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The Relationship Between Caffeine Consumption and Sleep Quality among Teenagers in Lahore, Pakistan

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ABSTRACT

Caffeine, a widely consumed stimulant, is prevalent among teenagers, particularly through beverages like tea, coffee, energy drinks, and soft drinks. As sleep is vital for physical and mental development in teenagers, increased caffeine intake may adversely affect their sleep quality. However, limited research exists on this association within the Pakistani context, particularly in urban centers. **Objectives:** To evaluate the relationship between caffeine consumption and sleep quality among teenagers in Lahore. **Methods:** An analytical cross-sectional study was conducted among 400 teenagers aged 13–19 years from selected schools and colleges in Lahore. Data were collected using a structured questionnaire that incorporated the Caffeine Consumption Questionnaire (CCQ) and the Pittsburgh Sleep Quality Index (PSQI). The CCQ assessed the frequency and quantity of caffeine intake, while the PSQI evaluated the participants' sleep quality. Participants were grouped based on caffeine consumption levels (low, moderate, high). Statistical analysis, including chi-square tests and logistic regression, was performed using SPSS to determine associations. **Results:** Many teens regularly consumed caffeine through tea or coffee, as revealed in our findings, which showed that 45.5% of teens consumed it daily and 31% consumed it frequently. The research showed that 68% of participants get poor sleep according to PSQI results, which indicates serious public health risks. **Conclusions:** The analysis revealed caffeine consumption led to poor sleep quality for teenagers according to research data.

INTRODUCTION

Caffeine is a natural stimulant found in beverages such as coffee, tea, energy drinks, and sodas, as well as in some foods, including chocolate. It is one of the most widely used psychoactive substances in the world and has found its way into the mainstream of many teens' drug use. The primary mechanism by which caffeine acts on the body is through its actions on the central nervous system; caffeine is an adenosine receptor antagonist [1]. Adenosine is a neurotransmitter which encourages sleep and relaxation in the body. Caffeine blocks adenosine receptors, making you feel less tired, experience greater alertness and an increase in overall energy. The stimulant effect of caffeine is why caffeine is often used by people wanting to stay awake and to help keep them focused. If caffeine is consumed, it is quickly absorbed into the bloodstream through the stomach and small intestine, and peaks in the

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blood in 30 -60 minutes. Caffeine gets into the bloodstream, and it binds to adenosine receptors in the brain, which are the main way that caffeine produces its effect. Normally, adenosine causes a sleep-promoting and drowsiness-promoting effect by slowing down nerve cell activity. But caffeine blocks these receptors, so the person doesn't become drowsy; instead, the caffeine is stimulating. This causes you to become more aware, to concentrate better, and, in most cases, to have an increased heart rate and blood pressure [2]. Caffeine provides these immediate benefits, but in large amounts, it can also have some rather dangerous effects on the body, particularly when consumed close to bedtime. Side effects of excessive caffeine include increased anxiety, jitteriness, digestive disturbances and palpitations. Additionally, caffeine overstimulated the body's systems, like the cardiovascular and nervous systems [3]. Continued caffeine overconsumption could eventually create problems like caffeine dependence, which can cause our bodies to become dependent on caffeine to achieve normal levels of alertness. Furthermore, they still find that regular high caffeine intake can lead to sleep disturbances, which could then turn into problems like insomnia or poor sleep quality. In contrast, sleep is a natural state of rest that is reversible and recurrent, which helps the body and mind recover and regenerate for overall health and well-being. Sleep also allows our body to go through various restoring processes like repairing muscles, consolidating our memory and boosting our immune system. Most of the body follows a circadian rhythm, which is an internal process that makes humans sleep at night and be awake during the day over a 24-hour period. Getting a proper sleep cycle helps when it comes to cognitive function, emotional regulation and physical health because it includes a crazy amount of deep sleep and light sleep stages [4]. Inadequate or poor sleep quality can lead to an array of health problems, from fatigue to mood disorders to impaired cognitive function, and a higher risk for chronic diseases. Caffeine, however, has a complicated relationship with sleep quality, and research has found that caffeine can break the natural sleep cycle when drunk close to bedtime or in high amounts. Caffeine is a stimulant and can override the way the body winds down at night by blocking the action of adenosine, the neurotransmitter that promotes sleep [5, 6]. Caffeine from various sources can have a particularly deleterious impact on sleep in teenagers, during a period of brain and body development. Competition for sleep in this group is already common: academic pressures, social activities, plus the normal biological shifts in circadian rhythms conspire against appropriate sleep. A combination with the effects of caffeine exacerbates sleep disturbance and produces negative effects, like anxiety, depression, lower academic performance and long-term health problems. With teenagers largely oblivious to the potentially harmful effects of too much caffeine, it's essential to learn how caffeine can detrimentally impact their sleep and wellness [7, 8]. Close to bedtime, caffeine can delay the onset of sleep and reduce the total duration and quality of deep restorative sleep. Consequently, people may find it hard to fall asleep, to sleep through to morning, or to spend the amount of time they need to in the rapid eye movement (REM) stage, vital for cognitive function and for good emotional health [9, 10]. For teenagers, especially, who are at a critical stage of physical and mental development and potentially more vulnerable to the negative effects of poor sleep, understanding the link between caffeine and sleep is important. So it's important to know how caffeine affects sleep quality in children and teens [11].

