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CAFFEINE, SLEEP, AND ACADEMIC PERFORMANCE: A CROSS-SECTIONAL STUDY AMONG UNIVERSITY STUDENTS

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ABSTRACT

Aim: Caffeine is a psychoactive substance frequently consumed by students to increase alertness and support academic performance. However, the effects of caffeine consumption on sleep quality, circadian rhythm, social jetlag, and academic achievement have not yet been clearly established. This study aimed to determine university students' caffeine intake levels and evaluate the relationships between these levels and sleep quality, circadian rhythm, social jetlag, and academic achievement.

Material and Method: This cross-sectional and descriptive study was conducted in Ankara between 2024–2025, and 457 university students were included in the study. Data were collected using a sociodemographic form, a quantitative caffeine intake frequency questionnaire, the Pittsburg Sleep Quality Index (PSQI), the Morningness-Eveningness Questionnaire (MEQ), and the Social Jetlag Form. Academic achievement was assessed using the general grade point average (GPA). Data were analyzed using SPSS 26.

Results: Positive significant relationships were found between caffeine intake and PSQI and social jetlag, and negative significant relationships were found with MEQ scores ($p<0.05$). No significant relationship was found between caffeine intake and academic success. The regression analysis determined that only the MEQ score had a positive significant effect on academic success ($\beta=0.173$, $p<0.001$).

Conclusion: Caffeine intake affects students' sleep and circadian parameters; however, these effects are not directly reflected in academic success. The contribution of morningness to academic success is emphasized, and biological rhythms should be considered in the future education system.

Keywords: Caffeine, Circadian rhythm, Sleep quality, Academic performance

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INTRODUCTION

Caffeine is one of the most popular and widely consumed psychoactive substances globally (1). It is commonly found in frequently consumed food and beverage items such as chocolate, tea, and coffee (2). Caffeine-containing products are typically used to enhance alertness, manage stress, and improve concentration and cognitive performance (3). According to a report published by the European Food Safety Authority (EFSA), daily caffeine intake of up to 400 mg is considered safe and does not pose any health risks (4). Due to their availability, caffeine-containing foods and beverages are consumed across all age groups. In particular, caffeinated beverages have gained popularity among young people, driven by marketing strategies and social influences (5). Among university students, caffeine is frequently used both as a means of socialization and as a stimulant during study periods to support concentration and maintain wakefulness. A study conducted in Türkiye found that the caffeine consumption rate among students was 87.8% (6). Some studies assessing caffeine intake among students have reported that students believe caffeine improves academic performance and consume it for this reason (7-9). In one study, 52% of students reported consuming caffeine to enhance academic performance and cope with academic stress (10). However, despite widespread belief, there is limited evidence supporting a direct positive effect of caffeine on academic success. Many studies have failed to demonstrate a significant relationship between caffeine intake and improved academic performance (8,11). In a U.S.-based study investigating the association between energy drink consumption and academic performance, a negative correlation was observed between caffeine intake and students' grade point averages (11). Additional studies also support the notion that increased caffeine intake may reduce academic performance (12,13).

Sleep is a biological process that significantly affects human behavior, as well as physical and psychological well-being (14). Research has shown that poor quality or insufficient sleep negatively affects both physical and mental health (15). Although sleep patterns are known to be an important factor influencing academic performance, insufficient and poor-quality sleep is a common issue among university students (16). Sleep deprivation has been associated with reduced attention and increased academic problems among students (17). Caffeine consumption has also been shown to affect sleep. Numerous studies in the literature have demonstrated that increased caffeine intake negatively impacts sleep duration and quality (18-20).

The circadian rhythm, also known as the biological clock, refers to the natural daily cycle of biological systems, particularly the sleep-wake cycle. The body's daily activities, including rest and wakefulness, are regulated by this rhythm (21). Any desynchronization in the circadian rhythm is reported to impact cognitive performance, motor functions, and memory. A meta-analysis revealed that individuals with different circadian rhythms demonstrate variations in cognitive abilities and academic performance (22). Similar to its impact on sleep, caffeine intake also influences circadian rhythm. Studies have shown that caffeine delays the circadian clock that regulates sleep timing by reducing delta wave activity during sleep (23). There is also evidence suggesting that disruptions in biological rhythms caused by caffeine may lead to reduced physical and cognitive performance (12,24,25).

