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Associations between exercise capacity, sleep quality, and academic stress in young sedentary adults: A cross-sectional study

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Abstract

The growing prevalence of sedentary behavior among university students raises concerns about its impact on functional capacity, sleep quality, and the ability to cope with academic pressure. This study aimed to assess exercise capacity, sleep quality, and academic stress levels in young sedentary individuals and to examine the associations among these parameters. In this cross-sectional study, 35 sedentary students from the Department of Physiotherapy and Rehabilitation at Bolu Abant İzzet Baysal University were included. Physical activity levels were assessed using the International Physical Activity Questionnaire–Short Form (IPAQ-SF), and exercise capacity was evaluated with the Six-Minute Walk Test (6MWT). Sleep quality and academic stress were measured using the Pittsburgh Sleep Quality Index (PSQI) and the Educational Stress Scale (ESS), respectively. Spearman correlation analysis was used to examine associations among variables. Participants had a mean age of 21.34±1.25 years and a mean BMI of 22.10±3.17 kg/m². Based on IPAQ-SF scores, 34.28% were physically inactive, while 65.72% were minimally active. The mean 6MWT distance was 491.62±53.65 meters. The average PSQI and ESS scores were 19.80±6.66 and 50.77±10.97, respectively. A significant positive correlation was found between physical activity level and 6MWT distance (r=0.464; p=0.005). Although no statistically significant associations were found between exercise capacity, sleep quality, and academic stress, a significant positive correlation was observed between physical activity level and functional capacity. These findings suggest that while physical activity may enhance functional performance in sedentary young adults, its short-term effects on sleep and academic stress remain inconclusive.

Keywords: Health behavior, lifestyle, physical fitness, sedentary behavior

Introduction

Technological advancements and the widespread use of digital media have substantially reshaped daily routines, contributing to increasingly sedentary lifestyles among young adults [1]. This trend is particularly evident among university students, who frequently engage in prolonged sitting due to academic studies, screen-based entertainment, and online coursework [2]. The widespread increase in sedentary behavior has raised significant public health concerns: longer sitting time has been shown to be strongly associated with sleep disturbances [3], while during the COVID-19 pandemic, sedentary time and poor sleep quality were linked to worsened mental health outcomes, including depression, anxiety, and stress among university students [4].

Academic stress has been identified as a key contributor to sleep disturbances and reduced psychological well-being among university students, with elevated stress levels often associated with lower sleep quality and increased symptoms of anxiety and depression [5,6]. Excessive academic demands can provoke emotional strain and disturb sleep patterns, often mediated by neuroendocrine mechanisms such as elevated cortisol secretion. Recent research among university students has shown that academic stress can elevate cortisol levels a key hormone secreted by the adrenal glands during stress while regular physical activity may help attenuate this physiological response [7,8]. These findings highlight the role of cortisol as a mediator between stress and sleep quality in academic settings. These findings underscore the mechanistic pathway through which academic stress may affect sleep patterns, with cortisol acting as a key mediator. This interplay may trigger a self-perpetuating cycle, whereby academic pressure contributes to poor sleep quality, which in turn exacerbates emotional exhaustion and

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weakens psychological resilience particularly in young adults coping with academic demands [9,10].

Engaging in regular physical activity may help students better cope with academic stress by improving sleep quality as mediated through reductions in ruminative thinking and depression [11] and by reducing symptoms of depression and anxiety more broadly, as supported by meta-analytic evidence [12]. Regular physical activity among university students may enhance sleep quality and alleviate academic pressure; recent research supports this: more active students report fewer sleep problems and lower stress [13], and physical activity has been shown to directly improve sleep quality, with stress acting as a partial mediator [14]. Naderi et al. reported that university students who engaged in regular physical activity experienced significantly lower levels of academic burnout [15]. Complementing this, Dunston et al. demonstrated a positive association between physical activity and psychological resilience, suggesting that the intensity of physical activity may play a key role in enhancing mental toughness [16]. These results underscore the potential of physical activity as an effective strategy to buffer the long-term adverse effects of academic stress, with particularly strong benefits observed among students with low activity levels [17,18].

