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A mixed methods study of sugar sweetened beverage consumption and sleep quality among university students in West Virginia

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Abstract

Objective University students are at a higher risk of poor sleep quality due to academic and behavioral stressors. This study examined the association between sugar-sweetened beverage (SSB) intake and sleep quality among university students in West Virginia, United States using a mixed-methods approach.

Methods A cross-sectional web-based survey was administered among students aged ≥ 18 years enrolled at a university from April to December 2024. The survey collected information on demographics, daily SSB use (≥ 1 /day), and sleep quality assessed using the Pittsburgh Sleep Quality Index. Students' perceptions of the impact of SSBs on sleep were captured through an open-ended question. Quantitative data were analyzed using logistic regression, and qualitative responses were analyzed thematically.

Results Among 426 participants, 33.1% reported daily SSB use. After adjusting for demographic, socioeconomic, and behavioral covariates, daily SSB intake was associated with lower odds of good sleep quality (OR = 0.55, 95% CI: 0.32–0.93, $p = 0.03$). Of the total sample, 304 participants responded to the open-ended question. Seven themes emerged from the qualitative analysis of which the most frequently reported themes were perceived effects of SSBs on sleep (36.2%), timing of consumption (17.1%), and avoidance strategies (15.1%).

Conclusions Daily SSB intake was associated with poor sleep quality among university students. Qualitative findings suggest that this relationship is complex and influenced by multiple behavioral and contextual factors. These results highlight the need for multifaceted health promotion strategies targeting multiple health behaviors to improve sleep quality among university students.

Keywords Sugar-sweetened beverages, Sleep quality, Young adults, University, Mixed-method

1 Introduction

Sugar-sweetened beverages (SSBs) are beverages sweetened with various forms of added sugars, such as sucrose, high-fructose corn syrup, brown sugar, and fruit juice concentrates [1]. These sugars increase the caloric content of the beverages without providing



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essential nutrients [2]. Common SSBs include sodas/soft drinks (excluding sugar-free soda), fruit drinks, energy drinks, sweetened water, sweetened tea, sports drinks, flavored coffees, and sweetened dairy (i.e., strawberry and chocolate milk) or plant-based milk [1, 2]. The Dietary Guidelines for Americans (DGA) recommends limiting foods and beverages with added sugars to less than 10% of daily calories (12 teaspoons (tsp) per day for a 2000-calorie diet) starting at age two and advises against added sugars for children under two [2]. However, United States (U.S.) based evidence indicates that the added sugar intake exceeds these recommendations among both children and adults.

A nationally representative study published in 2023 by the Centers for Disease Control and Prevention (CDC), utilizing the National Health Interview Survey (NHIS) data found that U.S. adults consumed an average of 17.0 teaspoons per day of added sugars in 2010 and 2015 [3]. Higher consumption was observed among younger adults (18–24 years old), males, non-Hispanic Black individuals, unmarried persons, those with lower educational attainment, residents of non-metropolitan areas, people with annual household incomes below \$35,000, and those living in the southern regions of the US [3]. Similarly, a National Health and Nutrition Examination Survey (NHANES) data study from 2015 to 2018 reported that the prevalence of high-added sugar consumers, defined as > 15% of total daily caloric intake from added sugar, was greater among adults aged 20–70 years (29–33%) compared to those ≥ 70 years (22%) [4]. Higher consumption was also observed in non-Hispanic Black (39%) and non-Hispanic White (31%) individuals compared to Hispanic individuals (26%), as well as among those with low educational attainment and lower household income. Among high consumers of added sugar, sweetened beverages (42%) and tea (12%) were reported as the primary sources of the daily added sugar intake [4]. Consistent with these findings, another NHANES-based study found that among adults aged 19–50 years, sweetened beverages (37.4%) and coffee or tea (10.4%) were the major sources of added sugars contributing to approximately half of the total daily added sugar intake [5].

Frequent consumption of sweetened beverages can lead to increased risk of obesity, type 2 diabetes mellitus (T2DM), cardiovascular disease (CVD), tooth decay and cavities, cardiometabolic effects, non-alcoholic fatty liver disease, gout, cancer, depression, cellular aging, and mortality [2, 6]. Research also indicates that SSB consumption is linked to poor sleep quality, shorter sleep duration, and increased frequency of sleep disturbances [7–10]. Such sleep challenges can lead to a vicious cycle of increased energy intake as people seek to offset energy deficits and diminished alertness [11–13]. A meta-analysis of cross-sectional studies found that adults with shorter sleep durations were 1.2 times more likely to consume sodas than those who slept adequately [7].

Sleep quality among college (or university) students is influenced by various behavioral, psychological, and sociodemographic factors, including stress, sleep patterns, self-control, substance use, screen use, and mental health conditions such as depression and anxiety [14, 15]. Due to academic and social pressures, students may engage in unhealthy lifestyle behaviors, such as frequent intake of caffeine and SSBs, making them more susceptible to sleep challenges. The relationship between SSB and sleep can be explained through multiple pathways. Biologically, high sugar content in beverages can alter neuroendocrine and circadian regulation, affecting sleep-wake rhythms and emotional stability [16]. Behaviorally and psychologically, the co-occurrence of SSB consumption with factors such as late-night eating habits, screen use, irregular sleep

routine, academic stress, and fatigue can increase sleep disturbances [14, 17]. These relationships have been further explained by the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB), which highlight that perceived behavioral control, behavioral intentions, and perceived risks can influence health-related behaviors and sleep quality [18–20]. For example, a study applying the HBM and TPB frameworks among college students reported that HBM constructs and TPB behavioral intentions were significantly associated with poor sleep quality [18].

Several international and U.S.-based studies have assessed the relationship between SSB or similar product intake and sleep quality among university students [21]. A Norwegian study conducted among adolescents (13–19 years) found high SSB intake and poor diet associated with insomnia and psychological distress [22]. Similarly, a study conducted in China among 800 undergraduate students reported the indirect effect of sugary beverage consumption on BMI and sleep duration [23]. In the U.S., few studies have examined the relationship between SSB intake and sleep quality in college samples. Most studies have focused on assessing the association between specific beverage types (e.g., caffeine or energy drinks), and broader dietary patterns with sleep quality. For example, a study conducted among 272 undergraduate nursing students from universities in the Southwestern and Western regions of the U.S. found that students who consumed energy drinks reported poorer sleep quality, shorter sleep duration, and higher perceived stress than caffeine-only consumers and non-consumers [24]. Another survey study conducted at a Mid-Atlantic University assessed caffeinated beverages only and identified caffeinated soda as significantly associated with poor subjective sleep quality in young adults (18–24 years) [25]. Beyond college samples, studies of young adults in the U.S. have reported associations between poor sleep and higher SSB intake. Additionally, although quantitative studies have suggested an association between high SSB intake and poor sleep, there is a lack of qualitative research exploring how students perceive this relationship.