Social jetlag refers to the discrepancy between sleep schedules on workdays versus free days and serves as an indicator of circadian misalignment (26). Under normal circumstances, circadian rhythms function in harmony and are synchronized with both social and natural environments. However, when endogenous sleep preferences are misaligned due to social demands, inappropriate sleep timing and sleep difficulties—referred to as social jetlag—may occur (27). As a form of circadian desynchrony, social jetlag has been associated with impaired cognitive performance. A study involving adolescents found that individuals experiencing social jetlag exhibited lower vocabulary knowledge, overall cognitive functioning, and academic achievement (28).

Sleep, circadian rhythm, and social jetlag are interconnected processes that influence each other. While sleep can be influenced by circadian rhythm, the rhythm itself can be modulated by sleep behavior. Moreover, dysfunction in either biological or physiological regulation can result in social jetlag (29,30). Among the most influential factors affecting these biological rhythms and sleep patterns is caffeine consumption, which is highly prevalent and increasingly popular among students. However, exceeding recommended caffeine intake may disrupt normal daily functioning and consequently hinder academic performance (31).

This study aims to assess the caffeine consumption status of university students and evaluate the effects of caffeine intake on sleep quality, circadian rhythm, social jetlag, and academic performance.

PARTICIPANTS AND METHODS

This descriptive cross-sectional study was conducted between September 2024 and January 2025 with voluntary participation of university students aged 18 to 25 years, who were residing and studying in Ankara. The sample size was calculated using the G*Power 3.1.9.7 program, referencing a similar study by Ekenler & Altınel (32). Based on the parameters of $\alpha = 0.05$, effect size (g) = 0.37, and power $(1-\beta) = 0.95$, it was determined that a minimum of 185 adult participants would be required. However, to enhance the representativeness of the sample, 457 participants were included in the study. Students with a physician-diagnosed chronic or metabolic condition, those regularly using caffeine-containing medications or dietary supplements, and those working in shifts were excluded from the study. Ethical approval was obtained from the Non-Interventional Research Ethics Committee of Ankara Medipol University (Approval No: 99, dated 08.07.2024).

Data Collection Tools

A structured questionnaire was used for data collection, consisting of sections to gather demographic information such as age, sex, academic year, and socioeconomic status, along with several validated scales. Data were collected through face-to-face interviews.

Anthropometric measurements:

Body weight and height of the participants were measured by trained researchers. Body weight was recorded with participants wearing minimal clothing and using a calibrated scale. Height was measured with participants barefoot, heels together, and head in the Frankfurt plane, using a non-flexible stadiometer. Body Mass Index (BMI) was calculated using the formula: weight (kg)/height (m^2).

Caffeine intake frequency questionnaire:

This section assessed the types, quantities, and frequency of caffeine-containing food and beverage consumption over the past three months. Specifically, the frequency and portion sizes of common caffeine sources widely consumed by students in Türkiye were evaluated. Based on these data, participants' average daily caffeine intake was calculated in milligrams (mg). Caffeine intake levels were categorized as safe and high. The analyses were conducted based on these two categories.

Grade point average (GPA):

Academic performance was assessed using students' cumulative grade point averages (GPA). Only students enrolled in their second, third, or fourth academic years were included in this evaluation. GPA was calculated using the standard 4.0 scale.

Pittsburgh sleep quality index (PSQI):

The Pittsburgh Sleep Quality Index was used to assess sleep quality. Originally developed by Buysse et al. (33) and adapted into Turkish by Ağargün (34), this tool evaluates sleep quality over the past month. Total scores range from 0 to 21; scores of ≤5 indicate good sleep quality, whereas scores >5 indicate poor sleep quality.

Morningness-eveningness questionnaire (MEQ):

The MEQ was used to determine participants' chronotype (circadian rhythm preference). Developed by Horne and Östberg (35) and adapted to Turkish by Pündük et al. (36), the questionnaire contains 19 items. Scores range from 16 to 86, with scores between 16–41 classified as "evening type", 42–58 as "intermediate type", and 59–86 as "morning type". Evening types tend to go to bed late and wake up late, with greater alertness in the evening, while morning types tend to sleep early and wake early, feeling more alert in the morning.

