The Consumption of Energy Drink and Its Potential Effect on Sleep Patterns: A Case Study in the Kumasi Metropolis

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Abstract

Background: The availability of energy drinks on the global market result from intensive marketing campaigns in the media. The purpose of this study was to evaluate the consumption of energy drink and its potential effect on sleep patterns of consumers.

Methods: A descriptive cross-sectional design with self-administered questionnaire was used for this survey. An online survey using google forms was created for the validated questionnaires after pre-testing and the link shared on different social media platforms. Period of data collection lasted between January and September, 2020.

Results: A total of 384 participants were involved in this study. From the study, prevalence of energy drink consumption in the metropolis is 61.5% (n=236). A percentage of 69.1 % (n=163) of the consumers are males relative to 30.9% (n=73) who are females. Results from the study indicate that most patronized energy drink in the metropolis has energy value per 100 ml of 158 kJ with no proteins and fats but an 8.9 g of carbohydrate. The caffeine content of this energy drink is 0.012% and 13% glucose syrup. A total of 29.6% (n=70) of energy drink consumers indicated it to be their preference. Least consumed energy drink (0.85%) has 30-35 mg/100 ml of caffeine with about 192 kJ energy value. Furthermore, results point out that 70.8% (n=167) of the consumers experienced change in sleep pattern. Although other factors may have caused this change in sleep pattern, Pearson Chi-Square result ($x2 = 83.277$, $p \leq 0.01$) reveals that indeed there is association between energy drink consumption and change in sleep pattern as majority of energy drink consumers indicated that they usually experience changes in wake-up time and/or bedtime.

Conclusion: The study has demonstrated that majority of the youth in the Kumasi Metropolis consume energy drinks which ultimately causes change in their sleep pattern. This change can alter their daily activities and health status.

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Keywords: Caffeine; Sleep Pattern; Energy Drink

Introduction

Energy drinks are beverages that contain caffeine as the active ingredient. In addition to caffeine, energy drinks have other ingredients such as amino acids, B vitamins, guarana and taurine. Primarily, energy drinks offer extra energy to its consumers and they obtain this energy enhancing property chiefly from caffeine and carbohydrates (1). They are consumed for other several reasons such as to reduce or avoid exhaustion, enhance physical strength and shape, and also improve cognitive efficiency (2). Caffeine, the active ingredient in almost all energy drinks has the ability to block adenosine which is a brain chemical involved with sleep, thus potentially interfering with the ability to sleep (3). Energy drinks are ubiquitous in several parts of the world and Ghana is no exception. In 2013, more than 5.8 billion liters of energy drinks were consumed in over 160 countries (4). This widespread usage is as a result of intensive marketing campaigns in the media, which are usually targeted at young people (5). In the United States, considering undergraduate university students, 39-80% had used at least an energy drink in the past. Other countries such as Argentina, Saudi Arabia and Turkey have also recorded such high prevalence. Ghana is no exception

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with 62.2% of student athletes using energy drinks at least once in a week (6). Several brands of energy drinks are on the Ghanaian market; these include Smart, Lucozade, Blue Jeans, Red bull, Burn, Boss, Five (5) Star, Storm, Emerge, Uncle T amongst others (7).

Sleep refers to the reversible state of decreased responsiveness and activity and these are defined by changes which occur in a person's brain wave activity (8). Sleep pattern is determined by regular observation of one's bedtime and wake-up time. Daytime activities influence sleep and sleep pattern probably has direct influence on waking behavior (9). Sleep pattern is also much impacted by sleep loss and sleep debt (10). Sleep is necessary in human health as it has critical roles in brain functions including memory consolidation, clearance of brain metabolites, mood regulation, nociception amongst others (11). Sufficient sleep has been positively related to good physical health, high work performance and enhanced memory. Insufficient sleep on the other hand has been found to adversely affect the endocrine, nervous and immune systems and may raise the risk of cardio-metabolic disruptions, such as metabolism modification and composition of the body (1). When caffeine is consumed, it acts as an adenosine receptor antagonist whereby it binds to G-protein coupled receptors in the brain that mediate the cellular effects of adenosine. Moreover, investigators have reported that caffeine reduces homeostatic sleep pressure and decreases slow wave power in the frontal, central and parietal regions. Another component in energy drinks, called taurine, improves the effects of caffeine (12).