West Virginia (WV), a U.S. state is a relevant setting to examine the relationship between SSB intake and sleep due to its high prevalence of SSB consumption, lack of sleep, and related chronic conditions [1, 26]. The state reports high rates of obesity (41%), CVD (14.6%), diabetes (17.4%), SSB intake (59.4%), and insufficient sleep (41.3%), indicating a substantial burden of behavioral and health risk factors [1, 26]. WV is the only U.S. state entirely located within the Appalachian region. Evidence from another Appalachian state, Kentucky suggests that SSB consumption is higher among young adults than among other age groups [27]. In spite of this situation, research examining the relationship between SSB intake and sleep quality among university-attending young adults in the Appalachian region remains limited. Furthermore, to our knowledge, no studies have integrated both quantitative assessment of SSB consumption and qualitative exploration of students' perceptions in college populations.

Hence, using a mixed-methods approach, this study aimed to:

1. Examine the association between SSB intake and sleep quality in university students aged ≥ 18 years in West Virginia, United States.
2. Explore students' perceptions of how SSB intake impacts their sleep quality.

2 Methods

2.1 Study design

A cross-sectional design was used for this study. Full-time university students aged ≥ 18 or older who could read, write, and understand English were eligible to participate. A non-probability convenience sampling strategy was applied at a major state university in WV.

2.2 Procedure

Approval for the study was acquired from the West Virginia University Institutional Review Board (#2403941544) to conduct this study. The survey was conducted in two phases and was managed and distributed through Qualtrics (Provo, UT), a web-based survey tool.

Once an initial draft of the survey questionnaire was developed, a pilot test of the survey was conducted with 8 participants from the target population via online or in-person interviews, depending on participant's preference. Feedback from the interviews was used to refine the survey questionnaire. Additionally, to improve user interface and minimize survey non-response, participants were asked to review the survey across different device formats (i.e., big screen and mobile device) and provide feedback on question clarity, layout, and user experience. The research team also conducted internal testing to evaluate skip logic and overall survey flow. Participants involved in pilot testing were not included in the final analysis.

The finalized survey was rolled out in phase two from April 3, 2024, to December 31, 2024, and distributed as a URL via advertisements through university listservs and the routine university survey program. The survey's purpose, confidentiality, and anonymity were outlined at the start of the survey, after which the participants provided electronic informed consent confirming their willingness to participate. Survey participation was completely voluntary, and participants were permitted to skip any questions and to exit the survey at any time. No direct incentives were provided for participation in this study. Settings in Qualtrics were adjusted to ensure that only a single response per IP address was recorded.

Study recruitment was conducted using open distribution channels (i.e., a survey URL). Hence, the total number of students who received or viewed the survey invitation could not be determined and therefore a response rate could not be calculated.

2.3 Instruments and measures

2.3.1 Demographic characteristics

Participants' reported age (in years), sex (Male and Female), race (White, Black/African American, Asian, American Indian/Alaska Native, and Native Hawaiian or Pacific Islander), ethnicity (Hispanic and Non-Hispanic), education level (Associate degree, Bachelor's degree, Master's degree or higher, and Professional degree), smoking status (Yes/No), and international student status (Yes/No). Additional variables included overall grade point average (GPA; categorized as below 2.0, 2.0–2.5, 2.6–3.0, 3.1–3.5, and ≥ 3.6), self-rated overall health (assessed using a 5-point scale: excellent, very good, good, fair, and poor), and physical illness (Yes/No).

2.3.2 Sugar-sweetened beverage (SSB) intake

The frequency of SSB intake was assessed by asking the participants, “During the past month, how many times did you drink sodas, fruit drinks, sports or energy drinks, and other sugar-sweetened drinks?” Response options included 1 to 6 times per week, one time per day, two times per day, three times per day, and ≥ 4 times per day. Responses were subsequently classified into daily SSB use (≥ 1 time per day) versus non-daily use because small sample sizes within certain categories resulted in sparse cell counts and unstable estimates. This dichotomization was also informed by prior studies on SSB intake that have used daily SSB consumption as an exposure variable [28–30].

2.3.3 Physical activity

Physical activity was assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF). Studies in the literature have shown that IPAQ-SF demonstrates moderate to high reliability [31–34]. The frequency (days per week) and duration (time per day) of walking, vigorous intensity, and moderate intensity physical activity were assessed. Time per day was converted from hours to minutes. Following the scoring protocol for IPAQ-SF, separate scores were obtained for walking, moderate-intensity, and vigorous-intensity activities, which were then used to calculate the total physical activity score [35]. These scores were then utilized to classify the participants into low-, moderate-, and high-intensity physical activity groups.

2.3.4 Stress level

Perceived stress was measured using a ten-item Perceived Stress Scale (PSS-10) questionnaire. The literature has reported high reliability and validity of the PSS-10 for assessing perceived stress among college students [36–38]. The respondents answered each questionnaire item using a Five-point Likert-type scale, ranging from 0 (never) to 4 (very often). The raw scores are obtained for each item, which are then summed up to get one PSS score. This total score ranges from 0 to 40, with higher scores indicating higher perceived stress. Following the scoring protocol for PSS-10, the total score obtained was used to create a categorical variable for stress levels with low (0–13), moderate (14–26), and high (27–40) perceived stress as the categories [38].

2.3.5 Sleep quality

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) questionnaire, a validated tool developed by Buysse et al. 1989 [39]. The PSQI has demonstrated strong diagnostic properties in the literature, with a global PSQI score > 5 yielding a sensitivity of 89.6% and specificity of 86.5% ($\kappa = 0.75$, $p < 0.001$) in distinguishing between good and poor sleepers [39]. The questionnaire consists of 19 self-rated questions that assess factors related to sleep quality, such as sleep duration, sleep disturbances, daytime dysfunction, sleep latency, habitual sleep efficiency, and use of sleeping medication. Question scores produce seven component scores, weighed on a scale of 0 to 3. The seven scores are then summed to form a global PSQI score ranging from 0 to 21. Following the scoring guidelines for PSQI, the global score was used to create a binary dependent variable, with a score ≤ 5 reflecting good sleep quality and a score > 5 indicating poor sleep quality.

2.3.6 Participant's views on SSB intake and sleep quality

Participants' perceptions on the impact of SSB intake on sleep quality were assessed using an open-ended question: "Do you think daily intake of sugar-sweetened beverages impacts sleep quality? Provide a reason for your response." Responses were collected as free-text entries.

2.4 Data preparation

Data was exported from Qualtrics to Microsoft Excel for cleaning and preparation. No duplicate responses were identified. Since sleep quality is the dependent variable, we removed participants with missing values for the variables required in PSQI score (sleep quality scale) calculation. Due to a small number of participants in certain categories, race was dichotomized as White and non-White, GPA was categorized as ≤ 3.0 , 3.1–3.5, and 3.6–4.0, and physical activity was categorized as low/moderate versus high. We examined $\leq 5\%$ missing values for race, ethnicity, education level, GPA, and stress level. Since the missing data for these variables was less than 10%, we did not impute or remove them from the analytical dataset.

