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Energy drink consumption and sleep parameters in college and university students: a national cross-sectional study

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ABSTRACT

Objectives To investigate the frequency of energy drink (ED) consumption, and the association between ED consumption and selected sleep characteristics and parameters in Norwegian college and university students. We also explored whether these associations varied based on sex.

Design Cross-sectional.

Setting Data were gathered from the SHOT2022 study (Students' Health and Well-being Study), a national survey.

Participants 53 266 students, aged 18–35 years, enrolled in higher education in Norway (2022).

Main outcome measures Estimated marginal means were computed from general linear models investigating the association between ED consumption and continuous sleep outcomes, while log-link binomial regression analysis was used for dichotomous sleep outcomes of sleep measures. All models were adjusted for age.

Results Among the participants, 4.7% of men and 3.3% of women reported consuming ED daily. The frequency of ED consumption was inversely associated with sleep duration and sleep efficiency, while a direct association was observed with the frequency of ED consumption and sleep patterns such as sleep onset latency and wake after sleep onset across sexes. The strongest association was found between daily ED consumption and short sleep duration where men had a risk ratio (RR) of 2.07; 95% CI 1.77 to 2.42, and women had a RR of 1.87; 95% CI 1.64 to 2.14.

Conclusion ED consumption was a strong determinant for negative sleep outcomes. Even small amounts of ED were associated with poorer sleep outcomes, which warrant more attention towards the consequences of consuming ED among college and university students.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The main strength of this study was the use of a wide range of sleep parameters including sleep duration and insomnia.
⇒ The current sample is derived from the SHOT2022 study (Students' Health and Well-being Study) which is a large national sample of college and university students in Norway.
⇒ The study relies on self-reported frequency of energy drink consumption, which can be susceptible to both recall bias and social desirability bias.

INTRODUCTION

Energy drinks (ED) are non-alcoholic beverages with an average caffeine content of 150 mg per litre in addition to sugar, vitamins, minerals and amino acids in varying amounts.[1 2] They are marketed as boosters of mental health and physical performance and often consumed by students for these reasons.[3–5] In contrast, negative effects of frequent ED consumption have been suggested in relation to mental health problems and sleep.[6 7]

In recent years, there has been an increase in ED consumption among adolescents in Norway[8] and ED consumption has been mostly focused on the adolescent population as they are deemed as more vulnerable to potential negative effects of ED.[2] Studies among Norwegian adolescents show that 1–1.5% consume ED every day.[8 9] However, estimates of daily ED consumption in other countries range from, for example, 1.1% in 23 610 students in Canadian[10] to 11.4% in a small study (n=919) in the United Arab Emirates.[11] Moreover, some studies have found a greater prevalence of ED consumption among male students,[9 12 13] but the results are inconclusive.

The literature on ED and sleep among young adults is limited, with some notable exceptions including four studies that have investigated consumption of ED in relation to sleep. These studies have reported shorter time in bed, lower sleep quality, later bedtime, more difficulty falling asleep and tiredness the next day, among young adults who consumed ED.[3 11 14 15] However, the literature remains somewhat conflicting, as a cross-sectional study (n=2793) found no differences between young adults who had one or more ED per week on trouble

sleeping or inadequate sleep compared with those who did not consume ED.[16] Furthermore, most of the studies have included crude sleep measures, such as only a single item assessing sleep quality and tiredness.[11 14 15 17] More comprehensive assessments of sleep quality such as the diagnostic criteria for insomnia have been used to a lesser extent.[3 18] Also, a more detailed assessment of some core sleep parameters such as sleep duration, sleep onset latency and wake after sleep onset could provide valuable information on which aspects of sleep may be more or less impacted by ED consumption. It is not known whether the associations are sex specific. In addition to the noted sex differences in ED consumption, sleep problems have also exhibited sex-specific rates. We have previously shown that young adult female students have higher rates of insomnia than males; however, we found no differences in sleep duration.[19]

