

## Evaluation of long-term caffeine consumption and cardiovascular risk in medical students

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Caffeine consumption by academics, especially those in medical school, is done indiscriminately due to the need to reduce fatigue during their activities and, consequently, increasing their performance. Although it seems to be a harmless practice, it can be related to some health problems. Among these other damages are: arrhythmias, urinary incontinence, loss of appetite, nausea, increased blood pressure, insomnia and sudden death. In this context, this work evaluated cardiovascular damage associated to long-term use of caffeine based on clinical evaluation of students aged 18 years or older in a private medical college in Espírito Santo. Analysis was performed through a brief questionnaire followed by assessment of heart rate and blood pressure. The work was performed with 26 men and 69 women and an average of 70% of the population claimed to consume caffeine. It was also seen that among the students who had the greatest changes in relation to blood pressure were those who were in the 1st and 3rd years of the course. In short, no significant changes were observed in relation to caffeine consumption throughout graduation or cardiovascular impacts associated with its use. However, the evaluated individuals are mostly young and the study follow-up time was short.

**Keywords:** Caffeine. Heart rate. Blood pressure. Chronic intoxication.

### INTRODUCTION

According to energy drinks were made to enhance productivity and focus. In addition, it reduces drowsiness and fatigue. Thus, individuals with exhausting working hours tend to overuse these drinks in order to increase their performance. Students, for example, commonly use it in large amounts and frequency to avoid exhaustion and thus achieve their academic goals. However, this uncontrolled consumption can cause damage to health, causing from milder problems to sudden death (Nadeem *et al.*, 2021; Hardy *et al.*, 2021).

There are several substances that can be classified as energetic, among them, caffeine is the most used. Energy drinks have high doses of caffeine, which stimulates nervous and cardiovascular systems and are consumed by on average of 30 to 50% of young adults. These beverages are widely available in supermarkets, bars and convenience stores. Those drinks may also others energetics such as taurine, riboflavin and nicotinamide, whose effects have not been completely elucidated. It is noteworthy that all those drinks have different concentrations of caffeine and others energetics. Filtered coffee, for example, has less caffeine than an espresso, for example (Carvalho *et al.*, 2018; Hanif *et al.*, 2020; Nadeem *et al.*, 2021).

The need to increase performance after going to college can be explained by new responsibilities and overload of tasks that arise in this context. Therefore, this can lead to fear and anxiety, negatively affecting this adaptation process,

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which can cause functional impairment and even interfere with the academic's quality of life. Therefore, caffeine consumption is significantly higher in populations with more intellectual activity, corroborating students with a good study target. In addition, the need to increase alertness and lucidity is frequently observed in this group, which is one of the main reasons for the consumption of food sources of caffeine (Ghozayel *et al.*, 2020; Hardy *et al.*, 2021; Protano *et al.*, 2023).

Adolescents are among the groups most likely to develop side effects or intoxication related to caffeine use. Arrhythmias, urinary incontinence, dependence, loss of appetite and sudden death are some of possible side effects. In addition, caffeine acts as a positive reinforce, causing slightly euphoric effects and inducing tolerance. A daily gram of caffeine is equivalent to about five cups of coffee, which, if ingested regularly for a week, is sufficient to generate withdrawal symptoms (Carvalho *et al.*, 2018; Nowak *et al.*, 2023; Veselska, Husarova, Kosticova, 2021). Given this scenario, this study evaluated cardiovascular alterations of medical students who use caffeine chronically in order to help determine educational and preventive measures.

## MATERIAL AND METHODS

After ethical approval by the Human Research Ethics Committee of UNESC (Certificate of Presentation for Ethical Appreciation: 58552622.3.0000.5062 and number: 5.427.096), medical students from a private college in Colatina, Espírito Santo, were evaluated by their individual characteristics (age, gender, year of college, medical history and use of caffeine) and cardiovascular aspects (measurement of systemic blood pressure and heart rate).