2.5 Analysis

2.5.1 Quantitative analysis

Descriptive statistics were used to summarize participant characteristics. Mean and standard deviation (SD) were reported for the continuous variables. While frequency (n) and percentage (%) were reported for categorical variables. Logistic regression was used to examine the association between sleep quality and daily SSB use. Two models were specified. First, an unadjusted logistic regression model assessed the association between SSB intake and sleep quality. Second, an adjusted logistic regression model was used to evaluate this relationship while controlling for demographic, socioeconomic, and behavioral covariates to account for potential confounding and isolate the true association between SSB intake and sleep quality. Model diagnostics for the adjusted model indicated no multicollinearity among covariates (variance inflation factor < 5). Odds ratios (ORs) and p-values were reported for both models, with statistical significance set at $p < 0.05$. All analyses were conducted in SAS version 9.4.

2.5.2 Qualitative analysis

Responses to the open-ended question were analyzed using thematic analysis informed by Braun and Clarke's approach, which included the following steps: data familiarization, generation of initial codes, theme identification, and theme refinement [40]. Two independent reviewers first familiarized themselves with the data. An initial subset of responses ($n = 40$) was used to inductively develop a preliminary codebook that captured recurring patterns in the data. These responses were later re-coded using the finalized codebook. The codebook was then pilot tested on an additional 60 responses, coded by both reviewers. Discrepancies were discussed and resolved through consensus among the reviewers, leading to the refinement of the codebook. Inter-rater reliability was assessed on these double-coded responses using Cohen's Kappa ($K = 0.83$). The remaining responses were divided equally between the two reviewers who independently coded them (102 responses per reviewer).

3 Results

3.1 Participant's characteristics

A total of 426 participants were included for quantitative analysis (Fig. 1). Table 1 presents the baseline characteristics of the study participants. The mean age was 21.38 (± 4.76) years old and 33.10% reported daily SSB use. The majority were female (68.78%), White (88.03%), and non-Hispanic (95.31%). Only 4.46% were international students. Most participants were pursuing a bachelor's degree (71.36%) and 33.33% reported smoking.

3.2 Quantitative analysis

Table 2 presents the results of the logistic regression analysis. In the unadjusted model, daily SSB use was significantly associated with lower odds of reporting good sleep quality (OR = 0.53, 95% CI: 0.35–0.82, $p = 0.004$). After controlling for demographics, socio-economic, and behavioral covariates in the adjusted model, this association remained statistically significant (OR = 0.55, 95% CI: 0.32–0.93, $p = 0.03$).

In the adjusted model, covariates such as self-rated health and stress level were also significantly associated with sleep quality. Specifically, poorer self-rated health (very good: OR = 0.40, 95% CI: 0.20–0.81, $p = 0.01$; good: OR = 0.36, 95% CI: 0.17–0.78, $p = 0.01$; fair/poor: OR = 0.03, 95% CI: 0.003–0.27, $p = 0.002$) and higher stress levels (moderate: OR = 0.22, 95% CI: 0.13–0.39, $p < 0.0001$; high: OR = 0.09, 95% CI: 0.03–0.27, $p < 0.0001$) were associated with lower odds of good sleep quality compared with those reporting excellent self-rated health and low stress.

3.3 Qualitative analysis

Of the 426 participants, 304 (71.3%) responded to the open-ended question. Thematic analysis identified seven major themes: (i) lack of knowledge or uncertainty regarding whether SSB intake affects sleep quality, (ii) disbelief that SSB intake negatively impacts sleep, (iii) perceived effects of SSBs on sleep, (iv) timing of beverage consumption, (v)

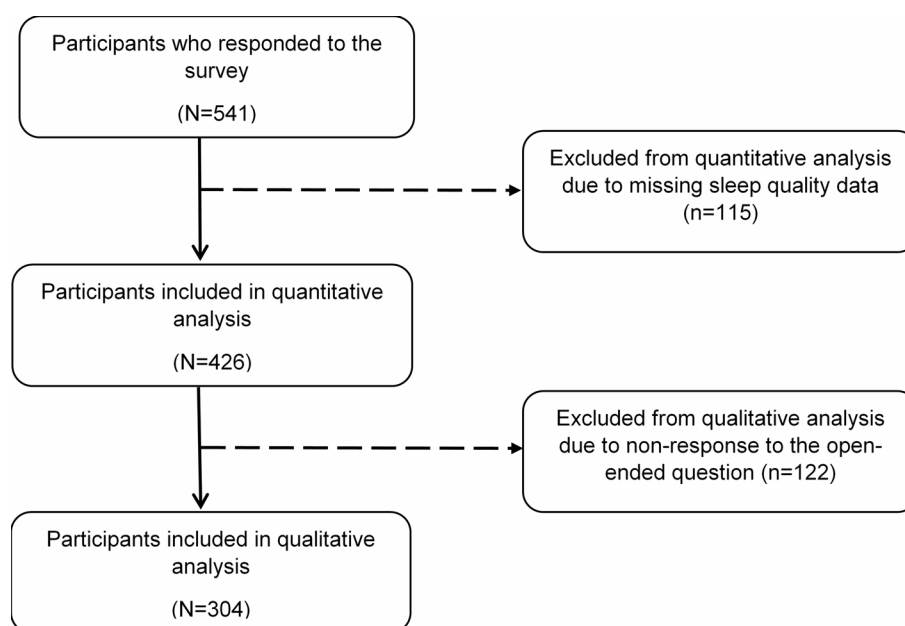


Fig. 1 Flow diagram of participant inclusion in the quantitative and qualitative components of the study

Table 1 Baseline characteristics of the survey participants^a

Characteristic	N = 426
Age, years Mean ($\pm$ SD)	21.38 ($\pm$ 4.76)
Daily SSB use, $\geq$ 1/day	
Yes	141 (33.10%)
No	285 (66.90%)
Sex	
Male	133 (31.22%)
Female	293 (68.78%)
Race ^a	
White	375 (88.03%)
Non-white	40 (9.39%)
Ethnicity ^a	
Hispanic	19 (4.46%)
Non-Hispanic	406 (95.31%)
International student	
Yes	19 (4.46%)
No	407 (95.54%)
Education level ^a	
Associate degree	17 (3.99%)
Bachelor's degree	304 (71.36%)
Master's degree	78 (18.31%)
Professional degree	26 (6.10%)
Overall GPA ^a	
$\leq$ 3.0	46 (10.80%)
3.1 to 3.5	108 (25.35%)
3.6 to 4.0	269 (63.15%)
Smoking status	
Yes	142 (33.33%)
No	284 (66.67%)
Physical activity	
Low/moderate	141 (33.10%)
High	285 (66.90%)
Self-rated overall health	
Excellent	68 (15.96%)
Very good	184 (43.19%)
Good	143 (33.57%)
Fair/poor	31 (7.28%)
Physical illness	
Yes	112 (26.29%)
No	314 (73.71%)
Stress level ^a	
Low	116 (27.23%)
Moderate	248 (58.22%)
High	42 (9.86%)

^aNumbers may not add up to 100% due to missing entries

non-SSB related behavioral factors affecting sleep such as excessive mobile phone use, alcohol use, etc., (vi) avoidance strategies employed by students to improve sleep, and (vii) general health beliefs about SSBs being unhealthy without specifically linking it to sleep. Table 3 presents the frequency of theme mentions and examples of participants' quotes for each theme. The most frequently reported themes were the perceived effects of SSBs on sleep (36.18%), the timing of beverage consumption (17.11%), and avoidance strategies to improve sleep (15.12%).