There may be multiple pathways in which ED consumption impacts sleep. One plausible mechanism is the effect of caffeine present in ED. For example, ED consumption has been found to be associated with heart palpitations,[20] elevated systolic blood pressure and increased QT interval[21]—all of which may potentially affect sleep and be mediated by caffeine. According to a review by the Norwegian Scientific Committee for Food and Environment, a young adult with an average weight of 70 kg would be at risk of sleep disturbance when drinking more than 98 mg/day of caffeine, which is approximately 300 mL of ED a day.[1 2] Moreover, it is possible that some of the other ingredients can potentiate caffeine's effect on sleep. As an example, the ingredient guarana is often added to ED, where 1 g of guarana contains 40 mg of caffeine which again contributes to the caffeine content of ED without being stated on the total caffeine content.[22] This might result in a higher intake of certain ingredients which in combination has an impact on sleep. The sugar content of ED is often high, with 65% of the ED sold in Norway containing sugar, though there are several sugar-free options available.[23] Sugar intake through sugar-sweetened beverages has a known impact on sleep,[24 25] making the intake of ED containing both sugar and caffeine a likely/potential source of poor sleep quality.

ED has a high caffeine content, and caffeine intake is a well-known risk factor for poor sleep.[26 27] However, research focusing on how ED consumption may impact sleep among young adults has been limited. Based on these considerations, the overall aim of the current study was to investigate the frequency of ED consumption and its association with several sleep characteristics, using a national sample of Norwegian college and university students. We specifically focused on sleep duration and insomnia as the primary outcomes, in addition to more detailed sleep parameters, such as sleep efficiency, sleep onset latency and wake after sleep onset. We also explored whether these associations varied based on sexes.

METHODS

Procedure

The current paper used data from the SHOT2022 study (Students' Health and Well-being Study), a large national survey of students enrolled in higher education (college and university students) in Norway, conducted by three large student welfare organisations. Four surveys have been completed since 2010. This paper is based on the most recent wave, conducted in 2022. The SHOT2022 study is a comprehensive survey of several domains of mental health and lifestyle factors which is distributed electronically through a web-based platform. Details of SHOT studies have been published elsewhere,[28] but in short, the SHOT2022 was conducted between 8 February and 19 April 2022, and invited all full-time Norwegian students pursuing higher education, both in Norway and abroad. During this period, close to all COVID-19 restrictions were lifted in Norway just before the data collection started, but there was still some online teaching in higher education.[29] In all, 169 572 students fulfilled the inclusion criteria of being a full-time student in higher education and aged 18–35 years. Of these 59 544 students completed the online questionnaires (after being sent two reminders), yielding a response rate of 35.1%. For the purpose of the current sample, we only included students aged 35 years or younger, and with valid responses on the ED and sleep variables, yielding a final study sample of 53 226 students.

Instruments

Sociodemographic information

Information about the participants' sex and age was extracted from their unique 11-digit National Identity Number. Participants were also asked about their relationship status, and if either the student or his/her parents were born outside of Norway. Finally, the participants indicated the educational level of their parents as either having completed primary education, secondary education or college/university education.

ED consumption

ED consumption was assessed with the following question (as part of a larger food and drink questionnaire): 'How often do you usually drink energy drinks (Red Bull, Battery, Monster, Burn or similar)?', with the following response options 'daily', '4–6 times per week', '2–3 times per week', '1 time per week', '1–3 times per month' and 'seldom/never'.

Sleep variables

Participants' self-reported usual bedtime and bed-rise time were indicated in hours and minutes, and data were reported separately for weekdays and weekends. Time in bed (TIB) was calculated as the difference between bedtime and rise time. For the purpose of the current study, late bedtime was operationalised as going to bed after midnight. Sleep onset latency (SOL: defined as the length of time that it takes to accomplish the transition

from full wakefulness to sleep) and wake after sleep onset (WASO: defined as amount of time a person spends awake after sleep onset) were also indicated separately for weekdays and weekends in hours and minutes. SOL and WASO were used both as continuous variables, as well as dichotomised at the 90th percentile, which corresponds to SOL ≥2 hours, and WASO ≥1 hour. Sleep duration was defined as TIB minus SOL and WASO, and sleep efficiency was calculated as sleep duration divided by TIB multiplied by 100 (reported as a percentage). Only the weekday sleep variables were used in the current study.

