	1.38 (0.96, 2.01)	1.23 (0.84, 1.79)	1.47 (0.98, 2.21)	1.49 (0.99, 2.24)
►Grade	1.01 (0.69, 1.46)	1.00 (0.68, 1.47)	0.85 (0.57, 1.28)	0.86 (0.57, 1.30)
►Father's education	1.19 (0.77, 1.83)	1.11 (0.71, 1.72)	1.09 (0.69, 1.75)	1.07 (0.67, 1.72)
►Mother's education	0.90 (0.59, 1.37)	0.90 (0.58, 1.38)	0.89 (0.56, 1.41)	0.90 (0.57, 1.43)
►Stress about grades	1.08 (0.73, 1.60)	1.11 (0.74, 1.66)	0.98 (0.64, 1.51)	0.98 (0.64, 1.51)
►Parents' health status	0.86 (0.46, 1.61)	0.90 (0.48, 1.71)	1.03 (0.53, 2.00)	0.99 (0.51, 1.95)
►Parents' economic status	0.96 (0.61, 1.52)	0.96 (0.60, 1.53)	0.96 (0.58, 1.57)	0.96 (0.58, 1.59)
►Pre-education of medicine	0.82 (0.58, 1.18)	0.92 (0.64, 1.33)	0.89 (0.60, 1.32)	0.89 (0.60, 1.32)
Perceived health threat [a]				
►Susceptibility		0.73 (0.50, 1.06)	0.62* (0.41, 0.94)	0.62* (0.41, 0.94)
►Severity		0.44* (0.29, 0.67)	0.41* (0.26, 0.64)	0.40* (0.25, 0.62)
Likelihood of action [b]				
►Benefits			4.43* (2.77, 7.09)	4.32* (2.69, 6.92)
►Harms			1.86* (1.16, 2.99)	1.78* (1.10, 2.86)
Cues to act [c]				
►Media				1.36 (0.91, 2.05)
►Recommendations of family members or friends				1.22 (0.68, 2.17)
Model summary				
Na R²	0.015*	0.070*	0.195*	0.202*
Δ R²	-	0.055*	0.125*	0.007*

Abbreviations: Na: Nagelkerke, OR: Odds ratio, CI: Confidence interval.
*Statistically significant.
[a] Perceptions of susceptibility and that health threat is serious
[b] Perceptions about expected benefits or harms using highly caffeinated energy drinks
[c] Motivation that put their perceptions from media or recommendations of family members or friends regarding consumption of highly caffeinated energy drinks into action

4

Contributors

Dongmun Ha and Ju-Young Shin designed the study and research concept. Gyeongil Jang acquired and arranged data. Analysis and interpretation of data was done by Eui-Kyung Lee and Inmyung Song. Dongmun Ha, Inmyung Song and Ju-Young Shin prepared manuscript. All authors contributed to the drafting of the paper and approved the final submitted version. The authors of this manuscript take responsibility for the integrity of the data and the accuracy of the data analysis.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests

None declared

Data sharing statement

No additional data are available

5

REFERENCES

1. Arria AM, O'Brien MC. The "high" risk of energy drinks. *Jama* 2011;305(6):600-1. doi: 10.1001/jama.2011.109 [published Online First: 2011/01/27]

2. Babu KM, Church RJ, Lewander W. Energy Drinks: The New Eye-Opener For Adolescents. *Clinical Pediatric Emergency Medicine* 2008;9(1):35-42. doi: 10.1016/j.cpem.2007.12.002

3. Oddy WH, O'Sullivan TA. Energy drinks for children and adolescents. *Bmj* 2009;339:b5268. [published Online First: 2009/12/17]

4. Reissig CJ, Strain EC, Griffiths RR. Caffeinated energy drinks--a growing problem. *Drug and alcohol dependence* 2009;99(1-3):1-10. doi: 10.1016/j.drugalcdep.2008.08.001 [published Online First: 2008/09/24]

5. Smit HJ, Cotton JR, Hughes SC, et al. Mood and cognitive performance effects of "energy" drink constituents: caffeine, glucose and carbonation. *Nutr Neurosci* 2004;7(3):127-39. doi: 10.1080/10284150400003041 [published Online First: 2004/11/06]

6. Buxton C, Hagan JE. A survey of energy drinks consumption practices among student -athletes in Ghana: lessons for developing health education intervention programmes. *J Int Soc Sports Nutr* 2012;9(1):9. doi: 10.1186/1550-2783-9-9 [published Online First: 2012/03/27]

7. The OECD. The OECD Health Statistics 2015. 2016

8. Korea National Statistics Office. Current status suicide rate in Korea 2015. 2016

9. Rath M. Energy drinks: what is all the hype? The dangers of energy drink consumption. *Journal of the American Academy of Nurse Practitioners* 2012;24(2):70-6. doi: 10.1111/j.1745-7599.2011.00689.x [published Online First: 2012/02/14]

10. Rottlaender D, Motloch LJ, Reda S, et al. Cardiac arrest due to long QT syndrome associated with excessive consumption of energy drinks. *Int J Cardiol* 2012;158(3):e51-2. doi: 10.1016/j.ijcard.2011.10.017 [published Online First: 2011/11/08]

11. Ding M, Bhupathiraju SN, Satija A, et al. Long-term coffee consumption and risk of cardiovascular disease: a systematic review and a dose-response meta-analysis of prospective cohort studies. *Circulation* 2014;129(6):643-59. doi: 10.1161/circulationaha.113.005925

6

[published Online First: 2013/11/10]

12. Hering-Hanit R, Gadoth N. Caffeine-induced headache in children and adolescents. *Cephalalgia :
    an international journal of headache* 2003;23(5):332-5. doi: 10.1046/j.1468-
    2982.2003.00576.x [published Online First: 2003/06/05]

13. Casuccio A, Bonanno V, Catalano R, et al. Knowledge, Attitudes, and Practices on Energy Drink
    Consumption and Side Effects in a Cohort of Medical Students. *Journal of addictive diseases*
    2015;34(4):274-83. doi: 10.1080/10550887.2015.1074501 [published Online First:
    2015/10/16]

14. Nordt SP, Claudius I, Rangan C, et al. Reasons for Energy Drink Use and Reported Adverse
    Effects Among Adolescent Emergency Department Patients. *Pediatr Emerg Care* 2016 doi:
    10.1097/pec.0000000000000644 [published Online First: 2016/06/02]

15. Miller JW, Naimi TS, Brewer RD, et al. Binge drinking and associated health risk behaviors
    among high school students. *Pediatrics* 2007;119(1):76-85. doi: 10.1542/peds.2006-1517
    [published Online First: 2007/01/04]

16. Hedges DW, Woon FL, Hoopes SP. Caffeine-induced psychosis. *CNS spectrums* 2009;14(3):127-9.
    [published Online First: 2009/05/02]

17. Guilbeau JR. Health risks of energy drinks: what nurses and consumers need to know. *Nursing for
    women's health* 2012;16(5):423-8. doi: 10.1111/j.1751-486X.2012.01766.x [published Online
    First: 2012/10/17]

18. Terry-McElrath YM, O'Malley PM, Johnston LD. Energy drinks, soft drinks, and substance use
    among United States secondary school students. *J Addict Med* 2014;8(1):6-13. doi:
    10.1097/01.adm.0000435322.07020.53 [published Online First: 2014/02/01]

19. Seifert SM, Schaechter JL, Hershorin ER, et al. Health effects of energy drinks on children,
    adolescents, and young adults. *Pediatrics* 2011;127(3):511-28. doi: 10.1542/peds.2009-3592
    [published Online First: 2011/02/16]

20. Health Behavior and Health Education.2008.

21. Villar OA, Montanez-Alvarado P, Gutierrez-Vega M, et al. Factor structure and internal reliability

7

of an exercise health belief model scale in a Mexican population. *BMC Public Health*

2017;17(1):229. doi: 10.1186/s12889-017-4150-x [published Online First: 2017/03/03]

22. Ha D, Song I, Park S, et al. Factors Associated With the Management of Adverse Drug Reactions

Among Community Pharmsacists in South Korea. *J Patient Saf* 2015 doi:

10.1097/pts.0000000000000211 [published Online First: 2015/10/10]

23. Azagba S, Langille D, Asbridge M. An emerging adolescent health risk: caffeinated energy drink

consumption patterns among high school students. *Prev Med* 2014;62:54-9. doi:

10.1016/j.ypmed.2014.01.019 [published Online First: 2014/02/08]

24. Visram S, Cheetham M, Riby DM, et al. Consumption of energy drinks by children and young

people: a rapid review examining evidence of physical effects and consumer attitudes. *BMJ*

Open 2016;6(10):e010380. doi: 10.1136/bmjopen-2015-010380 [published Online First:

2016/11/18]

25. Kristjansson AL, Sigfusdottir ID, Mann MJ, et al. Caffeinated Sugar-Sweetened Beverages and

Common Physical Complaints in Icelandic Children Aged 10-12 Years. *Prev Med* 2013 doi:

10.1016/j.ypmed.2013.10.011 [published Online First: 2014/02/12]

26. Arja Rimpela HH, P Lindfors, et al. Adolescents' use of energy drinks and caffeine. *European*

Journal of Public Health 2013;23(Supple) doi: 10.1542/peds.2006-1517

27. Kumar G, Park S, Onufrak S. Perceptions about energy drinks are associated with energy drink

intake among U.S. youth. *American journal of health promotion : AJHP* 2015;29(4):238-44.

doi: 10.4278/ajhp.130820-QUAN-435 [published Online First: 2014/01/28]

28. Reid JL, Hammond D, McCrory C, et al. Use of caffeinated energy drinks among secondary

school students in Ontario: Prevalence and correlates of using energy drinks and mixing with

alcohol. *Canadian journal of public health = Revue canadienne de sante publique*

2015;106(3):e101-8. doi: 10.17269/cjph.106.4684 [published Online First: 2015/07/01]

29. Reid JL, McCrory C, White CM, et al. Consumption of Caffeinated Energy Drinks Among Youth

and Young Adults in Canada. *Preventive medicine reports* 2017;5:65-70. doi:

10.1016/j.pmedr.2016.11.012 [published Online First: 2016/12/07]

8

30. Sherwood J. Energy drinks: beverage industry response. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne* 2010;182(15):1647-8. doi: 10.1503/cmaj.110-2104 [published Online First: 2010/10/20]

31. Greenwald PW, Farmer BM, O'Neill M, et al. Increasing frequency and fatality of poison control center reported exposures involving medication and multiple substances: data from reports of the American Association of Poison Control Centers 1984-2013. *Clin Toxicol (Phila)* 2016;54(7):590-6. doi: 10.1080/15563650.2016.1183777 [published Online First: 2016/05/24]

32. Mowry JB, Spyker DA, Brooks DE, et al. 2014 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 32nd Annual Report. *Clin Toxicol (Phila)* 2015;53(10):962-1147. doi: 10.3109/15563650.2015.1102927 [published Online First: 2015/12/02]

9

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5~6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	7
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(*b*) Report category boundaries when continuous variables were categorized	8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for	N/A

		a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10~11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10~11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	11~12

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Use Pattern and Predictors of Use of Highly Caffeinated Energy Drinks among South Korean Adolescents: a study using the Health Belief Model

SCHOLARONE™
Manuscripts

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Use Pattern and Predictors of Use of Highly Caffeinated Energy Drinks

among South Korean Adolescents: a study using the Health Belief Model

Dongmun Ha[1], Inmyung Song[1], Gyeongil Jang[1], Eui-Kyung Lee[1], Ju-Young Shin[1]

[1]School of Pharmacy, Sungkyunkwan University, Suwon, Korea

Word count: 3,295

Corresponding author:

Ju-Young Shin, PhD.

