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## Research Article

# Intra-Individual Variability in Sleep Quality Among Coffee Consumers: A Cross-Sectional Study

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## Abstract

**Background and Objective:** Coffee is one of the most popular beverages in the world. Caffeine contained in coffee is a stimulant that acts on adenosine receptors to prevent sleepiness and promote alertness. In this study, we investigated the effect of coffee consumption on sleep quality of undergraduate students studying medicine. **Materials and Methods:** A cross-sectional study and convenient sampling method was used. A total of 350 students were enrolled and data were collected via a self-administered questionnaire based on the validated Pittsburgh Sleep Quality Index (PSQI) questionnaire. **Results:** The majority of students (73.1%) in this study consumed coffee, with instant coffee being the most preferred type. Coffee consumption was most frequent after 8 pm and the most common volume consumed daily was between 251 and 500 mL. The volume of coffee consumed daily was related to sleep quality. **Conclusion:** Although, coffee consumption had a non-significant impact on the quality of sleep among the total study population, we observed a large degree of intra-individual variability in the effects of caffeine.

**Key words:** Coffee, sleep quality, depression, insomnia, medical students

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Coffee is typically consumed to reduce fatigue, although it can have negative effects on the quality and quantity of sleep. Coffee can prevent drowsiness through the action of caffeine, which acts as an antagonist of adenosine receptors that stimulate sleepiness. The rate of caffeine metabolism varies among individuals and the half-life of caffeine ranges between 2.7 and 9.9 h<sup>1</sup>.

Coffee consumption in the evening can cause high caffeine concentrations in the blood that in turn interfere with sleep, as was demonstrated in previous studies<sup>2</sup>. In particular, individuals who considered themselves to be sensitive to caffeine suffered from reduced sleep quality, higher sleep latency and woke up more frequently during the night after consuming coffee at dinner<sup>3</sup>. Some factors that are associated with poor sleep quality include coffee drinking, increased number of hours affected by daytime sleepiness and perceived stress<sup>4</sup>. Scores on the total Pittsburgh Sleep Quality Index, for which higher scores indicate poorer quality sleep, were found to be inversely correlated with the grade point average of students<sup>4</sup>.

Previous studies showed that students frequently consume coffee<sup>5,6</sup>. Coffee, latte and espresso represent the most common forms of coffee consumed by students<sup>7</sup>. In undergraduates, coffee is a main factor associated with sleep irregularities<sup>8</sup>. Undergraduates who described themselves as coffee drinkers were found to have disturbed sleep, reduced number of hours spent asleep and higher sleep latencies<sup>9</sup>. Students who preferred to consume coffee-based beverages such as spris (coffee mixed with tea), instant coffee and diluted coffee also experienced sleep disorders, although the differences between these students and those who did not consume coffee were not statistically significant<sup>10</sup>. Medical students who reported consuming coffee daily for one week were 1.48 times more likely to complain of increased sleep latency compared to those who rarely drank coffee<sup>10</sup>. The intense study load borne by medical students could also contribute to their poor sleep quality although poor sleep quality was also highly prevalent among non-medical students and the general population<sup>11,12</sup>.

An earlier study documented variability in sleeping habits among adults who worked non-traditional shifts<sup>13</sup>. Intra-individual variability in sleep was also reported to be associated with stress<sup>14</sup>. In older adults, variations in concentrations of inflammatory markers were associated with sleep variability<sup>15</sup>.

Studies using cross-sectional questionnaires established an association between sleep and caffeine consumption

among working adults<sup>16,17</sup>. However, few studies have focused on sleep variability among undergraduate students, particularly those who are studying medicine. In this study, we sought to examine the link between coffee consumption and sleep quality among undergraduates studying medicine in Malaysia. We assessed the effect of coffee on sleep quality of these students in terms of volume, time and type of coffee consumed. This information can increase our knowledge of how caffeine consumption affects sleep quality of undergraduates studying medicine and can provide the basis for increased awareness of the consequences of caffeine consumption for sleep quality that will be important for those students who will play a crucial role in delivering healthcare services in Malaysia in the future. This study was conducted to investigate the effect of coffee consumption on sleep quality of undergraduate medical students.