Although considerable research has examined the individual effects of academic stress, sleep quality, and physical activity, relatively few studies have investigated their combined influence in young adults. Current findings such as the positive association between physical activity, mood, and sleep in healthcare students [19], and the link between physical activity and lowered academic stress in university students [20] highlight that a comprehensive examination of these factors still remains scarce. Understanding these interrelations is essential for developing comprehensive strategies that support student well-being and academic performance. Recent findings not only reveal that many universities lack structured physical activity programs despite their benefits for mental health, but also underscore the mechanism through which increased physical activity improves sleep quality and reduces ruminative thinking and depression among university students [11,13]. The purpose of this study was to investigate the interrelations among physical activity habits, exercise performance, and sleep characteristics in university students with low activity levels. We hypothesized that students with insufficient physical activity would exhibit lower exercise performance, report poorer sleep quality, and experience higher levels of academic stress.

Material and Methods

Study type

Data were collected using a design that combined cross-sectional analysis with descriptive methodology. Between April and May 2024, undergraduate participants were recruited from the Physiotherapy and Rehabilitation division of the Health Sciences Faculty at Bolu Abant İzzet Baysal University. All data were obtained using structured self-report questionnaires administered in person under researcher supervision.

Population and Sample of Research

Participants were recruited following ethical approval. Individuals aged 18 to 30 years who met the International Physical Activity Questionnaire–Short Form (IPAQ-SF) criteria for physical inactivity were eligible for inclusion. To estimate the appropriate number of participants, a power analysis was conducted using G*Power 3.1.9.7 for a two-tailed Spearman correlation [21]. Based on a medium effect size of r=0.30 [22], an alpha level of 0.05, and power of 0.80, the minimum required number of participants was determined to be 29. To account for potential attrition, a target of 44 participants was set. Out of 53 individuals initially evaluated, 9 did not satisfy the predefined eligibility standards and were therefore excluded. The final sample consisted of 44 sedentary university students (see Figure 1 for participant flow).

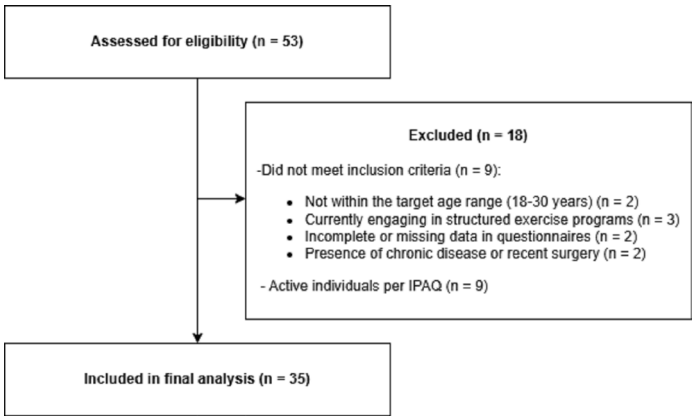

Figure 1. Flowchart of participant inclusion and exclusion process

Data Collection Tools

Sociodemographic Data Form. A structured questionnaire, specifically created for this study, was utilized to collect data on participants' demographic and health-related characteristics, including age, gender, anthropometrics, smoking habits, chronic conditions, surgical background, sleep issues, and exercise limitations.

To assess physical activity, the study used the validated Turkish form of the IPAQ-SF, which captures weekly engagement in walking, moderate exertion, and high-intensity activities. Activity levels were expressed as MET-minutes per week, based on standardized calculation procedures [23]. Participants were categorized as having low (<600 MET-min/week), moderate (600–2999), or high (≥3000) physical activity. Saglam et al. [24] confirmed the Turkish validity and reliability of the IPAQ-SF.