School of Pharmacy, Sungkyunkwan University

2066 Seobu-ro, Jangan-gu, Suwon, Gyeong gi-do, South Korea

Tel: 82-31-290-7702; Fax: 82-31-292-8800

E-mail: shin.jy@skku.edu

1

Abstract

Objectives: There is growing concern about the abuse of highly caffeinated energy drinks among Korean adolescents. This study compared adolescents' perceptions regarding the use of these drinks to their use behaviours and identified factors associated with said use.

Design: A structured questionnaire was developed based on the Health Belief Model (HBM) and administered to 850 freshmen and sophomores at 3 high schools in Bucheon, South Korea. Descriptive analysis was used to quantify the relationship between their beliefs about highly caffeinated energy drinks and their current use behaviours. Internal consistency was estimated using Cronbach's alpha. Hierarchical logistic regression analysis was used to compute odds ratios (ORs) and 95% confidence intervals (CIs) for the following predictors of use: (1) demographic factors, (2) perceived health threat (susceptibility and severity), (3) likelihood of action (perceptions of benefits and harms), and (4) cues to act (media and recommendations of friends or family members).

Results: Altogether, 833 students responded to the questionnaire (effective response rate = 98.0%). About 63.0% reported use of highly caffeinated energy drinks and 35.2% had used them as needed and habitually. The more susceptible the respondents perceived themselves to be to the risk of using these drinks, the less likely they were to use them (OR: 0.73, 95% CI: 0.50–1.06). The more severe the perception of a health threat, the less that perception was associated with use (OR: 0.44, 95% CI: 0.29–0.67). Likelihood of action was the strongest predictor of use, explaining 12.5% of the variance in use. Benefits and harms (OR: 4.43, 95% CI: 2.77–7.09; OR: 1.86, 95% CI: 1.16–2.99) also were significant predictors of use.

Conclusions: Enhancing adolescents' perceptions of benefits and harms regarding the risks of using highly caffeinated energy drinks could be an effective way to influence the use of these drinks.

Keywords: adolescents, caffeine use, health belief model, highly caffeinated energy drink

2

Strengths and limitations of this study

- Power of the factors associated with adolescents' use of highly caffeinated energy drinks was investigated through a hierarchical logistic regression model.

- The relationship between adolescents' beliefs about highly caffeinated energy drinks, such as the perceived health threat, likelihood of action, cues to act, and current use was identified using the Health Belief Model.

- The sample might not be representative of all Korean adolescents across regions and school types.

- Other sources of caffeine intake, such as colas, and measurements of caffeine intake, such as frequency, amount, and duration of use, were not considered.

3

INTRODUCTION

Highly caffeinated energy drinks are used often by surgeons to cope with fatigue and long working hours and by students for cognitive enhancement.[1, 2] Adolescents consume highly caffeinated energy drinks anticipating that these drinks will quickly increase their alertness and replenish their levels of mental and physical energy.[3-7] Caffeine was consumed in the forms of caffeinated drinks, tablets, as well as coffee by German adolescents.[8] Male students in North America tend to consume these drinks in conjunction with other substances while participating in sports.[9] High school students in Korea tend to consume these drinks to stay awake while studying for exams in an environment of fierce competition for admission to prestigious colleges. Students in Korea are under extraordinarily high pressure to academically achieve, and Korea has the highest suicide rate among member countries of the Organization for Economic Cooperation and Development.[10] It is particularly alarming regarding the high suicide rate among adolescents.[11]

Caffeine is a methylxanthine that stimulates the central nervous system. It increases alertness and concentration but excessive caffeine ingestion could result in numerous physical and psychological symptoms, including irritability, anxiety, depression, nervousness, sleep deprivation, and headache.[12] It also could elevate blood pressure and cause dehydration and, even, heart attack.[13] Long-term overconsumption of caffeine could cause stomach ulcers, erosive esophagitis, or gastroesophageal reflux disease.[14] The use of caffeinated energy drinks has been associated with symptoms, such as headache,[15] gastrointestinal problems,[16] insomnia,[17] loss of appetite,[18] and anxiety.[19] Caffeine also can negatively influence adolescents' development because it can disturb sleep between 11 pm and 2 am when growth hormones are mostly secreted. Also, over-secretion of peptic acid caused by caffeine intake can cause nausea that might deter the growth and development of very selective eaters.[20]

Users of highly caffeinated energy drinks are likely to experience feelings of depression.[21] Adolescents' use of highly caffeinated energy drinks has been strongly associated with their concurrent use of alcohol, tobacco, and narcotics.[22] Therefore, overuse of these drinks could negatively influence adolescents' health and behaviour. In 2011, based on the evidence of adverse health effects, the American Academy of Pediatrics recommended adolescents aged 12 to 18 years old

consume no more than 100 mg of caffeine a day.[23] Dariusz et al. (2015) studied the consumption patterns of energy drinks in Poland by defining overuse as daily consumption of energy drinks, too much use as consuming these drinks a few times a week, and much use as consuming these drinks once a week.[24] So far, little is known about Korean adolescents' patterns of use of highly caffeinated energy drinks or the factors associated with such use. This study analysed Korean adolescents' perceptions and behaviours regarding highly caffeinated energy drinks, including their awareness of the content, their patterns and reasons for use, and the factors associated with use by using the Health Belief Model (HBM),[25] which is a commonly employed theoretical model to explain the relationship between individuals' beliefs and their behaviours.[26]

METHODS

Study Participants

This study analysed survey data on 850 high students at three high schools in Bucheon, Korea. A paper questionnaire was distributed to all freshmen and sophomores at three selected high schools. They were asked to complete the questionnaire themselves and return the completed questionnaire to the survey administrator. The students anonymously responded to the structured questionnaire. The survey was conducted for eight days between April 5 and April 13, 2015. The Sungkyunkwan University Institutional Review Board approved the study protocol (IRB No. SKKU-2015-02-004).

Conceptual model and measurement

To identify the factors associated with using highly caffeinated energy drinks, survey questionnaire was developed based on the conceptual framework of the HBM. The HBM comprises three factors: perceived health threat, likelihood of action, and cues to act, and two questions per factor were constructed and responses to the questions were measured on a 5-point scale.

Perceived health threat: susceptibility and severity

5

The measure of perceived health threat was based on the premise that individuals choose certain health behaviours when they believe that their health is threatened. Perceived health threat had two measurable dimensions: perceived susceptibility and perceived severity. In this study, perceived susceptibility measured the belief that one is susceptible to health problems, diseases, disabilities, and injuries as the result of using highly caffeinated energy drinks. Perceived severity measured whether the respondent regarded the ill effects of using these drinks as serious rather than trivial, such as death, disability, numerous pains, economic difficulty, and damage to family or social relationships.

Likelihood of action: benefits and harms

A measure of the likelihood of action was in the model based on the assumption that individuals choose to use drinks when they expect the benefits of these drinks to be greater than the drinks' harms. We employed two variables to measure this factor: benefits and harms. The questions were directed to those respondents who reported that they had used these drinks.

Cues to act: media and recommendations of family members or friends

Cues to act were defined as strategies to activate the respondent's 'readiness' to engage in certain behaviours.[27] The variables concerned cues from media or recommendations from family members or friends. Media cues are about exposure to mass media, such as television, magazines, and the Internet, which might influence adolescents' beliefs that using highly caffeinated energy drinks is useful for fatigue recovery and drowsiness prevention. Recommendations from family members or friends were included because these individuals influence adolescents' behaviours.

Demographic factors

Age, sex, grade (academic report), extent of stress regarding grades (perceived pressure to academically achieve), the respondent's parents' economic status, health, and educational levels, and the respondent's previous education on safe drug use were in the model. The respondents were categorized into three groups by grade, stress regarding grades, socioeconomic status, and health of

6

parents. For each variable, the average was set based on the respondent's subjective evaluation. The

respondent was then asked to select one out of three choices (below average, average, or above

average).   Each parent's educational level was classified as high school degree or less, college

degree, or graduate degree. Previous education on safe drug use was the number of times the

respondent had attended those educational programs.

The structured questionnaire and coding

A structured questionnaire was developed based on the conceptual framework of the HBM. Each

factor of the HBM consists of two questions. All items except the demographic factors and dependent

variable (current use of highly caffeinated energy drinks) were measured on five-point scales where 1

= strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree

(Table 1). The dependent variable measured the current use of highly caffeinated energy drinks where

1 = current use and 0 = current non-use. The independent variables were perceived health threat,

likelihood of action, cues to act, and the demographic factors as described above.

Statistical Analysis

First, descriptive analysis was performed to identify the characteristics of the respondents. The

means and standard deviations were calculated on the variables. Internal consistency was measured

using Cronbach's alpha for factors related to adolescents' beliefs (perceived health threat, likelihood

of action, and cues to act). Second, chi-square tests were used to test the relationship between

adolescents' beliefs and current use of highly caffeinated drinks. Lastly, a hierarchical logistic

regression analysis was performed to test the relative effects of the independent variables on the use of

highly caffeinated energy drinks and to explore the relationships among the independent variables.

The parameters of the independent variables predicting use of highly caffeinated energy drinks were

estimated using odds ratios (ORs) and 95% confidence intervals (CIs) by entering blocks of variables

into the model in the following order: (1) demographic factors, (2) perceived health threat, (3)

likelihood of action, and (4) cues to act. With this approach, the stronger the effect that a block of

7

variables was expected to have on use, the later it was entered into the model. This order of entry allowed us to estimate the predictive power of each additional variable and block of variables controlling for the effects of the variables already entered. The explanatory power of the model was identified as Nagelkerke R^2. All of the statistical analyses were performed using SAS statistical application program (Version 9.4, SAS Institute Inc., Cary, NC, USA) and statistical significance was tested at the $p < 0.05$ level.

