ORIGINAL RESEARCH

Caffeine consumption of medical students in Korea: amount and symptoms based on a 2023 survey

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Purpose: To investigate the form and level of daily caffeine intake recommended above 400 mg in medical students expected to consume caffeinated beverages to enhance their performance.

Methods: From May to June 2023, freshman through senior medical students at a medical school in Korea were administered a seven-item questionnaire designed to measure the amount of caffeine-containing foods consumed, the weekly interval between consumption, the reason for consumption, and the level of caffeine-induced symptoms experienced.

Results: Out of 443 students, 361 responded (81.5%). The most commonly consumed caffeine beverages were coffee (79.2%), followed by soda (33.2%), tea (27.4%), chocolate (25.2%), and energy drinks (20.5%). The estimated (average±standard deviation) daily intake was estimated to 274.6±276.5 mg, and they consumed caffeine on an average of 4.25±2.26 days per week. Students who consumed 400 mg or more of caffeine daily consumed 19.9%. The primary motivation for caffeine intake was "to improve academic performance" (60.9%) and "preferred food" (51.8%). Among the responders, 98% of them replied they had symptoms that could be caused by caffeine, in order of palpitations (47.4%), frequent urination (42.9%), anxiety (27.1%), indigestion (17.5%), and excitement (17.5%). A total of 45.7% reported two symptoms, and 24.7% reported three or more.

Conclusion: Caffeinated beverage consumption was routine among current medical students, with 20% consuming more than the recommended daily amount. Most students experienced at least one caffeine-induced symptom, with two symptoms in half, suggesting the need for policy measures and warnings about caffeine-containing foods.

Key Words: Caffeine, Food addiction, Substance-related disorders

Introduction

Caffeinated beverages are rising across society. Caffeine stimulates the central nervous system and is believed to help fight fatigue, increase alertness, and improve endurance. As a result, Because of these effects, the consumption of caffeinated beverages tends to grow to fulfill a variety of motivations [1]. Most people consume caffeine to improve performance in the academic or athletic field, and medical students often consume it due to their heavy workload. When ingested, 99% of caffeine is absorbed into the body within 45 minutes, and when blood levels reach 15 mg/L, it can cause symptoms such as jitters, palpitations, and nausea. Furthermore, when the blood concentration comes to 50 mg/L, it becomes more

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toxic, and 80 mg/L is considered a lethal concentration and can be fatal [2-4]. As a result, death from caffeine overdose has been reported [5,6].

As an attempt to reduce its reported toxicities, the Ministry of Food and Drug Safety recommends a maximum daily caffeine intake of 400 mg or less for adults, 2.5 mg/kg or less for children, and 300 mg or less for pregnant women [7-9]. In an average adult, 400 mg of caffeine per day would be exceeded by consuming four cups of Americano coffee or five cans of energy drinks [10]. Nevertheless, no studies have been reported that examine the extent and propensity to consume caffeine in contemporary college students, especially medical students, who are thought to be highly motivated to drink caffeinated beverages to enhance their academic performance. Substance addiction and abuse are common medical problems in modern times and can be a practical issue for medical students who will grow up to be healthcare providers. In this background, this study aims to investigate caffeine consumption among students in a single medical school in 2023 to understand their caffeine consumption behavior, thereby suggesting ways to consume caffeine more healthily.

Methods

1. Study population and methods

After approval of insitutional review board (YUMC 2023-12-037), This study investigated the prevalence of caffeine consumption among all medical students, from first-year students to seniors of medical school at Yeungnam University College of Medicine in 2023. To determine the extent of caffeine intake, we (1) administered a survey of seven questions to all medical students and (2) examined the types and amounts of caffeine-containing beverages in vending machines on campus.

2. Survey on caffeine consumption among medical students

The type of caffeine-containing foods was categorized, and the subjects were asked whether they usually consumed each item. In order to estimate the caffeine intake per serving for each food, we set a daily serving size based on the caffeine-containing foods. The caffeine content of each food was calculated based on data published by the Korea Food and Drug Safety Evaluation Service in 2020 [6]. Participants were asked how many times per day they consumed each category of food, based on the number of servings, and multiplied by the number of servings to calculate their daily caffeine intake and the number of days per week they consumed caffeine. Also, the perception of caffeine consumption, reasons for caffeine consumption, and symptoms of caffeine consumption that can be associated with caffeine overdose were surveyed (Supplement 1). Multiple responses were allowed for all questions related to tastes and symptoms.