The institution had on average of 800 medical students during the data collection period (between June and August of 2022). Sample selection was made by convenience (n= 95 students), confidence level was estimated at 90% and 5% of sampling error. Only individuals aged 18 years or older were included in the study.

Cardiovascular function was evaluated using a stethoscope, sphygmomanometer and watch. When measuring blood pressure, the student sat comfortably, radial and brachial pulses were checked and the cuff was

positioned at heart level, 2 to 3 cm above the cubital fossa. First, systolic blood pressure (SBP) level was estimated by palpating the radial pulse and then the cuff was rapidly inflated until it exceeded the estimated SBP level obtained by palpation by 20 to 30 mmHg, followed by slow deflation to determine the SBP by auscultation of the first sound and diastolic blood pressure at the disappearance of the sounds. Blood pressure was measured in both arms and the arm with the highest value was used as a reference. For the heart rate assessment, the radial artery was identified, the index and middle fingers were positioned on the radial pulse and the pulsations were counted for one minute.

The relationship between the SBP value and heart rate of students chronically using caffeine was evaluated in comparison with students who do not use it, relating it to the known side effects of the use of these substances. The data obtained were tabulated in the SPSS software version 26, with 90% reliability ( $p < 0.05$ ). The statistical test chosen for the analysis of the variables was chi-square test and binary logistic regression.

## RESULTS

Of the 95 students who participated in the survey, none refused to answer the questionnaire or undergo clinical evaluation. Table I summarizes the characteristics of the studied population. The predominance was of female individuals 72.63% (69 students) aged 18 and 24 72.63% (69 students). Regarding caffeine use, 75.79% of the students consume it during graduation and this use, in general, is prior to the current graduation (86.31%, n = 82).

**TABLE I** - Characteristics of the studied population (n= 95). Colatina, Espírito Santo, Brazil, 2022

Variable	n (%)
<b>Sex</b>	
Female	69 (72.63%)
Male	26 (27.37%)
Did not inform	0 (0.00%)
<b>Age</b>	
18-24	69 (72.63%)
25-34	20 (21.05%)
35 or more	6 (6.32%)

**TABLE I** - Characteristics of the studied population (n= 95). Colatina, Espírito Santo, Brazil, 2022

Variable	n (%)
<b>Course year</b>	
1	15 (15.79%)
2	31 (32.63%)
3	30 (31.58%)
4	19 (20.00%)
<b>Do you use caffeine?</b>	
Yes	72 (75.79%)
No	23 (24.21%)
<b>Did you start using caffeine during graduation?</b>	
Yes	13 (13.68%)
No	82 (86.31%)

When we analyze whether the pattern of caffeine use changed over the years of the medical course, gender, comorbidities, exercises or smoking, we can observe that there was no change (Table II and III).

**TABLE II** - Distribution of caffeine consumption in the studied population according to the year of the course (n= 95). Colatina, Espírito Santo, Brazil, 2022

	Use caffeine	Do not use caffeine	Total
1 <sup>o</sup> Year	11 (15.28%)	4 (17.39%)	15 (15.79%)
2 <sup>o</sup> Year	23 (31.94%)	8 (34.78%)	31 (32.63%)
3 <sup>o</sup> Year	24 (33.33%)	6 (26.09%)	30 (31.58%)
4 <sup>o</sup> Year	14 (19.44%)	5 (21.74%)	19 (20,00%)
Total	72 (75.79%)	23 (24.21%)	95 (100.00%)

**TABLE III** - Comparison of caffeine consumption between men and women (n= 95). Colatina, Espírito Santo, Brazil, 2022

	Male	Female	Total
Use caffeine	19 (70.37%)	53 (76.81%)	72 (75.79%)