RESULTS

The sample comprised 836 students who responded to the questionnaire (response rate: 98.4%), and 833 cases were analysed after discarding three cases with missing data (effective response rate: 98.0%). The mean age was 16.5±0.8 years. The majority was male ($n = 463$, 55.6%). Of the 833 respondents, 792 (95.1%) reported that they were aware that the drinks they could buy in stores contained high amounts of caffeine. Five hundred twenty five (63.0%) reported that they had consumed these drinks and 293 (35.2%) reported consuming the drinks as needed or habitually. More males than females used highly caffeinated energy drinks. Most of the respondents' parents had no more than high school degrees (fathers = 36.9%, mothers = 54.0%) or college degrees (fathers = 54.5%, mothers = 40.9%). About 40.8% of the respondents reported no previous health education on safe drug use (Table 2). Cronbach's alpha values were 0.72, 0.76, and 0.71 on perceived health threat, likelihood of action, and cues to act, respectively (Table 3).

Beliefs and behaviours

The relationships between all of the independent variables (except media cues) and current use of highly caffeinated energy drinks were statistically significant. About 27.0% of the respondents who perceived a health threat were current users, whereas about 41.4% of the respondents who perceived no health threat were current users. About 28.5% of the respondents who perceived a severe health threat from use were current users, whereas about 54.2% of the respondents who did not perceive a

8

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

severe health threat were current users ($p < 0.05$). More respondents reported perceptions of severity ($n = 615$) than of susceptibility ($n = 359$) ($p < 0.05$).

Respondents who reported positively about benefits and harms were more likely to be current users than to be non-users (62.8% and 65.1%, respectively) ($p < 0.05$). About 36.0% of the respondents who reported exposure to media were currently using these drinks compared to those who did not report such exposure (33.7%), and the coefficient was non-significant. Respondents with recommendations from family members or friends (48.5%) were more likely than those without such recommendations to be current users (33.3%, p < 0.05) (Table 4).

Factors associated with using highly caffeinated energy drinks

In the hierarchical logistic regression analysis, the four groups of factors all significantly contributed to the use of highly caffeinated energy drinks. The demographic factors (Model 1) explained about 1.5% of the variance in use ($p < 0.05$); however, all subsequent variables of the demographic factors were not significant (Table 5). Perceived health threat, which was added in Model 2, explained an additional 5.5% ($p < 0.05$) of the variance. The more severe the perceived health threat, the less it was associated with current use (OR: 0.44, 95% CI: 0.29–0.67). The more susceptible the respondent felt to a perceived health threat, the less it was associated with current use (OR: 0.73, 95% CI: 0.50–1.06). The likelihood of action had the strongest effect, adding 12.5% ($p < 0.05$) to the overall explanatory power of the model. The more cognizant respondents were of benefits (OR: 4.43, 95% CI: 2.77–7.09) and harms (OR = 1.86, 95% CI: 1.16–2.99), the more likely they were to currently use these drinks. Cues to act added 0.7% ($p < 0.05$) to the explanatory power and all of the factors combined explained 20.2% of the variance. However, media and recommendations of family members or friends were not statistically significant (Table 5).

DISCUSSION

9

This study analysed Korean adolescents' beliefs and behaviours regarding using highly caffeinated energy drinks and investigated the factors associated with their use of these drinks, such as perceived health threat, likelihood of action, and cues to act. The respondents' perceptions of benefits and harms regarding threats to health from using these drinks were the strongest predictors of current use, explaining 12.5% of the variance in current use and increased the likelihood that a respondent currently used these drinks 4.43 times for those who perceived benefits and 1.86 times for those who perceived harms. These findings imply that the respondents do not perceive the harms as that worrying or they are not susceptible to the harms. Therefore, increasing adolescents' perceptions of benefits and harms regarding threats to health from using highly caffeinated energy drinks could be an effective way to lessen their use of these drinks.

Of the 833 respondents, 792 (95.1%) reported that they were aware that the highly caffeinated energy drinks sold in stores contained high amounts of caffeine. Five hundred and twenty-five (63.0%) reported that they had consumed these drinks and 293 (35.2%) consumed the drinks as needed or habitually. This finding is consistent with a study on Canadian high school students in 2012 that found that 62% of the students had consumed the drinks at least once during the previous year and 40% of them had done so at least once per month.[28] Similarly, 94% of German adolescents were aware of energy drinks and 53% of them had sampled these drinks.[23] More German students reported to have used caffeinated drinks than caffeine tablets for the purpose of cognitive enhancement.[8] Energy drinks were consumed by 67% of Polish adolescents and 58% of Switzerland adolescents were occasional users or regular users.[24,29] There are a number of motives for using energy drinks: insufficient sleep, to increase energy while studying, driving long periods, drinking alcohol, and to treat a hangover.[30]

In the current study's analysis, users of highly caffeinated drinks were more likely than non-users to perceive the severity of risk as below average and more likely than non-users to perceive the likelihood of risk occurrence as below average. According to a 2011 online survey of adolescents conducted by the Centers for Disease Control and Prevention,[31] those who used highly caffeinated energy drinks more than once per week were 7.7 times as likely as non-users to perceive these drinks as safe. These findings suggest that raising adolescents' awareness of the severity of risk and

susceptibility to caffeine over-consumption might reduce the number of users.

This study found that, among respondents who currently used energy drinks, perceived knowledge of benefits and harms were significantly influenced use status. The odds of current use were greater in respondents with higher perceived benefits and harms. Perceptions of expected benefits or harms of using these drinks were the strongest predictors of current use.

More males than females used highly caffeinated energy drinks. Consistently, the use of energy drinks is more common among male students in Canada.[32,33] Similarly, the number of boys who consumed these drinks every day has been found to be 2–2.3 times the number of girls who do so in North America and Europe,[34] Iceland,[35] and Finland.[36] This finding suggests that the gender distribution of users of highly caffeinated energy drinks is similar across countries and that health education programs should focus on raising awareness of perceived susceptibility among male students. However, except for gender, current use was not associated with sociodemographic factors, academic grades, pressure to academically perform, parents' educations, parents' socioeconomic and health status, or previous health education. Students who received recommendations from family members or friends tended to consume these drinks. However, exposure to media was not associated with current use.

The importance of health education regarding the judicious use of highly caffeinated energy drinks was highlighted by Sherwood (2010).[37] The current study also found that using these drinks was influenced by recommendations by family members and friends, suggesting the importance of guidance in school and family settings.

The severity of risk of caffeine addiction by adolescents is the reason why caffeine addiction is associated with health and welfare problems such as severely stressed, chronic depression, and overall poor health status.[38] The United States Poison Centers collect information on the adverse health effects of highly caffeinated energy drinks.[39, 40] However, Korea does not have a system of collecting and analysing such data to apply to health education and inform policymaking. Therefore, scientific evidence is lacking on the numbers of students experiencing health risks by using energy drinks or the long-term health effects. More research is needed to produce evidence on the effects of caffeine on

adolescent health.

This study identified the relationship between adolescents' beliefs about highly caffeinated energy drinks, such as the perceived health threat, likelihood of action, cues to act, and current use. Through a hierarchical logistic regression model, factors associated with adolescents' use of highly caffeinated energy drinks were identified and recommendations for changing their behaviours were derived. Despite its strengths, the findings of this study might not be generalizable because of the following limitations. First, the sample might not be representative of all Korean adolescents. High school seniors (third graders in the South Korean high school system) were excluded from our study, but should have been included to investigate their patterns of use for enhancing academic performance because these students experience the heaviest pressure to academically achieve. However, only freshmen and sophomores were included in this survey because we expected a low response rate from seniors. Future research should survey all students to increase representativeness.

Another limitation arose by not including students across regions and school types. We surveyed students at three preparatory schools in one city. Generalizability would have improved if the study had included students in rural areas and all school types (preparatory, vocational, and special purpose schools). Furthermore, other sources of caffeine intake, such as colas, and measurements of caffeine intake, such as frequency, amount, and duration of use, were not considered in this study. This makes it difficult to compare our findings to those of other studies because of differences in definitions of caffeine use and evaluation criteria (e.g., daily consumption, once-a-week consumption, frequency of consumption in the last month).

CONCLUSIONS

This study analysed South Korean adolescents' beliefs and behaviours regarding the use of highly caffeinated energy drinks and the factors associated with their use. Despite the stated limitations, this study's findings can provide a reference for future research on adolescent health behaviours to generate scientific evidence for the preparation of behaviour modification plans. Future research is needed to investigate adolescents' behaviours in detail that considers caffeine intake and dietary

habits as well as factors that influence adolescents' behavioural changes and motivations.

ACKNOWLEDGEMENTS

13

Table 1. Summary of scales, variables, measure values, and analysis values

Scale (composition)	Variable	Measure Value	Analysis Value
Demographic factors	Age	Years	Constant
	Sex	Male / female	Male = 0 and female = 1
	Grade / Stress about grades	3-point scale*	2 or 3 points = 1 and 1 points = 0
	Parents' education status (Father / mother)	High school degree or less / college degree / graduate degree	High school degree or less = 0, college degree and graduate degree = 1
	Socioeconomic and health statuses of parents (Economic / health)	3-point scale*	Above average=3 Average=2 Below average=1
	Previous health education on safe drug use	Frequencies	≥ 2 times = 1 and < 2 times = 0
Perceived health threat	Perceived susceptibility Perceived severity	5-point scale[†]	4 or 5 points = 1 (Positive) and ≤ 3 points = 0 (Negative)
Likelihood of action	Benefits Harms	5-point scale[†]	4 or 5 points = 1 (Positive) and ≤ 3 points = 0 (Negative)
Cues to act	Media Recommendation of family members or friends	5-point scale[†]	4 or 5 points = 1 (Positive) and ≤ 3 points = 0 (Negative)
Caffeine use	Current use of highly caffeinated energy drinks	2-point scale[‡]	Current use = 0, Current nonuse = 1

*More than middle = 3, middle = 2, and less than middle = 1.

