Original article

Effect of caffeine consumption on sleep quality of undergraduate medical students of Multan

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ABSTRACT

Background: Caffeine is extensively utilized as a stimulant of the central nervous system by more than 80% of the world's population. About 94% of medical students are reported using caffeine which is likely to have a detrimental impact on sleep quality. The purpose of the study was to evaluate the relationship between caffeine consumption and sleep quality among non-obese undergraduate medical students.

Subjects and methods: An Observational cross-sectional comparative study was carried out at Nishtar Medical University, Multan during the months of November and December 2022. Total 83, both male and female, non-obese undergraduate medical students (18-23 years old, BMI=18.5-24.9) selected by simple random sampling were included in this study, and they were divided into 3 groups on the basis of low (58 ± 29 mg/day), moderate (143±25 mg/day) or high (351±139 mg/day) caffeine consumption daily. Caffeine Consumption Questionnaire (CCQ) and Pittsburgh Sleep Quality Index Scale (PSQI) were used to assess the daily caffeine consumption (mg/day) and sleep quality, respectively. IBM SPSS-26 was used for data analysis. Mann-Whitney U test and Spearsman's rho correlation were applied.

Results: PSQI scores were high [11(8—16)] in highly caffeinated participants, moderate [7(5—9)] in moderately caffeinated participants, and low [3(1—6)] in low caffeinated (p=0.000). Low-caffeinated subjects had lower PSQI scores compared to moderately and highly caffeinated subjects (p=0.000 and p=0.000, respectively). PSQI scores in moderately caffeinated were also less as compared to highly caffeinated (p=0.000). Within the low caffeinated, moderately caffeinated, and highly caffeinated subjects caffeine consumption was positively correlated to PSQI scores (r=0.529, p=0.004), (r=0.579, p=0.002), (r=0.592, p=0.001) respectively.

Conclusion: Increase in Caffeine consumption reduces sleep quality, implying that caffeine consumption and sleep quality are inversely related to each other.

Keywords: Caffeine consumption, Medical students, Quality of sleep

INTRODUCTION

Caffeine, chemically known as trimethyl xanthine, has a varied half-life of 2-10 hours.[1] More than 80% of the world's population consumes approximately 120000 tons of caffeine every year.[2] Among the undergraduate medical students, 94% of them are using caffeine. The main reason for its consumption is its activating neurological effect which usually enhances alertness and in high doses (500-600mg) may cause sleep deprivation.[2] Evidence suggests that caffeine consumption before bedtime reduces sleep efficiency (SE), shortens deep sleep duration, and increases sleep onset latency (SOL).[3] Therefore, it is important to investigate the influence of caffeine on sleep in order to comprehend its significance when caffeine intake is considerable.

Sleep is a vital aspect of a person's well-being. The recommended amount of sleep for an adult is 7 to 9 hours each day.[4] Sleep quality, which is described as one's contentment with the sleep experience, incorporating characteristics of sleep initiation, sleep maintenance, sleep amount, and refreshment upon awakening, is also an important factor to consider.[5] Sleep efficiency (SE) of more than 85%, fragmentation of less than 25%, and sleep duration (SD) of more than 420 minutes are all indicators of good sleep quality while poor sleep quality is based on SE of less than 75%, fragmentation of more than 40% and SD less than 360 minutes.[6]According to a new model of wake-sleep circuitry, it uses fast neurotransmitters that are glutamate and gamma-aminobutyric acid (GABA), instead of modulatory neurotransmitters like monoamines, acetylcholine, and peptides.[7]

Caffeine is a stimulant of the central nervous system that non-selectively antagonizes the adenosine receptor. Mostly, the target for caffeine in the brain is A_{2A}. By blocking the A_{2A} receptor it causes a state of wakefulness. Adenosine is a modulator of dopaminergic neurotransmission. Blocking of the A_{2A} receptor on medium spiny neurons in the striatum increases dopaminergic neurotransmission. Adenosine also

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influences suprachiasmatic nucleus neuronal activity by suppressing retinohypothalamic tract activity. Caffeine inhibits adenosine receptors, boosting neuronal activity in the suprachiasmatic nucleus, the primary circadian pacemaker, which accounts for fluctuations in the depth of sleep.[8]

Empirical data suggests that the consumption of caffeine, present in tea, beverages and coffee, is considered to be safe. Intake of a small amount of caffeine (200 to 400 mg) causes improvement in alertness and alleviates the effects of sleep deprivation. Besides these, the consumption of large amounts of caffeine (more than 400 mg) causes less pleasant physiological effects like altering the sleep pattern and also causes adverse effects on the cardiovascular system.[9] This study mainly concerns with the extent to which caffeine affects the sleep quality of medical students.