Table 2 Unadjusted and adjusted odds ratio (OR) and 95% confidence intervals (CI) from logistic regression determining the association between daily sugar-sweetened beverage use and sleep quality

Variable	OR (95% CI)	p-value
<i>Model 1: Unadjusted</i>		
Daily SSB use, ≥ 1/day [ref: No]		
Yes	0.53 (0.35–0.82)	0.004
<i>Model 2: Adjusted</i>		
Daily SSB use, ≥ 1/day [ref: No]		
Yes	0.55 (0.32–0.93)	0.03
Age, years	0.97 (0.90–1.04)	0.32
Sex [ref: Male]		
Female	0.93 (0.54–1.60)	0.80
Race [ref: White]		
Non-white	0.56 (0.20–1.58)	0.27
Ethnicity [ref: Hispanic]		
Non-Hispanic	0.50 (0.15–1.69)	0.26
International student [ref: Yes]		
No	0.71 (0.15–3.27)	0.66
Education level [ref: Associate degree]		
Bachelor's degree	0.47 (0.15–1.44)	0.19
Master's degree	0.91 (0.23–3.51)	0.89
Professional degree	0.59 (0.13–2.64)	0.49
Overall GPA [ref: ≤3.0]		
3.1 to 3.5	0.60 (0.23–1.53)	0.28
3.6 to 4.0	0.78 (0.32–1.90)	0.58
Smoking status [ref: Yes]		
No	1.68 (0.99–2.85)	0.06
Physical activity [ref: Low/moderate]		
High	0.69 (0.40–1.19)	0.19
Self-rated overall health [ref: Excellent]		
Very good	0.40 (0.20–0.81)	0.01
Good	0.36 (0.17–0.78)	0.01
Fair/poor	0.03 (0.003–0.27)	0.002
Physical illness [ref: Yes]		
No	1.004 (0.56–1.81)	0.99
Stress level [ref: Low]		
Moderate	0.22 (0.13–0.39)	< 0.0001
High	0.09 (0.03–0.27)	< 0.0001

Theme 1: Lack of knowledge or uncertainty

About 13.45% of responses indicated a lack of knowledge or uncertainty about the impact of SSB intake on sleep. Students were unsure whether SSB intake affects sleep or whether there is a correlation between SSB intake and sleep. Some noted that they do not drink many beverages to notice a relationship between SSBs and sleep (For example: “I don’t think it has much of an effect on me but I can’t say for sure”).

Theme 2: Disbelief that SSB intake negatively impacts sleep

A small proportion of responses (6.11%) reported that there is no connection between SSB intake and sleep quality based on their personal experience. Students reported that they can fall asleep regardless of their beverage intake. (For example, “I don’t believe that beverages are impacting my sleep because when I want to get to sleep I can”).

Theme 3: Perceived effects of SSBs on sleep

Table 3 Thematic analysis of participants' responses on the impact of sugar-sweetened beverage use on sleep quality

Theme	Example participant quote	Theme mentions, n (%) (N = 409) ^a
Lack of knowledge/uncertainty	<i>"I don't know of any scientific evidence related to the relationship between sugar-sweetened beverages and sleep quality."</i> <i>"I don't think it has much of an effect on me but I can't say for sure"</i>	55 (13.45%)
Disbelief that SSB intake negatively impacts sleep	<i>"I don't believe that beverages are impacting my sleep because when I want to get to sleep I can."</i> <i>"While I do have a sugary beverage a few times a week, I feel that my sleep quality is excellent. I have no issues sleeping."</i>	25 (6.11%)
Perceived effects of SSBs on sleep	<i>"I think fortified/processed sugars affect the brain causing high stimulation followed by crashes. I also think there may be an association with the mind and gut and sugar can affect this leading to altered metabolism which can affect sleep."</i> <i>"I think intaking sugar-sweetened beverage disrupts the normal function of sleep habits by introducing excess sugar that our body does not need. Since January 2024, I have cut down on coffee to only consuming on the weekends and I felt like I have noticed a good change in sleep quality including sleeping longer, feeling more rested, falling asleep faster (still not great but better), and less anxiety or stress. Due to seeing these results, I believe SSB negatively impact sleep quality."</i>	148 (36.18%)
Timing of beverage consumption	<i>"For the most part, I mostly consume sugar-sweetened beverages in the morning if I plan to have any, but on the days that I have a later cup of (decaf) coffee with sugar or a glass of wine, I do notice that I don't sleep as well, so I would guess that daily intake would have an impact as well"</i> <i>"Just from personal experience in highschool, when I drank a sugared beverage right before bed, it noticeably affected how long it took to fall asleep"</i>	70 (17.11%)
Non-SSB related behavioral factors affecting sleep (i.e., alcohol, stress, mobile phone use)	<i>"I think that alcohol might sometimes impact my sleep"</i> <i>"I am not a "sugar-y" type of person and don't frequently drink sodas or extraordinarily sweetened beverages. My sleep quality has been a direct result of the stress I've experienced from courses and graduate school honestly."</i>	27 (6.60%)
Avoidance strategies to improve sleep	<i>"I have attempted to reduce sugary beverages and, more specifically, caffeine, and noticed that I felt like I slept better and it was easier to get out of bed and start moving."</i> <i>"I have cut out almost all sugar and I get 10x better sleep"</i>	62 (15.12%)
General health beliefs about SSBs being unhealthy	<i>"Artificial sugar in general is not good for the average person to consume"</i> <i>"Sugar is bad for you all around."</i>	22 (5.38%)

^aA total of 304 participants contributed to the qualitative analysis. Frequencies represent coded theme mentions, and individual responses could contribute to more than one theme. Therefore, the total number of theme mentions (N = 409) exceeded the number of participants

The majority of responses attributed poor sleep quality to the stimulant effects of SSBs. Students reported that caffeinated beverages can increase alertness and make it difficult to fall asleep (For example: *"Sugar can stimulate your brain to keep you awake at night and make it so that you have a harder time falling asleep"*).

Theme 4: Timing of beverage consumption

Students indicated that the timing of beverage consumption could be a factor impacting sleep (17.11%). They reported that consuming beverages in the evening, just before bed, or late at night could lead to poor sleep quality, whereas consuming beverages earlier in the day could be less disruptive to sleep (For example: *"However it depends on the*

time that the beverages were consumed. If consumed later at night then I believe they have more of a negative impact on sleep”).