1

Table 2. Demographic characteristics of the sample

Variable	Participants, No. (%)
Age (in years), mean (SD)	16.5 (0.8)
Sex	
Female	370 (44.4)
Male	463 (55.6)
Awareness that energy drinks contain high amounts of caffeine	
Yes	792 (95.1)
No	41 (4.9)
Use of caffeinated energy drink	
Current use[a]	293 (35.2)
Past use	232 (27.8)
Non-use	308 (37.0)
Grade*	
Below average	233 (28.0)
Average	310 (37.2)
Above average	290 (34.8)
Stress regarding grades[†]	
Below average	218 (26.2)
Average	375 (45.0)
Above average	240 (28.8)
Father's education	
High school degree or less	307 (36.9)
College degree	454 (54.5)
Graduate degree	72 (8.6)
Mother's education	
High school degree or less	450 (54.0)
College degree	341 (40.9)
Graduate degree	42 (5.0)
Parents' socioeconomic status	
Below average	206 (24.7)
Average	419 (50.3)
Above average	208 (25.0)
Parents' health status	
Below average	377 (45.3)
Average	376 (45.1)
Above average	71 (9.6)
Previous health education on safe drug use	
More than three times	75 (9.0)
Two or three times	260 (31.2)
One time	158 (19.0)
None	340 (40.8)
Total	**833 (100.0)**

*Academic reports.

†Pressure felt to academically achieve

[a] Current use of caffeinated energy drinks as needed or habitually

1

Table 3. Descriptive statistics of perceived health threat, likelihood of action, and cues to act with Cronbach's alphas

Variable	Mean	Standard deviation	Cronbach's alpha
Perceived health threat [a]			
Susceptibility	3.96	0.84	0.72
Severity	3.24	1.02	
Likelihood of action [b]			
Benefits	3.75	0.43	0.76
Harms	1.20	0.43	
Cues to act [c]			
Media	3.63	0.96	
Recommendations of family members or friends	2.23	1.03	0.71

[a] Adolescents' perception of susceptibility and that health threat is serious
[b] Adolescents' perception about expected benefits or harms of using highly caffeinated energy drinks
[c] Adolescents' motivation that put their perceptions from media or recommendations of family members or friends regarding consumption of highly caffeinated energy drinks into action

2

Table 4. Positive and negative responses to questions on perceived health threat, likelihood of action, and cues to act for current use and non-use of highly caffeinated energy drinks

Category	Variables	Response	Current use No. (%)	Non-use No. (%)	Total No. (%)	*p*-value
Perceived health threat [a]	Susceptibility*	Positive	97 (27.0)	262 (73.0)	359 (100.0)	
		Negative	196 (41.4)	278 (58.6)	474 (100.0)	<0.001†
		Total	293 (35.2)	540 (64.8)	833 (100.0)	
	Severity*	Positive	175 (28.5)	440 (71.5)	615 (100.0)	
		Negative	117 (54.2)	99 (45.8)	216 (100.0)	<0.001†
		Total	292 (35.1)	539 (64.9)	831 (100.0)	
Likelihood of action [b]	Benefits*	Positive	251 (62.8)	149 (37.3)	400 (100.0)	
		Negative	41(31.3)	90 (68.7)	131 (100.0)	<0.001†
		Total	292 (55.0)	239 (45.0)	531 (100.0)	
	Harms*	Positive	82 (65.1)	44 (34.9)	126 (100.0)	
		Negative	211 (51.8)	196 (48.2)	407 (100.0)	0.010†
		Total	293 (55.0)	240 (45.0)	533 (100.0)	
Cues to action [c]	Media*	Positive	193 (36.0)	343 (64.0)	536 (100.0)	
		Negative	100 (33.7)	197 (66.3)	297 (100.0)	0.496
		Total	293 (35.2)	540 (64.8)	833 (100.0)	
	Recommendations of family members or friends*	Positive	49 (48.5)	52 (51.5)	101 (100.0)	
		Negative	244 (33.3)	488 (66.7)	732 (100.0)	0.004†
		Total	293 (35.2)	540 (64.8)	833 (100.0)	

*Positive: agree or strongly agree, negative: neither agree nor disagree, disagree, or strongly disagree.
†Statistically significant.
[a] Perceptions of susceptibility and that health threat is serious
[b] Perceptions about expected benefits or harms of using highly caffeinated energy drinks
[c] Motivation that put their perceptions from media or recommendations of family members or friends regarding consumption of highly caffeinated energy drinks into action

3

Table 5. Results of hierarchical logistic regression analysis

Variables	Step1 OR (95% CI)	Step2 OR (95% CI)	Step3 OR (95% CI)	Step4 OR (95% CI)
Demographic characteristics				
►Age	1.01 (0.81, 1.26)	1.01 (0.81, 1.27)	0.96 (0.76, 1.21)	0.97 (0.76, 1.22)
►Sex	1.38 (0.96, 2.01)	1.23 (0.84, 1.79)	1.47 (0.98, 2.21)	1.49 (0.99, 2.24)
►Grade	1.01 (0.69, 1.46)	1.00 (0.68, 1.47)	0.85 (0.57, 1.28)	0.86 (0.57, 1.30)
►Father's education	1.19 (0.77, 1.83)	1.11 (0.71, 1.72)	1.09 (0.69, 1.75)	1.07 (0.67, 1.72)
►Mother's education	0.90 (0.59, 1.37)	0.90 (0.58, 1.38)	0.89 (0.56, 1.41)	0.90 (0.57, 1.43)
►Stress about grades	1.08 (0.73, 1.60)	1.11 (0.74, 1.66)	0.98 (0.64, 1.51)	0.98 (0.64, 1.51)
►Parents' health status	0.86 (0.46, 1.61)	0.90 (0.48, 1.71)	1.03 (0.53, 2.00)	0.99 (0.51, 1.95)
►Parents' economic status	0.96 (0.61, 1.52)	0.96 (0.60, 1.53)	0.96 (0.58, 1.57)	0.96 (0.58, 1.59)
►Pre-education of medicine	0.82 (0.58, 1.18)	0.92 (0.64, 1.33)	0.89 (0.60, 1.32)	0.89 (0.60, 1.32)
Perceived health threat [a]				
►Susceptibility		0.73 (0.50, 1.06)	0.62* (0.41, 0.94)	0.62* (0.41, 0.94)
►Severity		0.44* (0.29, 0.67)	0.41* (0.26, 0.64)	0.40* (0.25, 0.62)
Likelihood of action [b]				
►Benefits			4.43* (2.77, 7.09)	4.32* (2.69, 6.92)
►Harms			1.86* (1.16, 2.99)	1.78* (1.10, 2.86)
Cues to act [c]				
►Media				1.36 (0.91, 2.05)
►Recommendations of family members or friends				1.22 (0.68, 2.17)
Model summary				
Na R²	0.015*	0.070*	0.195*	0.202*
Δ R²	-	0.055*	0.125*	0.007*

Abbreviations: Na: Nagelkerke, OR: Odds ratio, CI: Confidence interval.
*Statistically significant.
[a] Perceptions of susceptibility and that health threat is serious
[b] Perceptions about expected benefits or harms using highly caffeinated energy drinks
[c] Motivation that put their perceptions from media or recommendations of family members or friends regarding consumption of highly caffeinated energy drinks into action

4

Contributors

Dongmun Ha and Ju-Young Shin designed the study and research concept. Gyeongil Jang acquired and arranged data. Analysis and interpretation of data was done by Eui-Kyung Lee and Inmyung Song. Dongmun Ha, Inmyung Song and Ju-Young Shin prepared manuscript. All authors contributed to the drafting of the paper and approved the final submitted version. The authors of this manuscript take responsibility for the integrity of the data and the accuracy of the data analysis.

Competing interests

The authors have no conflicts of interest that are directly relevant to the content of this study.

Data sharing statement

No additional data are available

5

REFERENCES

1.   Franke AG, Bagusat C, McFarlane C, Tassone-Steiger T, Kneist W, Lieb K. The Use of
        Caffeinated Substances by Surgeons for Cognitive Enhancement. Annals of surgery.
        2015;261(6):1091-5.

2.   Dietz P, Soyka M, Franke AG. Pharmacological Neuroenhancement in the Field of
        Economics—Poll Results from an Online Survey. Frontiers in Psychology. 2016;7(520).

3.   Arria AM, O'Brien MC. The "high" risk of energy drinks. Jama. 2011;305(6):600-1.

4.   Babu KM, Church RJ, Lewander W. Energy Drinks: The New Eye-Opener For Adolescents.
        Clinical Pediatric Emergency Medicine. 2008;9(1):35-42.

5.   Oddy WH, O'Sullivan TA. Energy drinks for children and adolescents. Bmj. 2009;339:b5268.

6.   Reissig CJ, Strain EC, Griffiths RR. Caffeinated energy drinks--a growing problem. Drug
        and alcohol dependence. 2009;99(1-3):1-10.

7.   Smit HJ, Cotton JR, Hughes SC, Rogers PJ. Mood and cognitive performance effects of
        "energy" drink constituents: caffeine, glucose and carbonation. Nutr Neurosci.
        2004;7(3):127-39.

8.   Franke AG, Christmann M, Bonertz C, Fellgiebel A, Huss M, Lieb K. Use of coffee,
        caffeinated drinks and caffeine tablets for cognitive enhancement in pupils and students in
        Germany. Pharmacopsychiatry. 2011;44(7):331-8.

9.   Buxton C, Hagan JE. A survey of energy drinks consumption practices among student -
        athletes in Ghana: lessons for developing health education intervention programmes. J Int
        Soc Sports Nutr. 2012;9(1):9.

10.   The OECD. The OECD Health Statistics 2015. 2016.

11.   Korea National Statistics Office. Current status suicide rate in Korea 2015. 2016.

12.   Rath M. Energy drinks: what is all the hype? The dangers of energy drink consumption.
        Journal of the American Academy of Nurse Practitioners. 2012;24(2):70-6.

13.   Rottlaender D, Motloch LJ, Reda S, Larbig R, Hoppe UC. Cardiac arrest due to long QT
        syndrome associated with excessive consumption of energy drinks. Int J Cardiol.

6

2012;158(3):e51-2.

14. Ding M, Bhupathiraju SN, Satija A, van Dam RM, Hu FB. Long-term coffee consumption and risk of cardiovascular disease: a systematic review and a dose-response meta-analysis of prospective cohort studies. Circulation. 2014;129(6):643-59.

15. Hering-Hanit R, Gadoth N. Caffeine-induced headache in children and adolescents. Cephalalgia : an international journal of headache. 2003;23(5):332-5.

16. Casuccio A, Bonanno V, Catalano R, Cracchiolo M, Giugno S, Sciuto V, et al. Knowledge, Attitudes, and Practices on Energy Drink Consumption and Side Effects in a Cohort of Medical Students. Journal of addictive diseases. 2015;34(4):274-83.

17. Nordt SP, Claudius I, Rangan C, Armijo E, Milano P, Yanger S, et al. Reasons for Energy Drink Use and Reported Adverse Effects Among Adolescent Emergency Department Patients. Pediatr Emerg Care. 2016.