SUBJECTS AND METHODS

An observational cross-sectional comparative study was carried out at Nishtar Medical University, Multan, Pakistan during the months of November and December 2022. The formula used to compute the sample size was derived from the program "Sample size determination in health studies-A practical manual 10 (version 2.0.21)[10] " issued by the WHO Geneva. It was adjusted for a population size of 1657, a 95% confidence level, and a 5% margin of error.

$$n = \frac{NZ^2 P(1-P)}{d^2 (N-1) + Z^2 P(1-P)}$$

Eighty-three (83) non-obese (BMI=18.5—24.9 and Waist Hip Ratio (WHR) <0.9)[11] undergraduate medical students, from first year to final year of MBBS, who ranged in age 18 to 23 years were selected through simple random sampling. Depending on how much caffeine each subject consumed each day, the subjects were separated into three groups. Ranges of daily caffeine consumption were taken from previous study.[12] Group 1 consisted of 28 low caffeinated subjects (58 ± 29 mg/day)[12], Group 2 consisted of 27 moderately caffeinated (143±25 mg/day)[12] and Group 3 consisted of 28 highly caffeinated (351±139 mg/day)[12] subjects. Students with a BMI>24.9 or WHR>0.9, with a family history of psychiatric ailment, with a history of an endocrine disorder, and already on psycho-psychiatric and/or recreational drugs were excluded because these conditions may alter the outcome of study, as obesity is a major confounding factor.[20] All subjects gave informed consent on specifically developed proforma before the collection of data. Ninety-eight students gave consent, out of them nine were non-caffeinated and six proformas were incomplete so they were excluded. The final study consisted of 83 subjects (as calculated by the sample size calculator). The individuals' height and weight were measured in accordance with the guidelines recommended by the WHO procedures of 2008 guidelines. The weight (in kg) was measured using the portable weighing machine, on a flat firm surface. To measure height, portable height/length measuring was used. Waist circumference (in cm) was taken at the umbilicus level, while hip circumference (in cm) was taken at the broadest part of the hips. The Body Mass Index (BMI) and Waist-Hip Ratio (WHR) were then computed using conventional formulas. The caffeine Consumption Questionnaire (CCQ), a self-reported measure that assesses the daily caffeine intake in various forms based on a weekly diet, was used to calculate daily caffeine consumption (in mg).[13] It has a Reliability coefficient (Cronbach's alpha) ≥ 0.80.[13]We had modified CCQ according to the caffeinated food items used in Multan, as it varies from region to region. The Pittsburgh Sleep Quality Index Scale (PSQI) was used to evaluate respondents' sleep quality.[14] It is a self-assessment questionnaire that analyses sleep quality and disruptions during a one-month period. It contains 19 self-rated questions, which are categorized into seven components and the score of each component is added to get a Global PSQI score. For its seven components, it has a Cronbach's alpha of 0.83.[14]

IBM SPSS-26 was used for data analysis. The data were initially checked for normality using the Shapiro-Wilk and Kolmogorov-Smirnov tests. Due to the non-normal distribution of the majority of the study's parameters, the median (IQR) of the variables was estimated. To ascertain whether or not there is a statistically significant difference between the medians of three separate groups, the Kruskal-Wallis test was then used. The [Median (IQR)] of PSQI scores for groups 1, 2, and 3 were compared using the Mann-Whitney U test, and the correlation between caffeine consumption and sleep quality within each group was determined using Spearman's rho correlation.

RESULTS

The median (IQR) of the study subjects' general characteristics (across all three groups) has been depicted in Table 1. A statistically significant difference between the median PSQI scores of the three groups was found, according to the Kruskal-Wallis test results (p=0.000). Low-caffeinated subjects had lower PSQI

scores compared to moderately and highly caffeinated subjects (p=0.000 and p=0.000, respectively). PSQI scores of moderately caffeinated were also less as compared to highly caffeinated (p=0.000). Table 2 illustrates this comparison that was made using the Mann-Whitney U Test. This indicates that with the increase in the consumption of caffeine, PSQI scores also increase.

Within the subjects of all three groups (low-caffeinated, moderately caffeinated, and highly caffeinated) caffeine consumption was positively correlated to PSQI scores (Table 3).

Within the low caffeinated, moderately caffeinated, and highly caffeinated subjects caffeine consumption was positively correlated to PSQI scores (r=0.529, p=0.004), (r=0.579, p=0.002), (r=0.592, p=0.001) respectively. Caffeine consumption and PSQI scores had a substantial positive correlation across the entire study population (Figure 1).