The purpose of this study was to evaluate the potential effect of energy drinks consumption on sleep patterns of consumers amongst residents in Kumasi Metropolis. Presently, there is not much data available on energy drink consumption and its health-related implications in our part of the world. It is therefore necessary to add to the knowledge pool the potential effect consumption of energy drinks has on sleep patterns. This is critical in setting up long term educational initiatives on the consumption of energy drinks.

Methods

A descriptive cross-sectional design with self-administered questionnaires was used for this study. Questionnaires were designed such that respondents were to choose from available options. An online survey using google forms was created for the validated questionnaires after pre-testing and the link shared on different social media platforms. Period of data collection lasted between January and September, 2020.

The study area was the Kumasi Metropolis. Kumasi, the second most populous city in Ghana is situated within the transitional wooded field zone, roughly 270 km north of the national capital, Accra. Kumasi is bounded to the north by the Kwabre District, to the east by the Ejisu Juabeng District, to the west by the Atwima Nwabiagya District, and to the south by the Bosomtwe-Atwima Kwanwoma District.

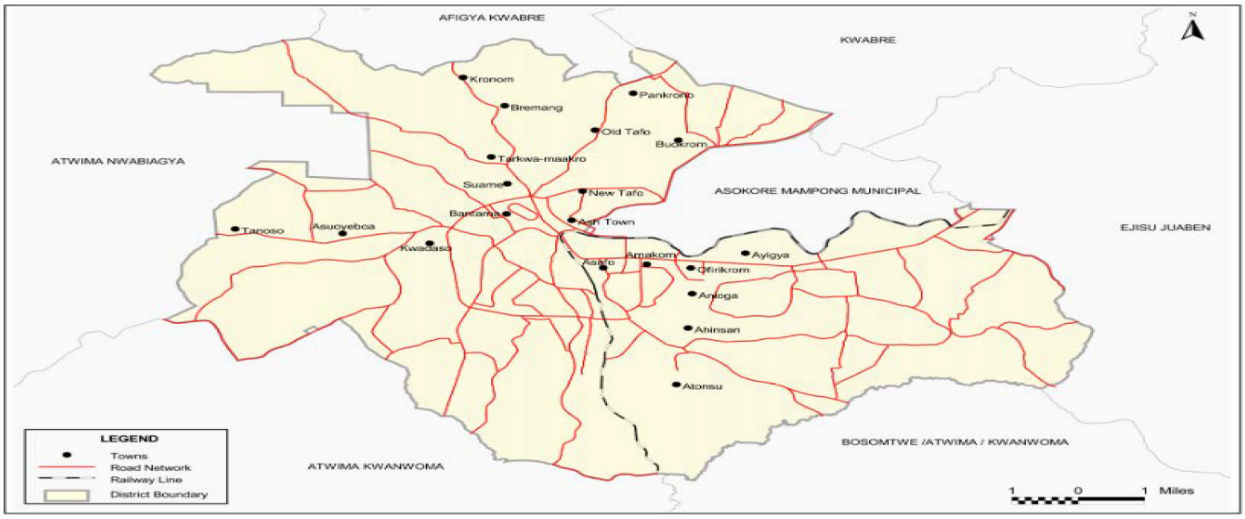

Figure 1.Map of Kumasi Metropolitan area.

Participants in the study were potential energy drink consumers in the metropolis. They were selected because most energy drinks on the markets do not have age limit restrictions. A total of 384 participants were involved.

Ethical clearance with reference number CHRPE/AP/007/21 was obtained from the Committee on Human Research, Publication and Ethics of the School of Medical Sciences, KNUST, Kumasi.

A descriptive cross-sectional design was used for this survey. Pre-testing was done using sampled residents in the metropolis. All completed questionnaires were anonymous, and no personal identifiers were used. An online survey using google forms was created for the validated questionnaires and the link shared on different social media platforms. With a confidence level of 95%, the sample size of 384 was arrived at using Cochran formula from an estimated 2019 population size of 2,096,053 for the metropolis (statsghana.gov.gh).