Theme 5: Non-SSB related behavioral factors affecting sleep

About 6.6% of the responses mentioned that sleep quality is not only impacted by SSB intake but also by health behaviors such as alcohol use, academic stress, or phone use. For example, *“I always drink sugary drinks up until I go to bed. I think my phone causes me not to go to sleep “.*

Theme 6: Avoidance strategies to improve sleep

Several students described strategies they have employed to reduce SSB consumption, such as substituting SSBs with water or reducing SSB intake to improve sleep (For example: *“I have attempted to reduce sugary beverages and, more specifically, caffeine, and noticed that I felt like I slept better and it was easier to get out of bed and start moving”).*

Theme 7: General health beliefs about SSBs

A few respondents (5.38%) expressed a broader negative impact of SSBs on overall health and not specifically linking it to sleep. For example: *“I stopped drinking soda and most other sugary & caffeinated beverages a few years ago because I realized the negative effects they were having on my health.”*

4 Discussion

This mixed-methods study examined the association between sleep quality and SSB intake among university students aged ≥ 18 years. Quantitative results showed a statistically significant association between daily SSB use and sleep quality in the regression model after adjusting for demographics, socioeconomic, and behavioral factors. Self-rated overall health and stress level also emerged as significant predictors of sleep quality in the model. Qualitative analysis of open-ended responses identified seven themes, including lack of knowledge or uncertainty, disbelief that SSB intake negatively impacts sleep, perceived effects of SSBs, timing of beverage consumption, non-SSB related behavioral factors affecting sleep (i.e., alcohol use, stress), avoidance strategies, and general beliefs about SSBs.

The association between SSB consumption and sleep quality observed in this study aligns with prior US-based research linking high SSB consumption to poor sleep. For instance, a study conducted using the National Health and Nutrition Examination Survey (NHANES) data (2005–2012) found that US adults (age ≥ 18 years) who reported short sleep duration (≤ 5 h), which is a component of sleep quality, had high consumption of SSBs [9]. Similarly, another study reported that consumers of energy drinks (7.08 ± 0.51 vs. 6.24 ± 0.39 ; $p = 0.04$) or high calorie coffee drinks (7.14 ± 0.51 vs. 6.14 ± 0.42 ; $p = 0.02$) had higher mean PSQI scores (poor sleep quality) compared to those who did not consume these beverages [41].

Our findings regarding self-rated health and stress as correlates of sleep quality can be supported by existing literature. For example, a study conducted among adults (≥ 18 years) reported that both short (≤ 5 – 6 h) and longer (8 or ≥ 9 h) sleep duration was associated with poor or fair self-rated health compared to those who slept for 7 h [42]. This can be corroborated by an international systematic review and meta-analysis which reported that poor sleep quality is associated with poor self-rated health (OR = 2.10, 95% CI = 1.62–2.74, $p = 0.007$; $I^2 = 71.4\%$) [43]. Stress has also been linked to poor sleep quality in literature. For example, a study reported that academic and emotional stress

negatively impact sleep among students and stress accounted for 24% variance in the PSQI score in regression model [17]. Similarly, a study by Dietch et al. 2016 assessing psychometric properties of PSQI among college students reported that PSQI scores demonstrated overlap with stress suggesting that stress is linked to poor sleep quality [44].

Qualitative findings provided important context on how students perceive the impact of SSBs on sleep quality and meaningfully complemented the quantitative results. Limited studies have qualitatively examined the potential impact of SSBs on sleep. In our study, some students expressed uncertainty about whether SSB intake is associated with their sleep, suggesting knowledge gaps and opportunities for health education. While a few denied or expressed disbelief that SSB affects sleep. These perceptions may reflect limited consideration of health when making beverage choices. For example, a qualitative study conducted by Block et al. 2012 reported that many college students had limited awareness of beverage caloric content and did not prioritize health when making beverage choices, which they attributed to their youth [45]. Additionally, students' views may be explained by broader behavioral processes, in which individuals are less likely to recognize subtle, delayed, or not immediately perceptible outcomes for specific behaviors. As the literature suggests, individuals tend to discount delayed consequences, which may further reduce the likelihood of linking dietary behaviors to outcomes such as sleep quality [46, 47]. Furthermore, students with lower or infrequent SSB consumption may be less likely to associate beverage intake with sleep based on their personal experiences.

Students also emphasized that the timing of beverage consumption impacts sleep, which can be supported by the literature [9, 48]. For example, Drake et al. 2013 reported that beverages taken at bedtime, and 3–4 h prior to bedtime have significant effects on sleep disturbance [49]. These qualitative findings have important implications for the quantitative measurement of beverage consumption. Themes related to disbelief or uncertainty about SSB-related effects on sleep suggest that some students may not closely monitor or accurately report their beverage consumption in relation to sleep which may suggest inconsistent reporting of exposure. Moreover, the timing of beverage consumption represents a temporal dimension which was not captured in the quantitative analysis and may influence the association between daily SSB use and sleep.

Although caffeinated and non-caffeinated SSBs were not distinguished in the quantitative analysis, qualitative findings indicated that students perceived caffeine and high sugar content as contributors to poor sleep. This is supported by prior evidence showing that sugar or caffeine in beverages may delay sleep onset and reduce sleep duration [7, 9, 50]. In addition, students identified non-SSB related behavioral factors such as prolonged phone use, academic stress, and alcohol use as contributors to poor sleep and can be corroborated by prior research [17, 44, 51, 52]. For example, a study reported higher odds of sleep latency among young adults using cell phone before bedtime (Exp (B) = 1.091, $p < 0.001$) [51]. Another study reported that longer average screen-time, especially during bedtime, was associated with poor sleep quality and longer sleep onset latency [52].

Some students described strategies they employed to limit SSBs intake or substitute beverages with water to improve sleep reflecting self-regulation strategies reported in the literature [53–55]. These behaviors suggest students' awareness of a link between dietary

patterns and sleep hygiene and underscore the importance of promoting behavioral self-regulation interventions to reduce SSB consumption among university students. Lastly, few students expressed general negative perceptions of SSBs being unhealthy for overall well-being without specifically linking them to sleep outcomes [56]. This suggests broad health awareness about the adverse effects of SSB consumption. It does not necessarily mean that students believe SSBs have no impact on sleep rather they may view SSBs as unhealthy in general, irrespective of its effect on sleep quality.

The findings of this study have important educational and public health implications. The association between daily SSB consumption and poor sleep quality highlights the need for student wellness programs aimed at reducing the effects of SSBs on sleep quality. Incorporating health education on the effects of sugar and caffeine on sleep may help address observed gaps in awareness and skepticism among some students. The identification of co-occurring behaviors such as stress, phone use, and alcohol consumption highlights the multifactorial nature of sleep problems in this population and supports the need for integrated, behaviorally informed interventions. Students reported use of self-regulation strategies also suggests opportunities to promote self-efficacy and goal-setting approaches to reduce SSB consumption and improve sleep.