Six-Minute Walk Test (6MWT): Functional exercise capacity was measured via the 6MWT using a 30-meter indoor track, following the American Thoracic Society protocol. Each participant completed a six-minute walk at a self-selected pace, during which the total distance covered (in meters) was measured. Predicted 6MWT distances were calculated using sex-specific

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equations based on age, height, and weight. Previous research has demonstrated that this test produces consistent and accurate results when applied to samples of young adults [25].

Sleep quality was assessed using the *Pittsburgh Sleep Quality Index (PSQI)*, a widely used instrument that evaluates subjective sleep disturbances over the past month. Comprising 19 self-assessment questions, the PSQI measures sleep through seven categories, including quality, onset latency, duration, efficiency, nighttime disruptions, medication use, and daytime impact. These components are summed to yield a global score ranging from 0 to 21, with higher scores indicating poorer sleep quality. A global score above 5 was used to classify poor sleepers [26]. The Turkish version of the PSQI, which has demonstrated satisfactory reliability and validity, was used in this study [27].

To evaluate academic stress, the study utilized the Educational Stress Scale (ESS), a 16-question instrument developed to assess stress arising from factors like high academic standards, study load, self-imposed goals, and external academic pressures. A five-level Likert scale was employed to quantify responses, with values ranging from 1 (strongly disagree) to 5 (strongly agree with the statement). Scores on the scale can fall between 16 and 80, with greater values representing more intense experiences of educational stress. The Turkish adaptation of the scale, validated in university student samples, was used in this study [28].

Statistical analysis

Data analyses were conducted with IBM SPSS Statistics (v20.0). The normality of continuous variables was assessed using the Shapiro-Wilk test. Descriptive statistics were reported as mean±standard deviation (SD) for normally distributed variables and as median with interquartile range (IQR) for non-normally distributed variables. Categorical variables were presented as frequencies and percentages.

Participants were divided into low and high academic stress groups using a median split of the ESS total scores for subgroup analyses. Differences between high and low academic stress groups were evaluated through non-parametric testing, with the Mann-Whitney U test addressing continuous variables and chi-square tests used for categorical ones. Correlations among physical activity level (IPAQ), exercise capacity (6MWT), and sleep quality (PSQI) were assessed using Spearman's rank correlation coefficients within each stress group. In addition, 95% confidence intervals for correlation coefficients were calculated using bootstrap resampling with 1,000 iterations. A significance level of $p < 0.05$ (two-tailed) was used to determine meaningful differences or associations.

Potential Bias

As this study relied on self-reported instruments, including the IPAQ-SF, PSQI, and ESS, the potential for recall bias and social desirability bias should be acknowledged. Participants may have overestimated or underestimated their physical activity, sleep quality, or perceived stress due to memory limitations or the tendency to respond in a socially favorable manner. Since all respondents were selected from a single academic unit, the diversity of perspectives was constrained, affecting the external validity of the study outcomes.

Ethical considerations

Before the study was started, we received approval for the study from Bolu Abant İzzet Baysal University Non-Interventional Clinical Research Ethics Committee (Date 16.04.2024 and Decision no 2024-93). We planned our research in accordance with the current Helsinki Declaration guidelines. All individuals received detailed information regarding the study, and those who agreed to take part did so by signing a voluntary informed consent form.

Result

A total of 44 sedentary university students (91.4% female, mean age=21.34±1.26 years) participated in the study. The mean Pittsburgh Sleep Quality Index (PSQI) score was 19.80±6.66, indicating poor sleep quality. Only one participant (2.9%) met the criteria for good sleep (PSQI ≤ 5). The average physical activity score measured by the IPAQ-SF was 1264.31±913.46 MET-min/week. The 6MWT distance was 491.62±53.65 meters, corresponding to 77.52±12.31% of the predicted performance. The mean educational stress score was 50.77±10.98 (range: 26–72), with a median value of 50.0 used to stratify participants into low and high stress groups for subgroup analysis (Table 1).