All participants also indicated the average number of nights per week they experienced difficulties initiating sleep (DIS), difficulties maintaining sleep (DMS), and early morning awakenings (EMA), as well as daytime sleepiness and tiredness. Those suffering from sleep problems were asked about how long the problems had been present. The following three criteria were used as an operationalisation for insomnia disorder, in line with the the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria: (1) the presence of either DIS, DMS or EMA for at least three nights per week, (2) the presence of daytime sleepiness and tiredness for at least 3 days per week and (3) duration of the sleep problems for at least 3 months. Oversleeping was measured with one question ('How often do you oversleep?') and scored on a 5-point scale ('never', 'sometimes per year', 'sometimes per month', 'sometimes per week' and 'every day'). Students who responded 'sometimes per week' or 'every day' were categorised as frequently oversleeping. More details about the sleep inventory used in the SHOT studies have been published elsewhere.[19] In the current study, sleep duration and insomnia were the primary outcome measures.

Statistics

IBM SPSS V.28 (SPSS Inc., Chicago, IL, USA) for Windows was used for all analyses. Pearson χ^2 test was used to examine the sex differences in ED consumption. General Linear Model (GLM) with Least Significant Difference (LSD) post hoc multiple comparisons, calculating age-adjusted estimated marginal means (EMM), were used to examine the association between ED consumption and the continuous outcome measures. Analyses were conducted separately for men and women, but in addition, we also tested for interactions between ED and sex in the full sample on the sleep outcomes by including an interaction term (ED×sex) in the models. We conducted log-link binomial regression analysis to calculate effect-sizes for the dichotomous outcomes, adjusting for age. Rather than the more commonly used logistic regressions (producing odds ratios), log-link binomial regressions (producing risk ratios (RR)) provide more correct estimates when the prevalence of the outcome of interest (eg, insomnia or short sleep duration) is relatively high. The following dichotomous cut-offs were used: late bedtime after 24:00, short sleep duration (<6 hours), sleep onset latency (>2 hours), wake after sleep onset (>1 hour), sleep efficiency (score <85), weekly oversleeping and insomnia according to the DSM-5. Results are presented as RR with 95% confidence intervals (CI). The normality of the data was examined using skewness and kurtosis, and all continuous measures were well within the recommended ranges (±2).[30] There was generally very little missing data (n<0.5%), and hence missing values were handled using listwise deletion.

Patients and public involvement

The SHOT2022 study was initiated and governed by the three largest student welfare organisations in Norway. This

Table 1 Sociodemographic characteristics of the SHOT2022 study

	Men		Women		Total	
SHOT2022						
Age, mean (SD)	24.3	(3.3)	23.8	(3.2)	24.0	(3.2)
Sex, % (n)	33.6%	(17 939)	66.4%	(35 423)		
Single, % (n)	44.7%	(8023)	51.2%	(18 142)	49.0%	(26 165)
Self and/or parent(s) born abroad, % (n)						
Born in Norway	89.6%	(16 080)	89.6%	(31 741)	89.6%	(47 821)
Born outside Norway	10.4%	(1859)	10.4%	(3682)	10.4%	(5541)
Maternal education, % (n)						
Primary	4.3%	(736)	4.9%	(1671)	4.7%	(2407)
Secondary	26.5%	(4510)	29.6%	(10 197)	28.6%	(14 707)
College/university	69.2%	(11 798)	65.5%	(22 528)	66.7%	(34 326)
Paternal education, % (n)						
Primary	5.8%	(983)	6.6%	(2199)	6.3%	(3182)
Secondary	32.9%	(5536)	39.3%	(13 199)	37.2%	(18 735)
College/university	61.3%	(10 300)	54.1%	(18 146)	56.5%	(28 446)

included both planning and design of the study, agreeing on inclusion and exclusion criteria, and selecting potential research questions and instruments used in the study. Recruitment was also conducted in close collaboration with the student welfare organisations, but there were no students involved in the actual data collection.

RESULTS

The total sample comprised 53 226 young adults (66.4% women), with a mean age of 24 years (SD: 3.2). The majority of the sample had parents who had attended college/university as shown in table 1.

There was a significant sex difference in the overall ED consumption (χ^2 (5, n=52 695)= 547.844, p<0.001), as displayed in figure 1. More women (49.6 %) than men (39.6 %) had never or seldom consumed ED. Moreover, among women, 5.5% reported consuming ED 4–6 times a week and 3.3% consumed ED daily. Men reported consuming ED more often than women, where 7.8% consumed ED 4–6 times a week and 4.7% consumed ED daily.