This study has several strengths and limitations. First, we utilized a mixed-method approach which allowed for both a quantitative and a qualitative analysis providing a comprehensive understanding of the relationship between SSB consumption and sleep quality. Second, we utilized validated survey instruments (i.e., PSQI) which enhanced the reliability of our findings. Third, pilot interviews were conducted to get feedback on the survey questions for improvement before the final survey was released. However, several limitations should also be considered. The cross-sectional study design limits the ability to infer any causal relationships between daily SSB use and sleep quality. The survey was self-administered by the students, which can lead to both recall and social-desirability biases [57]. Importantly, the study did not differentiate between types of SSBs such as, caffeinated vs. non-caffeinated which may have influenced the observed association between SSB and sleep. Caffeine, a stimulant with well-documented effects on sleep quality is commonly found in energy drinks and sodas, may partly account for this relationship [58–61]. Without accounting for caffeine content, it is difficult to determine whether the observed association reflects sugar intake, stimulant effects, or related behaviors. Therefore, the quantitative findings should be interpreted with caution. Additionally, the dichotomization of SSB consumption may have limited the ability to assess the potential dose-response relationships between varying levels of SSB consumption and sleep quality. Furthermore, although the quantitative analysis adjust for selected demographic and behavioral factors in the regression model, the relationship between SSB intake and sleep quality may be influenced by factors such as mental health conditions (i.e., anxiety and depression), financial pressure, and higher body mass index (BMI) which were not controlled for in our study [10, 62]. Finally, the data were collected from students at a single university which could limit the generalizability of the study findings to other populations. Since the participation in the study was voluntary, students who chose to participate in the survey could systematically differ from those who did not participate which could introduce selection bias.

Future research should employ longitudinal study designs and consider more detailed assessments of SSB consumption such as beverage type, beverage quantity, timing of

consumption, and caffeine content to better determine the relationship between SSB intake and sleep outcomes. Incorporating additional factors such as screen time and alcohol use into quantitative analysis may improve understanding of the multifactorial determinants of sleep quality among university students. Lastly, studies involving more diverse student populations across multiple institutions are needed to enhance generalizability and inform evidence-based interventions.

5 Conclusions

Daily SSB use was associated with poor sleep quality among university students. Qualitative findings indicated that while many students recognized the impact of SSBs on sleep, some expressed uncertainty or disbelief. Students additionally identified factors such as timing of beverage consumption, academic stress, phone use, and alcohol use as contributors to poor sleep quality. Together, these findings suggest that the relationship between SSB intake and sleep quality is complex and influenced by various behavioral and contextual factors. Improving sleep quality among university students may therefore benefit from health promotion interventions addressing multiple health behaviors.

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Author contributions

M.P. performed conceptualization, methodology, formal analysis, and wrote the main manuscript text. S.D. contributed to methodology, formal analysis, and manuscript review and editing. A.K. contributed to conceptualization, supervision, IRB approval, and manuscript review and editing. All authors reviewed the manuscript.

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Data availability

The data underlying this study are protected under Institutional Review Board approval and are not available for public sharing.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the institutional review board (IRB) of West Virginia University, Morgantown, West Virginia, USA (Protocol no. #2403941544; approved on 20th March 2024). Clinical trial number: not applicable. This study was conducted in accordance with the principles of the Declaration of Helsinki and its subsequent amendments. The study included participants aged 18 years and older. Informed consent was obtained from all participants prior to their participation in the survey.

Consent for publication

This study used anonymous, de-identified data that was collected from adults (≥ 18 years). Any excerpts from open-ended question are presented without identifying information. All authors approve submission and publication.

Competing interests

The authors declare no competing interests.

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References

1. Centers for Disease Control and Prevention (CDC). Fast facts: sugar-sweetened beverage consumption | Nutrition | CDC. 2024. <https://www.cdc.gov/nutrition/php/data-research/sugar-sweetened-beverages.html>. Accessed 16 Apr 2026.
2. Phillips JA. Dietary Guidelines for Americans, 2020–2025. *Workplace Health Saf.* 2021;69:395. <https://doi.org/10.1177/21650799211026980>.
3. Lee SH, Park S, Blanck HM. Consumption of Added Sugars by States and Factors Associated with Added Sugars Intake among US Adults in 50 States and the District of Columbia–2010 and 2015. *Nutrients.* 2023. <https://doi.org/10.3390/NU15020357>.
4. Lee SH, Zhao L, Park S, Moore LV, Hamner HC, Galuska DA, et al. High Added Sugars Intake among US Adults: Characteristics, Eating Occasions, and Top Sources, 2015–2018. *Nutrients.* 2023;15:265. <https://doi.org/10.3390/NU15020265>.

