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Energy drink consumption pattern and the effect of consumption on university students' blood pressure and heart rate

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Abstract. Energy drink (ED) consumption, even mixed with alcohol, is popular among adolescents and young adults. The side effects of ED are attributed to their active ingredients and their cumulated effect. A cross-sectional study to identify university students' ED consumption habit was realized. A small sample size (n = 10) experiment examining the effect of ED consumption on arterial blood pressure and heart rate was carried out.

From the total number of 240 interviewed students, 87.1% consumed ED at least once, and one third of them did so on a monthly basis. Students consume energy drinks mainly for its taste, very rarely for studying. Differences in consumption place preferences were observed between sexes, females preferring bars, while males the dormitory. We have demonstrated the increase of systolic blood pressure (SBP) for one type of energy drink in young and healthy volunteer students. Other changes in blood pressure and heart rate were not observed.

Keywords and phrases: caffeinated drinks, questionnaire survey, volunteer students, cardiovascular parameters

1 Introduction

Energy drinks are a relatively new product category on the food market. The first energy drink was launched in Japan in 1960 followed by the appearance of Red Bull on the European market in 1987 (*Zucconi et al.*, 2013). A unanimous definition is still missing. Such drink category includes beverages that contain various ingredients, including: caffeine, herbal extracts, B vitamins, amino acids (taurine), amino acid derivatives (carnitine), sugar derivatives (glucuronolactone), and sugars or sweeteners (*Malinauskas et al.*, 2007; *Zucconi et al.*, 2013). Energy drinks may contain from 70 mg to 400 mg/L caffeine (*Zucconi et al.*, 2013). Energy drinks are most frequently used as energizers, stimulants, and performance enhancers. They should not be confused with isotonic beverages and sports drinks, which are considered functional foods. Energy drinks are not recommended to be consumed during physical activities, such as exercising or making physical effort, because the fluid loss and sweating can lead to an intense dehydrated condition and sodium imbalance (*Alsunni*, 2015).

There is a growing demand of energy drinks on a global scale due to the increased consumption in the past two decades mainly among adolescents and young adults. The global sale was 14.68 billion litres in 2018. The major market of energy drinks is North America followed by Asia-Pacific and Europe. On the global market, there are hundreds of different brands with major players such as Red Bull, Monster Beverages, and Rockstar Inc. (Mordor Intelligence, 2019).

Major companies have a very effective advertising, involving movie stars and famous people influencing mainly the vulnerable age-groups such as adolescents and young adults. They are the main targets of the marketing slogans, easily impressionable by the allocated effects to these drinks, such as boosting performance, feeling more energetic, reducing fatigue, helping to stay awake, etc. The susceptibility of adolescents and young adults are confirmed by the literature data. According to a European survey covering 16 Member States including Romania and Hungary, 30% of adults (18–68 years) and 68% of adolescents (10–18 years) interviewed were energy drink consumers (*Zucconi et al.*, 2013).

The side effects of energy drinks are attributed to their active ingredients such as caffeine, taurine, and glucuronolactone and their cumulated effect with other substances (*Itany et al.*, 2014). Therefore, it is required on the European market that beverages containing at least 150 mg/L caffeine to be labelled as "High caffeine content" (Directive 2002/67/EC). Caffeine has numerous

effects on the organism such as vasoconstriction due to antagonized adenosine receptors, increased basal metabolic rate caused by the upregulated circulation of cathecolamines, and water and sodium secretion (*Persad*, 2011; *Oprea et al.*, 2019). Taurine is a normal constituent of human cells; it was associated with several physiological functions such as neuro- and cellular membrane modulation or the modulation of Ca^{2+} levels (*Oprea et al.*, 2019). Energy drink consumption in excess may cause cardiovascular, neurological, psychological, gastrointestinal, metabolic, and renal diseases (*Lee et al.*, 2005; *Bichler et al.*, 2006; *Alsunni*, 2015; *Shah et al.*, 2016; *Utter et al.*, 2017).

Young adults tend to mix energy drinks with alcohol. In the USA, the prevalence of alcohol mixing with energy drink (AMED) varied between 8.1 and 64.7% and in Australia between 21.1 and 77% (*Verster et al.*, 2018). In an expanded European study, co-consumption with alcohol showed similar values: 56% among adults versus 53% among adolescents (*Zucconi et al.*, 2013). The potential risks of AMED are the following: increased total alcohol intake, masked intoxication effects and increased risk-taking behaviour (*McKetin et al.*, 2015; *Verster et al.*, 2018; *Benson et al.*, 2019).