Based on the median ESS score, participants were divided into low stress (n=22) and high stress (n=22) groups. Table 2 presents the comparisons of physical activity, exercise capacity, and sleep quality between groups. The high stress group demonstrated significantly greater six-minute walk test (6MWT) distances compared to the low stress group (median [IQR]: 504.60 [480.00–547.20] m vs. 472.80 [429.20–502.80] m, p=0.038). No significant differences were observed between groups in terms of PSQI scores (p=0.986) or IPAQ total MET scores (p=0.373).

Descriptive statistics and between-group comparisons based on academic stress levels are summarized in Table 3. Overall, participants exhibited poor sleep quality, with a mean PSQI score of 19.80±6.66, and only one individual (2.9%) classified as having good sleep quality (PSQI≤5). No statistically significant difference was observed in PSQI scores between low and high stress groups (p=0.986). Similarly, total physical activity levels, as measured by the IPAQ, did not differ significantly across groups (p=0.373). In contrast, a significant difference was found in exercise performance between stress groups. The high stress group demonstrated greater walking distances during the 6-minute walk test (median [IQR]: 504.60 [480.00–547.20] m) compared to the low stress group (472.80 [429.20–502.80] m), with this difference reaching statistical significance (p=0.038). Although expected 6MWT distances and performance percentages were numerically higher in

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the high stress group, the differences were not statistically significant (p>0.05 for both). These findings suggest that academic stress levels may be associated with enhanced short-term exercise output, despite similar baseline cardiorespiratory capacity. This group difference is further illustrated in Figure 2.

When stratified by stress level, a moderate positive correlation was observed between physical activity and exercise capacity in both the low stress (ρ=0.416, p=0.086) and high stress groups (ρ=0.336, p=0.187); however, these associations did not reach statistical significance. In the low stress group, sleep quality showed negligible correlation with physical activity (ρ=-0.048, p=0.850) and a small, non-significant negative correlation with exercise capacity (ρ=-0.242, p=0.334). Similarly, in the high stress group, the correlation between sleep quality and physical activity was weak (ρ=0.103, p=0.693), and the negative correlation between sleep quality and exercise capacity remained statistically non-significant (ρ=-0.314, p=0.220) (Table 4). Bootstrapped 95% confidence intervals for all correlation coefficients included zero, further supporting the absence of statistically significant relationships across subgroups.

Table 1. Sociodemographic and behavioral characteristics of the participants

Variable	Low Stress (n=17)	High Stress (n=18)	p-value
Gender (Female/Male)	**15/2**	**17/1**	**0.6026†**
Age (Mean±SD, years)	21.24±1.15	21.44±1.38	0.5530‡
Height (Mean±SD, cm)	164.82±6.76	164.00±6.13	0.8169‡
Weight (Mean±SD, kg)	59.29±10.66	60.61±11.23	0.7914‡
BMI (Mean±SD, kg/m²)	21.71±2.89	22.47±3.47	0.5860‡
Stress score	42.39±6.85	59.65±6.59	-
Chronic Illness (Yes/Total)	2/17	4/18	0.6635†
Recent Surgery (Yes/Total)	0/17	2/18	0.4862†
Sleep Disorder (Yes/Total)	0/17	2/18	0.4862†
Ever Smoked (Yes/Total)	4/17	3/18	0.6802†
Exercise Barriers (Yes/Total)	0/17	2/18	0.4862†

Continuous variables are presented as Mean±Standard Deviation (SD). Categorical variables are presented as frequencies. † Fisher's Exact Test; ‡ Mann–Whitney U Test. No statistically significant differences were observed between groups (p>0.05 for all)

Table 2. Physical activity categories and IPAQ scores by educational stress

IPAQ Category	Low Stress (n=17)	High Stress (n=18)	Total (n)
Low	6	6	12
Moderate	11	12	23
High	0	0	0

Physical activity levels were classified according to the IPAQ scoring system as follows: Low (<600 MET-min/week), Moderate (600–2999 MET-min/week), and High (≥3000 MET-min/week)

