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CIRCADIAN RHYTHMS OF UNIVERSITY STUDENTS DURING STUDY AND EXAM PERIODS

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ABSTRACT

Purpose: The aim of this study was to examine the impact of study and exam periods on circadian rhythms, sleep quality, physical activity, psychological well-being, and autonomic functions in university students.
Methods: This prospective observational study was conducted with 30 university students (mean age: 21.10 ± 1.70 years; body mass index: 24.20 ± 7.20 kg/m²). Assessments included the Morningness-Eveningness Questionnaire, Pittsburgh Sleep Quality Index, International Physical Activity Questionnaire–short form, and Depression-Anxiety-Stress Scale–21. Autonomic functions were measured through evaluations of body temperature, blood pressure, heart rate, oxygen saturation, and skin moisture. All assessments were performed in controlled environments during study periods (2–3 weeks before exams) and exam periods (the second week of finals).
Results: Students shifted toward evening chronotypes during exams ($p < 0.001$) and exhibited poorer sleep quality ($p < 0.001$), reduced physical activity ($p < 0.001$), and increased depression, anxiety, and stress levels ($p = 0.040$). Significant increases in systolic ($p = 0.006$), diastolic blood pressure ($p = 0.028$), and heart rate ($p = 0.014$) were observed during exams, while body temperature, oxygen saturation, and skin moisture remained unchanged.
Conclusion: The pressures of academic life, especially during exam periods, can significantly disrupt circadian rhythms, sleep quality, and psychological well-being, with physiological stress responses becoming more pronounced. Physical activity, stress, and time management in university students can be beneficial for both academic success and overall health.
Key Words: Circadian rhythm, sleep quality, stress, student

ÖZET

Amaç: Bu çalışmanın amacı, ders ve sınav dönemlerinin üniversite öğrencilerinin sirkadiyen ritmi, uyku kalitesi, fiziksel aktivite düzeyi, psikolojik durumu ve otonomik fonksiyonları üzerindeki etkilerini incelemektir.
Yöntem: Prospektif gözlemsel planlanan bu çalışma, 30 üniversite öğrencisiyle (ortalama yaş: 21,10 ± 1,70 yıl ve vücut kitle indeksi: 24,20 ± 7,20 kg/m²) gerçekleştirilmiştir. Değerlendirmelerde Sabahçıl-Akşamcıl Anketi, Pittsburgh Uyku Kalitesi İndeksi, Uluslararası Fiziksel Aktivite Anketi–kısa form ve Depresyon-Anksiyete-Stres Ölçeği–21 kullanılmıştır. Otonom fonksiyonlar vücut sıcaklığı, kan basıncı, kalp hızı, oksijen satürasyonu ve cilt nemi değerlendirmeleri ile ölçülmüştür. Tüm değerlendirmeler ders (sınavlardan 2-3 hafta önce) ve sınav dönemlerinde (finallerin ikinci haftasında) kontrollü ortamlarda uygulanmıştır.
Bulgular: Öğrenciler sınav döneminde akşamcıl kronotip özelliklere kaymış ($p < 0.001$), daha kötü uyku kalitesi ($p < 0.001$), azalmış fiziksel aktivite ($p < 0.001$) ve artmış depresyon, anksiyete ve stres seviyeleri ($p = 0.040$) sergilemiştir. Sınav döneminde sistolik ($p = 0.006$) ve diyastolik kan basıncı ($p = 0.028$) ile kalp hızında ($p = 0.014$) anlamlı artışlar gözlenirken, vücut sıcaklığı, oksijen satürasyonu ve cilt neminde değişiklik saptanmamıştır.
Sonuç: Akademik yaşamın getirdiği baskılar, özellikle sınav dönemlerinde, sirkadiyen ritimleri, uyku kalitesini ve psikolojik iyi oluşu ciddi şekilde bozabilir, fizyolojik stres yanıtları daha belirgin hale gelebilir. Üniversite öğrencilerinde fiziksel aktivite, stres ve zaman yönetimi hem akademik başarı hem de genel sağlık için faydalı olabilir.
Anahtar Kelimeler: Sirkadiyen ritim, uyku kalitesi, stres, öğrenci

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INTRODUCTION

Circadian rhythms are natural processes that regulate the body's physiological and biological functions over a roughly 24-hour cycle, driven by the Earth's rotation and the alternating light-dark cycle. These rhythms help the human body adapt to environmental changes and maintain its internal balance. Among these, the sleep-wake cycle is the most prominent and is regulated by the suprachiasmatic nucleus in the anterior hypothalamus. Circadian clocks play a vital role in coordinating key bodily functions, such as digestion, hormone secretion, body temperature, blood pressure, and the sleep-wake cycle, ensuring the body operates harmoniously (1, 2).