The aim of the study was to identify energy drink consumption habits and their effect on arterial blood pressure and heart rate in the context of possible risk of cardiovascular diseases among university students of Sapientia Hungarian University of Transylvania.

2 Materials and methods

Questionnaire survey

A cross-sectional study was conducted among the students of Sapientia Hungarian University of Transylvania (Cluj-Napoca), Faculty of Economics, Socio-Human Sciences and Engineering, Miercurea Ciuc. The data were collected online via Google anonymous questionnaire during the spring of 2019. The questionnaire consisted of 19 questions on students' socio-demographic characteristics, habits, energy-drink-related habits, and health-impairment-related knowledge. The questionnaire was filled by 240 (27.97%) students from the 858 total active students of the faculty in the academic year 2018–2019.

Subjects

The energy drink consumption study was set up with a group of twelve volunteer students recruited from Sapientia Hungarian University of Transyl-

vania, Faculty of Economics, Socio-Human Sciences and Engineering, Miercurea Ciuc. Exclusion criteria were: cardiovascular diseases and certain kind of chronic diseases. Before starting the experiment, volunteers received verbal and written instructions, and they signed a statement of consent on study participation and on using their data anonymously for the purposes of our study. Before the experiment, participants were asked not to consume any caffeine-containing drinks for 12 hrs before the study. After the experiment, we managed to collect full data on 10 students.

Study protocol

For the experiment, three popular energy drinks and a control drink was purchased in a shop. The ingredients of these drinks are shown in *Table 1.*

Each volunteer consumed 250 mL drink (three types of energy drink and one control drink) on experimental days. Arterial blood pressure (systolic SBP and diastolic DBP) and heart rate (HR) were measured before consuming and 20 min after consuming the drinks. Arterial blood pressure and heart rate were measured with a Beurer Blood Pressure Monitor. All measurements were performed on the arm of the non-dominant hand and were repeated three times.

Table 1: Ingredients in 100 g drink used during the experiment

Ingredient	**Control drink**	**Drink 1**	**Drink 2**	**Drink 3**
Caffeine	–	29 mg	32 mg	33 mg
Taurine	–	400 mg	400 mg	250 mg
Sugar	9.09 g	10.22 g	11 g	10.93 g
Ginseng extract	–	–	–	40 mg
Niacin	–	9.82 mg	8 mg	10.16 mg
Vitamin B-6	–	2.16 mg	0.8 mg	1.01 mg
Vitamin B-12	–	1.97 mg	0.2 μg	2.57 mg
Pantothenic acid	–	–	2.0 mg	–

Statistical analysis

All the data were processed in Microsoft Excel by calculating the mean and standard deviation. To interpret the results of two samples, paired t-test and chi-square test were used, performed with Past3 and SPSS (Version 22) software. P-values lower than 0.05 were considered as significant.

3 Results and discussions

Socio-demographic characteristics, participants' habits and energy drink consumption pattern

The questionnaire was filled by a total number of 240 (27.97% of the totality of faculty's students) students of Sapientia Hungarian University of Transylvania. Students' socio-demographic characteristics are presented in *Table 2*. Of the participants, 159 (66.2%) were females and 81 (33.8%) were males. Participants included in data analysis ranged from 18 to 30 years of age. The age distribution was the following: 45 students (18.8%) were under 20 years, 157 students (65.4%) were between 20 and 24 years, and 38 students (15.8%) were above 24 years. Regarding accommodation, the participants shared residency with parents, lived in dormitories or in lodgings approximately in the same proportion (30%, 35.4%, 29.2%), whereas 5.4% commuted from home to university. Concerning the parents' educational level, 58.8% of the mothers and 66.3% of the fathers were high-school graduated.

Table 2: Participants' socio-demographic characteristics

Characteristics	**No. (n = 240)**	**Percentage**
Gender		
Male	81	33.8%
Female	159	66.3%
Age-groups		
< 20	45	18.8%
20–24	157	65.4%
> 24	38	15.8%
Accommodation		
At home with the family	72	30%
Live in dormitory	85	35.4%
Live in lodgings	70	29.2%
Commute	13	5.4%
Mother's educational level		
Primary-school graduate	14	5.8%
High-school graduate	141	58.8%
College/university graduate (including postgraduate degrees)	85	35.4%
Father's educational level		
Primary-school graduate	11	4.6%
High-school graduate	159	66.3%
College/university graduate (including postgraduate degrees)	70	29.1%

Table 3 presents students' cigarette, alcohol, and energy drink consumption patterns. More than half of the students (58.3%) are non-smokers, and 41.7% are smokers. 88.3% of the students reported that they consumed alcohol with variable frequency, while 11.7% did not consume any alcohol. The majority of the students (87.1%) consumed at least once, whereas 12.9% never tried it out. Of those who never tried it, 87.1% considered energy drink unhealthy. A similarly high proportion of students that consumed at least once energy drink was observed in Hungary (95.3%; *Dojcsákné Kiss-Tóth & Kiss-Tóth*, 2018), Italy (75.8%; *Vitiello et al.*, 2016), *Lebanon* (63.6%; *Itany et al.*, 2014), and the USA (70.1%; *Pettit & DeBarr*, 2011). A significant difference between our results and those obtained at a Turkish university was observed, where 53.5% of the interviewed students never tried consuming any energy drinks (*Bulut et al.*, 2014).