This study aims to evaluate the relationship between caffeine consumption and sleep quality among teenagers in Lahore.

METHODS

The study employed an analytical cross-sectional design to investigate the effects of caffeine consumption on sleep quality in teenagers. Ethical approval for the study was obtained from the Research Ethics Committee of the University of South Asia under IRB No: USA-RW/DR/2023/04/064. The study was conducted across Co-educational private schools and colleges in Lahore between October 2024 and April 2025, with informed consent obtained from all participants. Sample size was calculated using Cochran's formula for estimating a proportion in large populations, followed by the finite population correction when applicable [12]. A total of 400 participants, aged between 13 and 19 years, were gathered using a convenient sampling technique, chosen for its ease of access and consideration of time constraints. The study was carried out over a period of six months following the approval of the research protocol. In terms of sample selection, the inclusion criteria required participants to be teenagers within the specified age range, 13-19 years, who regularly consumed caffeine from sources such as coffee, tea, energy drinks, or chocolates. Participants with chronic illnesses, such as hypertension, or mental health disorders like depression and anxiety, were excluded to minimize confounding variables. Additionally, pregnant and lactating females, individuals with a history of psychiatric disorders, or those using psychoactive substances were also excluded. Data were collected using a structured questionnaire that incorporated the Caffeine Consumption Questionnaire (CCQ) and the Pittsburgh Sleep Quality Index (PSQI). The CCQ assessed the frequency and quantity of caffeine intake, while the PSQI evaluated the participants'

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sleep quality. The Caffeine Consumption Questionnaire (CCQ) categorizes caffeine intake into three levels based on the total score. A score between 5 and 8 points indicates low caffeine consumption, a score between 9 and 14 points reflects moderate caffeine consumption, while a score ranging from 15 to 20 points represents high caffeine consumption. Similarly, the Pittsburgh Sleep Quality Index (PSQI) is used to assess the quality of sleep and the severity of sleep difficulties. A score of 0 suggests no sleep difficulty, scores between 1 and 7 indicate mild sleep difficulty, scores between 8 and 14 reflect moderate sleep difficulty, and scores from 15 to 21 demonstrate severe sleep difficulty. Questionnaires were distributed to students in the selected institutions and completed under the supervision of the research team to ensure accuracy. Caffeine intake was not self-reported in milligrams by participants. It was assessed using the standardized Caffeine Consumption Questionnaire (CCQ), which includes predefined caffeine values (in mg) for various items. Participants selected their consumption frequency and calculated total intake by summing these values as per CCQ interpretation guidelines. For statistical analysis, IBM SPSS software version 27 was used. Quantitative variables were summarized using mean and standard deviation, while categorical data, such as caffeine intake levels, were expressed in frequencies and percentages. The Chi-square test was applied to examine the distribution of variables and determine associations between caffeine consumption and sleep quality.