The entire questionnaire was composed of three (3) major parts. The first part recorded biodata of the

respondents. This biodata included the age group within which participants fall, sex of the participants, their occupation, their educational level and their respective places of residence. The second part obtained participants responses on consumption of energy drinks. This part involved participants' preference to energy drink or not, their brand of preference, duration since initiation of consumption, frequency of consumption, purpose of consumption and any side effect(s) experienced. The last part of the questionnaire focused on sleep pattern of respondents and their social lifestyle which may likely influence the sleep patterns. These social lifestyles included the frequency of having naps during the day, exercising, alcohol consumption, smoking, night work, and medication amongst others.

As the different sub-metros have different population sizes the sample size for each sub-metro was obtained by proportional allocation.

Descriptive statistics was used to delineate the basic features of the quantitative data from the questionnaires. Absolute numbers, frequencies and percentages were used to present the results and findings from the respondents' questionnaires. Descriptive analyses were performed using International Business Machines Corporation (IBM) Statistical Package for the Social Sciences (SPSS) Statistics.

Results and Discussion

Gender distribution of the respondents is represented in Table 1. Out of the 384 respondents sampled, 62.5 % (n=240) of them were males whereas 37.5 % (n=144) of the respondents were females. These revelations were quite surprising because the population of females is higher than that of males in the metropolis (13). However, the dominance of males compared to females can be attributed to males' willingness to participate in online surveys (14).

The study established that majority,53.1 % (n=204), of the respondents age ranged from 26 to 40 years. The respondents from the age of 18 to 25 years constituted 35.2 % (n=135). Age groups of below 18years and above 60years had the same percentages of 1.3 % (n=5) (Table 1). Majority of the respondents being aged 26 to 40years may be due to easy access of internet amongst this age group.

The respondents' areas of residence results (Table 1) show that the research was not centered at a particular area in the Kumasi Metropolis. It can therefore be deduced that the findings obtained for this study is a representative of the sentiments of entire metropolis to some extent. By and large, the residence distribution of the respondents indicates a clear representation of the metropolis. The use of stratified sampling contributes to not having equal respondents from the areas of the study. Most respondents,17.4 % (n=67), were residents of Oforikrom, while Nhyiaeso populace constituted the minority,7.8 % (n=30).

Most of the respondents, 71.4 % (n=274), have attained tertiary level of education. Also, 22.4 % (n=86) of the respondents indicated that they have attained secondary education. Additionally, few, 5.2 % (n=20) of the respondents have only basic education. By far, the results and the findings of this study were obtained from a descending majority because about 99 % of the respondents have received some level of education (Table 1). More so, most of the respondents having a tertiary level of education shows a direct reflection of age group distribution as seen in Table 1.

Table 1. Demographic profile of participants.

Characteristic	Frequency (n)	Percentage (%)
Age range in years		
Below 18	05	1.30
18-25	135	35.16
26-40	204	53.13
41-60	35	9.11
Above 60	05	1.30
Gender		
Male	240	62.5
Female	144	37.5
Residence		
Tafo	33	8.59
Nhyiaeso	30	7.81
Bantama	58	15.10
Kwadaso	56	14.59
Suame	36	9.38
Manhyia	34	8.85
Asokwa	31	8.07
Subin	39	10.16
Oforikrom	67	17.45
Academic qualification		
Tertiary	274	71.35
Secondary	86	22.40
Basic	20	5.21
No formal education	04	1.04

The responses from the respondents suggest that the prevalence of energy drinks consumption in the Kumasi Metropolis is very high (Table 2). Out of 384 sampling units or respondents interviewed, a substantial 61.5% (n=236), of them indicated that they consume energy drinks. From Table 2, it can be observed that, the respondents who were non consumers of energy drinks constitutes 38.5% (n=148). The prevalence of energy drinks consumption was relatively high compared to findings in similar studies by (15, 16). This high prevalence may be attributed to the fact that energy drink market in Ghana has only recently begun to expand, hence, many people are aware of its availability and are making use of it.