## MATERIALS AND METHODS

**Experimental design:** A cross-sectional study method and a convenient method of sampling were used for this study. Randomly selected medical undergraduates regardless of age, gender and ethnicity were requested to sign a letter of consent to participate in this study.

**Experimental site:** This study involved undergraduates studying medicine at a private medical university in Selangor, Malaysia.

**Research procedure:** Study objectives, instruments and population were selected based on a literature review of previous related studies. A validated questionnaire was used and further measures were taken for data collection.

**Materials and tools:** We used the Pittsburgh Sleep Quality Index (PSQI), a commonly used sleep quality assessment questionnaire that yielded dependable results in many previous studies<sup>18</sup>. This questionnaire was used as a subjective measure of quality of sleep and sleep disturbances over a one-month period.

**Data collection:** Undergraduates studying medicine who were enrolled were briefed on the study purpose before the survey was conducted and after obtaining informed written consent. The questionnaires were then distributed and collected after 15 min. SPSS version 19.0 was used to analyze the data.

**Data analysis:** Questionnaires that lacked responses or were incorrectly completed were excluded from data analysis.

**Data management:** Descriptive statistical analysis for categorical variables was carried out by computing frequency of coffee consumption and percentage of students that consumed coffee. A Chi square test was used to study the association between quality of sleep and coffee drinking habits. A  $p < 0.05$  was considered to be significant.

## RESULTS AND DISCUSSION

The chi-square test showed no statistical significant association between quantity, time and type of coffee consumed by coffee drinkers to overall score of the PSQI. A  $p$  value less than 0.05 was considered for statistical significance (Fig. 1, 2 and 3).

The study included 350 undergraduate students studying medicine at a private medical university in Selangor, Malaysia. The majority (60%) were female and around one-third were Chinese (32%), followed by Indian and Malay students (24.3 and 21.1%, respectively; Table 1). Nearly three-quarters (73.1%) of the study population consumed coffee daily (Table 1). According to the PQSI results, 60% of the population had no clinically significant insomnia, whereas 33% had sub threshold insomnia and 7% suffered from clinical insomnia

(Fig. 1). Of the 206 participants who had no clinically significant insomnia, 149 (72%) were coffee drinkers and the other 57 (28%) did not drink coffee. These coffee consumption rates were identical to those seen for participants who had sub threshold insomnia (72% consumed coffee and 28% did not).

There is conflicting evidence for the health benefits of coffee consumption. Consuming two to three cups of coffee daily is considered to be safe and is associated with neutral to beneficial effects on human health<sup>19</sup>. However, coffee drinking has been associated with depression and insomnia, particularly among students<sup>20</sup>. Caffeinated substances inhibit sleep and can compromise mental alertness among undergraduate students irrespective of gender<sup>21</sup>. College students who experienced various sleep disorders carried a higher risk for academic failure<sup>22</sup>. Sleep disturbances, reduced sleep quality and excessive sleepiness during the day are common among medical students during their clinical training, as are high levels of stress associated with the need to maintain grades<sup>23</sup>. However, most previous data concerning the health effects of coffee consumption were based on observational data that did not quantitatively analyze the association between coffee consumption and reduced sleep quality.

Although, most of the students in this study who consumed coffee were not affected by clinically significant