Social jetlag assessment form:

Social jetlag was assessed by calculating the difference between the median sleep times on weekdays and weekends, based on self-reported sleep schedules. This form is based on the method described by Wittmann et al. (37).

Statistical Analysis

All statistical analyses were performed using IBM SPSS version 26. The normality of continuous variables was assessed using the Kolmogorov-Smirnov test. Descriptive statistics were reported as mean ($\bar{X}$) and standard deviation (SD) for continuous variables and as frequency (n) and percentage (%) for categorical variables. Independent sample t-tests were used for comparison of continuous variables between two groups, and Chi-square (χ^2) tests (Pearson and continuity correction) were used for categorical variables. Relationships between variables were analyzed using Pearson correlation and multiple linear regression analysis. A p-value of <0.05 was considered statistically significant.

RESULTS

The general characteristics of the participating students are presented in Table 1. The mean age of the participants was 20.6±1.70 years, with 91.0% identifying as female. Most participants (97.6%) were single, 57.8% were living with their families, and a majority (74.0%) were second-year university students. When participants were compared based on caffeine intake status, those in the high-caffeine group had a mean age of 21.0±1.76 years, while those in the moderate/acceptable intake group had a mean age of 20.6±1.68 years ($p<0.05$). The prevalence of smoking was 47.8% in the high-caffeine group versus 20.9% in the lower intake group ($p<0.05$). Similarly, the prevalence of alcohol consumption was 34.8% among those with high caffeine intake and 17.0% in the lower intake group ($p<0.05$).

Table 1. General characteristics of individuals

	Safe intake <400 mg (n=388)	**High intake >400 mg (n=69)**	**Total (n=57)**	**p**
Age (years) ($\bar{X} \pm SD$)	20.6±1.68	21.0±1.76	20,6±1.70	**0.044**[a]
Gender (n, %)				
Male	36 (9.3)	5 (7.2)	41 (9.0)	0.752[b]
Female	352 (90.7)	64 (92.8)	416 (91.0)	
Marital status (n, %)				
Married	9 (2.3)	2 (2.9)	11 (2.4)	1.000[b]
Single	379 (97.7)	67 (97.1)	446 (97.6)	
Place of residence (n, %)				
With family	233 (60.1)	31 (44.9)	264 (57.8)	0.064[c]
With friends	18 (4.6)	3 (4.3)	21 (4.6)	
Alone	25 (6.4)	9 (13.0)	34 (7.4)	
Dormitory	112 (28.9)	26 (37.7)	138 (30.2)	
Class level (n, %)				
2nd year	289 (74.5)	49 (71.0)	338 (74.0)	0.778[c]
3rd year	87 (22.4)	17 (24.6)	104 (22,8)	
4th year	12 (3.1)	3 (4.3)	15 (3.3)	
Smoking status (n, %)				

Yes	81 (20.9)	33 (47.8)	114 (24.9)	**<0.001[b]**
No	307 (79.1)	36 (52.2)	343 (75.1)	
Alcohol consumption (n, %)				
Yes	66 (17.0)	24 (34.8)	90 (19.7)	**0.003[b]**
No	322 (83.0)	45 (65.2)	367 (80.3)	
Body weight (kg) (X̄ ± SD)	60.5±13.69	62,7±12.73	60,8±13.56	0.185[a]
BMI (kg/m^2) (X̄ ± SD)	21.9±3.99	22.1±3.53	21.9±3.92	0.571[a]
Caffeine intake (mg/day) (X̄ ± SD)	189.2±110.67	469.0±53.43	231.4±144.50	**<0.001[a]**

a: Independent samples t-test; b: Continuity correction χ2 test; c: Pearson χ2 test; BMI: Body Mass Index

Table 2 presents the comparison of PSQI, MEQ, social jetlag scores, and academic performance based on caffeine intake levels. No significant differences were found across these variables based on caffeine intake level (p>0.05).

