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CAFFEINE – A POPULAR STIMULANT AS A CAUSE OF INSOMNIA AMONG MEDICAL STUDENTS – A REVIEW OF THE LATEST LITERATURE

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ABSTRACT

Introduction and Objective
Caffeine is a common stimulant frequently used by young people, particularly medical students. Despite its numerous beneficial properties, it also causes various adverse effects, including addiction. The aim of this study is to examine the relationship between insomnia among medical students and their caffeine consumption.

Materials and Methods
This review paper uses resources available in the Google Scholar databases. All the studies included in the review were published in 2024. The phrase "caffeine insomnia medical student" was used to search for relevant studies. These articles are available online and free-full text.

Results
Many medical students regularly consume caffeinated drinks. The reasons of using include combating fatigue, improving cognitive functions and concentration. However, its consumption is associated with negative health effects such as insomnia. Results of studies included in this review show that sleep disorders were reported by approximately 30% to nearly 50% of surveyed medical students consuming caffeinated drinks. Medical students suffering from insomnia showed worse test results. Sleep plays a crucial role in memory retention and information processing. Most of them lacked sufficient knowledge about the side effects of caffeine and the determination of a safe daily dose.

Conclusions
Insomnia is a common health issue among medical students. Regular caffeine consumption increases the risk of its occurrence. The surveyed students have limited knowledge about the side effects associated with caffeine use. To raise awareness among future doctors about the serious health consequences of excessive caffeine consumption, appropriate health education should be introduced during medical studies.

Introduction – characteristics of caffeine

Caffeine is an organic purine alkaloid that belongs to the methylxanthines, naturally occurring in many plant materials and identified in over 60 different plant species (Völker, Koch, Becker & Klenk, 2020). It was first isolated from coffee beans, which are the main source of natural caffeine. This was achieved by German chemist Friedrich Ferdinand Runge in 1820, and the discovery was confirmed in the same year by von Giese (Lin et al, 2023). Today, caffeine can also be produced synthetically. On average, Europeans consume approximately 4 kg of coffee beans per year, with Finns consuming over three times as much (Bułdak et al, 2018). Nearly 90% of people worldwide drink, on average, one cup of coffee per day (Shin et al, 2022). According to the latest EFSA (European Food Safety Authority) report published in May 2015, the highest daily caffeine intake is observed among individuals aged 75 and above. The report defines a safe daily caffeine dose for adults, including pregnant and breastfeeding women, as 3 mg/kg body weight, roughly 200 mg. Consuming 400 mg/day, approximately 5.7 mg/kg body weight, does not negatively impact the health of adults, excluding pregnant and breastfeeding women. For children and adolescents, a similar daily caffeine intake limit of 3 mg/kg body weight is recommended (*EFSA explains risk assessment: caffeine*, 2015). The increasing consumption of energy drinks among children and adolescents caused the sale of energy drinks containing caffeine and taurine was legally banned in Poland for minors from 1 January 2024.
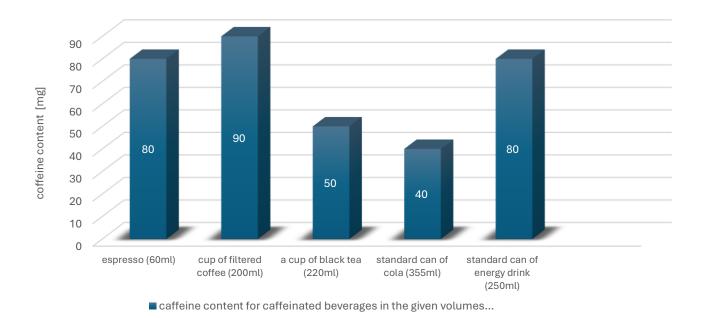
Fig. 1. *Chart is showing average caffeine content in popular caffeinated drinks by volume (EFSA explains risk assessment: caffeine, 2015).*