3. Investigation of the proportion and amount of caffeinated beverages sold in vending machines on campus

To determine how much students are exposed to caffeine, we surveyed caffeine content in vending machines on the medical school campus. A total of four vending machines were investigated: two at Yeungnam University's Gyeongsan Campus, which are used by first- and second-year students (at the entrance to the student union room on the first floor of the College of Natural Sciences building), and two at Yeungnam University's Daemyung Campus, which are used by other students (inside the book cafe). Each beverage sold in these vending machines was examined and analyzed for caffeine content.

Results

1. General characteristics of the study subjects

The above seven questions were administered to all grades, and 361 out of 443 students responded, which is a response rate of 81.5%. Among the respondents, 248 (68.7%) were male, and 113 (31.3%) were female. Respondents aged 20 to 24 years made up 198 (54.8%), followed by 151 (34.1%) aged 24 to 28 years, and 12 (3.3%) over the age of 28 years (Table 1).

2. Caffeinated food consumption amount among medical students

Coffee was the most common food consumed by respondents, with 286 (79.2%) reporting that they usually drink coffee. This was followed by soda (120, 33.2%), tea (99, 27.4%), chocolate (91, 25.2%), and energy drinks (74, 20.5%).

Based on this, the calculated average±standard deviation daily caffeine intake of all respondents was estimated to be 274.6±276.5 mg, and they consumed caffeine on an average of 4.25±2.26 days per week (Table 2). Students who consumed 400 mg or more of caffeine per day were 19.9% of the total, in order of first-year medicine (25.4%), first-year pre-med (26.3%), second-year medicine (19.2%), second-year pre-med (15.6%), third-year medicine (15.1%), and fourth-year medicine students (12.5%). First-year medicine students had the highest average daily caffeine intake at 314.5±278.2 mg, and second-year medicine students consumed the most caffeine days per week at 4.94±2.49 days.

As for the motivation of caffeine intake, the most commonly reported "to improve academic performance (60.9%)," followed by "preferred food (51.8%)" and "to improve workout performance (9.7%)." First-year and

Table 1. Summary of the Grade, Gender, and Age of Medical Students Who Participated in the Survey

Grade	Gender		Age (yr)			Total (%)
	Male	Female	20–23	24–27	≥28	
1st year of pre-med	55 (72.4)	21 (27.6)	68 (89.5)	8 (10.5)	-	76 (21.1)
2nd year of pre-med	49 (76.6)	15 (23.4)	53 (82.8)	10 (15.6)	1 (1.6)	64 (17.7)
1st year of medicine	46 (73.0)	17 (27.0)	40 (63.5)	21 (33.3)	2 (3.2)	63 (17.5)
2nd year of medicine	51 (69.9)	22 (30.1)	27 (37.0)	45 (61.6)	1 (1.4)	73 (20.2)
3rd year of medicine	29 (54.7)	24 (45.3)	10 (18.9)	39 (61.6)	4 (7.5)	53 (14.7)
4th year of medicine	18 (56.3)	14 (43.7)	-	28 (87.5)	4 (12.5)	32 (18.8)
Total	248 (68.7)	113 (31.3)	198 (54.8)	151 (41.8)	12 (3.3)	361 (100.0)

Data are presented as number (%).

Table 2. The Amount of Caffeine Beverage and Motivations for Caffeine Consumption by Grade Level

Grade	Calculated caffeine intake (mg)	Calculated caffeine intake (day)	Motivations of caffeine intake		
			Academic performance	Preferred food	Workout performance
1st year of pre-med	306.7±236.8	3.5±2.0	31 (40.8)	60 (78.9)	4 (5.3)
2nd year of pre-med	263.1±404.6	3.5±2.0	32 (50.0)	36 (56.3)	9 (14.1)
1st year of medicine	314.5±278.2	4.9±2.3	51 (90.0)	21 (33.3)	3 (4.8)
2nd year of medicine	278.6±244.2	4.9±2.5	60 (82.2)	31 (42.5)	5 (6.8)
3rd year of medicine	239.2±214.0	4.4±2.2	30 (56.6)	23 (43.4)	8 (15.1)
4th year of medicine	192.5±185.4	4.4±2.2	16 (50.0)	16 (50.0)	6 (18.8)
Total	274.6±276.5	4.25±2.2	220 (60.9)	187 (51.8)	35 (9.7)

Data are presented as mean±standard deviation or number (%).