Table 2. Sleep characteristics of individuals

	Safe intake <400 mg (n=388)	**High intake >400 mg (n=69)**	**Total (n=457)**	**p**
PSQI total (X̄ ± SD)	8.8±3.85	8.9±3.72	8.9±3.82	0.867[a]
PSQI classification (n, %)				
Good sleep	78 (20.1)	16 (23.2)	94 (20.6)	0.673[b]
Poor sleep	310 (79.9)	53 (76.8)	363 (79.4)	
MEQ total (X̄ ± SD)	43.7±8.72	43.2±9.61	43.6±8.85	0.711[a]
MEQ classification (n, %)				
Morning type	19 (4.9)	5 (7.2)	24 (5.3)	
Intermediate type	212 (54.6)	36 (52.2)	248 (54.3)	0.682[c]
Evening type	157 (40.5)	28 (40.6)	185 (40.5)	
Social jetlag total (X̄ ± SD)	1.6±1.18	1.9±1.24	1.7±1.19	0.162[a]
Social jetlag classification (%)				
<2	228 (58.8)	35 (50.7)	263 (57.5)	0.266[b]
≥2	160 (41.2)	34 (49.3)	194 (42.5)	
Academic performance score (X̄ ± SD)	2.9±0.45	2.9±0.49	2.9±0.46	0.113[a]

a: Independent samples t-test; b: Continuity correction χ2 test; c: Pearson χ2 test. MEQ: Morningness-Eveningness Questionnaire, PSQI: Pittsburgh Sleep Quality Index.

Table 3 shows the relationships between daily caffeine intake, sleep quality, circadian preference, social jetlag, and academic performance. Positive correlations were observed between caffeine intake and both PSQI (r=0.108) and social jetlag (r=0.110) scores, while a negative correlation was found with MEQ scores (r=–0.130) (p<0.05 for all). No statistically significant relationship was found between caffeine intake and academic performance (p>0.05); however, a significant correlation was found between MEQ scores and academic performance (p<0.05).

Table 3. Relationships between caffeine ıntake, scale scores, and academic performance

	Caffeine	PSQI	MEQ	Social Jetlag	Academic Performance (r)
Caffeine	-	**0.108***	**-0.130****	**0.110***	-0.013
PSQI	**0.108***	-	**-0.307****	**0.113***	-0.048
MEQ	**-0.130****	**-0.307****	-	-0.068	**0.175****
Social Jetlag	**0.110***	**0.113***	-0.068	-	-0.056
Academic Performance	-0.013	-0.048	**0.175****	-0.056	-

Pearson Correlation, *p<0.05 **p<0.001. MEQ: Morningness-Eveningness Questionnaire; PSQI: Pittsburgh Sleep Quality Index.

Additionally, according to the regression model presented in Table 4, MEQ scores had a significant positive effect on academic performance (β=0.173, p<0.001). No other variables in the model were found to be significant predictors of academic success (p>0.05).

Table 4. Factors potentially influencing academic performance

	β	**SE**	**t**	**p**	**95% CI**	
Caffeine	-0.007	<0.001	-0.138	0.890	0.000	0.000
PSQI	-0.009	0.006	-0.177	0.859	-0.010	0.012
MEQ	0.173	0.003	3.537	**<0.001**	0.004	0.014
Social jetlag	-0.057	0.018	-1.209	0.227	-0.057	0.014
Age	0.078	0.013	1.651	0.099	-0.004	0.045

Lineer regresyon. MEQ: Morningness-Eveningness Questionnaire; PSQI: Pittsburgh Sleep Quality Index

DISCUSSION

This study investigated the relationship between caffeine consumption and sleep quality, circadian rhythm, social jetlag, and academic performance. The findings indicated that while sleep quality, chronotype, social jetlag, and academic performance did not significantly differ between individuals with high and moderate caffeine intake, there were statistically significant associations between caffeine intake and certain sleep-related parameters (PSQI, MEQ, and social jetlag). Notably, only circadian preference was found to have a significant impact on academic achievement. To the best of our knowledge, this study is among the limited number of investigations in the literature that simultaneously evaluate the interplay between caffeine intake, sleep patterns, circadian characteristics, social jetlag, and academic performance.