Figure 2 shows the ED consumption and associations with different sleep parameters, separately for men and women when using general linear models to compute estimated marginal means. For both sexes, there was a clear dose-response relationship between ED consumption and reduced sleep. For example, both men and women who consumed ED daily slept approximately 30 min less (7:06 and 7:10 hours, respectively), compared with those who seldom or never consumed ED (both sexes: 7:39 hours). Similar associations were also observed for WASO and SOL; increasing consumption of ED was associated with a corresponding increase in both nocturnal wake time and time spent falling asleep. Furthermore, the prevalence of insomnia was 51%, among those women who consumed ED daily, compared with 33% among women who seldom or never consumed ED, and a similar graded pattern was observed for men (37% vs 22 %, respectively). The ED and sex interaction analyses showed significant effects for risetime and bedtime (and to some extent insomnia), with men displaying a stronger association with ED for these sleep outcomes.

As shown in table 2, similar graded dose-response associations were observed when outcome variables were dichotomised using log-link binomial regression models: higher ED consumption was associated with an increasing risk of sleep problems across all sleep parameters. The strongest associations for both sexes were observed between ED consumption and short sleep duration. Compared with never or seldom consuming ED, men who daily consumed ED had more than a twofold increased risk of sleeping less than 6 hours (RR=2.07; 95% CI 1.77 to 2.42), and a similar pattern was observed for women (RR=1.87; 95% CI 1.64 to 2.14). As also detailed in table 2, infrequent use of ED (1–3 times per month) was significantly associated with an increased risk of poor sleep across

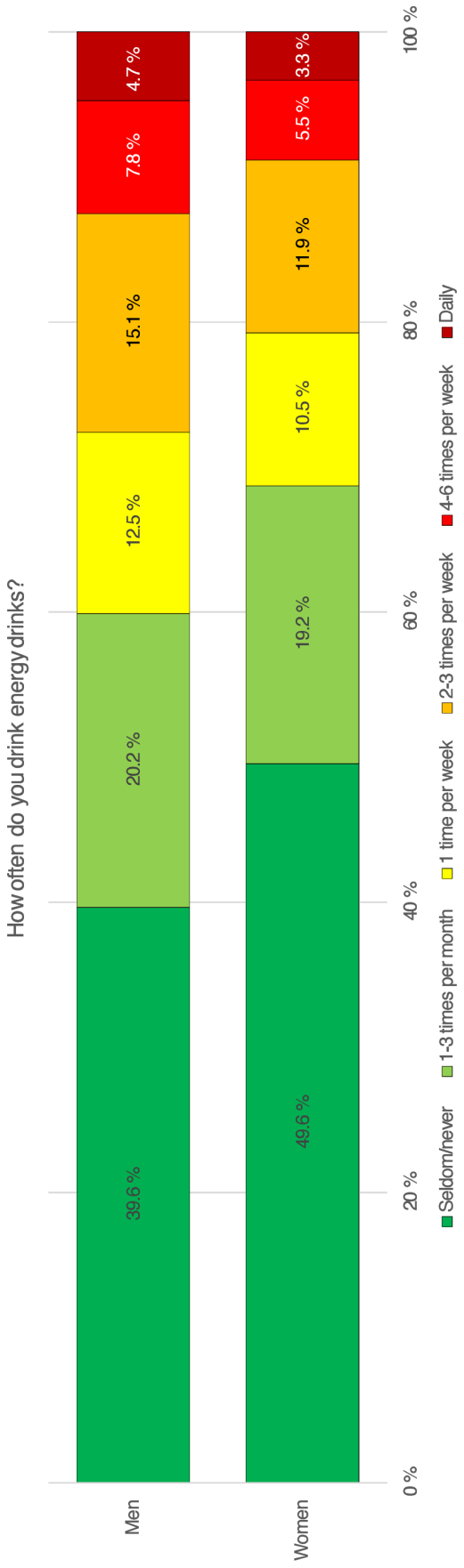

Figure 1 Response pattern of energy drink consumption in male and female college and university students in the SHOT2022 study.