Caffeine belongs to the group of psychoactive substances stimulants similar to cocaine, modafinil, methylphenidate, amphetamine, and ephedrine. Caffeine is the most commonly psychostimulant in the word. The psychostimulant properties of caffeine have been known since ancient times, with infusions made from tea leaves or coffee beans (Fredholm, 2011). The widespread inclusion of caffeine in the daily diet stems from its beneficial effects on the human body. The primary reasons for consuming caffeine are the desire to improve concentration, motor coordination, reaction time, cognitive functions such as awareness, information processing, memory, combating fatigue. Due to its lipophilic properties, caffeine freely crosses the blood-brain barrier, enabling its psychostimulant effects (Grzegorzewski, Bartsch, Köller & König, 2022). Its stimulating impact on the CNS (central nervous system) results from caffeine's blocking action on adenosine receptors (A2A receptors) in the brain. Adenosine naturally inhibits the release of the neurotransmitter dopamine. Caffeine's action enhances the dopaminergic pathway, increasing alertness and concentration (Jacobson, Gao, Matricon, Eddy & Carlsson, 2022).

Moreover, the blockade of adenosine receptors results in the constriction of blood vessels, increased vascular resistance, and consequently, a temporary rise in blood pressure. The positive inotropic effect after caffeine consumption is also caused by the blockade of adenosine receptors and is further intensified by increased catecholamine secretion (Kaur, Yousuf, Ramgobin-Marshall, Jain & Jain, 2022). Caffeine also demonstrates antioxidant properties (Vieira, Gaspar & Santos, 2020). Excessive caffeine consumption leads to heart rhythm disturbances, increased blood pressure, anxiety attacks, gastrointestinal disorders and sleep disturbances. Long-term use can lead to tolerance development and consequently addiction. The colloquial term for this phenomenon is "caffeinism." In the ICD-10 classification, it is categorized in F.15: "Mental and behavioral disorders due to the use of other stimulants, including caffeine". The lethal dose of caffeine has been determined to be approximately 200 mg/kg body weight, which is roughly 10 g. The market for caffeine-enriched beverages is constantly expanding and gaining popularity. Young people, in particular, eagerly reach for these products to boost their productivity during work or study.

According to research, knowledge about its side effects, such as insomnia, is poor, even among medical students. The aim of this review paper is to examine the relationship between caffeine consumption and the development of insomnia among medical students. The choice of the analyzed group was made due to the increased consumption of caffeinated beverages among medical students, driven by high academic demands and the desire to achieve the best educational outcomes.

Methodology

This review paper aims to showcase the latest scientific findings regarding insomnia among medical students, which is influenced by caffeine consumption. All papers included in the review were published in 2024. The Google Scholar database was utilized to search for these studies. The phrase "caffeine insomnia medical student" was employed to identify relevant works. These articles are available online, free of charge, in their complete versions.

Results

To investigate the negative effects of caffeine, including sleep deprivation and the development of insomnia, Hend Mohammed Ahmed et al. conducted a cross-sectional study among medical students at the Sohag Medical University in Egypt. Approval was obtained, and 350 students from their 1st to 5th years of study were included in the study, with 70 students from each year. The vast majority (302 participants, 86.3%) initially declared regular consumption of caffeinated beverages. Among caffeine consumers, men constituted 51.7% and women 48.3%. The predominant reason for consuming caffeinated beverages was to enhance concentration and improve cognitive functions (66.6%). The remaining participants cited increased physical activity (30.3%) as their reason. It was observed that first-year students consumed caffeinated drinks less frequently (13.6%) compared to fifth-year students (23.2%). Among the 302 caffeine-consuming students, 249 participants (82.5%) reported symptoms associated with intoxication, with 138 (45.6%) experiencing insomnia. In the group of students who used caffeine, a significant reduction in sleep duration was observed compared to those who did not consume caffeine, with the result being statistically significant ($p < 0.001$). Out of the 350 surveyed, 197 participants (56.3%) considered caffeinated beverages to be dangerous, while the remaining 153 participants (43.7%) found them to be useful. Participants were also asked whether they had sufficient knowledge about the caffeine content in caffeinated beverages. Among the consumers, as many as 74% answered negatively, while 81% of non-consumers gave the same response. Additionally, awareness and knowledge of the side effects of caffeine were compared. Among non-consumers, 95.6% reported being aware, whereas only 59.9% of consumers did so. This was deemed a statistically significant correlation ($p = 0.001$) (Ahmed, Bakheet, Hassan & Aref, 2024).