Considering the number that consumed energy drinks, 69.1% (n=163) were males and 30.9% (n=73) being

females (Table 2). The study findings are consistent with another study (16), where there was 62.9% prevalence amongst men in Thailand. This may be because the various advertisements of energy drinks primarily show young athletic men, and women tend to be afraid to try out new items. Also, because of the rumors of its effect as sex booster males tend to consume more to enhance their sexual ability. A research in the United States of America amongst undergraduates showed that risk-taking and masculinity were correlated with the frequency and level of energy drink consumption (17). The study however refutes the finding of (15, 18), which states that females drink more energy drinks than males.

Majority, 62.7% (n=148), of the respondents stated that they consume energy drink once in a while, thus, when they found it necessary to take in energy drink, 28.4% (n=67) consumed 1-3 bottles/week, 4.7% (n=11) of the respondents indicated that they consume 4-6 bottles of energy drink in a week. Those who consumed energy drink on daily basis were the least with 4.2% (n=10). The fact that majority of the consumers consumed energy drink once in a while may be due to the fear of addiction to caffeine since caffeine is known to be addictive (19).

Considering the factors or reasons that influences the consumption of energy drink, there were divergent views solicited from the respondents. Respondents agreed to the following reasons for the consumption of energy drinks; i.e. "To recover from illness", "help to work for long hours", "Improve performance", "Increase/Replenish energy", "energy drinks taste good" amongst others (Table 2). Ironically, about 53% of the respondents indicated that energy drink consumption does not help them stay awake. This result debunks the wide held assertion that energy drink consumption does keep one awake. Concerning, whether energy drink serves as a panacea to replenish lost energy, even though, majority (64%) of the respondents agreed with this statement, about 36 % of sampling units disagreed (Table 2). Caffeine helps increase the release of catecholamines (such as adrenaline) through the sympathetic nervous system which are critical in energy production in the body (20).

Table 2. Profile of energy drink consumption.

Consumption of energy drinks	**Frequency (n)**	**Percentage (%)**	
Yes	236	61.46	
No	148	38.54	
Gender distribution of consumers			
Male	163	69.07	
Female	73	30.93	
Frequency of consumption			
Once in a while	148	62.70	
1-3 bottles/week	67	28.39	
4-6 bottles/week	11	4.67	
7 or more bottles/week	10	4.24	
Reasons for consumption	**Agree**	**Neutral**	**Disagree**
To stay awake	100 (42.4 %)	11 (4.7 %)	125 (53.0 %)
Increase/Replenish energy	151 (64.0 %)	00 (0 %)	85 (36.0 %)
Improve performance	182 (77.1 %)	00 (0 %)	54 (22.9 %)
Hydration of the body	46 (19.5 %)	115 (48.7 %)	75 (31.8 %)
Energy drinks are affordable	69 (29.2 %)	00 (0 %)	167 (70.8 %)
My friends influenced me	99 (41.9 %)	00 (0 %)	137 (58.1 %)
I can't function without energy drinks	65 (27.5 %)	12 (5.1 %)	159 (67.4 %)
Energy drinks taste good	131 (55.5 %)	22 (9.3 %)	83 (35.2 %)
Help me to work for long hours	129 (54.7 %)	09 (3.8 %)	98 (41.5 %)
I am enticed by their commercials	46 (19.5 %)	101 (4.3 %)	89 (37.7 %)
Drink them without specific reason	24 (10.2 %)	02 (0.8 %)	210 (89.0 %)
To recover from illness	156 (66.1 %)	13 (5.5 %)	67 (28.5 %)

This section presents the responses from the respondents on the subject of the different brands of energy drinks the consumers utilized. The respondents who said they consume energy drinks were asked to indicate the brand of energy drink they consume most or frequently. The results are presented in Figure 2. The findings from this

study reveal that the most patronized energy drink is Lucozade (29.66%), followed by Storm (13.14%). The energy value per 100 ml of Lucozade energy drink is 158 kJ with no proteins and fats but an 8.9 g of carbohydrate. The caffeine content of this energy drink is 0.012 % and 13 % glucose syrup. Also present in Lucozade energy is ascorbic acid which serves as an antioxidant. However, unlike most energy drinks it lacks ingredients such as guarana and taurine. Also, ingredients available in Storm energy drink are carbonated water, sucrose, caffeine, taurine, and vitamins. It also has phenylalanine, a precursor for tyrosine. Few of the consumers said that they patronize Royce gold (0.85%) and Buffalo (0.85%) whose caffeine contents exceeds 30 mg/100 ml.