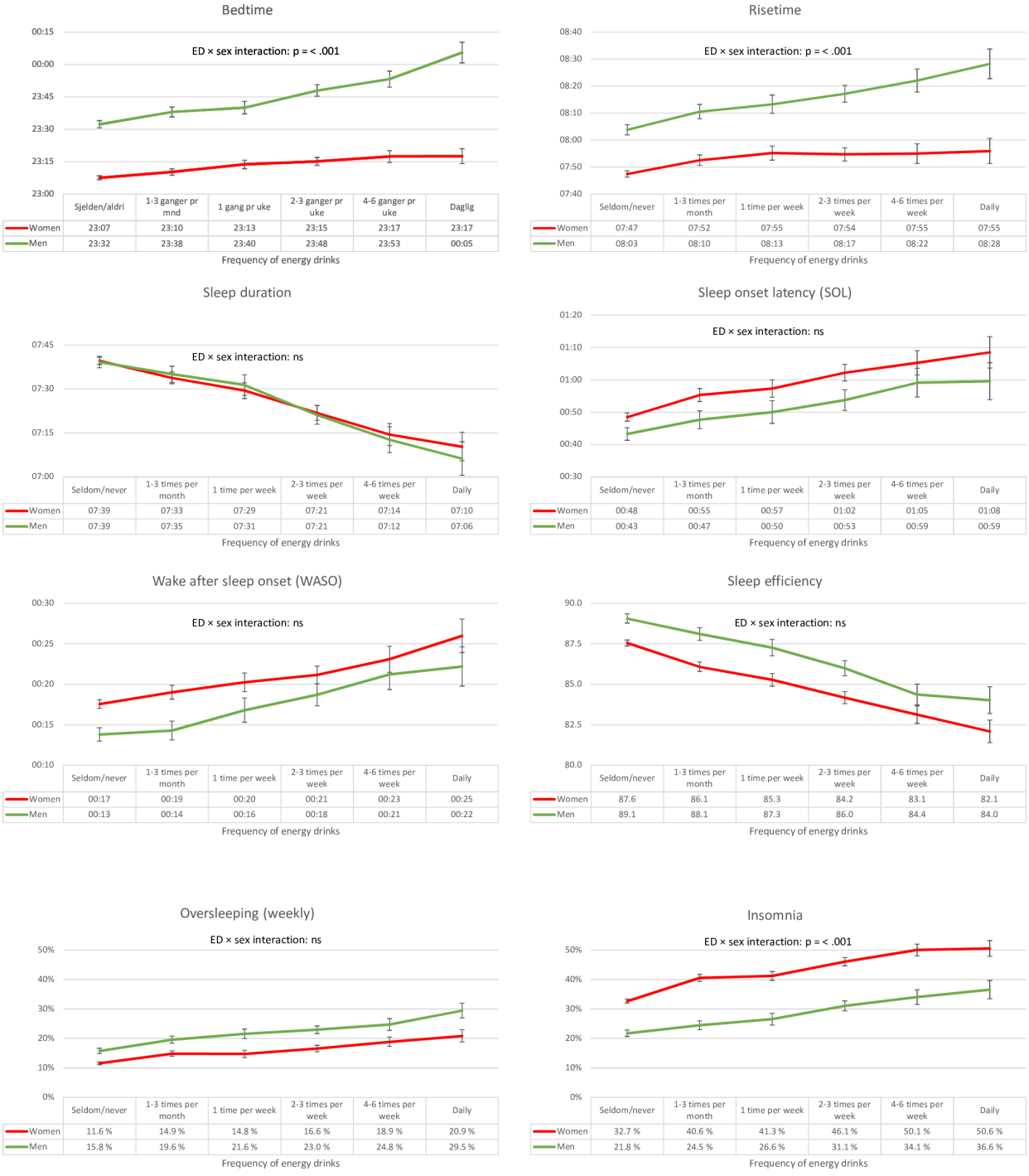

Figure 2 Energy drink consumption (X axis) and age-adjusted sleep parameters (Y axis) in male and female college and university students. Error bars represent 95% CIs. ED, energy drinks.

most sleep parameters, but not including late bedtime and short sleep duration for both men and women.