18. Miller JW, Naimi TS, Brewer RD, Jones SE. Binge drinking and associated health risk behaviors among high school students. Pediatrics. 2007;119(1):76-85.

19. Hedges DW, Woon FL, Hoopes SP. Caffeine-induced psychosis. CNS spectrums. 2009;14(3):127-9.

20. Guilbeau JR. Health risks of energy drinks: what nurses and consumers need to know. Nursing for women's health. 2012;16(5):423-8.

21. Richards G, Smith AP. A Review of Energy Drinks and Mental Health, with a Focus on Stress, Anxiety, and Depression. Journal of caffeine research. 2016;6(2):49-63.

22. Terry-McElrath YM, O'Malley PM, Johnston LD. Energy drinks, soft drinks, and substance use among United States secondary school students. J Addict Med. 2014;8(1):6-13.

23. Seifert SM, Schaechter JL, Hershorin ER, Lipshultz SE. Health effects of energy drinks on children, adolescents, and young adults. Pediatrics. 2011;127(3):511-28.

24. Nowak D, Jasionowski A. Analysis of the Consumption of Caffeinated Energy Drinks among Polish Adolescents. International journal of environmental research and public health. 2015;12(7):7910-21.

7

25. Colombo G, Altomare G, Peris K, Martini P, Quarta G, Congedo M, et al. Moderate and severe plaque psoriasis: cost-of-illness study in Italy. Therapeutics and clinical risk management. 2008;4(2):559-68.

26. Villar OA, Montanez-Alvarado P, Gutierrez-Vega M, Carrillo-Saucedo IC, Gurrola-Pena GM, Ruvalcaba-Romero NA, et al. Factor structure and internal reliability of an exercise health belief model scale in a Mexican population. BMC Public Health. 2017;17(1):229.

27. Ha D, Song I, Park S, Lee EK. Factors Associated With the Management of Adverse Drug Reactions Among Community Pharmacists in South Korea. J Patient Saf. 2015.

28. Azagba S, Langille D, Asbridge M. An emerging adolescent health risk: caffeinated energy drink consumption patterns among high school students. Prev Med. 2014;62:54-9.

29. Barrense-Dias Y, Berchtold A, Akre C, Suris JC. Consuming energy drinks at the age of 14 predicted legal and illegal substance use at 16. Acta paediatrica (Oslo, Norway : 1992). 2016;105(11):1361-8.

30. Malinauskas BM, Aeby VG, Overton RF, Carpenter-Aeby T, Barber-Heidal K. A survey of energy drink consumption patterns among college students. Nutrition journal. 2007;6:35.

31. Kumar G, Park S, Onufrak S. Perceptions about energy drinks are associated with energy drink intake among U.S. youth. American journal of health promotion : AJHP. 2015;29(4):238-44.

32. Reid JL, Hammond D, McCrory C, Dubin JA, Leatherdale ST. Use of caffeinated energy drinks among secondary school students in Ontario: Prevalence and correlates of using energy drinks and mixing with alcohol. Canadian journal of public health = Revue canadienne de sante publique. 2015;106(3):e101-8.

33. 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. Preventive medicine reports. 2017;5:65-70.

34. Visram S, Cheetham M, Riby DM, Crossley SJ, Lake AA. Consumption of energy drinks by children and young people: a rapid review examining evidence of physical effects and

8

consumer attitudes. BMJ Open. 2016;6(10):e010380.

35. Kristjansson AL, Sigfusdottir ID, Mann MJ, James JE. Caffeinated Sugar-Sweetened

Beverages and Common Physical Complaints in Icelandic Children Aged 10-12 Years. Prev

Med. 2013.

36. Arja Rimpela HH, P Lindfors, et al. Adolescents' use of energy drinks and caffeine.

European Journal of Public Health. 2013;23(Supple).

37. Sherwood J. Energy drinks: beverage industry response. CMAJ : Canadian Medical

Association journal = journal de l'Association medicale canadienne. 2010;182(15):1647-8.

38. Rockett I. Caffeine "Addiction" in High School Youth: Evidence of an Adverse Health

Relationship. Addiction Research & Theory. 2002;10(1):31-42.

39. Greenwald PW, Farmer BM, O'Neill M, Essner RA, Flomenbaum NE. Increasing frequency

and fatality of poison control center reported exposures involving medication and multiple

substances: data from reports of the American Association of Poison Control Centers 1984-

2013. Clin Toxicol (Phila). 2016;54(7):590-6.

40. Mowry JB, Spyker DA, Brooks DE, McMillan N, Schauben JL. 2014 Annual Report of the

American Association of Poison Control Centers' National Poison Data System (NPDS):

32nd Annual Report. Clin Toxicol (Phila). 2015;53(10):962-1147.

9

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5~6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	7
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(*b*) Report category boundaries when continuous variables were categorized	8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for	N/A

		a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10~11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10~11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	11~12

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Use Pattern and Predictors of Use of Highly Caffeinated Energy Drinks among South Korean Adolescents: a study using the Health Belief Model

SCHOLARONE™
Manuscripts

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Use Pattern and Predictors of Use of Highly Caffeinated Energy Drinks among South Korean Adolescents: a study using the Health Belief Model

Dongmun Ha[1], Inmyung Song[1], Gyeongil Jang[1], Eui-Kyung Lee[1], Ju-Young Shin[1]

[1]School of Pharmacy, Sungkyunkwan University, Suwon, Korea

Word count: 3,454

Corresponding author:

Ju-Young Shin, PhD.

School of Pharmacy, Sungkyunkwan University

2066 Seobu-ro, Jangan-gu, Suwon, Gyeong gi-do, South Korea

Tel: 82-31-290-7702; Fax: 82-31-292-8800

E-mail: shin.jy@skku.edu

1

Abstract

Objectives: Concerns about the use of highly caffeinated energy drinks among Korean adolescents remains. We compared adolescents' perceptions regarding the use of drinks to their behaviours and factors.

Design: A structured questionnaire based on the health belief model was administered to 850 freshmen and sophomores at three high schools in Bucheon, South Korea. Benefits were defined as beneficial effects from the use of highly caffeinated energy drinks (e.g. awakening from sleepiness) and harms as adverse effects of the drinks (e.g., cardiac palpitation). Likelihood of action represents the likelihood of taking actions that are perceived to be more beneficial after comparison of the benefits and harms of caffeine use. Descriptive analysis was used to quantify the relationship between their beliefs about highly caffeinated energy drinks and their use. We conducted hierarchical logistic regression to compute odds ratios (ORs) and 95% confidence intervals (CIs) for: (1) demographic factors, (2) health threat, (3) likelihood of action, and (4) cues to act.

Results: Altogether, 833 students responded to the questionnaire (effective response rate = 98.0%). About 63.0% reported use of highly caffeinated energy drinks and 35.2% had used them as needed and habitually. The more susceptible the respondents perceived themselves to be to the risk of using these drinks, the less likely they were to use them (OR: 0.73, 95% CI: 0.50–1.06). The more severe the perception of a health threat, the less that perception was associated with use (OR: 0.44, 95% CI: 0.29–0.67). Likelihood of action was the strongest predictor of use, explaining 12.5% in use. Benefits and harms (OR: 4.43, 95% CI: 2.77–7.09; OR: 1.86, 95% CI: 1.16–2.99) also were significant predictors.

Conclusions: Enhancing adolescents' perceptions of benefits and harms regarding using highly caffeinated energy drinks could be an effective way to influence the use of these drinks.

Keywords: adolescents, caffeine use, health belief model, highly caffeinated energy drink

2

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Strengths and limitations of this study

■ This study measured the explanatory power of each factor influencing the consumption of highly caffeinated energy drinks and compared these power levels between factors.

■ The relationship between adolescents' beliefs concerning highly caffeinated energy drinks, such as perceived health threat, and likelihood of action, cues to action, and current use, was identified using the health belief model.

■ The sample used might not be representative of all Korean adolescents across regions and school types.

■ Other sources of caffeine intake, such as colas, and measurements of caffeine intake, such as frequency, amount ingested, and duration of use, were not considered.

3

INTRODUCTION

Highly caffeinated energy drinks are often used by surgeons to help address the fatigue caused by long working hours and by students seeking cognitive enhancement.[1, 2] Many adolescents consume highly caffeinated energy drinks, expecting these drinks to quickly increase their alertness and replenish their levels of mental and physical energy.[3-7] Caffeine was consumed in the forms of caffeinated drinks, tablets, as well as coffee by German adolescents.[8] Male students in North America tend to consume these drinks in conjunction with other substances while participating in sports.[9] High school students in Korea tend to consume these drinks to stay awake while studying for exams in an environment of fierce competition for admission to prestigious colleges. Students in Korea are under extraordinarily high pressure to academically achieve, and this is evidenced by the fact that in 2013 the academic stress index in Korea was found to be 50.5% higher than the average (33.3%) of the 30 countries surveyed.[10]

Caffeine is a methylxanthine that stimulates the central nervous system. It increases alertness and concentration but excessive caffeine ingestion can result in numerous physical and psychological symptoms, including irritability, anxiety, depression, nervousness, sleep deprivation, and headaches.[11] It also could elevate blood pressure and cause dehydration and, in extreme cases, heart attack.[12] Long-term overconsumption of caffeine can cause stomach ulcers, erosive esophagitis, or gastroesophageal reflux disease.[13] The use of caffeinated energy drinks has been associated with symptoms, such as headache,[14] gastrointestinal problems,[15] insomnia,[16] loss of appetite,[17] and anxiety.[18] Moreover, caffeine can also negatively influence adolescents' development because it can disturb sleep between 11 pm and 2 am a time when growth hormones are mostly secreted. Also, the over-secretion of peptic acid caused by caffeine intake can cause nausea that might deter the growth and development of very selective eaters.[19]

Users of highly caffeinated energy drinks are likely to experience feelings of depression.[20] Adolescents' use of highly caffeinated energy drinks has been strongly associated with their concurrent use of alcohol, tobacco, and narcotics.[21] Therefore, overuse of these drinks could negatively influence adolescents' health and behaviour. In 2011, based on the evidence of adverse

health effects, the American Academy of Pediatrics recommended adolescents aged 12 to 18 years old consume no more than 100 mg of caffeine a day.[22] Dariusz et al. (2015) studied the consumption patterns of energy drinks in Poland (2,629 students in junior and senior high schools) by defining overuse as daily consumption of energy drinks, too much use as consuming these drinks a few times a week, and much use as consuming these drinks once a week.[23]

The Health Belief Model (HBM)[24] is a commonly employed theoretical model used to explain the relationship between individuals' beliefs and their behaviours in individual areas of health.[25] In order to assist decisions concerning the correct actions to adopt to address certain issues, the model advocates considering 'perceived health threat', 'likelihood of action', and 'cue to action'.[26] Specifically, 'perceived health threat' relates to perceived susceptibility to a particular health problem and the perceived severity of that health problem; 'likelihood of action' is defined as when an individual considers the perceived benefits and barriers associated with certain actions; and 'cue to action' is defined as exposure to commercial advertisements and recommendations from acquaintances that encourage the user to make a behavioural change.