Table 3: Participants' habits regarding smoking, alcohol, and energy drink consumption

Characteristics	**No. (n = 240)**	**Percentage**
Cigarette smoking		
Non-smokers	140	58.3%
Smokers	100	41.7%
Alcohol use		
Not using	28	11.7%
Using	212	88.3%
Energy drink consumption		
Consumed at least once	209	87.1%
Never tried	31	12.9%
Main reason for NOT trying ED		
No particular reason	4	12.9%
Consider unhealthy	27	87.1%

The pattern of energy drink consumption by the faculty students is presented in *Table 4*. The highest proportion of students consume one energy drink per month (67%), 19.1% of the surveyed students consume energy drinks on a weekly basis, while 5.8% of them does it on a daily basis. Other studies report different energy drink consumption frequency from our data: 51% of USA students consume more than one energy drink per month (*Malinauskas et al.*, 2007), while those from Lebanon consume less than one energy drink per month (*Itany et al.*, 2014). The weekly consumption of energy drinks was

observed in a similar proportion in Danish (*Friis et al.*, 2014), Italian (*Vitiello et al.*, 2016), and Hungarian (*Dojcsákné Kiss-Tóth & Kiss-Tóth*, 2018) students (15.8%, 15.8%, 14.4%), which correlates with our data.

Table 4: Participants' habits of energy drink consumption

Characteristics	No. (n = 209)	Percentage
Frequency of ED consumption (n = 209)		
>1 bottle/month	17	8.1%
1 bottle/month	140	67%
>1 bottles/week	22	10.5%
1 bottle/week	18	8.6%
1 bottle/day	6	2.9%
>1 bottle/day	6	2.9%
Main reason for consuming EDs		
Good taste	118	56.5%
Energy need	22	10.5%
Studying	8	3.8%
To stay awake for hours	26	12.4%
Reduce fatigue	27	12.9%
Other reason	8	3.8%
Time of first experience with EDs		
In primary school	69	33%
In high school	119	56.9%
In college/university	21	10%
Place of first time for trying ED		
At home	39	18.7%
Bar	38	18.2%
Coffee shop	11	5.3%
At a party	20	9.6%
Other places	14	6.7%
Not remember	87	41.6%
Companion when first tried an ED		
None	29	13.9%
Friend(s)	163	78%
Family members	15	7.2%
Not remember	2	1%
Type of preferred ED		
Hell	144	71.6%
Red Bull	37	18.4%
Monster	12	6%
Crazy Wolf	4	2%
Burn	1	0.5%
Other	3	1.5%
Place of consumption		
Bar	81	39.1%
At home	46	22.2%
In dormitory	42	20.3%
Coffee shop	13	6.3%
Other	13	6.3%
At university	7	3.4%
At work	5	2.4%

For more than half of the interviewed students (56.5%), the main reason for consuming energy drinks was their taste. In a Turkish study, 48.3% (*Sema & Çakir*, 2011) while in an Italian study 31% of the students consumed energy drinks for their taste (*Scuri et al.*, 2018). One eighth of our students consume energy drinks to reduce fatigue (12.9%) and to stay awake (12.4%). Similar values (10.3%) for reducing fatigue were observed in Turkish students (*Bulut et al.*, 2014), whereas the ratio of students consuming energy drinks for staying awake was lower (5%) in a Turkish study (*Sema & Çakir*, 2011) and higher (33%) in an Italian study (*Scuri et al.*, 2018). Our data show that one tenth (10.5%) of students consume energy drinks to feel more energetic. This reason was mentioned in a higher proportion (15.9%) among Turkish students (*Sema & Çakir*, 2011) and Italian students (32.5–44%) (*Vitiello et al.*, 2016; *Scuri et al.*, 2018). The smallest proportion of the students (3.8%) consume energy drinks to boost performance during studying. Similar data (4%) were obtained by *Sema & Çakir* (2011) among Turkish university students. In other studies, this reason was determining for a higher proportion of students (14%–28.6%) (*Bulut et al.*, 2014; *Vitiello et al.*, 2016; *Scuri et al.*, 2018). The most frequent places of consumption are bars (39.1%), homes (22.2%), and dormitories (20.3%). Our data correlates with those obtained at the Turkish university (*Sema & Çakir*, 2011).