**TABLE III** - Comparison of caffeine consumption between men and women (n= 95). Colatina, Espírito Santo, Brazil, 2022

	Male	Female	Total
Do not use caffeine	7 (25.93%)	16 (23.19%)	23 (24.21%)
Total	26 (27.37%)	69 (72.63%)	95 (100.00%)

During data collection, the average caffeine consumed daily by individuals who confirmed to use caffeine, in general (n=72), was 264.48mg of caffeine per day, standardizing that 1 cup of coffee has 100mg of caffeine, which in 300 ml of “Red Bull energy drink” has 96mg of caffeine and that in each capsule has 150mg of caffeine. Of these 72 participants who used caffeine, only 1 was a smoker and had used cigarettes before the survey.

For the analysis of cardiac alterations in individuals, individuals with comorbidities that could directly or indirectly influence the analyzed parameters were excluded, namely: hypothyroidism (3 students), unspecified anemia (1 student), cardiac arrhythmia (1 student), migraine (1 student), gastritis (1 student), hypercholesterolemia (1 student), systemic lupus erythematosus (1 student), polycystic ovary syndrome (1 student), psoriasis (1 student), insulin resistance (1 student) and attention deficit disorder with hyperactivity (1 student).

Despite the high rate of chronic caffeine use, not many changes in blood pressure (Table IV) or heart rate (Table V) were observed in the studied population. Individuals with high blood pressure were found in the first (23.07%) and third year (11.54%). Regarding optimal blood pressure and heart rate, the second year had a higher percentage 92.31% for both measurements but no correlation led to significant cardiac effects (Tables VI and VII).

**TABLE IV** - Distribution of blood pressure (BP) in the population without diagnosed comorbidities (n= 81). Colatina, Espírito Santo, Brazil, 2022

	Normal BP	High BP (≥140/90)	Low BP (≤90/60)	Total (100%)
1° Year	10 (76.92%)	3 (23.07%)	0 (0.00%)	13 (16.05%)
2° Year	24 (92.31%)	2 (7.69%)	0 (0.00%)	26 (32.11%)
3° Year	22 (84.61%)	3 (11.54%)	1 (3.85%)	26 (32.11%)
4° Year	16 (100.00%)	0 (0.00%)	0 (0.00%)	16 (19.75%)
Total	72 (88.88%)	8 (9.88%)	1(1.23%)	81 (100.00%)

**TABLE V** - Distribution of HR in the population without diagnosed comorbidities (n= 81). Colatina, Espírito Santo, Brazil, 2022

	Normal HR	HR (60 – 100)	Total (100%)
1° Year	11 (84.61%)	2 (15.38%)	13 (16.05%)
2° Year	24 (92.31%)	2 (7.69%)	26 (32.11%)
3° Year	21 (80.77%)	5 (19.23%)	26 (32.11%)
4° Year	12 (75.00%)	4 (25.00%)	16 (19.75%)
Total	72 (88.89%)	8 (9.87%)	81 (100.00%)

**TABLE VI** - Chi-square test comparing variables with caffeine use

Variable	Use caffeine (n=72)	Do not use caffeine (n=23)	P-value
Sex	<b>72</b>	<b>23</b>	<b>0.705</b>
Male	19(18.10)	7(6.70)	
Female	53(50.40)	26(24.70)	
Comorbidities	<b>72</b>	<b>23</b>	<b>0.103</b>
No	59(56.10)	22(20.90)	
Yes	13(12.40)	1(1.00)	

**TABLE VII** - Chi-square test comparing variables with caffeine use

Variable	Use caffeine (n=72)	Do not use caffeine (n=23)	P-value
Worked-out	<b>72</b>	<b>23</b>	<b>0.079</b>
No	35(33.30)	16(15.20)	
Yes	37(35.20)	7(6.70)	
Smoked	<b>72</b>	<b>23</b>	<b>0.419</b>
No	70(66.50)	23(21.90)	
Yes	2(1.90)	0(0.00)	
BP	<b>72</b>	<b>23</b>	<b>0.335</b>
High	8(7.60)	1(1.00)	
Normal	64(60.80)	22(20.90)	