Analysis of one report found that the most important factor of customer demand and consumption of energy drinks was packaging, which accounted for 31.78% of consumer demand. The second most critical element after packaging was the price (23.84%) and the next most important factor impacting buying choices was the concentration of caffeine (20.59%). The last factor affecting consumer purchasing decisions was the selling point of the product (7.40%) (21).

Lucozade energy drink is a well-established brand of energy drink presented in well-designed 330ml can and 380ml bottle. Containers of the drink reflect the brand's quality which easily resonate with target customers. Product authenticity is therefore noticed by buyers which make the buyers gravitate towards the product even before realizing what it is. Also, Lucozade primarily contains glucose syrup and carbonated water. The glucose in Lucozade is easily assimilated into the body for quicker generation of energy. Consumption of Lucozade is therefore essential when energy is in swift need and in times of illness when there is loss of appetite. Moreover, the caffeine content of Lucozade is relatively low (0.012%) making it a better choice to avoid caffeine addiction.

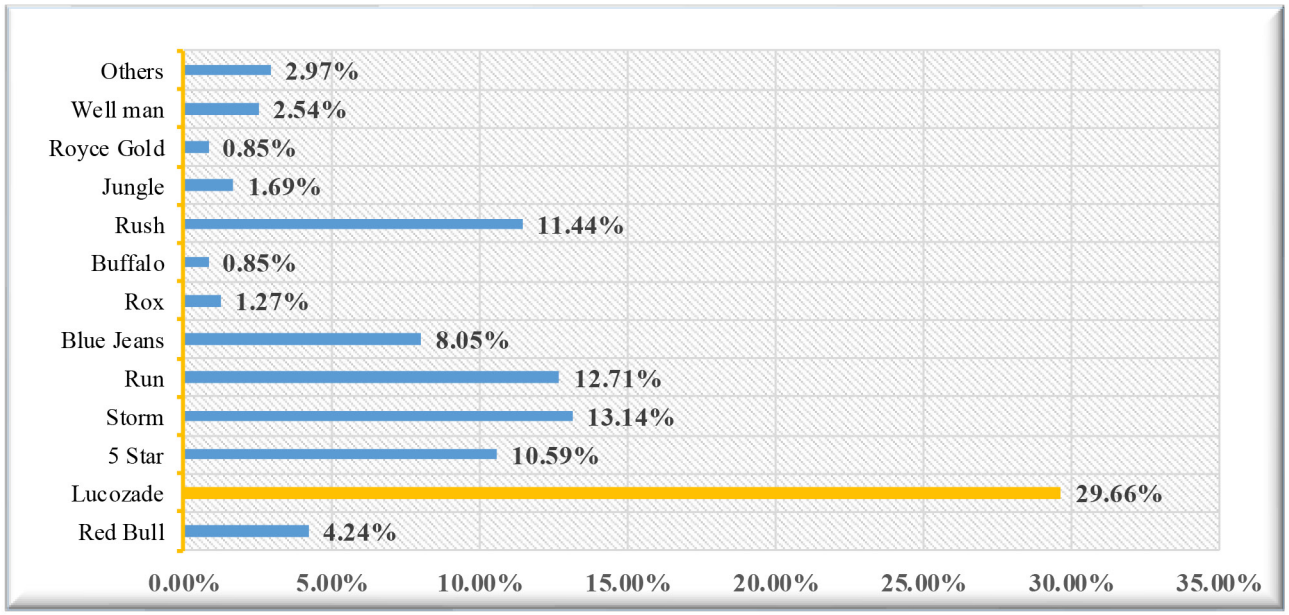

Figure 2. Distribution of various energy drinks utilized

The amount of adenosine in the brain influences the extent and length of sleep since it is a physiological sleep factor. In addition, adenosine is an important component of homeostatic sleep control. It induces sleepiness, lowers electroencephalogram agitation, and enhances slow wave activation throughout sleep (22,16). Adenosine levels decrease slowly as a result of sleep. Clearly, there's a reason one tends to feel sleepy around the same time each night and why, if no alarm is set, wake-up time is mostly around same time in the mornings. As long as we are not pulling all-nighters or traveling across several time zones, our bodies tend to want to follow consistent sleep patterns (which is key for getting the high-quality sleep we need). However, sleep schedules do vary from person to person, depending in large part on the environmental cues we give our bodies when we set our alarms, when we are most active during the day, when we eat, and when we let ourselves hit the pillow. Our body clocks regulate our bodies' circadian rhythms; the patterns of physical, mental, and behavioral changes, including sleep patterns, regulated by body temperature, hormone secretion, and external factors like caffeine, light and darkness (23). It can be observed from Table 3 that while most (50.4 %) of the exposed group indicated that they "wake up" in the hours of 5am GMT. Less people, 4 (1.7%) stated that they wake up after 7am every day. Also, others indicated waking up at 4am, 6am and 7am. Concerning the time they go bed, out of the 236 exposed group, 40.3% (n=95) said 9pm is the time they go bed to sleep in the evening.

Table 3. Sleeping pattern of the energy drinks consumers (N= 236).