Ujjwala Gangwal et al. published the results of a study aimed at determining the impact of caffeine consumption among medical students. The cross-sectional study was conducted at the Jammu Medical University in India. A total of 329 students from all academic years (1st, 2nd, and 3rd year of the 1st and 2nd degree) were participated. However, the study only included students who declared caffeine consumption, which accounted for 282 individuals, approximately 86% of the total. Among them, 61% were women, and 39% were men. The students were divided into two groups. The first group consisted of 1st- and 2nd-year students, while the second group included 3rd-year students of the 1st and 2nd degree. Results indicated higher caffeine consumption among students in the second group compared to the first group. No gender-based differences in the amount of caffeine consumed were observed. These were most frequently consumed on weekdays and less often on days off from studying. The most common reason for consuming caffeinated drinks among both men and women was to refresh their minds, followed by combating fatigue and drowsiness. Insomnia, as a side effect of caffeine consumption, was reported by 84 out of the 282 participants, which corresponds to approximately 28% of men and 30% of women (Gangwal et al, 2024). The problem of insomnia among medical students has been thoroughly examined by Aljafen, Bandar N., and colleagues. Researchers aimed to assess the factors causing sleep disorders in medical students. A cross-sectional study was conducted at Dar Al Uloom University in Riyadh, Saudi Arabia, involving 2,413 medical students. The study included pre-medical students, first- fifth-year medical students, and trainee doctor doctors. The majority of participants were women (1,390) compared to men (1,023). Participants were classified based on their cumulative grade point average (CGPA). The highest percentage consisted of students with the best academic results 1,194 individuals (49.5%), while the lowest percentage included those with the poorest academic performance 52 individuals (2.2%). Respondents completed an online questionnaire that included scales related to insomnia, such as the Insomnia Severity Index (ISI) and the Pittsburgh Sleep Quality Index (PSQI). The average score obtained by the surveyed students according to the ISI scale was 11.6, with a standard deviation of 6.2. Among the participants, 39% were identified with subthreshold insomnia, 28% with moderate clinical insomnia, and 6% with severe insomnia. For 27% of participants, clinical insomnia was excluded. The average PSQI score was 8.4, with a standard deviation of 3.7. A positive correlation was found between insomnia and caffeine consumption, smoking, extended time spent at university, internet using, and a preference for late-night study hours. Participants with chronic illnesses were more prone to experiencing insomnia. It was demonstrated that

diabetes, hypertension, depression, anxiety disorders, obstructive sleep apnea, and recent surgeries were also predictors of insomnia ($p < 0.05$).

The Spearman correlation coefficient for the diagnosis of clinical insomnia using ISI, compared to caffeine consumption by students, was 0.081 ($p < 0.0005$). It was observed that a higher educational level, food consumption, and water intake were negatively correlated with the development of insomnia. Students achieving better grades (CGPA) were less likely to report insomnia. Moreover, individuals without clinical insomnia achieved better academic results ($p < 0.032$) (Aljafen et al, 2024).

Pulla A. and co-authors published the results of a study conducted in Secunderabad, Telangana, India, which revealed that over 30% of medical students consumed more caffeine than the safe, permissible limit during examination periods ($p < 0.01$). This finding was statistically significant. More than half of the respondents lacked sufficient knowledge about the side effects of caffeine consumption. Determining the safe, permissible dose of caffeine also proved challenging for 80.4% of women and 86.4% of men surveyed. Additionally, greater caffeine consumption in adulthood was observed among medical students who began consuming caffeine during childhood (Pulla, Syed & Bolisetti, 2024). Similar conclusions were presented in a 2022 study by Kharaba Z. and co-authors, who reported that individuals exposed to caffeine products during adolescence were more prone to caffeinism (Kharaba et al, 2022). Giuseppe Di Martino et al. published a study aimed at investigating whether the COVID-19 pandemic influenced changes in the amount of caffeine consumed among students from various Italian universities. Among the 404 respondents, medical students constituted a minority—8.7%. The study's results and conclusions were not analyzed in relation to the fields of study. The research considered three time periods: pre-quarantine, quarantine, and post-pandemic, referred to as the present time. Comparing the pre-pandemic period to the present time: The percentage of individuals drinking coffee four or more times a day increased from 7.4% to 15.8%. There was a slight rise in the number of individuals drinking coffee 2–3 times a day. Additionally, the percentage of individuals consuming coffee only once a day decreased from 28% to 22.7%. Meanwhile, the percentage of individuals who did not consume coffee at all fell from 33.2% to 22.6%. During lockdown, the percentage of individuals drinking coffee at least four times a day rose compared to the pre-pandemic period—from 7.4% to 12.6%. During lockdown, 23% of respondents reported consuming more coffee than before the pandemic ($p < 0.001$), and a 4.5% increase was observed in individuals consuming caffeine supplements ($p = 0.004$). After the quarantine ended, compared to the period before the COVID-19 pandemic, 36.1% of respondents increased coffee consumption ($p < 0.001$), 9.2% increased energy drink consumption ($p = 0.041$), and 16.6% increased consumption of caffeinated beverages ($p < 0.001$). The increase in coffee consumption was positively correlated with female gender ($p = 0.046$) and negatively correlated with age ($p < 0.001$). Of the 404 students, 132 were diagnosed with clinical insomnia using the ISI (Insomnia Severity Index) questionnaire. These individuals were more likely to experience co-occurring anxiety disorders ($p < 0.001$). Among those who increased coffee consumption post-pandemic, higher ISI scores were observed compared to others ($p = 0.014$). Similarly, this trend was observed among individuals who consumed larger quantities of caffeine supplements ($p < 0.001$) and energy drinks ($p = 0.004$) after the end of the COVID-19 pandemic (Di Martino et al, 2024).