Thus far, little is known about Korean adolescents' patterns of use regarding highly caffeinated energy drinks or the factors associated with such use. Consequently, this study analyses Korean adolescents' perceptions and behaviours regarding highly caffeinated energy drinks, including their awareness of the health impacts, their patterns and reasons for use, and the factors associated with their use of such drinks. Specifically, we hypothesise that adolescents' patterns of use of highly caffeinated energy drinks may be determined using the HBM models' aspects of 'perceived health threat', 'likelihood of action', and 'cues to action'.

METHODS

Study Participants

This study analysed survey data sourced from 850 high students from three high schools based in Bucheon, Korea. To obtain these data, a structured, paper-based questionnaire was distributed to all

5

freshmen and sophomores at the three selected high schools. Each student was asked to complete the questionnaire independently, and then return it to the survey administrator; the students' responses were anonymous. Survey distribution and collection was conducted over eight days, from April 5 to April 13, 2015. The study protocol was approved by the Sungkyunkwan University Institutional Review Board (IRB No. SKKU-2015-02-004).

Conceptual model and measurement

To identify the factors associated with the use of highly caffeinated energy drinks, the survey questionnaire used was developed based on the conceptual framework of the HBM. As mentioned above, the HBM comprises three factors: perceived health threat, likelihood of action, and cues to action; we decided to allocate two questions to each factor, and to use a five-point scale to measure responses.

Perceived health threat: susceptibility and severity

The decision to measure perceived health threat in the study was based on the premise that individuals choose to adopt certain health behaviours when they believe that their health is threatened. Perceived health threat has two measurable dimensions: perceived susceptibility and perceived severity. In this study, we defined perceived susceptibility as relating to the belief that one is susceptible to health problems, diseases, disabilities, and injuries as a result of using highly caffeinated energy drinks, and we defined perceived severity as relating to whether respondents regarded the ill effects of using these drinks, such as death, disability, chronic pain, economic difficulties, and damage to family or social relationships, as serious rather than trivial.

Likelihood of action: benefits and harms

To measure likelihood of action, we based our questions on the assumption that individuals choose to use drinks when they expect the benefits of these drinks to outweigh the drinks' harms. We employed two variables to measure this factor: benefits and harms. Specifically, we defined benefits

6

as the beneficial effects obtained from the use of highly caffeinated energy drinks (e.g., increased alertness), and harms as the adverse effects of such drinks (e.g., cardiac palpitation). Further, we defined likelihood of action as the likelihood that a user, after comparing the benefits and harms of caffeine use, chooses to continue drinking caffeinated drinks because the consequences are perceived to be more beneficial than harmful. The questions in this regard were only directed towards respondents who reported that they had used these drinks.

Cues to action: Media and the recommendations of family members and friends

Cues to action is defined as strategies used to activate individuals' 'readiness' to engage in certain behaviours.[27] In regard to this study, the variables in question concerned cues from the media or recommendations from family members or friends to use caffeinated drinks. Specifically, media cues relate to exposure to mass media, such as television, magazines, and the Internet, that might influence adolescents' beliefs that using highly caffeinated energy drinks is useful for recovery from fatigue and preventing drowsiness. Meanwhile, recommendations from family members or friends were also included in this study because these individuals commonly influence adolescents' behaviours.

Demographic factors

Age, sex, grade (academic report), extent of stress regarding grades (perceived pressure to academically achieve), the respondent's parents' economic status, health, and educational levels, and the respondent's previous education on safe drug use were in the model. The respondents were categorized into three groups by grade, stress regarding grades, socioeconomic status, and health of parents. For each variable, the average was set based on the respondent's subjective evaluation. The respondent was then asked to select one out of three choices (below average, average, or above average). Each parent's educational level was classified as high school degree or less, college degree, or graduate degree. Previous education on safe drug use was the number of times the respondent had attended those educational programs.

7

The structured questionnaire and coding

A structured questionnaire was developed based on the conceptual framework of the HBM. Each factor of the HBM consists of two questions. All items except the demographic factors and dependent variable (current use of highly caffeinated energy drinks) were measured on five-point scales where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree (Table 1). The dependent variable measured the current use of highly caffeinated energy drinks where 1 = current use and 0 = current non-use. The independent variables were perceived health threat, likelihood of action, cues to act, and the demographic factors as described above.

Statistical Analysis

First, descriptive analysis was performed to identify the characteristics of the respondents. The means and standard deviations were calculated on the variables. Internal consistency was measured using Cronbach's alpha for factors related to adolescents' beliefs (perceived health threat, likelihood of action, and cues to act). Second, applying a 2×2 table, chi-square tests were used to examine the relationship between adolescents' beliefs concerning (positive and negative responses) and current use (whether they were a user or non-user) of highly caffeinated drinks. Lastly, a hierarchical logistic regression analysis was performed to test the relative effects of the independent variables on the respondents' use of highly caffeinated energy drinks and to explore the relationships between the independent variables. The parameters of the independent variables predicting the use of highly caffeinated energy drinks were estimated using odds ratios (ORs) and 95% confidence intervals (CIs) by entering blocks of variables into the model in the following order: (1) demographic factors, (2) perceived health threat, (3) likelihood of action, and (4) cues to action; specifically, the stronger the effect a block of variables was expected to have on use, the later it was entered into the model. This order of entry allowed us to estimate the predictive power of each additional variable and block of variables, controlling for the effects of the variables already entered. The explanatory power of the model was identified using Nagelkerke's R2. All of the statistical analyses were performed using a SAS statistical application program (Version 9.4, SAS Institute Inc., Cary, NC, USA) and statistical

8

significance was tested at the p < 0.05 level.

RESULTS

The sample comprised 836 students who responded to the questionnaire (response rate: 98.4%), and 833 cases were analysed after discarding three cases with missing data (effective response rate: 98.0%). The mean age was 16.5±0.8 years. The majority was male (*n* = 463, 55.6%). Of the 833 respondents, 792 (95.1%) reported that they were aware that the drinks they could buy in stores contained high amounts of caffeine. Five hundred twenty five (63.0%) reported that they had consumed these drinks and 293 (35.2%) reported consuming the drinks as needed or habitually. More males (42.6%) than females (25.1) used highly caffeinated energy drinks. Additionally, most of the respondents' parents had college degrees or lower (fathers = 91.4%, mothers = 94.9%). Finally, approximately 40.8% of the respondents reported that they had received no previous health education on safe drug use (Table 2). Cronbach's alpha values were 0.72, 0.76, and 0.71 on perceived health threat, likelihood of action, and cues to action, respectively (Table 3).

Beliefs and behaviours

The relationships between all of the independent variables (except media cues) and the current use of highly caffeinated energy drinks were found to be statistically significant. Of current users, approximately 27.0% perceived caffeinated drinks to pose a health threat, while approximately 41.4% perceived no health threat. Further, approximately 28.5% of current users perceived a severe health threat, and approximately 54.2% did not perceive a severe health threat (p < 0.05). In fact, more respondents reported perceptions of severity (n = 615) than of susceptibility (n = 359) (p < 0.05).

Respondents who reported positively concerning benefits and harms were more likely to be current users than non-users (62.8% and 65.1%, respectively) (p < 0.05). Moreover, approximately 36.0% of the respondents who reported exposure to related media were current users of these drinks, while 33.7% reported experiencing no such exposure; further, the coefficient was non-significant.

9

Lastly, respondents who received recommendations from family members or friends (48.5%) were more likely to be current users than those who did not receive such recommendations (33.3%, p < 0.05) (Table 4).

Factors associated with using highly caffeinated energy drinks

In the hierarchical logistic regression analysis, the four groups of factors were found to all significantly contribute to the use of highly caffeinated energy drinks. The demographic factors (Model 1) explained approximately 1.5% of the variance in use (p < 0.05); however, none of the subsequent variables of the demographic factors were found to be significant (Table 5). Perceived health threat, which was added in Model 2, explained an additional 5.5% (p < 0.05) of the variance; the more severe the perceived health threat, the less it was associated with current use (OR: 0.44, 95% CI: 0.29–0.67), and the more susceptible the respondent felt to a perceived health threat, the less it was associated with current use (OR: 0.73, 95% CI: 0.50–1.06). Likelihood of action had the strongest effect, adding 12.5% (p < 0.05) to the overall explanatory power of the model; specifically, the more cognizant respondents were of benefits (OR: 4.43, 95% CI: 2.77–7.09) and harms (OR = 1.86, 95% CI: 1.16–2.99), the more likely they were to be current users of these drinks. Lastly, cues to action added 0.7% (p < 0.05) to the explanatory power, and all of the factors combined explained 20.2% of the variance; however, media and recommendations of family members or friends were not statistically significant (Table 5).

DISCUSSION

This study analysed Korean adolescents' beliefs and behaviours regarding the use of highly caffeinated energy drinks, and investigated the factors associated with their use of these drinks, such as perceived health threat, likelihood of action, and cues to action. The respondents' perceptions of benefits and harms regarding threats to health as a result of using these drinks were the strongest predictors of current use, explaining 12.5% of the variance in current use; further, those who

10

perceived benefits were 4.43 times more likely to be current users of these drinks, while those who perceived harms were 1.86 times more likely. These findings imply that the more cognizant an individual is of the benefits and harms of energy drinks, the more likely they are to consume these drinks. It is natural that knowledge of benefits is associated with a greater use of highly caffeinated energy drinks; however, it is probable that the positive association between the recognition of harms and the use of these drinks represents a case of a reverse causal relationship: in other words, high consumers of these drinks have greater knowledge of their harms.