DISCUSSION

This study examined the frequency of ED consumption related to different sleep parameters in a large sample of Norwegian college and university students. The results showed a clear dose-response association between the frequency of ED consumption and the primary outcomes measures sleep duration and insomnia, next to WASO, SOL and oversleeping. There was also a negative dose-response association between increasing ED consumption and both sleep duration and sleep efficiency. Even small amounts of ED had an impact on sleep where daily ED consumption increased the risk of sleep problems across all parameters for both sexes. Furthermore, most of the associations between ED and sleep were similar for male and female students but with a few notable exceptions.

Table 2 Association between energy drink consumption and risk of poor sleep among male and female students, adjusted for age

ED consumption	Late bedtime (after 24:00)	Short sleep duration (<6 hours)	Sleep onset latency (>2 hours)	Wake after sleep onset (>1 hour)	Sleep efficiency (<85%)	Oversleeping (weekly)	Insomnia (DSM-5)
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
Men							
Never	Ref	Ref	Ref	Ref	Ref	Ref	Ref
1–3 times per month	1.08 (1.00, 1.17)	1.04 (0.92, 1.18)	1.23 (1.10, 1.39)	1.01 (0.89, 1.14)	1.10 (1.04, 1.17)	1.23 (1.13, 1.34)	1.12 (1.05, 1.19)
1 time per week	1.16 (1.06, 1.27)	1.14 (0.98, 1.32)	1.35 (1.18, 1.54)	1.20 (1.04, 1.39)	1.19 (1.11, 1.28)	1.34 (1.22, 1.47)	1.21 (1.12, 1.30)
2–3 times per week	1.35 (1.25, 1.46)	1.52 (1.34, 1.72)	1.58 (1.41, 1.78)	1.31 (1.15, 1.49)	1.37 (1.29, 1.45)	1.41 (1.29, 1.53)	1.36 (1.27, 1.44)
4–6 times per week	1.44 (1.31, 1.59)	1.90 (1.65, 2.20)	1.78 (1.56, 2.04)	1.60 (1.38, 1.86)	1.49 (1.39, 1.59)	1.48 (1.34, 1.64)	1.40 (1.29, 1.51)
Daily	1.75 (1.57, 1.94)	2.07 (1.77, 2.42)	1.89 (1.62, 2.21)	1.78 (1.50, 2.12)	1.50 (1.38, 1.62)	1.66 (1.48, 1.86)	1.48 (1.36, 1.61)
Women							
Never	Ref	Ref	Ref	Ref	Ref	Ref	Ref
1–3 times per month	1.05 (0.97, 1.15)	1.09 (1.00, 1.19)	1.23 (1.15, 1.32)	1.10 (1.02, 1.19)	1.15 (1.11, 1.20)	1.27 (1.18, 1.36)	1.19 (1.15, 1.23)
1 time per week	1.09 (0.99, 1.21)	1.29 (1.16, 1.43)	1.26 (1.16, 1.37)	1.16 (1.06, 1.28)	1.24 (1.19, 1.30)	1.26 (1.16, 1.37)	1.19 (1.14, 1.24)
2–3 times per week	1.20 (1.10, 1.32)	1.58 (1.44, 1.73)	1.55 (1.45, 1.66)	1.24 (1.13, 1.36)	1.30 (1.25, 1.36)	1.37 (1.27, 1.48)	1.29 (1.25, 1.34)
4–6 times per week	1.27 (1.12, 1.43)	1.70 (1.51, 1.91)	1.57 (1.43, 1.72)	1.33 (1.18, 1.50)	1.41 (1.34, 1.48)	1.51 (1.37, 1.67)	1.35 (1.29, 1.41)
Daily	1.56 (1.35, 1.79)	1.87 (1.64, 2.14)	1.77 (1.60, 1.97)	1.62 (1.42, 1.85)	1.48 (1.39, 1.56)	1.63 (1.45, 1.83)	1.32 (1.25, 1.39)

DSM-5, Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; ED, energy drinks; RR, risk ratio.