Discussion

According to the ICD-10 classification (International Classification of Diseases 10th Revision), non-organic insomnia is defined as dissatisfaction with the quality and/or quantity of sleep at least three times a week for a minimum of one month. Insomnia includes not only difficulty falling asleep but also premature awakening or trouble maintaining sleep. It is conventionally accepted that waiting for sleep for more than 30 minutes is considered abnormal. Frequent night awakenings lasting a total of more than 30 minutes, as well as waking up at least 30 minutes before the alarm clock in the morning and before reaching a total sleep time of 6.5 hours, are also considered abnormal. To diagnose insomnia, the patient must experience a deterioration in functioning in specific areas of life—such as work, learning, physical activity, or social life. Patients with insomnia may display daytime symptoms including irritability, mood instability, anxiety, or depressive episodes.

According to the DSM-V classification (Diagnostic and Statistical Manual of Mental Disorders 5th Edition), sleep disturbances lasting for three months are required to diagnose insomnia. Those with symptoms lasting between one and three months are diagnosed with short-term insomnia, whereas chronic insomnia applies to disturbances exceeding three months. Insomnia diagnosis often utilizes scales, primarily the Insomnia Severity Index (ISI) and the Pittsburgh Sleep Quality Index (PSQI). Sleep deprivation negatively affects both physical and mental health. Insomnia reduces learning efficiency, as sleep plays a critical role in memory consolidation and transferring information from short-term to long-term memory. This is particularly

crucial for those who must absorb large volumes of material quickly, such as medical students. Among the causes of insomnia are psychoactive substances, including caffeine. Studies indicate that the majority of medical students, regardless of gender, report consuming caffeine. Moreover, about 30% consume quantities exceeding levels considered safe for health.

Findings reveal that 30% to 50% of medical students consuming caffeinated drinks develop insomnia. Increased caffeine consumption among students has been linked to the Covid-19 pandemic, as changes in caffeine consumption trends during lockdowns influenced post-pandemic habits. The lack of awareness among medical students about caffeine's side effects is alarming. Research shows that future physicians also lack sufficient knowledge about the safe daily dosage of caffeine. Education on caffeine's systemic effects and adverse health outcomes could be beneficial in combating insomnia among medical students. Maintaining healthy dietary habits and avoiding stimulants during childhood and adolescence, including caffeine, is crucial. People who consume caffeine from an early age are more likely to have increased caffeine consumption in adulthood.

Conclusions

Insomnia among medical students is a common issue. It negatively impacts both mental and physical well-being and reduces the effectiveness of education. One of its causes is the excessive consumption of caffeine. The majority of medical students report regular caffeine intake, which increases during periods of intensive study. Their knowledge about the side effects of caffeine is insufficient. It would be beneficial to implement an informational campaign among students or expand the educational content in medical studies to include the side effects of caffeine.

Institutional Review Board Statement
Not applicable.

Informed Consent Statement
Not applicable.

Data Availability Statement
Not applicable.

Conflict of Interest Statement
The authors reported no potential conflict of interest

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