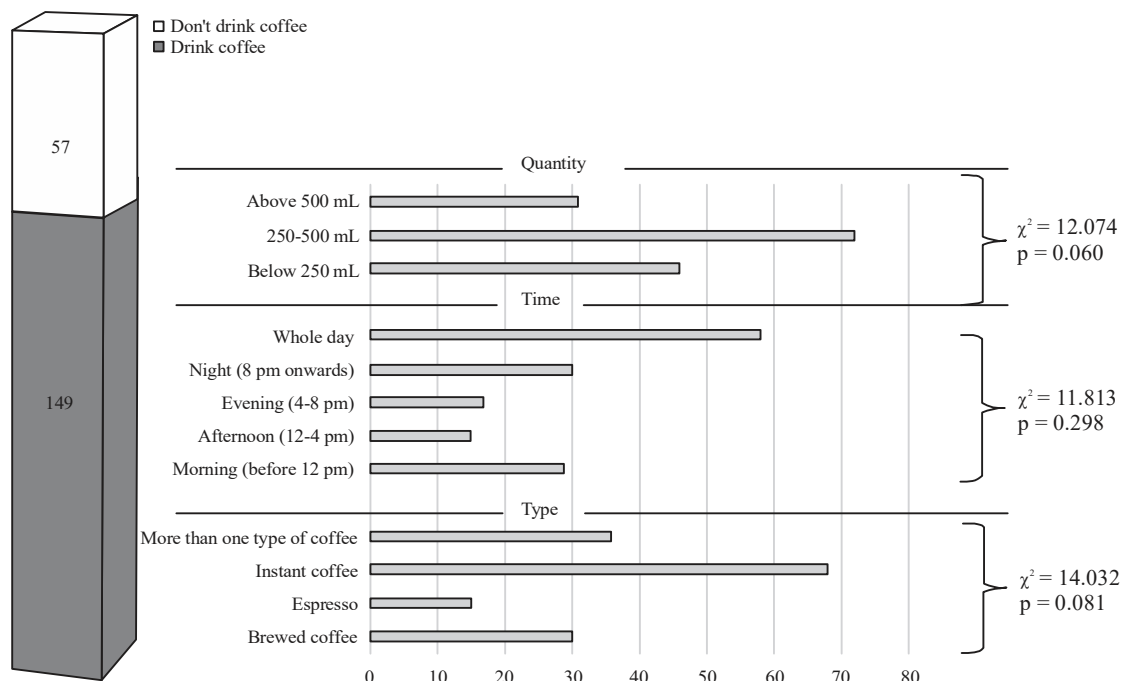


Fig. 1: Characteristics of study population that had no clinically significant insomnia