Table 3. Descriptive statistics and group comparisons of sleep quality, exercise capacity, and physical activity by stress level

Patients	Gender	Age	Reason	Result
PSQI Total Score	19.80±6.66	20.00 [15.00–23.00]	19.00 [16.50–23.50]	0.986
Good Sleep (PSQI ≤ 5), n (%)	1 (2.9%)	–	–	–
6MWT Distance (m)	491.62±53.65	472.80 [429.20–502.80]	504.60 [480.00–547.20]	0.038
Expected 6MWT Distance (m)	634.26±71.62	629.80 [598.20–661.30]	636.10 [608.70–673.30]	0.254
6MWT Performance (%)	77.52±12.31	76.14 [67.35–83.56]	79.44 [70.52–88.73]	0.298
IPAQ Score (MET-min/week)	1264.31±913.46	831.60 [524.70–1684.80]	1493.60 [583.05–2075.90]	0.373

*Total sample values are reported as Mean±Standard Deviation unless otherwise stated. †Group comparisons were made using the Mann–Whitney U test. PSQI: Pittsburgh Sleep Quality Index. 6MWT: Six-Minute Walk Test. IPAQ: International Physical Activity Questionnaire. Bold p-values indicate statistical significance at p<0.05

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Table 4. Spearman correlation coefficients and 95% confidence intervals between physical activity, exercise capacity, and sleep quality by stress group

Group	n	Variables Compared	Spearman's ρ	p-value	95% Confidence Interval
Low Stress	18	Physical Activity vs. Exercise Capacity	0.416	0.086	–0.060 to 0.718
Low Stress	18	Physical Activity vs. Sleep Quality	–0.048	0.850	–0.589 to 0.487
Low Stress	18	Exercise Capacity vs. Sleep Quality	–0.242	0.334	–0.596 to 0.203
High Stress	17	Physical Activity vs. Exercise Capacity	0.336	0.187	–0.225 to 0.757
High Stress	17	Physical Activity vs. Sleep Quality	0.103	0.693	–0.422 to 0.536
High Stress	17	Exercise Capacity vs. Sleep Quality	–0.314	0.220	–0.678 to 0.245

Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ) total MET-min/week. Exercise capacity was measured via the Six-Minute Walk Test (6MWT). Sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI), where higher scores indicate poorer quality. Spearman's rank-order correlation coefficients (ρ) are reported with associated p-values and 95% confidence intervals calculated via bootstrapping (1,000 resamples). Statistical significance was set at $p<0.05$

Figure 2. Box plot showing the distribution of 6MWT distances by stress group. The high stress group demonstrated significantly greater performance (p=0.038)

Discussion

Although no significant associations were found between physical activity, sleep quality, and academic stress, students with higher stress levels exhibited significantly better 6MWT performance, contrary to expectations. There were no significant differences in physical activity levels or sleep quality between students with low and high academic stress; however, the high-stress group exhibited significantly higher 6MWT performance. No significant correlations were found between physical activity, sleep quality, and functional capacity across groups, although moderate, non-significant associations were noted between physical activity and exercise capacity.

The observed positive relationship between physical activity and 6MWT performance is consistent with prior research emphasizing the role of physical activity in enhancing functional capacity in sedentary individuals. Lavie et al. reported that regular exercise improves cardiovascular endurance and physical performance, even in physically inactive populations [29]. The current findings support this interpretation, despite the absence of strong statistical associations in subgroup analyses.

Interestingly, sleep quality did not differ across stress levels in the present study. Contrary to earlier literature highlighting the detrimental influence of academic pressure on sleep, the current results suggest a different pattern [30,31]. Yang et al. previously noted that sedentary behavior contributes to poor sleep outcomes; however, this relationship was not clearly reflected in our cohort [32]. The discrepancy may stem from sample homogeneity, individual variability in sleep hygiene, or limitations of the PSQI in capturing acute stress-related changes.