The first experience with energy drinks was in high school for more than half of the students (56.9%) in the companion of friends (78%). At a Turkish university, energy drink consumption took place later in life, as university students (58.9%), in the companion of friends (59.2%) (*Sema & Çakir*, 2011).

The most popular energy drink brands among the faculty students were Hell (71.6%) and Red Bull (18.4%). The popularity of Red Bull was greater in studies from Italy, Turkey, and Lebanon (51.7–73.6%) (*Sema & Çakir*, 2011; *Itany et al.*, 2014; *Scuri et al.*, 2018). The popularity of the Hell energy drink in our region can be explained by the Eastern European (Hungary) origin of the company.

Energy drink consumption frequency differs significantly between males and females, being higher in females for bottle per month and lower for bottle per day consumption (*Table 5*).

Malinauskas et al. (2007) reported in a study based on American students that significantly more females (53%) than males (42%) consumed energy drinks. Other studies highlight the difference between sexes in favour of the male gender, which is more exposed to consumption (*Pettit & DeBarr*, 2011; *Bulut et al.*, 2014; *Friis et al.*, 2014; *Itany et al.*, 2014; *Vitiello et al.*, 2016).

Table 5: Frequency of energy drink consumption among energy drink consuming university students

Frequency	**% males**	**% females**	χ^2	**p (sex)**
> 1 bottle/month	7.7	8.4	0.03	0.85
1 bottle/month	57.7	72.5	4.85	< 0.05
>1 bottle/week	15.4	7.6	3.11	0.07
1 bottle/week	9	8.4	0.02	0.88
> 1 bottle/day	3.8	2.3	0.42	0.51
1 bottle/day	6.4	0.8	5.59	< 0.05

$n = 78$ males, 131 females, $\chi^2(1, N = 209)$

Table 6 presents the data on genders regarding the main reason of energy drink consumption. Differences between the sexes were not statistically significant for this issue. The same results were obtained for American students by *Malinauskas et al.* (2007).

Table 6: Situation of energy drink consumption among energy drink consuming university students

Situation	**% males**	**% females**	χ^2	**p (sex)**
To stay awake for hours	16.7	10.7	1.55	0.21
Good taste	59	55	0.32	0.57
Energy need	9	11.5	0.31	0.57
Reduce fatigue	7.7	15.3	2.57	0.10
Studying	3.8	3.8	0.00	0.99

$n = 78$ males, 131 females, $\chi^2(1, N = 209)$

Differences between the sexes regarding the preferences for the place of consumption were observed (*Table 7*), females opting more often to consume energy drinks in bars while males in dormitories.

Table 7: Place of consumption of energy drinks among energy drink consuming university students

Place of consumption	**% males**	**% females**	χ^2	**p (sex)**
Bar	26.3	46.6	8.27	< 0.01
At home	19.7	13	0.42	0.51
In dormitory	32.9	13	11.79	< 0.001
Coffee shop	7.9	5.3	0.53	0.46
At work	2.6	2.4	0.02	0.87
At university	2.6	3.8	0.20	0.64

$n = 104$ males, 145 females, $\chi^2(1, N = 207)$

Effects of consumption on blood pressure and heart rate

The baseline characteristics of volunteers are listed in *Table 8*. Originally, five female and seven male volunteers were involved in the study, but complete datasets were obtained only for five participants from each gender. The mean age of the volunteer students was 21.4 ± 2.31 years. Nine of them had normal body mass index (BMI), and one was overweight.

Table 8: Study subjects

Parameters	**Volunteer Group**
Sex	
Female	5
Male	5
Age, years	21.4 ± 2.31
Height (m)	1.74 ± 0.075
Weight (kg)	70.3 ± 10.73
BMI	
> 24.9	1
18.5–24.9	9
< 18.5	0

Table 9 describes the blood pressure (SBP, DBP) and heart rate (HR) parameters observed during the experiment. All parameters were recorded in triplicate before and after energy or control drink consumption. Statistically significant changes were observed in heart rate in the case of the control drink, whereupon 20 minutes after consumption the heart rate declined (*Fig. 1*).

The second energy drink (Drink 2) used in the experiment caused statistically significant increase in volunteers' systolic blood pressure (*Table 9*, *Fig. 1*).