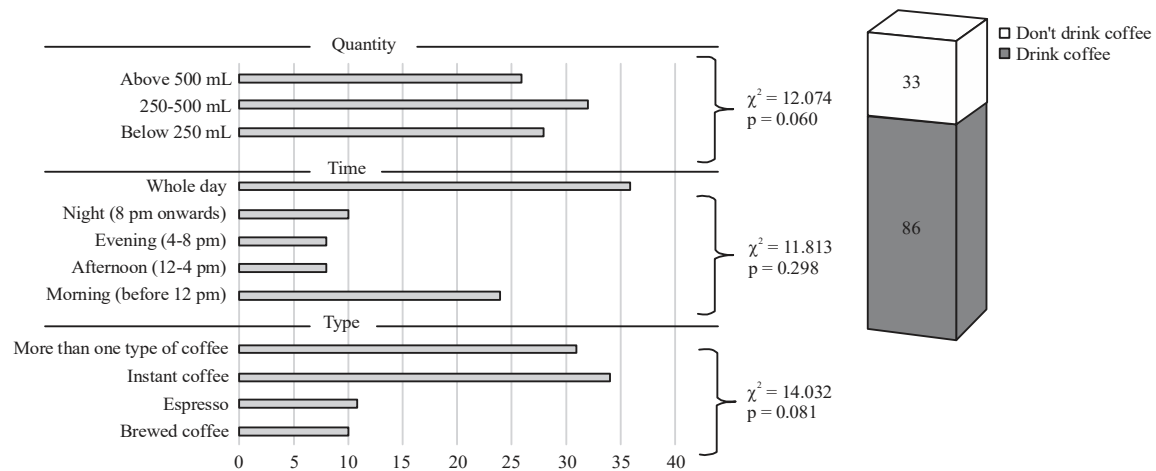


Fig. 2: Characteristics of study population that had sub-threshold insomnia

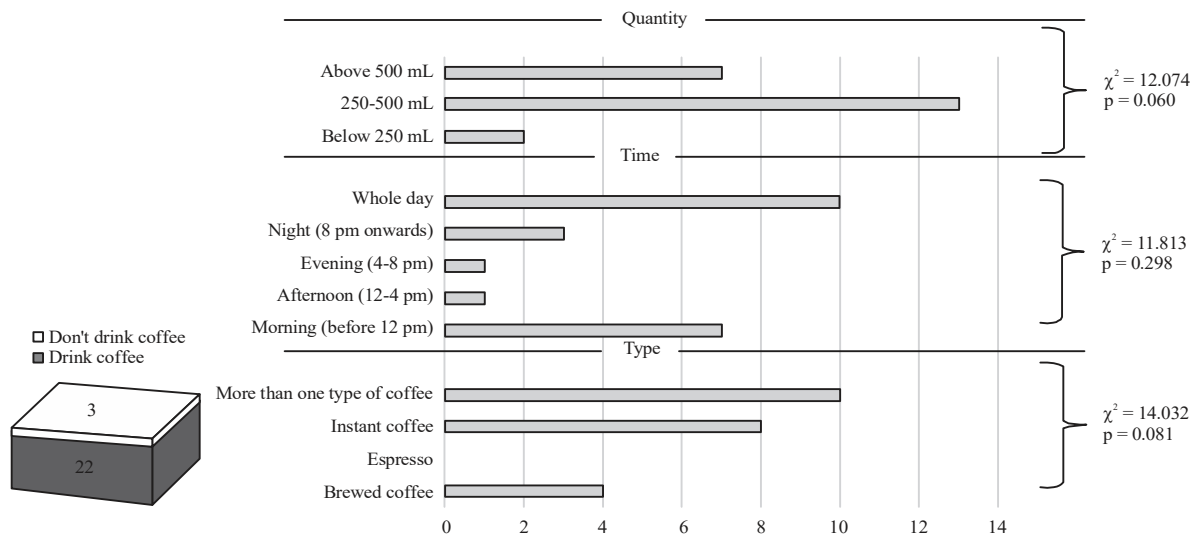


Fig. 3: Characteristics of study population that had clinically significant insomnia

insomnia, there could be risks associated with the intake of high amounts of caffeine, which can induce anxiety, tremors and heart palpitations<sup>19</sup>. Here the daily volume of coffee consumed ( $p = 0.60$ ), the time of consumption ( $p = 0.298$ ) and coffee type ( $p = 0.081$ ) had no significant effect on the likelihood of insomnia. Thus, the presence of insomnia could be attributed to other factors such as genetic inheritance, as was shown in a previous study<sup>23</sup>. Heavy coffee drinkers typically experience an immediate and heightened stimulant effect that can manifest as increased alertness and euphoria relative to those who consume less coffee<sup>24</sup>. However, in our study, we found no change in symptoms with increasing volume of coffee intake.

Heavy coffee drinkers that miss their morning coffee can experience headache, nervousness, restlessness, lethargy and

impaired ability to work<sup>24</sup>. Some coffee drinkers who stopped coffee consumption exhibited signs of caffeine dependency, as evidenced by withdrawal symptoms such as headaches, drowsiness and fatigue as well as various other adverse effects<sup>25</sup>. Another study that used Mendelian randomization showed that there was no effect of caffeine intake on sleep quality<sup>26</sup>.

More students who drank coffee tended to suffer from sub threshold insomnia relative to non-drinkers but, as with those who had no clinical insomnia, there was no statistically significant association between the presence of sub threshold insomnia and quantity ( $p = 0.60$ ), time ( $p = 0.298$ ) and type ( $p = 0.081$ ) of coffee consumed. Even though coffee drinking can affect sleep quality when consumed just before bedtime, results from one study suggested that a routine, constant