RESULTS

This chapter presents the findings derived from the analysis of data collected from 400 teenagers across various educational institutes in Lahore, using the Caffeine Consumption Questionnaire (CCQ) and the Pittsburgh Sleep Quality Index (PSQI). The age of the participants was recorded to understand the demographic makeup of the sample. The study included 400 teenagers from Lahore. The participants were divided into two age groups: 13-15 years and 16-19 years. The results indicated a slightly higher representation of teenagers in the 16-19 years' age group (210 respondents, 52.5%) compared to the 13-15 years' age group (190 respondents, 47.5%), as mentioned in figure 1.

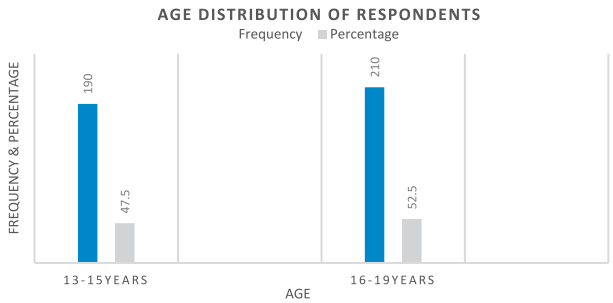

Figure 1: Age Distribution of Respondents

Participants were asked to estimate their total daily caffeine consumption in milligrams. The largest group of respondents (155 teenagers, 38.75%) estimated their daily caffeine intake to be between 100 and 200mg. 100 teenagers (25%) reported consuming 201-300mg, 95 teenagers (23.75%) consumed less than 100mg, and 50 teenagers (12.5%) reported consuming more than 300mg of caffeine daily. These estimations suggest that a considerable number of teenagers consume caffeine levels that may impact sleep, as mentioned in figure 2.

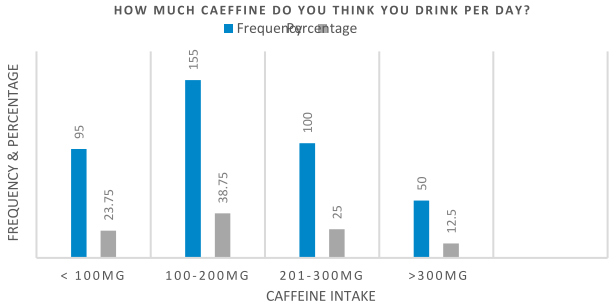

Figure 2: Caffeine Intake (mg/day)

Total scores from the Caffeine Consumption Questionnaire (CCQ) were calculated and categorized to provide an overall assessment of caffeine consumption levels. The results showed that the majority of teenagers (235 respondents, 58.75%) fell into the moderate caffeine consumption category. 90 respondents (22.5%) were categorized as low consumers, and 75 respondents (18.75%) as high consumers, indicating varied levels of caffeine dependence or habituation across the sample, as mentioned in figure 3.

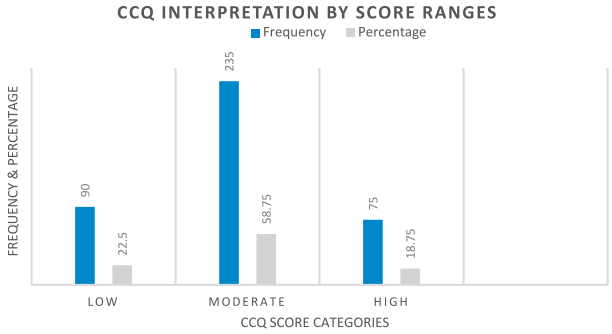

Figure 3: CCQ Interpretation by Score Ranges

The Pittsburgh Sleep Quality Index (PSQI) was used to assess the overall sleep quality of the participants over the past month. According to the PSQI scores, 168 respondents (42%) had fair sleep quality. Poor sleep quality was reported by 130 respondents (32.5%), while 102 respondents (25.5%) reported good sleep quality. These findings highlight that a significant majority (74.5%) of the surveyed teenagers experienced sleep quality that was either fair or poor, as mentioned in figure 4.