Table 3. The Frequency of Potential Caffeine Overdose Symptoms by Grade Level

Grade	No. of symptoms (%)			Total
	Single symptom	Two symptoms	Over 3 symptoms	
1st year of pre-med	76 (100.0)	22 (28.9)	10 (13.2)	76
2nd year of pre-med	64 (100.0)	29 (45.3)	10 (15.6)	64
1st year of medicine	63 (100.0)	31 (49.2)	17 (27.0)	63
2nd year of medicine	73 (100.0)	42 (57.5)	26 (35.6)	73
3rd year of medicine	53 (100.0)	24 (45.3)	15 (28.3)	53
4th year of medicine	25 (78.1)	17 (53.1)	11 (34.4)	32
Total	354 (98.1)	165 (45.7)	89 (24.7)	361

second-year pre-med students were most likely to consume caffeine for "preferred food" (78.9% and 56.3%, respectively), while first-year to third-year medicine students were most likely to consume caffeine to "improve academic performance" (90%, 82.2%, and 56.6%, respectively).

3. Symptoms and effects of caffeine consumption

Among the responders, 98% replied they had symptoms that could be caused by caffeine. The most reported symptom was "palpitations" (171, 47.4%), followed by "frequent urination" (155, 42.9%), "anxiety" (98, 27.1%), "indigestion" (63, 17.5%), and "excitement" (63, 17.5%), "restless" (53, 14.7%), and "distraction" (35, 9.7%). The frequency of potential caffeine overdose symptoms by grade level is summarized in Table 3.

4. Investigated the caffeine content of beverages sold in on-site vending machines

Of the 22 beverage items sold in the vending machines surveyed, 11 (50%) contained caffeine, averaging 52 mg (Supplement 2).

Discussion

The extent of caffeine-containing beverage consumption among medical students known for their heavy academic workload has been scarcely reported. The first data was published based on a cross-sectional study investigating caffeine use for "academic purposes" by first—to third-year medical students at the University of the Free State of South Africa in 2006 [11]. The second cross-sectional report was published based on 400 medical students of the Dao University of Pakistan in 2016 [12]. Unlike the West, where coffee and other beverages are commonplace, these countries have been drinking caffeine-containing beverages since the 20th century, like South Korea, so comparing their data with ours is helpful, especially in the early 21st century, when caffeinated drinks are more readily available and exposed in the media globally.

The survey of our data had a high response rate of 81.5%, which ensured its reliability. In particular, the study was conducted among all grades, confirming the caffeine consumption needs of students in the familiar medical school environment. Regarding caffeine consumption among students, coffee was the most commonly consumed food, accounting for 79.2%. This may be attributed to the ease of access to coffee, as coffee franchises are widely located in and around schools.

In terms of intake by grade, first-year medical students and first-year pre-med students were found to have higher intake than other grades. When examining reasons for consumption, 90% (51) of first-year medical students

reported studying as the reason for caffeine consumption, compared to 40.8% (31) of first-year pre-med students and 50% (32) of second-year pre-med students. Other reasons for consumption (preferred food, workout performance) decreased over the years. This suggests that medical students have an increased workload compared to pre-med students, which naturally increases the demand for caffeine (Table 2). This can be interpreted as an overall trend in the medical department, as 82.2% (60 students) and 56.6% (30 students) of the first-year medical students, as well as the second and third-year medical students, reported caffeine consumption as a reason for studying. This differs significantly from a 2006 survey of South African medical students, which showed that academic improvement was only the third most common goal (62.6%), with the most common goals being taste (72.4%) and socializing (70%), which reflects the South Korean value of purposeful consumption of caffeinated beverages [11].

We can relate this to the average number of days per week and the average amount of caffeine per day consumed by each academic year. First- and second-year medical students consumed an average of 314.5 mg and 278.6 mg of caffeine per day, respectively, and had the highest average number of caffeinated days per week of all grades at 4.9 days and 4.94 days, respectively. First- and second-year pre-med students had average daily caffeine intakes of 306.7 mg and 263.1 mg, respectively, and 3.54 and 3.52 caffeinated days per week, respectively. Comparing these results, there was no significant difference in average daily caffeine intake between medical and pre-med students, but there was a difference in the number of days per week they consumed caffeine. This suggests that medical students tend to consume caffeine more frequently for academic reasons because of the sustained effect of caffeine in their daily routine. In contrast, pre-med students consume caffeine according to their leisure life, such as taste and exercise.