Table 1: Characteristics of study participants and coffee consumption habits

Variables	No.	Percentage
<b>Gender</b>		
Male	144	41.1
Female	206	58.9
<b>Ethnicity</b>		
Malay	85	24.3
Chinese	113	32.3
Indian	74	21.1
Others	78	22.3
<b>Do you drink coffee?</b>		
Yes	256	73.1
No	94	26.9
<b>Type of coffee consumed</b>		
Brewed coffee	44	17.2
Espresso	26	10.2
Instant coffee (3 in 1)	110	43.0
More than one type of coffee	76	30.0
<b>Volume of coffee consumed per day</b>		
<250 mL	72	28.1
251-500 mL	117	45.7
501-750 mL	46	18.0
>751 mL	21	8.2
<b>Time of coffee consumption</b>		
Whole day	104	40.6
Night (8 pm onwards)	43	16.8
Evening (4-8pm)	26	10.2
Afternoon (12-4 pm)	24	9.4
Morning (before 12 pm)	59	23.0

pattern of high coffee consumption together with contributing environmental factors is more likely to be linked with decreased sleep quality than simply the time of consumption<sup>26</sup>. According to our results, the amount of coffee consumed could play a significant role in determining the detrimental effect of coffee and caffeine in about 70% of coffee consumers who suffered from subthreshold insomnia ( $p < 0.05$ ) (Fig. 2). Most study subjects (61%) consumed an average volume of 251-500ml of coffee a day (Table 1). A previous study showed that people with poor sleep quality consumed  $192.1 \pm 122.5$  mg of caffeine, which was significantly higher compared to those who had good sleep quality ( $p = 0.008$ )<sup>27</sup>. However, the amount of coffee consumed was not measured in our study.

There was also no statistically significant association between the presence of clinical insomnia and quantity ( $p = 0.60$ ), time ( $p = 0.298$ ) and type ( $p = 0.081$ ) of coffee consumed. Caffeine can have dual effects. Administered at low dosages, caffeine can have antidepressant effects but has an opposite effect at high doses<sup>28</sup>. However, we have no data concerning the propensity of this study population toward depression, which, along with insomnia, can be more common in individuals who have experienced greater levels

of childhood adversity, which is associated with increased levels of depression and insomnia that could be partially mediated by perceived stress<sup>25</sup>. Thus, increased incidence of depressive symptoms could lead to insomnia among the participants. Meanwhile, in another study, the use of caffeine and insomnia symptoms were shown to be dependent on habitual sleeping hours<sup>29</sup>.

Among coffee types consumed, instant coffee was the most common type in this study (61.8%) followed by those who consumed more than one type of coffee (46.8%), brewed coffee (68.2%) and espresso (57.7%) (Table 1). Those who drank more than one type of coffee had the highest percentage of clinical insomnia but the difference in insomnia incidence relative to those who drank only a single type was not significant ( $p = 0.08$ ) (Fig. 3). These findings are similar to a previous study involving 341 medical students in the United States that showed no significant association between poor sleep quality and the type of coffee consumed<sup>4</sup>. Similarly, a large survey carried out at a Midwestern university in the United States found consumption of different types of coffee was not a significant predictor of sleep quality<sup>30</sup>.

For this study population, the morning was the most frequent time for coffee consumption, whereas that for the afternoon was the lowest (60.4 and 52.2%, respectively). Those who reported consuming coffee after 8 pm had the highest PSQI scores; higher PSQI scores are associated with poorer sleep quality. In a previous study, individuals who were considered to be heavy coffee drinkers showed increased drowsiness that was likely associated with more frequent coffee consumption at night, yet they also had reduced levels of anxiety relative to light coffee drinkers that could be attributed to coffee drinking in morning<sup>24</sup>. Coffee drinking could be a crucial risk factor for insomnia complaints in adolescents and our results showed that students who drank coffee throughout the day were more likely to suffer from insomnia (Fig. 3)<sup>31</sup>. As such, students who are more aware of the harmful effects of caffeine on sleep quality could choose to avoid consuming coffee in the evening<sup>32</sup>.

## CONCLUSION

It is concluded that the rate of caffeine metabolism and caffeine sensitivity may vary significantly among the students in this study population. A large degree of intra-individual variability in the effects of caffeine was observed. This study provides a basis for future research and education focusing on the potential effects of coffee on sleep quality.

## SIGNIFICANCE STATEMENT

This study discovered that coffee drinking does not necessarily result in increased rates of clinically significant insomnia, as sleep for most study subjects was not affected by coffee consumption in terms of amount and time coffee was consumed.

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