The proper maintenance of circadian rhythms, regulated by the sleep-wake cycle, is essential for the body's internal homeostasis. Circadian rhythms, influenced by factors such as light, temperature, and melatonin, have undergone significant changes in modern life. Today, factors like shift work, long working hours, night shifts, extended air travel, and sleep problems can disrupt circadian rhythms. Such disruptions are associated with an increased risk of conditions including insulin resistance, diabetes, cardiovascular diseases, obesity, cancer, and psychiatric disorders (3, 4).

In university life, sleep problems are commonly observed due to factors such as stress, irregular or unsuitable working hours, high workloads, intense social activities, alcohol and caffeine consumption, insufficient or excessive exercise, exposure to environments with excessive external stimuli, poor time management, internet addiction, or excessive social media use. Poor sleep quality is often associated with physical and mental health problems in students, particularly anxiety, fatigue, and depression. Additionally, inadequate and low-quality sleep among university students is known to negatively affect their physical and mental health, study capacity, and ultimately lead to a decline in academic performance (5, 6).

The light-dark cycle, along with social and physical activity, are key parameters in regulating circadian rhythms. Autonomic functions such as body temperature, blood pressure, heart rate, and hormonal fluctuations are rhythmically regulated over a 24-hour period. Disruptions in circadian rhythms can lead to changes in autonomic functions. Circadian rhythm characteristics can vary from person to person and are influenced by factors such as physical activity, sleep patterns, mental and physical performance, and stress (7, 8).

While it is well-known that academic stress during exams can lead to increased anxiety, reduced sleep quality, and greater fatigue (9, 10), the effects of these changes on the circadian rhythms of university students between study and exam periods remain unclear. Furthermore, no studies in the literature have investigated whether there are changes in autonomic functions closely linked to circadian rhythms, such as blood pressure, heart rate, and body temperature, during study and exam periods in university students. Therefore, the aim of this study was to examine the circadian rhythms of university students during study and exam periods and to identify potential circadian rhythm changes between these periods.

METHODS

This study was designed as a prospective observational study and was approved by the non-interventional ethics committee of a local institution (decision number: 2023-17, approval date: November 1, 2023). All participants provided written informed consent, following the ethical guidelines outlined in the Helsinki Declaration.

Participants were university students enrolled in associate and undergraduate programs. Inclusion criteria required participants to be between 18 and 30 years old, free from chronic health conditions (neurological, orthopedic, rheumatological, metabolic, or mental), and willing to take part in the study. Assessments were conducted during both study and exam periods to explore potential differences in circadian rhythms and related factors. Measurements were specifically performed 2–3 weeks before the exams, representing the study period, and during the second week of the two-week exam (final) period.

The evaluations included the Morningness-Eveningness Questionnaire (MEQ), Pittsburgh Sleep Quality Index

(PSQI), International Physical Activity Questionnaire – short form (IPAQ), and Depression-Anxiety-Stress Scale – 21 (DASS-21). In addition, autonomic functions such as body temperature, blood pressure, heart rate, oxygen saturation, and skin moisture were measured during both periods.

Morningness-Eveningness Questionnaire

The MEQ, initially developed by Horne and Östberg to assess circadian rhythms and behavioral patterns in biological rhythms, was utilized in this study. The Turkish version of the MEQ, validated and proven reliable by Punduk et al. (11, 12), was employed. This questionnaire comprises 19 items. Participants with scores between 16 and 41 were categorized as evening chronotypes, those with scores between 42 and 58 as intermediate chronotypes, and those scoring between 59 and 86 as morning chronotypes.

Pittsburgh Sleep Quality Index

The PSQI, originally developed by Buysse et al. to evaluate sleep quality and detect sleep disorders, was used in this study. The validated and reliable Turkish version of the scale was employed (13, 14). The PSQI is a self-report questionnaire consisting of 19 items, with 18 contributing to seven key components: subjective sleep quality, sleep latency, habitual sleep efficiency, sleep duration, sleep disturbances, use of sleep medication, and daytime dysfunction. Each component is scored on a scale between 0 – 3, with the total score ranging between 0 – 21. A total score exceeding 5 indicates "poor sleep quality."

Assessment of Physical Activity

The IPAQ short form, designed to evaluate physical activity levels across diverse populations, was utilized in its validated and reliable Turkish version (15, 16). This seven-item questionnaire collects information on the time spent walking, engaging in moderate-intensity activities, vigorous activities, and sedentary behaviors. The total physical activity score is calculated by summing the duration and frequency of walking, moderate-intensity, and vigorous activities.