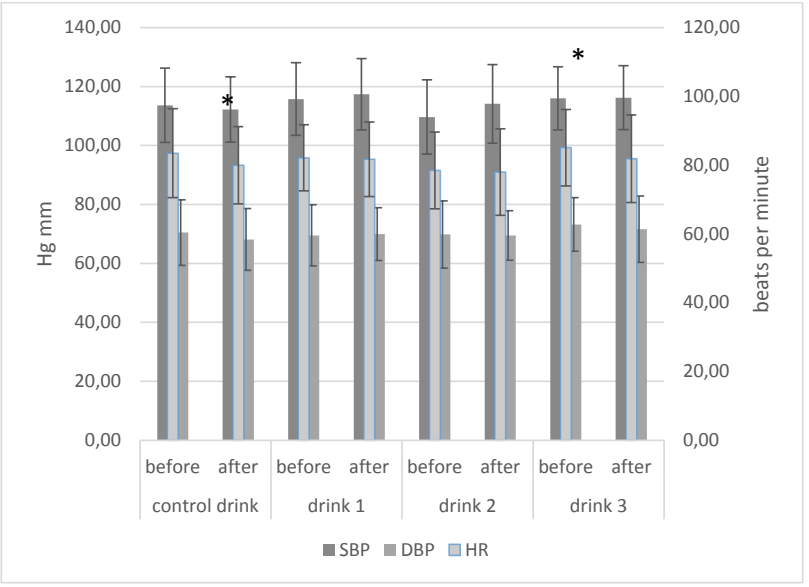

Figure 1: Changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) among participants (n = 30, 10 volunteers, 3 repeats)

* Significance (at $p < 0.05$) was only stated in the case of HB (decreased) in control drink and in the case of SBP in Drink 2 (increased)

Similarly to our findings, other studies report no significant difference in heart rate after energy drink consumption (*Shah et al.*, 2016; *Nowak et al.*, 2018). In contrast with our data, a significant heart rate decline was observed by *Hajsadeghi et al.* (2016) in the case of 44 volunteer students from Iran after consuming energy drinks.

Significant increase in systolic blood pressure (SBP) was observed in the case of 38 German students after 1 hour of 750–1000 ml energy drink administration (*Basrai et al.*, 2019) and 34 Canadian volunteers after 30 minutes of 500 ml energy drink consumption (*Shah et al.*, 2019), which is in accordance with our results for Drink 2. No significant changes in systolic blood pressure was observed by *Hajsadeghi et al.* (2016) and *Nowak et al.* (2018), whereas the latter study reported a significant increase in diastolic blood pressure after the consumption of three doses of energy drinks.

Table 9: Blood pressure and heart rate data recorded during the experiment

Parameters	Control drink (n = 30, 10 volunteers, 3 repeats)			Drink 1			Drink 2			Drink 3		
	Before ED	**After ED**	**p**	**Before ED**	**After ED**	**p**	**Before ED**	**After ED**	**p**	**Before ED**	**After ED**	**p**
SBP (mm Hg)	113.63 ± 12.58	112.20 ± 11.08	0.349	115.77 ± 12.31	117.40 ± 12.12	0.293	109.67 ± 12.57	114.13 ± 13.33	< 0.05	116.03 ± 10.73	116.20 ± 10.85	0.240
DBP (mm Hg)	70.47 ± 11.12	68.13 ± 10.45	0.302	69.50 ± 10.39	69.93 ± 8.96	0.681	69.80 ± 11.37	69.47 ± 8.4	0.820	73.20 ± 9.1	71.60 ± 11.28	0.261
HR (beats per minute)	83.47 ± 12.95	79.97 ± 11.21	< 0.05	82.13 ± 9.63	81.70 ± 10.85	0.743	78.47 ± 11.19	77.97 ± 12.60	0.611	85.10 ± 11.13	81.90 ± 12.74	0.093

Data on both increase and no difference in blood pressure and heart rate were published in the literature, being highly influenced by the amount of energy drink consumed and the timing of measurements after consumption.

4 Conclusions

Energy drinks are popular among the examined faculty students; as shown in our study, 87.1% of the students consumed ED at least once. Two-thirds of the consumers use one bottle per month – significantly more females, while significantly more males consume ED with daily frequency. Students consume energy drinks mainly for its taste and very rarely to enhance learning efficiency. Differences between the sexes in consumption place preferences were observed: females preferring bars while males dormitories.

We demonstrated the increase in systolic blood pressure (SBP) in young and healthy volunteer students for one type of energy drink. Other changes in blood pressure and heart rate were not observed. Due to the fact that the experiment depends on the type and quantity of energy drinks and exposure time, future investigations are necessary on a larger population.

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