5. Ricciuto L, Fulgoni VL, Gaine PC, Scott MO, DiFrancesco L. Sources of Added Sugars Intake Among the U.S. Population: Analysis by Selected Sociodemographic Factors Using the National Health and Nutrition Examination Survey 2011–18. *Front Nutr*. 2021;8:687643. <https://doi.org/10.3389/FNUT.2021.687643/TEXT>.
6. Malik VS, Hu FB. The role of sugar-sweetened beverages in the global epidemics of obesity and chronic diseases. *Nat Rev Endocrinol Nat Rev Endocrinol*. 2022;18:205–18. <https://doi.org/10.1038/S41574-021-00627-6>.
7. Shahdadian F, Boozari B, Saneei P. Association between short sleep duration and intake of sugar and sugar-sweetened beverages: A systematic review and meta-analysis of observational studies. *Sleep Health*. 2023;9:159–76. <https://doi.org/10.1016/j.sleh.2022.07.006>.
8. Boozari B, Saneei P, Safavi SM. Association between sleep duration and sleep quality with sugar and sugar-sweetened beverages intake among university students. *Sleep Breath*. 2020;25:649–56. <https://doi.org/10.1007/S11325-020-02155-5>.
9. Prather AA, Leung CW, Adler NE, Ritchie L, Laraia B, Epel ES. Short and sweet: Associations between self-reported sleep duration and sugar-sweetened beverage consumption among adults in the United States. *Sleep Health*. 2016;2:272–6. <https://doi.org/10.1016/j.sleh.2016.09.007>.
10. Nucci A, Di, Cardamone E, Rossi L, Silano M, Desirée V-M, Sampieri-Cabrera R. How does sugar-sweetened beverage consumption relate to sleep and mental health in adolescents? A scoping review. *Front Nutr*. 2026;12:1718230. <https://doi.org/10.3389/FNUT.2025.1718230>.
11. Markwald RR, Melanson EL, Smith MR, Higgins J, Perreault L, Eckel RH, et al. Impact of insufficient sleep on total daily energy expenditure, food intake, and weight gain. *Proc Natl Acad Sci U S Natl Acad Sci*. 2013;110:5695–700. <https://doi.org/10.1073/PNAS.1216951110/-DCSUPPLEMENTAL>. [cited 2026 Apr 19].
12. Zuraikat FM, Makarem N, Liao M, St-Onge MP, Aggarwal B. Measures of Poor Sleep Quality Are Associated With Higher Energy Intake and Poor Diet Quality in a Diverse Sample of Women From the Go Red for Women Strategically Focused Research Network. *J Am Heart Association: Cardiovasc Cerebrovasc Disease*. 2020;9:e014587. <https://doi.org/10.1161/JAH.A.119.014587>.
13. Covassin N, Singh P, McCrady-Spitzer SK, St Louis EK, Calvin AD, Levine JA, et al. Effects of Experimental Sleep Restriction on Energy Intake, Energy Expenditure, and Visceral Obesity. *J Am Coll Cardiol*. 2022;79:1254. <https://doi.org/10.1016/J.JACC.2022.01.038>.
14. Wang Y, Dai X, Zhu J, Xu Z, Lou J, Chen K. What complex factors influence sleep quality in college students? PLS-SEM vs. fsQCA. *Front Psychol*. 2023;14:1185896. <https://doi.org/10.3389/FPSYG.2023.1185896/TEXT>.
15. Kenney SR, Paves AP, Grimaldi EM, LaBrie JW. Sleep quality and alcohol risk in college students: Examining the moderating effects of drinking motives. *J Am Coll Health*. 2014;62:301–8. <https://doi.org/10.1080/07448481.2014.897953>.
16. McHill AW, Wright KP. Role of sleep and circadian disruption on energy expenditure and in metabolic predisposition to human obesity and metabolic disease. *Obes Rev*. 2017;18:15–24. <https://doi.org/10.1111/OBR.12503>.
17. Lund HG, Reider BD, Whiting AB, Prichard JR. Sleep Patterns and Predictors of Disturbed Sleep in a Large Population of College Students. *J Adolesc Health*. 2010;46:124–32. <https://doi.org/10.1016/j.jadohealth.2009.06.016>.
18. Alamir YA, Zullig KJ, Kristjansson AL, Wen S, Misra R, Montgomery-Downs H. A theoretical model of college students' sleep quality and health-related quality of life. *J Behav Med*. 2022;45:925–34. <https://doi.org/10.1007/S10865-022-00348-9>.
19. Knowlden AP, Sharma M, Bernard AL. A Theory of Planned Behavior Research Model for Predicting the Sleep Intentions and Behaviors of Undergraduate College Students. *J Prim Prev*. 2012;33:19–31. <https://doi.org/10.1007/S10935-012-0263-2>.
20. Knowlden AP, Sharma M. Health belief structural equation model predicting sleep behavior of employed college students. *Fam Community Health*. 2014;37:271–8. <https://doi.org/10.1097/FCH.0000000000000043>.
21. Wang F, Biró É. Determinants of sleep quality in college students: A literature review. *Explore*. 2021;17:170–7. <https://doi.org/10.1016/j.explore.2020.11.003>.
22. Kleppang AL, de Ridder K, Haugland SH, Stea TH. Physical activity, sugar-sweetened beverages, whole grain bread and insomnia among adolescents and psychological distress in adulthood: prospective data from the population-based HUNT study. *Int J Behav Nutr Phys Act*. 2021. <https://doi.org/10.1186/S12966-021-01215-7>.
23. Li W, Wu M, Yuan F, Zhang H. Sugary beverage consumption mediates the relationship between late chronotype, sleep duration, and weight increase among undergraduates: a cross-sectional study. *Environ Health Prev Med*. 2018;23. <https://doi.org/10.1186/S12199-018-0754-8>.
24. Higbee MR, Gipson CS, El-Saidi M. Caffeine Consumption Habits, Sleep Quality, Sleep Quantity, and Perceived Stress of Undergraduate Nursing Students. *Nurse Educ*. 2022;47:120–4. <https://doi.org/10.1097/NNE.0000000000001062>.
25. Claydon EA, Kahwash JM, Lilly CL, Alamir Y, Zullig KJ. Subjective Sleep Quality, Caffeine, and Dieting Behaviors Among University-Attending Young Adults. *Nat Sci Sleep Nat Sci Sleep*. 2023;15:737–47. <https://doi.org/10.2147/NSS.S420568>. [cited 2025 Oct 25].
26. WV Health Statistics Center. West Virginia behavioral risk factor surveillance system report. 2022. 2025. <https://dhhr.wv.gov/HSC/SS/BRFSS/Pages/BRFSS.aspx>. Accessed 19 Apr 2026.
27. Norman-Burgdolf H, DeWitt E, Cardarelli KM, Gillespie R, Slone S, Gustafson A. Sugar-sweetened beverage consumption among adults in rural Appalachia. *Prev Med Rep*. 2021. <https://doi.org/10.1016/j.pmedr.2021.101642>.
28. Lundeen EA, Park S, Pan L, Blanck HM. Daily intake of sugar-sweetened beverages among US adults in 9 states, by state and sociodemographic and behavioral characteristics, 2016. *Prev Chronic Dis*. 2018. <https://doi.org/10.5888/PCD15.180335>.
29. Park S, Xu F, Town M, Blanck HM. Prevalence of Sugar-Sweetened Beverage Intake Among Adults — 23 States and the District of Columbia, 2013. *MMWR Morb Mortal Wkly Rep*. 2019;65:169–74. <https://doi.org/10.15585/MMWR.MM6507A1>.
30. Park S, Pan L. A data user's guide to the BRFSS sugar-sweetened beverage questions: how to analyze consumption of sugar-sweetened beverages. Centers for Disease Control and Prevention (CDC). https://www.cdc.gov/brfss/data_documentation/pdf/brfss_ssb-userguide.pdf. Accessed 19 Apr 2026.
31. Dinger MK, Behrens TK, Han JL. Validity and Reliability of the International Physical Activity Questionnaire in College Students. *Am J Health Educ*. 2006;37:337–43. <https://doi.org/10.1080/19325037.2006.10598924>.
32. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. *Int J Behav Nutr Phys Act*. 2011. <https://doi.org/10.1186/1479-5868-8-115>.