Bedtime in the evening	Frequency	Percentage (%)
7pm	12	5.08
8pm	74	31.36
9pm	95	40.25
10pm	32	13.56
After 10pm	23	9.75
Wakeup time in the morning		
4am	19	8.05
5am	119	50.42
6am	78	33.05
7am	16	6.78
After 7am	04	1.70

From Table 4, the results show that about 70.8% of the exposed group pointed out that they experienced change in sleep pattern since they started consuming energy drinks. Caffeine is the active ingredient in energy drinks (24) and also the main component in energy drinks suspected to play a major role in the biological process by which energy drinks influence sleep rhythm and consistency. Aside this active ingredient are other major ingredients such as ginseng, carbohydrate, B-vitamins and taurine which complement activity of caffeine. Other ingredients found in energy drink include inositol, l-carnitine, yohimbine, green tea extract, gingko biloba, sulphur, preservatives (e.g., sorbic acid, benzoic acid, and sodium benzoate), colourings (e.g., caramels, beta-carotene), acidity regulators, flavorings and stimulants. The established correlations of having sleep problems with the intake of caffeine products are biologically plausible. Temporarily, caffeine is a adenosine and methylxanthine receptor antagonist with potent psychoactive effects (25). When caffeine is consumed, it acts as an adenosine receptor antagonist whereby it binds to G-protein coupled receptors in the brain that mediate the cellular effects of adenosine. Moreover, investigators have reported that caffeine reduces homeostatic sleep pressure and decreases slow wave power in the frontal, central and parietal regions. Another component in energy drinks, called taurine, improves the effects of caffeine (12).

Table 4. Energy drink consumption and change of sleep pattern.

Group	Change in Sleep Pattern		
	Yes	**No**	**Total**
Exposed group (Consumers)	167	69	236
Unexposed Group (Non-Consumers)	34	114	148
Total	**201**	**183**	**384**

With this, can one say the energy drink consumption is the cause of same? Well, the Pearson Chi-Square result ($x2 = 83.277$, $p \leq 0.01$) for this study reveals that yes indeed there is association between energy drink consumption and change in sleep pattern. This is because the p-value obtained is less than the alpha value (P=0.05) (Table 5). However, one cannot base on the Chi-Square result alone to suggest that energy drinks consumption affects sleeping pattern, because there are other factors that affects sleep pattern or contribute to change in sleeping pattern. Regarding the individual behaviors and habits that can also contribute to change in sleep pattern, the study reveals the following are contributing factors; frequent daytime napping, spending too much time in bed, late evening exercises, night work, insufficient bright light exposure, evening alcohol consumption, smoking in the evening, late heavy dinner, watching television at night, clock watching and environmental factors such as the room being too warm, too noisy, or too bright as well as taking medication which affects sleep.