Of the 833 respondents, 792 (95.1%) reported that they were aware that the highly caffeinated energy drinks sold in stores contained high amounts of caffeine. Five hundred and twenty-five (63.0%) reported that they had consumed these drinks and 293 (35.2%) consumed the drinks as needed or habitually. This finding is consistent with a study on Canadian high school students in 2012 that found that 62% of the students had consumed the drinks at least once during the previous year and 40% of them had done so at least once per month.[28] Similarly, 94% of German adolescents were aware of energy drinks and 53% of them had sampled these drinks.[22] More German students reported to have used caffeinated drinks than caffeine tablets for the purpose of cognitive enhancement.[8] Energy drinks were consumed by 67% of Polish adolescents and 58% of Switzerland adolescents were occasional users or regular users.[23,29] There are a number of motives for using energy drinks: insufficient sleep, to increase energy while studying, driving long periods, drinking alcohol, and to treat a hangover.[30]

In the current study's analysis, users of highly caffeinated drinks were found to be more likely than non-users to perceive the severity of risk as below average, and were also more likely than non-users to perceive the likelihood of risk occurrence as below average. According to a 2011 online survey of adolescents conducted by the Centers for Disease Control and Prevention,[31] those who use highly caffeinated energy drinks more than once per week are 7.7 times more likely than non-users to perceive these drinks as safe. These findings suggest that raising adolescents' awareness of the severity of risk concerning and their susceptibility to engaging in caffeine over-consumption might reduce the number of users.

This study also found that, among respondents who currently used energy drinks, perceived

knowledge of benefits and harms significantly influenced use status. The odds of current use were greater in respondents with higher perceived benefits and harms, while perceptions of expected benefits or harms as a result of using these drinks were the strongest predictors of current use.

More males than females use highly caffeinated energy drinks. In Canada, studies have found that the use of energy drinks is consistently more common among male than female students.[32,33] Similarly, the number of boys who consumed these drinks every day has been found to be 2–2.3 times the number of girls who do so in North America and Europe,[34] Iceland,[35] and Finland.[36] This finding suggests that the gender distribution of users of highly caffeinated energy drinks is similar across countries, and that health-education programs should focus on raising awareness of perceived susceptibility among male students. However, aside from gender, current use has not been found to be associated with sociodemographic factors, academic grades, pressure to academically perform, parents' educations, parents' socioeconomic and health statuses, or previous health education. Additionally, while it was found that students who received recommendations from family members or friends tended to consume these drinks, exposure to media was not associated with current use.

The importance of health education regarding the judicious use of highly caffeinated energy drinks has been highlighted by Sherwood (2010).[37] Further, as the current study found that using these drinks is influenced by recommendations from family members and friends, it is clear that the implementation of guidance in school and family settings is required.

The severe consequences of adolescents developing caffeine addiction relate to the fact that caffeine addiction is associated with health and welfare problems such as severe stress, chronic depression, and overall poor health status.[38] The United States Poison Centers collect information on the adverse health effects of highly caffeinated energy drinks.[39, 40] However, Korea does not have a system of collecting and analysing such data to apply to health education and inform policymaking. Therefore, scientific evidence is lacking on the numbers of students experiencing health risks by using energy drinks or the long-term health effects. More research is needed to produce evidence on the effects of caffeine on adolescent health.

This study identified the relationship between adolescents' beliefs concerning highly caffeinated

12

energy drinks, such as perceived health threat, likelihood of action, cues to action, and current use. Through a hierarchical logistic regression model, factors associated with adolescents' use of highly caffeinated energy drinks were identified, and recommendations for changing their behaviours were derived. Despite its strengths, however, the findings of this study might not be generalizable because of the following limitations: First, the sample might not be representative of all Korean adolescents. High-school seniors (third graders in the South Korean high school system) were excluded from our study because we expected a low response rate from students at this level; however, these should have been included in order to investigate their patterns of use of caffeinated drinks to enhance academic performance; this is important because these students experience the heaviest pressure to academically achieve. Thus, in order to increase representativeness, future research should survey all students.

Another limitation arose by not including students across regions and school types. In this study, we surveyed students from three preparatory schools located within a single city; however, generalizability would have been improved if the study had included students from rural areas and all school types (preparatory, vocational, and special purpose schools). Furthermore, other sources of caffeine intake, such as colas, and measurements of caffeine intake, such as frequency, amount ingested, and duration of use, were not considered in this study. This makes it difficult to compare our findings to those of other studies, because differences exist in terms of definitions of caffeine use and evaluation criteria (e.g., daily consumption, once-a-week consumption, frequency of consumption in the last month).

CONCLUSIONS

This study analysed South Korean adolescents' beliefs and behaviours regarding the use of highly caffeinated energy drinks and the factors associated with their use. Despite the stated limitations, this study's findings can help future research on adolescent health behaviours generate scientific evidence that supports the preparation of behaviour-modification plans. To build on these findings, future research should investigate in detail adolescents' behaviours considering caffeine intake and dietary

habits, as well as factors that influence adolescents' behavioural changes and motivations.

ACKNOWLEDGEMENTS

14

Table 1. Summary of scales, variables, measure values, and analysis values

Scale (composition)	Variable	Measure Value	Analysis Value
Demographic factors	Age	Years	Constant
	Sex	Male / female	Male = 0 and female = 1
	Grade / Stress about grades	3-point scale*	2 or 3 points = 1 and 1 points = 0
	Parents' education status (Father / mother)	High school degree or less / college degree / graduate degree	High school degree or less = 0, college degree and graduate degree = 1
	Socioeconomic and health statuses of parents (Economic / health)	3-point scale*	Above average=3 Average=2 Below average=1
	Previous health education on safe drug use	Frequencies	≥ 2 times = 1 and < 2 times = 0
Perceived health threat	Perceived susceptibility Perceived severity	5-point scale†	4 or 5 points = 1 (Positive) and ≤ 3 points = 0 (Negative)
Likelihood of action	Benefits Harms	5-point scale†	4 or 5 points = 1 (Positive) and ≤ 3 points = 0 (Negative)
Cues to act	Media Recommendation from family members or friends	5-point scale†	4 or 5 points = 1 (Positive) and ≤ 3 points = 0 (Negative)
Caffeine use	Current use of highly caffeinated energy drinks	2-point scale‡	Current use = 0, Current do not use = 1

*More than middle = 3, middle = 2, and less than middle = 1.

1

Table 2. Demographic characteristics of the sample

Variable	Participants, No. (%)
Age (in years), mean (SD)	16.5 (0.8)
Sex	
Female	370 (44.4)
Male	463 (55.6)
Awareness that energy drinks contain high amounts of caffeine	
Yes	792 (95.1)
No	41 (4.9)
Use of caffeinated energy drink	
Current use[a]	293 (35.2)
Past use	232 (27.8)
Non-use	308 (37.0)
Grade*	
Below average	233 (28.0)
Average	310 (37.2)
Above average	290 (34.8)
Stress regarding grades[†]	
Below average	218 (26.2)
Average	375 (45.0)
Above average	240 (28.8)
Father's education	
High school degree or lower	307 (36.9)
College degree	454 (54.5)
Graduate degree	72 (8.6)
Mother's education	
High school degree or lower	450 (54.0)
College degree	341 (40.9)
Graduate degree	42 (5.0)
Parents' socioeconomic status	
Below average	206 (24.7)
Average	419 (50.3)
Above average	208 (25.0)
Parents' health status	
Below average	377 (45.3)
Average	376 (45.1)
Above average	71 (9.6)
Previous health education on safe drug use	
More than three times	75 (9.0)
Two or three times	260 (31.2)
One time	158 (19.0)
None	340 (40.8)
Total	**833 (100.0)**

*Academic reports.

[†]Pressure felt to academically achieve

[a] Current use of caffeinated energy drinks as needed or habitually

1

Table 3. Descriptive statistics of perceived health threat, likelihood of action, and cues to act with Cronbach's alphas

Variable	Mean	Standard deviation	Cronbach's alpha
Perceived health threat [a]			
Susceptibility	3.96	0.84	0.72
Severity	3.24	1.02	
Likelihood of action [b]			
Benefits	3.75	0.43	0.76
Harms	1.20	0.43	
Cues to act [c]			
Media	3.63	0.96	
Recommendations of family members or friends	2.23	1.03	0.71

[a] Adolescents' perception of their susceptibility and that the health threat of caffeinated drinks is serious

[b] Adolescents' perception of the expected benefits or harms of using highly caffeinated energy drinks

[c] The effect of suggestions from media or recommendations from family members or friends on adolescents' motivation to consume highly caffeinated energy drinks

2

Table 4. Positive and negative responses to questions concerning perceived health threat, likelihood of action, and cues to action and their effect on current use and non-use of highly caffeinated energy drinks

Category	Variables	Response	Current use No. (%)	Non-use No. (%)	Total No. (%)	*p*-value
Perceived health threat [a]	Susceptibility*	Positive	97 (27.0)	262 (73.0)	359 (100.0)	
		Negative	196 (41.4)	278 (58.6)	474 (100.0)	
		Total	293 (35.2)	540 (64.8)	833 (100.0)	<0.001†
	Severity*	Positive	175 (28.5)	440 (71.5)	615 (100.0)	
		Negative	117 (54.2)	99 (45.8)	216 (100.0)	
		Total	292 (35.1)	539 (64.9)	831 (100.0)	<0.001†
Likelihood of action [b]	Benefits*	Positive	251 (62.8)	149 (37.3)	400 (100.0)	
		Negative	41(31.3)	90 (68.7)	131 (100.0)	
		Total	292 (55.0)	239 (45.0)	531 (100.0)	<0.001†
	Harms*	Positive	82 (65.1)	44 (34.9)	126 (100.0)	
		Negative	211 (51.8)	196 (48.2)	407 (100.0)	
		Total	293 (55.0)	240 (45.0)	533 (100.0)	0.010†
Cues to action [c]	Media*	Positive	193 (36.0)	343 (64.0)	536 (100.0)	
		Negative	100 (33.7)	197 (66.3)	297 (100.0)	
		Total	293 (35.2)	540 (64.8)	833 (100.0)	0.496
	Recommendations from family members or friends*	Positive	49 (48.5)	52 (51.5)	101 (100.0)	
		Negative	244 (33.3)	488 (66.7)	732 (100.0)	
		Total	293 (35.2)	540 (64.8)	833 (100.0)	0.004†

*Positive: agree or strongly agree; negative: neither agree nor slightly disagree, disagree, or strongly disagree.