33. Nascimento-Ferreira MV, Rosa ACA, Azevedo JC, Santos AR, de Araujo-Moura A, Ferreira K. Psychometric Properties of the Online International Physical Activity Questionnaire in College Students. *Int J Environ Res Public Health*. 2022. <https://doi.org/10.3390/IJERPH192215380>.
34. Fred Wen CK, Schneider S, Junghaenel DU, Toledo MJL, Lee PJ, Smyth JM, et al. Evaluating the Psychometric Properties of a Physical Activity and Sedentary Behavior Identity Scale: Survey Study With Two Independent Samples of Adults in the United States. *JMIR Form Res*. 2024;8:e59950. <https://doi.org/10.2196/59950>.
35. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35:1381–95. <https://doi.org/10.1249/01.MSS.0000078924.61453.FB>.
36. Roberti JW, Harrington LN, Storch EA. Further Psychometric Support for the 10-Item Version of the Perceived Stress Scale. *J Coll Couns*. 2006;9:135–47. <https://doi.org/10.1002/J.2161-1882.2006.TB00100.X>.
37. Cohen S. Perceived stress in a probability sample of the United States. *The social psychology of health*. 1988. <https://psycn.et.apa.org/record/1988-98838-002>
38. Smith KJ, Rosenberg DL, Haight GT. An assessment of the psychometric properties of the Perceived Stress Scale-10 (PSS10) with business and accounting students. *Acc Perspect*. 2014;13:29–59. <https://doi.org/10.1111/1911-3838.12023>
39. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research [Índice de calidad del sueño de Pittsburgh: un nuevo instrumento para la práctica y la investigación psiquiátrica]. *Psychiatry Res*. 1989;28:193–213.
40. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006;3:77–101. <https://doi.org/10.1191/1478088706QP0630A>.
41. Young DR, Sidell MA, Grandner MA, Koebrick C, Troxel W. Dietary behaviors and poor sleep quality among young adult women: watch that sugary caffeine! *Sleep Health*. 2020;6:214–9. <https://doi.org/10.1016/j.sleh.2019.12.006>.
42. Shankar A, Sabanayagam C, Kalidindi S. Sleep duration and self-rated health: the national health interview survey 2008. *Sleep*. 2011;34:1173–7. <https://doi.org/10.5665/SLEEP.1232>.
43. Amiri S. Sleep Duration, Sleep Quality, and Insomnia in Association With Self-Rated Health: A Systematic Review and Meta-Analysis. *Sleep Med Res*. 2023;14(2):66–79. <https://doi.org/10.17241/smr.2023.01732>.
44. Dietrich JR, Taylor DJ, Sethi K, Kelly K, Bramoweth AD, Roane BM. Psychometric Evaluation of the PSQI in U.S. College Students. *J Clin Sleep Med*. 2016;12:1121–9. <https://doi.org/10.5664/JCSM.6050>.
45. Block JP, Gillman MW, Linakis SK, Goldman RE. If It Tastes Good, I'm Drinking It: Qualitative Study of Beverage Consumption Among College Students. *J Adolesc Health*. 2013;52:702–6. <https://doi.org/10.1016/J.JADOHEALTH.2012.11.017>.
46. Scholten H, Scheres A, de Water E, Graf U, Granic I, Luijten M. Behavioral trainings and manipulations to reduce delay discounting: A systematic review. *Psychon Bull Rev*. 2019;26:1803–49. <https://doi.org/10.3758/S13423-019-01629-2/TABLES/2>.
47. Kakoschke N, Dickinson DL, Drummond SPA. The effects of sleep restriction and time of day on food-specific impulsivity, approach-avoidance bias and delay discounting. *Health Psychol Behav Med*. 2025. <https://doi.org/10.1080/21642850.2025.2520838>.
48. Iao SI, Jansen E, Shedden K, O'Brien LM, Chervin RD, Knutson KL, et al. Associations between bedtime eating or drinking, sleep duration and wake after sleep onset: findings from the American time use survey. *Br J Nutr*. 2022;127:1888–97. <https://doi.org/10.1017/S0007114521003597>.
49. Drake C, Roehrs T, Shambroom J, Roth T. Caffeine Effects on Sleep Taken 0, 3, or 6 Hours before Going to Bed. *J Clin Sleep Med*. 2013;9:1195–200. <https://doi.org/10.5664/JCSM.3170>.
50. Alahmary SA, Alduhaylib SA, Alkawii HA, Olwani MM, Shablan RA, Ayoub HM et al. Relationship between added sugar intake and sleep quality among university students: a cross-sectional study. *Am J Lifestyle Med*;16:122–9. <https://doi.org/10.1177/1559827619870476>.
51. Joshi SC, Woodward J, Woltering S. Nighttime cell phone use and sleep quality in young adults. *Sleep Biol Rhythms*. 2021;20:97. <https://doi.org/10.1007/S41105-021-00345-6>.
52. Christensen MA, Bettencourt L, Kaye L, Moturu ST, Nguyen KT, Olgin JE, et al. Direct Measurements of Smartphone Screen-Time: Relationships with Demographics and Sleep. *PLoS ONE*. 2016;11:e0165331. <https://doi.org/10.1371/JOURNAL.PONE.0165331>.
53. Judah G, Mullan B, Yee M, Johansson L, Allom V, Liddelow C. A Habit-Based Randomised Controlled Trial to Reduce Sugar-Sweetened Beverage Consumption: the Impact of the Substituted Beverage on Behaviour and Habit Strength. *Int J Behav Med*. 2020;27:623–35. <https://doi.org/10.1007/S12529-020-09906-4>.
54. Ames SL, Wurpts IC, Pike JR, MacKinnon DP, Reynolds KR, Stacy AW. Self-regulation interventions to reduce consumption of sugar-sweetened beverages in adolescents. *Appetite*. 2016;105:652–62. <https://doi.org/10.1016/j.appet.2016.06.036>.
55. Hu Z, Meng R, Sheng T, Cao Q, Sun Y, Yin J, et al. Using an integrated model of the extended theory of planned behavior and the temporal self-regulation theory to explain the sugar-sweetened beverage consumption in college students. *Appetite*. 2025. <https://doi.org/10.1016/j.appet.2025.108140>.
56. Haynes-Maslow L, Ray S, Giombi K. Perceptions of sugar-sweetened beverages among adolescents in North Carolina. *Front Public Health*. 2022;10:943295. <https://doi.org/10.3389/FPUBH.2022.943295/FULL>.
57. Althubaiti A. Information bias in health research: definition, pitfalls, and adjustment methods. *J Multidiscip Healthc*. 2016;9:211. <https://doi.org/10.2147/JMDH.S104807>.
58. O'callaghan F, Muurlink O, Reid N. Effects of caffeine on sleep quality and daytime functioning. *Risk Manag Healthc Policy*. 2018;11:263–71. <https://doi.org/10.2147/RMHP.S156404>.
59. Gardiner C, Weakley J, Burke LM, Roach GD, Sargent C, Maniar N, et al. The effect of caffeine on subsequent sleep: A systematic review and meta-analysis. *Sleep Med Rev*. 2023;69:101764. <https://doi.org/10.1016/J.SMRV.2023.101764>.
60. Keast RSJ, Swinburn BA, Sayompark D, Whitelock S, Riddell LJ. Caffeine increases sugar-sweetened beverage consumption in a free-living population: a randomised controlled trial. *Br J Nutr*. 2015;113:366. <https://doi.org/10.1017/S000711451400378X>.
61. Sigala DM, Falbe J. Sugar-sweetened beverages and caffeine: the role of addiction. *Food & addiction: a comprehensive handbook*. Oxford University Press; 2024. pp. 347–53. <https://doi.org/10.1093/OSO/9780190671051.003.0038>.

62. Ahn S, Zaman WSBWK, Goh SK, Chan CK. Relationship of sleep quality, BMI, Dietary, and socioeconomic attributes among young adults: A systematic review. *J Health Psychol*. 2025. <https://doi.org/10.1177/13591053251365446>.

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