Trials have found minimal to no improvements in sleep following exercise training (26) and objective sleep parameters have rarely been found to change in the few trials that have utilized actigraphy or polysomnography (27,28). Alcohol consumption is another known factor that may influence sleep. Ethanol, the alcohol in alcoholic drinks, blocks the action of N-methyl-D-aspartate (NDMA) receptors, which are key targets for glutamate, an excitatory neurotransmitter of significance (29). In addition, alcohol has been found to promote the functioning of Gamma-aminobutyric acid (GABA), an inhibitory neurotransmitter, and is also known to contribute to increased adenosine production and boosted adenosine receptor activity contributing to the sleep starts (29). However, alcohol also has rapid eye movement (REM) inhibitory effect that may justify the correlation between alcohol intake and poor sleep (29). It may be that the link between alcohol intake and poor sleep is bi-directional with pre-existing poor sleep contributing to escalated alcohol consumption. Medications such as alpha blockers and beta blockers affect sleep by preventing access to deep REM sleep and lowering levels of melatonin, a hormone necessary for controlling sleep cycle, respectively (30). Daytime naps have shown to be used as a countermeasure to sleepiness. However, it has no negative effect on sleep parameters such as sleep pattern (31).

It can be obtained from Table 6 that, generally most of the respondent from the exposed group said they do not engage in such behaviors and habits. Although, out of 236 respondents in the exposed group, 128 respondents representing 54.2 % widely held that they watch television or engage in other stimulating activities at night, a significant percentage of 45.8 % did not engage in this activity.

Table 5. Chi-Square Tests Results.

Test	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	**83.277**[a]	**1**	**.000**		
Continuity Correction[b]	81.373	1	.000		
Likelihood Ratio	86.752	1	.000		
Fisher›s Exact Test				.000	.000
N of Valid Cases	384				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 70.53.
b. Computed only for a 2x2 table

Table 6. Behaviors and habits contributing to change in sleep pattern.

Behaviors and habits	Exposed group * N=236		Unexposed Group N=148	
	Yes	No	Yes	No
Frequent daytime napping	67 (28.4 %)	169 (71.6 %)	09 (6.1 %)	139 (93.9 %)
Spending too much time in bed	73 (30.9 %)	163 (69.1 %)	77 (52.0 %)	71 (48.0 %)
Night work	56 (23.7 %)	180 (76.3 %)	73 (49.3 %)	75 (50.7 %)
Late evening exercises	43 (18.2 %)	193 (81.8 %)	30 (20.3 %)	118 (79.7 %)
Insufficient bright light exposure	76 (32.2 %)	160 (67.8 %)	26 (17.6 %)	122 (82.4 %)
Evening alcohol consumption	10 (4.2 %)	226 (95.8 %)	05 (3.4 %)	143 (96.6 %)
Smoking in the evening	14 (5.9 %)	222 (94.1 %)	12 (8.1 %)	136 (91.9 %)
Late heavy dinner	18 (7.6 %)	218 (92.4 %)	73 (49.3 %)	75 (50.7 %)
Watching television or engaging in other stimulating activities at night	128 (54.2 %)	108 (45.8 %)	102 (68.9 %)	46 (31.1 %)
Clock watching	10 (4.2 %)	226 (95.8 %)	62 (41.9 %)	86 (58.1 %)
Taking medication that affects sleep	06 (2.5 %)	230 (97.5 %)	57 (38.5 %)	91 (61.5 %)

From all indications, the chi-square results as well as the results from the consumers' social habits support that energy drink consumption potentially causes change in sleep pattern.

In conclusion, the study has demonstrated that majority of the youth in the Kumasi Metropolis consume energy drinks which ultimately causes change in their sleep patterns. This change can alter their daily activities and hence, health status.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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