†Statistically significant.

a Perceptions of susceptibility and that the health threat of caffeinated drinks is serious

b Perceptions of the expected benefits or harms of using highly caffeinated energy drinks

c The effect of suggestions from media or recommendations from family members or friends on motivation to consume highly caffeinated energy drinks

3

Table 5. Results of the hierarchical logistic regression analysis

Variables	Step1 OR (95% CI)	Step2 OR (95% CI)	Step3 OR (95% CI)	Step4 OR (95% CI)
Demographic characteristics				
►Age	1.01 (0.81, 1.26)	1.01 (0.81, 1.27)	0.96 (0.76, 1.21)	0.97 (0.76, 1.22)
►Sex	1.38 (0.96, 2.01)	1.23 (0.84, 1.79)	1.47 (0.98, 2.21)	1.49 (0.99, 2.24)
►Grade	1.01 (0.69, 1.46)	1.00 (0.68, 1.47)	0.85 (0.57, 1.28)	0.86 (0.57, 1.30)
►Father's education	1.19 (0.77, 1.83)	1.11 (0.71, 1.72)	1.09 (0.69, 1.75)	1.07 (0.67, 1.72)
►Mother's education	0.90 (0.59, 1.37)	0.90 (0.58, 1.38)	0.89 (0.56, 1.41)	0.90 (0.57, 1.43)
►Stress about grades	1.08 (0.73, 1.60)	1.11 (0.74, 1.66)	0.98 (0.64, 1.51)	0.98 (0.64, 1.51)
►Parents' health status	0.86 (0.46, 1.61)	0.90 (0.48, 1.71)	1.03 (0.53, 2.00)	0.99 (0.51, 1.95)
►Parents' economic status	0.96 (0.61, 1.52)	0.96 (0.60, 1.53)	0.96 (0.58, 1.57)	0.96 (0.58, 1.59)
►Pre-education of medicine	0.82 (0.58, 1.18)	0.92 (0.64, 1.33)	0.89 (0.60, 1.32)	0.89 (0.60, 1.32)
Perceived health threat [a]				
►Susceptibility		0.73 (0.50, 1.06)	0.62* (0.41, 0.94)	0.62* (0.41, 0.94)
►Severity		0.44* (0.29, 0.67)	0.41* (0.26, 0.64)	0.40* (0.25, 0.62)
Likelihood of action [b]				
►Benefits			4.43* (2.77, 7.09)	4.32* (2.69, 6.92)
►Harms			1.86* (1.16, 2.99)	1.78* (1.10, 2.86)
Cues to act [c]				
►Media				1.36 (0.91, 2.05)
►Recommendations from family members or friends				1.22 (0.68, 2.17)
Model summary				
Na R^2	0.015*	0.070*	0.195*	0.202*
Δ R^2	-	0.055*	0.125*	0.007*

Abbreviations: Na: Nagelkerke, OR: Odds ratio, CI: Confidence interval.
*Statistically significant
a Perceptions of susceptibility and that the health threat of caffeinated drinks is serious
b Perceptions of the expected benefits or harms of using highly caffeinated energy drinks
c The effect of suggestions from media or recommendations from family members or friends on
  motivation to consume highly caffeinated energy drinks

4

Contributors

Dongmun Ha and Ju-Young Shin designed the study and research concept. Gyeongil Jang acquired and arranged the data. Analysis and interpretation of data was performed by Eui-Kyung Lee and Inmyung Song. Dongmun Ha, Inmyung Song, and Ju-Young Shin prepared the manuscript. All authors contributed to the drafting of the paper and approved the final submitted version. The authors of this manuscript take responsibility for the integrity of the data and the accuracy of the data analysis.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests

The authors have no conflicts of interest that are directly relevant to the content of this study.

Data sharing statement

No additional data are available

5

REFERENCES

1.   Franke AG, Bagusat C, McFarlane C, Tassone-Steiger T, Kneist W, Lieb K. The use of caffeinated substances by surgeons for cognitive enhancement. Ann Surg. 2015;261(6):1091-5.

2.   Dietz P, Soyka M, Franke AG. Pharmacological neuroenhancement in the field of economics—Poll results from an online survey. Front Psychol. 2016;7(520).

3.   Arria AM, O'Brien MC. The "high" risk of energy drinks. JAMA. 2011;305(6):600-1.

4.   Babu KM, Church RJ, Lewander W. Energy drinks: The new eye-opener for adolescents. Clin Pediatr Emerg Med. 2008;9(1):35-42.

5.   Oddy WH, O'Sullivan TA. Energy drinks for children and adolescents. BMJ. 2009;339:b5268.

6.   Reissig CJ, Strain EC, Griffiths RR. Caffeinated energy drinks--a growing problem. Drug Alcohol Depend. 2009;99(1-3):1-10.

7.   Smit HJ, Cotton JR, Hughes SC, Rogers PJ. Mood and cognitive performance effects of "energy" drink constituents: caffeine, glucose and carbonation. Nutr Neurosci. 2004;7(3):127-39.

8.   Franke AG, Christmann M, Bonertz C, Fellgiebel A, Huss M, Lieb K. Use of coffee, caffeinated drinks and caffeine tablets for cognitive enhancement in pupils and students in Germany. Pharmacopsychiatry. 2011;44(7):331-8.

9.   Buxton C, Hagan JE. A survey of energy drinks consumption practices among student - athletes in Ghana: lessons for developing health education intervention programmes. J Int Soc Sports Nutr. 2012;9(1):9.

10.   The Korea Institute for Health and Social Affairs. The subjective well-being of Korean children and its policy implications. 2015.

11.   Rath M. Energy drinks: what is all the hype? The dangers of energy drink consumption. J Am Acad Nurse Pract. 2012;24(2):70-6.

12.   Rottlaender D, Motloch LJ, Reda S, Larbig R, Hoppe UC. Cardiac arrest due to long QT syndrome associated with excessive consumption of energy drinks. Int J Cardiol. 2012;158(3):e51-2.

13.   Ding M, Bhupathiraju SN, Satija A, van Dam RM, Hu FB. Long-term coffee consumption

6

and risk of cardiovascular disease: a systematic review and a dose-response meta-analysis of prospective cohort studies. Circulation. 2014;129(6):643-59.

14.   Hering-Hanit R, Gadoth N. Caffeine-induced headache in children and adolescents. Cephalalgia. 2003;23(5):332-5.

15.   Casuccio A, Bonanno V, Catalano R, Cracchiolo M, Giugno S, Sciuto V, et al. Knowledge, attitudes, and practices on energy drink consumption and side effects in a cohort of medical students. Journal Addict Dis. 2015;34(4):274-83.

16.   Nordt SP, Claudius I, Rangan C, Armijo E, Milano P, Yanger S, et al. Reasons for energy drink use and reported adverse effects among adolescent emergency department patients. Pediatr Emerg Care. 2016.

17.   Miller JW, Naimi TS, Brewer RD, Jones SE. Binge drinking and associated health risk behaviors among high school students. Pediatrics. 2007;119(1):76-85.

18.   Hedges DW, Woon FL, Hoopes SP. Caffeine-induced psychosis. CNS Spectr. 2009;14(3):127-9.

19.   Guilbeau JR. Health risks of energy drinks: What nurses and consumers need to know. Nurs Women's Health. 2012;16(5):423-8.

20.   Richards G, Smith AP. A review of energy drinks and mental health, with a focus on stress, anxiety, and depression. J Caffeine Res. 2016;6(2):49-63.

21.   Terry-McElrath YM, O'Malley PM, Johnston LD. Energy drinks, soft drinks, and substance use among United States secondary school students. J Addict Med. 2014;8(1):6-13.

22.   Seifert SM, Schaechter JL, Hershorin ER, Lipshultz SE. Health effects of energy drinks on children, adolescents, and young adults. Pediatrics. 2011;127(3):511-28.

23.   Nowak D, Jasionowski A. Analysis of the consumption of caffeinated energy drinks among Polish adolescents. Int J Environ Res Public Health. 2015;12(7):7910-21.

24.   Colombo G, Altomare G, Peris K, Martini P, Quarta G, Congedo M, et al. Moderate and severe plaque psoriasis: Cost-of-illness study in Italy. Ther Clin Risk Manag. 2008;4(2):559-68.

25.   Villar OA, Montanez-Alvarado P, Gutierrez-Vega M, Carrillo-Saucedo IC, Gurrola-Pena

7

GM, Ruvalcaba-Romero NA, et al. Factor structure and internal reliability of an exercise health belief

model scale in a Mexican population. BMC Public Health. 2017;17(1):229.

26.   Glanz K, Lewis FM, Rimer BK (Eds.). Health behavior and health education (3rd ed). San

Francisco: Jossey-Bass. 2002.

27.   Ha D, Song I, Park S, Lee EK. Factors associated with the management of adverse drug

reactions among community pharmacists in South Korea. J Patient Saf. Epub ahead of print. 2015.

28.   Azagba S, Langille D, Asbridge M. An emerging adolescent health risk: Caffeinated energy

drink consumption patterns among high school students. Prev Med. 2014;62:54-9.

29.   Barrense-Dias Y, Berchtold A, Akre C, Suris JC. Consuming energy drinks at the age of 14

predicted legal and illegal substance use at 16. Acta Paediatrica (Oslo, Norway : 1992).

2016;105(11):1361-8.

30.   Malinauskas BM, Aeby VG, Overton RF, Carpenter-Aeby T, Barber-Heidal K. A survey of

energy drink consumption patterns among college students. Nutr J. 2007;6:35.

31.   Kumar G, Park S, Onufrak S. Perceptions about energy drinks are associated with energy

drink intake among U.S. youth. American journal of health promotion : American J Health Promot.

2015;29(4):238-44.

32.   Reid JL, Hammond D, McCrory C, Dubin JA, Leatherdale ST. Use of caffeinated energy

drinks among secondary school students in Ontario: Prevalence and correlates of using energy drinks

and mixing with alcohol. Canadian J Public Health. 2015;106(3):e101-8.

33.   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.

2017;5:65-70.

34.   Visram S, Cheetham M, Riby DM, Crossley SJ, Lake AA. Consumption of energy drinks by

children and young people: a rapid review examining evidence of physical effects and consumer

attitudes. BMJ Open. 2016;6(10):e010380.

35.   Kristjansson AL, Sigfusdottir ID, Mann MJ, James JE. Caffeinated sugar-sweetened

beverages and common physical complaints in Icelandic children aged 10-12 years. Prev Med. 2013.

8

36.   Huhtinen H, Rimpelä A, Lindfors P. Adolescents' use of energy drinks and caffeine. Eur J Public Health. 2013;23(supplement).

37.   Sherwood J. Energy drinks: Beverage industry response. CMAJ. 2010;182(15):1647-8.

38.   Rockett I. Caffeine "addiction" in high school youth: Evidence of an adverse health relationship. Addict Res Theory. 2002;10(1):31-42.

39.   Greenwald PW, Farmer BM, O'Neill M, Essner RA, Flomenbaum NE. Increasing frequency and fatality of poison control center reported exposures involving medication and multiple substances: data from reports of the American Association of Poison Control Centers 1984-2013. Clin Toxicol (Phila). 2016;54(7):590-6.

40.   Mowry JB, Spyker DA, Brooks DE, McMillan N, Schauben JL. 2014 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 32nd Annual Report. Clin Toxicol (Phila). 2015;53(10):962-1147.

9

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5~6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5~6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5~6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6~8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5~6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7~8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for	N/A

		a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12~13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11~12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11~12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	N/A

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.