Depression-Anxiety-Stress Scale

The DASS-21, developed to measure depression, anxiety, and stress levels, was used in this study. The Turkish validity and reliability study of the scale was conducted in 2017. The DASS-21 consists of 21 items divided into three subscales. Each item is scored on a Likert-type scale ranging between 0 – 4 (17, 18).

Assessment of Autonomic Functions

Autonomic functions were conducted using non-invasive digital devices routinely applied to the body. Body temperature was measured with an infrared thermometer (Respirox JM – 01801), heart rate and oxygen saturation were evaluated using a non-invasive digital pulse oximeter (Iron Pulse Oximeter X1805), blood pressure was measured with a digital sphygmomanometer (Omron M3 Comfort, Kyoto – Japan), and skin moisture was assessed with a digital skin moisture meter (Moisture Monitor, SK). Assessments were conducted twice for each participant—once during the study period and once during the exam period—to detect changes over time. All evaluations were carried out in a controlled environment to maintain consistency. The assessment room conditions included stable temperature (22 – 24°C), neutral lighting, and low noise levels to minimize external influences. Measurements were performed at the same time of day for both periods to account for circadian variations. To prepare for assessments, participants were given standardized instructions: they were advised to avoid caffeine, alcohol, and strenuous physical activity for at least 12 hours prior to testing and to rest for 5 – 10 minutes before measurements. These steps ensured accurate baseline readings and minimized confounding factors (19, 20).

Statistical Analysis

The data were analyzed using SPSS version 25 (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was applied to assess whether the data followed a normal distribution. For all comparisons, a significance level of $p<0.050$ was considered statistically significant. Differences in MEQ, PSQI, IPAQ, DASS scores, and autonomic functions (body temperature, blood pressure, heart rate, oxygen saturation,

and skin moisture) between study and exam periods were analyzed using the Wilcoxon test.

Sample size calculations were performed using the G*Power 3.1 program. Based on an effect size of 0.52, an alpha error probability of 0.050, and a power of 0.80, the minimum required sample size was determined to be 25 participants.

RESULTS

A total of 30 participants were included in the study, with a mean age of 21.10 ± 1.70 years and a mean body mass index of 24.20 ± 7.20 kg/m^2.

Statistically significant differences were observed in MEQ, PSQI, IPAQ, and DASS scores between the study and exam periods ($p < 0.050$) (Table 1). During the study period, participants were predominantly classified as intermediate chronotypes, whereas a shift toward evening chronotypes was noted during the exam period ($p < 0.001$). Additionally, poorer sleep quality ($p < 0.001$), lower physical activity levels ($p < 0.001$), and elevated depression, anxiety, and stress levels ($p = 0.040$) were identified during the exam period.

Regarding autonomic functions, no statistically significant differences in body temperature were observed between the study and exam periods ($p = 0.485$). However, significant increases were detected in systolic blood pressure ($p = 0.006$), diastolic blood pressure ($p = 0.028$), and heart rate ($p = 0.014$) during the exam period. In contrast, oxygen saturation ($p = 0.961$) and skin moisture ($p = 0.869$) remained unchanged between the two periods (Table 2).

DISCUSSION

This study provides valuable insight into how academic stress, particularly during exam periods, impacts university students' daily rhythms, mental health, activity levels, and bodily functions. The findings shed light on the challenges students face as they navigate these high-pressure situations.

Table 1. Comparison of questionnaire results between study and exam periods

		Study Period (n = 30)	Exam Period (n = 30)	*p*
MEQ scores	mean ± sd	51.00 ± 19.50	43.90 ± 18.50	< 0.001*
	median (min – max)	53.00 (17.00 – 85.00)	38.00 (18.00 – 75.00)	
PSQI scores	mean ± sd	4.40 ± 1.90	6.20 ± 2.00	< 0.001*
	median (min – max)	5.00 (2.00 – 8.00)	7.00 (3.00 – 10.00)	
IPAQ total scores	mean ± sd	2585.70 ± 2473.60	1000.10 ± 2129.70	< 0.001*
	median (min – max)	1632.00 (297.00 – 8316.00)	198.00 (132.00 – 6852.00)	
DASS-21 scores	mean ± sd	12.20 ± 7.90	15.20 ± 7.00	0.040*
	median (min – max)	11.00 (1.00 – 35.00)	15.00 (3.00 – 29.00)	

MEQ: Morningness-Eveningness Questionnaire, PSQI: Pittsburgh Sleep Quality Index, IPAQ: International Physical Activity Questionnaire – short form, DASS-21: Depression – Anxiety – Stress Scale-21. sd: standard deviation, min: minimum, max: maximum. (*) Indicates a statistically significant difference ($p < 0.050$) based on the Wilcoxon test.