**TABLE VII** - Applied logistic regression model

Variable	Binary logistic regression			
	B	df	p	Exp(B)
Age	0,118	1	0,099	1,126
HR	-0,011	1	0,616	0,990
Sex	0,738	1	0,230	2,091
Comorbidities	-1,585	1	0,142	0,205
Worked-out	-0,733	1	0,211	0,480
Smoked	-19,281	1	0,999	0,000
BP	1,010	1	0,403	2,746
Constant	19,875	1	0,999	428316026,749

## DISCUSSION

Caffeine is the most consumed psychostimulant worldwide, being the only substance, among foods and beverages, legally accessible for all ages. Caffeine-based beverages are mainly consumed to relieve sleep, with higher intakes usually in the afternoon (Carvalho *et al.*, 2018; Nadeem *et al.*, 2021).

Neurons have adenosine, a nucleoside that in hypothalamus stimulates sleep by facilitating non-REM sleep (sleep without rapid eye movement). When adenosine

A2 receptors are blocked by caffeine, there is an increase in cAMP (cyclic adenosine monophosphate) levels, increasing neural activities with reduced sleep and increased heart and respiratory rate. Furthermore, caffeine amplifies calcium release by skeletal muscle, improving physical performance in exercises or daily activities (Espinosa, Sobrino, 2017; Faudone, Arifi, Merk, 2021).

This work highlights a population known by you high consume of caffeine: medical students. In fact, most of the students do use caffeine and this use preceded college time, them most of them used it through adolescence. The long-term use of caffeine in the population can be already indicate a pattern of tolerance, due to the time of use and doses. Gender or college year did not influence the substance consumption pattern.

Energy drink consumption by children and adolescents raised as a great concerned nowadays and should be reduced. It is related to psychological damage, such as, sensation seeking, irritability and suicide ideation. Moreover, is related to students with a lower school performance and sleeping problems (Almulla, Faris, 2020; Marinoni *et al.*, 2022; Veselska, Husarova, Kosticova, 2021). Therefore, these students might have some issues due to their troubles when teenagers and the caffeine use during these days. It could even impact their health and academic performance until now. Thereby, it is a cycle: the student has bad grades and emotional issues, he or she takes caffeine as a way to change it, but it only gets worse.

When caffeine is absorbed, it reaches its highest plasma concentration in 30 to 45 minutes, containing on average 400mg, equivalent to 4 to 5 cups of coffee. However, the intake of 1 gram of caffeine in a single day is enough to trigger intoxication signs, for example, agitation, insomnia, palpitations and tremors. In more severe cases, due to a higher consumption of between 7 and 10 mg/L of plasm concentration, it can progress to vomiting, convulsions and, in rarer cases, death (Cappelletti *et al.*, 2018; Nadeem *et al.*, 2021). Studied population claimed to consume an average of 264.48mg of caffeine per day, which is about 2.6 cups of coffee, a not toxic dose. Although, as described, that dose was enough for a small increase heart rate and blood pressure in the students.

Although, the lack of effects may be attributed to the influence of others factors, such as, smoking, frequency of consumption and quantity. In this work, however, the population was very young, the number of smoking students was low and the average consumption of coffee was also low. Therefore, no major cardiovascular changes were observed. Studies even suggest that an increased cardiovascular risk results from 450mg/day in adults and young people, whereas in children the use of 100 to 400mg/day of caffeine already enough to harm them (Carvalho *et al.*, 2018).

## CONCLUSION

No significant changes were observed in relation to caffeine consumption throughout graduation and cardiovascular effects among students. This work was limited by the number of students evaluated, the young age of the population analyzed and the short time of use to exposure time to higher doses of caffeine. Another highlight is that in future work we should also investigate the effects of caffeine on sleep and learning in this population.

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