As one of the most widely used psychoactive substances, caffeine is commonly consumed by both adults and adolescents, with particularly high prevalence among younger populations (38). While caffeine intake generally increases with age during adolescence and young adulthood, it tends to decrease in middle age (39). In a study conducted in Austria with individuals aged 14–39, those in the 26–39 age group had significantly higher caffeine intake than those aged 14–17 or 18–25 (40). In the current study, which focused on a younger population, the mean caffeine intake was 231.4±144.50 mg/day. Additionally, the high caffeine intake group was significantly older than the acceptable intake group ($p<0.05$), consistent with prior literature indicating a positive age-related trend in caffeine consumption during early adulthood. While caffeine may confer short-term cognitive benefits through its effects on brain activity and energy regulation, excessive intake—especially in younger individuals—has been associated with sleep disturbances and potential developmental concerns. Therefore, caution is advised regarding caffeine consumption among young populations (41,42).

This study found significant positive associations between caffeine intake and both poor sleep quality and extended social jetlag duration (Table 3), which aligns with previous literature.

Caffeine acts as an adenosine receptor antagonist, blocking the sleep-promoting effects of adenosine (43). Experimental studies have shown that caffeine delays sleep onset, reduces sleep efficiency, and shortens total sleep time (44-47). However, some research suggests these adverse effects may be dose-dependent (48,49). For example, a double-blind, randomized, placebo-controlled study found that 400 mg of caffeine had detrimental effects on sleep, while consumption of 100 mg up to 4 hours before bedtime did not significantly disrupt sleep (19). In this study, although higher-than-recommended caffeine intake was associated with poorer sleep scores, no significant difference in sleep quality was found between the high and acceptable intake groups (Table 2).

Caffeine’s disruption of sleep patterns may also contribute to social jetlag, which reflects the misalignment between biological and social timing. While direct studies on caffeine and social jetlag are limited, several investigations suggest an indirect relationship (50-52). One study identified caffeine consumption as a significant factor influencing social jetlag (50), while another reported that energy drink and coffee consumption were significantly associated with elevated social jetlag levels in adolescents (52). In the current study, caffeine intake was positively associated with increased social jetlag (Table 3), although no significant difference in social jetlag scores was found between high and acceptable intake groups (Table 2). Given that social jetlag may be influenced by dietary habits and lifestyle factors such as substance use, this insignificant difference could stem from such confounding factors (53).

A statistically significant negative correlation was also found between caffeine intake and chronotype scores (Table 3), indicating that individuals with higher caffeine consumption tended to exhibit evening-type characteristics. This may reflect a behavioral preference among evening types for staying awake later, thus using caffeine to maintain alertness. As a stimulant, caffeine is known to promote wakefulness (54), making it a preferred choice among evening chronotypes. Previous research has shown that evening types tend to consume more caffeine

(55-57). In a study involving 880 university students, 80.2% reported consuming caffeine after 6 PM (57). One of the most striking findings of this study is the lack of a statistically significant relationship between caffeine intake and academic performance. This may be due to individual variability and moderating factors. Although low to moderate doses of caffeine have been shown to enhance short-term attention, memory, and processing speed (58), long-term overuse may impair cognitive performance by disrupting sleep quality (59). Especially in children and adolescents, poor sleep quality resulting from caffeine intake has been linked to a range of adverse academic and psychological outcomes (60). Therefore, the influence of caffeine on academic performance should be evaluated not solely by intake quantity but also by timing, individual tolerance, and sleep hygiene practices.

Regression analysis identified MEQ score as the strongest predictor of academic performance in this study. Participants with stronger morning-type tendencies demonstrated significantly higher academic performance (Table 4). This finding is consistent with literature indicating that morning types typically have more regular routines, higher cognitive function during morning hours, and better executive functioning skills (61-63). A similar study conducted with 236 young adults aged 18–24 also found that high academic achievers were predominantly morning types (61). These findings underscore the potential role of circadian rhythm in academic success and highlight the need for further investigation.

CONCLUSION

This study demonstrated that caffeine consumption may directly influence sleep patterns and circadian rhythm. However, its impact on academic achievement appears to be more complex and multifactorial. The significant predictive role of chronotype in academic success supports the need for individualized education strategies aligned with students' biological rhythms. Future research should explore the timing of caffeine intake, incorporate more detailed and longitudinal assessments of sleep behavior, and consider psychological and lifestyle variables (e.g., stress, mood, attention) in order to yield more comprehensive results.

Abbreviations

BMI: Body Mass Index

EFSA: European Food Safety Authority

GPA: General grade point average

MEQ: Morningness-Eveningness Questionnaire

PSQI: Pittsburg Sleep Quality Index

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