Table 2. Comparison of autonomic functions between study and exam periods

		Study Period (n = 30)	Exam Period (n = 30)	*p*
Body Temperature (°C)	mean ± sd	36.50 ± 0.10	36.60 ± 0.30	0.485
	median (min – max)	36.60 (36.10 – 36.90)	36.60 (36.00 – 37.00)	
Systolic Blood Pressure (mmHg)	mean ± sd	106.80 ± 14.10	113.60 ± 15.00	0.006*
	median (min – max)	105.00 (83.00 – 131.00)	115.00 (83.00 – 147.00)	
Diastolic Blood Pressure (mmHg)	mean ± sd	72.10 ± 9.20	76.50 ± 11.60	0.028*
	median (min – max)	70.50 (54.00 – 94.00)	74.50 (54.00 – 99.00)	
Heart Rate (bpm)	mean ± sd	86.00 ± 15.80	91.90 ± 17.60	0.014*
	median (min – max)	86.00 (54.00 – 137.00)	90.50 (50.00 – 148.00)	
Oxygen Saturation (%)	mean ± sd	95.80 ± 2.00	90.30 ± 22.10	0.961
	median (min – max)	96.00 (93.00 – 99.00)	96.0 (93.00 – 99.00)	
Skin Moisture (%)	mean ± sd	58.80 ± 11.50	57.50 ± 25.20	0.869
	median (min – max)	59.40 (36.30 – 88.60)	58.10 (35.50 – 89.60)	

(*) Indicates a statistically significant difference ($p < 0.050$) based on the Wilcoxon test. sd: standard deviation, min: minimum, max: maximum.

The shift to a later bedtime during exams is likely due to longer study hours and less structured daily routines, which interfere with the body's natural light-dark cycle. This disruption was evident in higher PSQI scores, signaling worse sleep quality. Sleep is vital for focus, memory, and emotional well-being, so this decline in quality could have ripple effects beyond academics. Chronic sleep deprivation can increase the risk of various diseases, including heart disease and mental health disorders (21).

The decrease in students' physical activity during the exam period is another significant finding of this study. Physical activity is known to stabilize circadian rhythms and support overall health. The substantial decrease in activity levels suggests that students may deprioritize exercise due to academic pressures, which can increase stress levels and further destabilize their circadian rhythms (8, 22). Encouraging regular physical activity, even during busy periods, could mitigate some of these negative effects.

The elevated depression, anxiety, and stress levels observed during exams highlight the psychological burden of academic evaluations. Exam anxiety is a recognized source of acute stress that can exacerbate existing mental health challenges or lead to new ones. Implementing strategies such as mindfulness-based practices, stress management programs, and effective time management training could help students cope with these pressures and maintain better mental health (23, 24).

While some autonomic functions, such as body temperature, oxygen saturation, and skin moisture, remained stable, significant increases in systolic and diastolic blood pressure and heart rate were recorded during exams. These physiological changes reflect acute stress responses mediated by the autonomic nervous system. High blood pressure and increased heart rate are well-known signs of stress, reflecting the body's attempt to cope with perceived challenges (25). It is notable that body temperature and oxygen saturation showed no significant changes, suggesting that not all physiological systems respond in the same way to short-term stress. In contrast, blood pressure and heart rate appear to be more sensitive markers of acute stress, emphasizing the need for further research to understand how different systems react to stressful conditions.

This study sheds light on the significant effects of academic challenges on students' health, particularly during intense periods like exams. The findings underscore the importance of focusing on sleep quality, physical activity, and stress

management to support students' well-being. Future research should explore the long-term impacts of academic stress and evaluate strategies such as structured exercise programs, mindfulness-based practices, and tailored stress management interventions to provide students with effective coping mechanisms. Further exploration of long-term effects and follow-up studies would provide valuable insights into the chronic impacts of academic stress on circadian rhythms and overall student health.

Limitation

The small sample size (n=30) may limit the generalizability of the findings. Increasing the number of participants in future studies could enhance the robustness of the findings and provide a more comprehensive understanding of the observed effects.

CONCLUSION

In conclusion, this study shows how academic pressures can profoundly affect university students' sleep patterns, mental health, physical activity levels, and bodily functions. Encouraging healthy habits—such as regular exercise, better sleep routines, and stress management techniques—is crucial not only for improving academic performance but also for safeguarding students' long-term physical and mental well-being.

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