For bedtime and risetime, we observed a significantly stronger effect for men compared with women. In terms of other sex-specific patterns, we found a higher rate of ED consumption among men, which is also consistent with previous findings.[9 12 13]

We found that 3.3% of women and 4.7% of men were daily ED consumers, which is different from previous findings as both higher and lower overall consumption rates have been found.[10 11] The reasons for these differences could be due to smaller sample sizes and thereby more selected population or the year of data collection where more recent data show a higher percentage of consumption since ED consumption is increasing in popularity. When comparing to the adolescent population in Norway (2017–2019, n=297 102), the frequency of ED consumption was higher in the student population than in the adolescent population where 1.5% consumed ED daily.[8] These results could suggest that ED becomes a more regular drink when becoming a college or university student or that there is a general increase across age groups during the last years which could account for the differences. The latter could also be affected by the precursing COVID-19 pandemic. One study showed that ~10% of young adults reported consuming more sugary drinks (including ED) during the pandemic than before,[31] while another review indicated a slight decrease in ED consumption during the pandemic.[32] Regardless, the reasons for different prevalence rates of ED consumption should be further investigated in studies with a longitudinal design to investigate changes across development or repeated cohort studies to investigate time trends.

In the current study, even low frequencies of ED consumption were associated with an increased risk of insomnia. This finding is in line with a study that found ED to be a risk factor for poor sleep quality[11 15] and tiredness,[14] and extends on previous findings which have found an association with insomnia symptoms.[3] We also found ED consumption associated with later bedtime and short sleep duration that correspond to findings in a study among high school students where later bedtime and shorter sleep duration were associated with increased odds of ED consumption among both middle and high school students.[24] The current study extends the findings from these studies by providing more in-depth information on which sleep characteristics are more closely related to ED consumption.

Strength and limitations

Strengths of the current study include the large samples and detailed assessment battery of sleep parameters. The most important limitation is the observational design of the study which limits the ability to infer causality. For example, reverse causality could also explain the association, where ED consumption may be a consequence of poor sleep[33] rather than the frequency of ED consumption leading to reduced sleep. Also, we do not know at what time during the day that ED was consumed, nor the specific amount of ED consumed each time, as only the frequency of ED consumption was reported in the current study.

Another limitation is the modest response rate of 35.1%, and we have limited information about the non-participants other than their age and sex distribution. One potential reason for the low response rate may be that people are more likely to participate in a survey if they feel it is relevant to them.[34] Additionally, all of the responses were based on self-report which makes the answers prone to recall bias. There may also be unmeasured confounders that could account for the association, such as other lifestyle-related measures including physical activity (either low or high), screen time, stress, academic pressure, depression and alcohol consumption, which may impact both ED consumption and sleep problems.[7 35–39] These potential factors were not considered in the current analysis.

The SHOT2022 study was performed shortly after COVID-19 restrictions were lifted, and this might have affected both sleep patterns and ED consumption. Some studies have demonstrated the relationship between COVID-19 and sleep, both longer sleep duration[40] and increased sleep problems.[41] Another study from Norway, though in adolescents, demonstrated a higher intake of ED during the COVID-19 pandemic compared with before,[42] consequently one could speculate whether the pandemic had an impact on the consumption rates of ED that we found in the current study.

In conclusion, the results from the current study show that there is a robust association between the frequency of ED consumption and the different sleep parameters. Identifying modifiable risk factors for sleep problems among college and university students is vital and our results suggest that the frequency of ED consumption could be a possible target for interventions.

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Contributors BS is the guarantor of the study. BS and MH conceptualised the study. BS performed the data analyses while SK wrote the first draft of the manuscript in close cooperation with BS, MH and TAS. All authors have read and approved the manuscript for submission.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design and dissemination plans of this research. Please see the Methods section for further details.

Patient consent for publication Consent obtained directly from patient(s).

Ethics approval This study involves human participants and was approved by The SHOT2022 study was approved by the Regional Committee for Medical and Health Research Ethics in Western Norway (no. 2022/326437). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The dataset for this article is not publicly available because of privacy regulations from the Norwegian Regional Committees for Medical and Health Research Ethics (REC). Requests to access the datasets should be directed to BS (borge.sivertsen@fhi.no). Guidelines for access to SHOT2022 data are found at https://www.fhi.no/en/more/access-to-data. Approval from REC (https://helseforskning.etikkom.no) is a pre-requirement.

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