Table 1: Median (IQR) of (non-normallydistributed) anthropometric parameters

Study Parameters	Group 1 (low Caffeinated) n=28	Group 2 (moderately caffeinated) n=27	Group 3 (highly caffeinated) n=28
Age(year)	22(1.75)	22(1.00)	22(1.00)
Height (in m)	1.7(0.15)	1.67(0.09)	1.63(0.28)
Weight (in kg)	58(10.63)	60(12)	59(15.38)
Body Mass Index	20(3.09)	22(3.6)	21.94(3.31)
Waist Circumference (cm)	76(10.38)	78(9.00)	76.5(12.5)
Hip Circumference (cm)	95(5.75)	94(7.00)	95(6.00)
Waist-Hip Ratio	0.82(0.13)	0.82(0.08)	0.79(0.1)

Table 2: Comparisons of PSQI scores of study groups [Median (IQR)] via Mann- Whitney U Test

Groups in Comparison		p-value
Group 1 (low caffeinated) 3.00 (2.00)	Group 2 (moderately caffeinated) 7.00(2.00)	0.000*
Group 1 (low caffeinated) 3.00 (2.00)	Group 3 (highly caffeinated) 11(2.75)	0.000*
Group 2 (moderately caffeinated) 7.00 (2.00)	Group 3 (highly caffeinated) 11(2.75)	0.000*

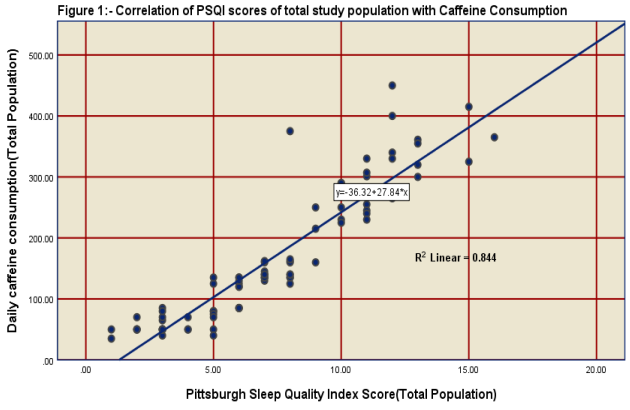
*Significant

Table 3: Correlations of PSQI scores with Caffeine Intake derived via Spearman's Correlation

	Group 1 (low caffeinated)		Group 2 (moderately caffeinated)		Group 3 (highly caffeinated)	
Parameter	*r*	*P*	*r*	*P*	*r*	*p*
PSQI	0.529	0.004*	0.579	0.002*	0.592	0.001*

r = correlation coefficient (*rho)*

*Significant



DISCUSSION

According to this study, prevalence of caffeine consumption in 1657 undergraduate medical students, from 1st year to final year of MBBS, of Nishtar Medical University, Pakistan is 90.8 percent, which is in consonance with the fact that 80 percent of the world's population consumes caffeine regularly, and according to a study conducted among medical students at Dow University of Health Science (DUHS) in Karachi, Pakistan, 94 percent of students consume caffeine in any form such as tea or coffee.[2,15] In another research conducted at the University of the Balearic Islands, Spain it was found that 91.1 percent of their students consume caffeine.[16] The key finding of this study was that the PSQI scores increase with the increase in caffeine consumption. PSQI scores of highly caffeinated were more than the PSQI scores of moderately caffeinated and low caffeinated subjects. Likewise, the PSQI scores of moderately caffeinated subjects were high in comparison to low caffeinated. This finding is in concordance with the previous cross-sectional study conducted among podiatric medical students.[17] The mean age of podiatric medical students (24.9 ±2.9 years) is also comparable to the mean age of Nishtar Medical University students (21.4 ± 1.3 years).[17]

In present study, increase in PSQI scores with the increase in caffeine consumption indicated that caffeine consumption negatively affects sleep quality, a fact which has been also projected by the study which reviewed the different articles for the determinants of sleep quality.[18] The results are also consistent with an experimental laboratory study where it is reported that caffeine has dose-dependent negative effects on sleep onset as well as on sleep quality.[19]

These results are attributed to the verity that caffeine is an antagonist of adenosine receptors therefore it increases the dopaminergic neurotransmission in the striatum and also inhibits the activity of the retino-hypothalamic tract thus increasing the neuronal activity in the suprachiasmatic nucleus.[8]

In this study, non-obese medical students (BMI=18.5—24.9 and WHR<0.9) were included and the obese students were excluded. Obesity plays a role as a confounding factor and it affects sleep quality because in obese individuals the level of circulating proinflammatory cytokines is increased and also the increase in body mass index causes the mechanical hindrance to normal breathing which may result in Obstructive sleep apnea.[20] The comforting prospect of this study is that the distribution of age, WHR and BMI was same across all the groups (1, 2 and 3) so there was the minimum chance of confounding effects of these anthropometric parameters as the aging [21] and obesity [20] both affect sleep quality.[20,21] Also, this is the first study, conducted in South Asia, which relates the extent to which caffeine affects sleep quality. Although the hypothesis that Caffeine negatively affects sleep quality in medical students has been proven yet there are some limitations that must be considered. First of all, this study is cross-sectional with a small sample size. Secondly, to assess sleep quality subjective measure (self-report questionnaire) was used instead of objective measures such as Actigraphy and Polysomnography due to cost issues.

CONCLUSION

This study in non-obese medical students divulged that there is a considerable association between caffeine intake and sleep quality. Reduction in sleep quality with increased caffeine consumption suggests that caffeine intake and sleep quality are inversely related to each other.

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