Among medical students, 98% have experienced abnormal symptoms after consuming caffeine, 49% have experienced two or more, and more than 25% have experienced three or more. Caffeine acts on the central nervous system to produce a stimulant effect, increasing intracellular calcium concentrations and stimulating the release of norepinephrine, which sensitizes dopamine receptors [13]. This process causes the body to block signals from the brain that it needs to rest, and blood pressure and heart rate increase. Beyond the short-term discomfort of performing daily activities, these symptoms can lead to problems such as anxiety, digestive issues, restlessness, and even death [14-17]. These side effects and overconsumption have led to the establishment of a recommended daily allowance for caffeine in Korea, but 20% of medical students consume more than the recommended amount. This suggests that most students continue to consume caffeine despite experiencing adverse symptoms. There is a need for policy research and procedures to prevent caffeine overuse and abuse, such as awareness of the amount of caffeine consumed by individuals and information and education on the recommended intake.

According to data from the Ministry of Food and Drug Safety of Korea, the average daily intake of caffeine per person in Korea over the past 3 years (2015-2017) was 65.7 mg, which is 17.6% higher than the maximum recommended daily intake of 400 mg [18]. In addition, according to a previous study on the consumption of high-caffeine beverages by college students, the average daily intake of caffeine from high-caffeine beverages was 13.81 mg, and the average daily intake of caffeine from caffeine-containing drinks such as coffee, excluding high-caffeine beverages, was 75.19 mg among the 291 college students who participated in the study. The average daily caffeine intake from energy drinks during the trial was 30.00 mg,

more than double the usual amount [19]. In comparison, the average daily of the present study was 306.7 mg in the first year of pre-med, 263.1 mg in the second year of pre-med, 314.5 mg in the first year of medicine, 278.6 mg in the second year of medicine, 239.2 mg in the third year of medicine, and 192.5 mg in the fourth year of medicine, which is significantly higher than the average daily caffeine intake per person in Korea. Notably, 20% of people consumed more than 400 mg per day, which is considerably higher than other countries reported in 2016, when only 7.0% consumed more than 400 mg per day [12]. It is also higher than other university students' average daily caffeine intake through high-caffeine drinks. While the reasons for the prevalence of caffeine consumption by grade level may vary, it is essential to note that frequent caffeine consumption does not result from a particular grade level. Still, across all grades, it is worth exploring ways to reduce caffeine consumption among our students. Based on this investigation, a pamphlet containing information about the caffeine content of the beverages they choose and the maximum recommended daily amount, a QR code (quick-response code) for keeping a caffeine diary, and a recommended application were created and posted on campus and promoted on social media, so that students could become aware of their increased caffeine consumption and think about alternatives they could choose to reduce their caffeine consumption at unnecessary times. Substance overdose is an increasingly important theme of medical education. Preventing their own addiction may provide them with the ethical challenges they will face in the future when caring for patients experiencing the same problem. In this respect, we believe that the educational significance of this paper, which reveals that many medical students are at risk of caffeine addiction, is significant.

Limitations of this study include that the response rate was lower among third- and fourth-year medical students than other students. In addition, this study was conducted on medical students at a single University in South Korea. If other medical students were surveyed, it would be possible to identify the actual caffeine intake of medical students in Korea and find ways to improve it. Also, it would be helpful to investigate students' caffeine intake changes after the project. Finally, considering that this survey was conducted during the examination period, it would be beneficial to complete another study at a different time to see if the students' caffeine consumption is influenced by their studies or how much they influence it.

In conclusion, caffeine consumption was routine among current medical students, with 20% taking more than 400 mg daily. Most students experienced at least one caffeine-induced symptom, with two symptoms in half, suggesting the need for policy measures and warnings about caffeine-containing foods.

Supplementary materials

Supplementary files are available from https://doi.org/10.3946/kjme.2024.301

Supplement 1. Survey Forms Used in This Study.

Supplement 2. Types and Content of Caffeine-Containing Beverages in Four Vending Machines on Campus.

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