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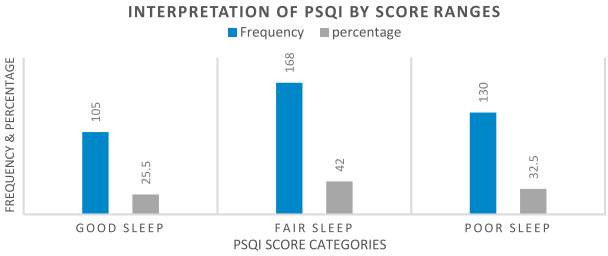

Figure 4: Interpretation of PSQI by Score Ranges

A Chi-square test was conducted to analyze the association between caffeine consumption levels (derived from CCQ scores and categorized as low, moderate, and high) and PSQI sleep quality categories (good, fair, and poor). The test result ($\chi^2 = 41.38$, df = 4, $p \leq 0.05$) indicated a statistically significant association. This suggests that the level of caffeine consumption among teenagers in Lahore is significantly related to their reported sleep quality. Teenagers with higher caffeine scores were more likely to report poor sleep quality. A Pearson correlation of r = +0.80 ($p \leq 0.05$) indicates a very strong positive linear relationship between caffeine intake and the sleep quality variable, as mentioned in table 1.

Table 1: Cross-tabulation and Correlation of Caffeine Score with PSQI Categories

Caffeine Level	Good Sleep	Fair Sleep	Poor Sleep	Total	p-Value	r
Low	55	25	10	90	≤0.05*	+0.8
Moderate	40	115	80	235		
High	7	28	40	75		

*indicates statistical significance at p≤0.05

DISCUSSIONS

The current research establishes that teenage residents of Lahore display poor sleep quality due to their caffeine intake. Research support suggests that the high prevalence of poor sleepers (68%) presents an increasing concern for public health throughout different regions. The research data matches scientific interpretations of caffeine because this stimulating substance blocks adenosine, which works as a neuromodulator to induce sleep [4, 5]. A relationship between daily caffeine intake and increased PSQI scores was found to be significant in this study, similar to Nasir et al. and Reichert et al. who reported the same pattern among adolescents and university students [13, 14]. This study extends previous research through its investigation of Lahore teenagers, even though little academic attention has been given to this relationship within this population. The analysis of when students consumed caffeine validates that it is essential to recognize both the amount consumed and the timing of consumption. The sleep quality of adolescents worsened when they used caffeine as a nighttime or evening beverage. The studies confirm that caffeine stays in the bloodstream for a long time, thus leading to delayed sleep onset and disrupted restful sleep periods [15, 16]. The rise of energy drinks as significant caffeine suppliers demands immediate attention because their advertisements target young people without control. Traditional beverages have fewer stimulants in them, so the disruptive sleep effect of energy drinks becomes stronger because they contain more caffeine and stimulants such as taurine and guarana. The research suggests that both parents and teenagers need strict regulation and awareness programs about the dangers that develop from excessive and frequent energy drink use [6, 8]. The survey results demonstrating high incidences of sleep complaints regarding falling asleep difficulty and nighttime disruptions, and daytime exhaustion, confirm how caffeine affects sleep at multiple levels. The sleep disturbances caused by caffeine intake affect more than basic sleeplessness because they disrupt both circadian rhythm function and hormone equilibrium. Public health experts express worry about findings which demonstrate how extended sleep problems in teenagers generate negative long-term consequences, including inferior academic achievements, higher anxiety-depression risks and obesity risks along with cardiovascular disease risks [17, 18]. Additionally, the results from this research indicate that caffeine impact and sleep troubles affect male and female in equivalent ratios, although Van der Linden et al. and Vézina-Im et al. established that female adolescents exhibit stronger effects. Additional studies need to analyze whether natural sexual differences combined with behavioural elements result in diverse sleep-related effects [19, 20]. The research contains certain restrictions in its methodology. The research design depends on historical data rather than following a timeline, so it restricts any conclusion about cause-and-effect relationships, and self-reported data can have inaccuracies due to recall memory issues. The established sleep assessment tool (PSQI), together with numerous study participants, contributes to the credibility of the analyzed data. Further research should integrate measurement tools such as actigraphy and polysomnography to confirm results while studying how physical activity, screen time, and dietary habits modify relationships between caffeine and sleep problems.

CONCLUSIONS

The research concluded that the majority of teenagers have poor sleep quality caused by excessive and mismanaged consumption of caffeine.

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Authors Contribution

Conceptualization: MI, RN
Methodology: MI, MH, AF, RN
Formal analysis: MI, NA
Writing review and editing: MI, MH, AF, WN, RN, AA

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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