Contrary to expectations, students in the high-stress group demonstrated better 6MWT performance. This finding may suggest that some individuals under academic stress engage in physical activity as a coping mechanism or experience transient stress-induced hyperactivation that enhances short-term physical performance. While speculative, these explanations are partially supported by Wald et al., who reported that physically active students demonstrate better cognitive and academic outcomes under pressure [33].

Unlike previous research suggesting that mindfulness and emotional control may mediate the interplay between sleep, stress, and physical capacity, the present study did not reveal statistically relevant connections among these variables. According to findings by Naderi et al., consistent physical activity and healthy sleep practices played a role in protecting nursing students from experiencing academic burnout [15]. These discrepancies might stem from methodological constraints, including modest sample size, dependence on participant-reported data, and differing personal coping mechanisms. Zhu et al. suggested that academic pressure adversely affects physical activity and sleep patterns [34], while Yang et al. emphasized the connection between sedentary behavior and sleep disturbances that may indirectly impact physical performance [32]. Moreover, less frequent physical activity has been linked to increased academic stress, highlighting the potential protective role of exercise [35]. Wald et al. similarly noted that healthy lifestyle behaviors, including adequate physical activity and sleep, are positively associated with academic performance [33]. Although this relationship was

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not observed in our sample, it may be attributed to the specific characteristics of the cohort.

Despite the mixed findings, the positive effects of physical activity on sleep and stress regulation are well documented. In earlier research, improvements in sleep patterns among college students were linked to increased physical engagement, with the relationship partially explained by mindfulness and adaptive thought processes [36]. Coşkun likewise found that students who exercised regularly experienced better sleep quality than their sedentary peers [37]. These results support the idea that physical activity may indirectly mitigate academic stress by enhancing sleep. A large-scale longitudinal study further demonstrated that maintaining an active lifestyle from adolescence into adulthood contributes to reduced stress and improved psychological well-being [38]. This is consistent with findings by Cuellar et al., who emphasized that adequate physical activity, sleep, and nutrition collectively predict better academic outcomes and mental health [39].

The internal consistency of these findings suggests the existence of complex but subtle interrelationships among lifestyle, stress, and functional performance. Nonetheless, generalizability is limited by the homogeneous nature of the sample, which consisted exclusively of physiotherapy students from a single institution. Future studies with larger and more diverse samples, using objective measurement tools such as accelerometry or actigraphy, are warranted to clarify these relationships.

The link between academic burden and reduced physical activity appears to vary by gender, suggesting a potential moderating role. Chust-Hernández et al. highlighted that being female and having insufficient physical activity were associated with increased academic stress among health sciences students [28,40].

The internal consistency of our findings suggests the existence of complex but subtle interrelationships between lifestyle, stress, and functional performance. Nonetheless, the generalizability of these findings is limited by the single-department recruitment and the relatively small sample size. Future studies should consider using objective activity trackers or actigraphy and recruiting more diverse populations.

Study Limitations and Strengths

This research is subject to certain constraints. Primarily, the cross-sectional nature of the design limits the ability to establish cause-and-effect associations among the studied variables. Second, all measurements were based on self-report instruments (IPAQ-SF, PSQI, and ESS), which are susceptible to recall bias and social desirability effects. Participants may have misestimated their physical activity levels, sleep quality, or perceived stress. Additionally, selection bias may have occurred, as the sample consisted exclusively of students from a single physiotherapy department, limiting the diversity and generalizability of the findings. A lower participant count might have diminished the sensitivity of the analyses, making it harder to observe weaker correlations.

Although some methodological constraints exist, this research is distinguished by several key strengths. It is among the few studies that simultaneously examined physical activity, exercise performance, sleep quality, and academic stress in a sedentary university student population. The inclusion of an objective functional capacity measure (6MWT) alongside self-reported questionnaires enhances methodological rigor. Furthermore, the analysis of correlations within stratified stress groups provides a novel perspective that may guide future stress-related lifestyle research in higher education settings.

Conclusion

In conclusion, this study demonstrates that increasing physical activity levels can positively impact exercise capacity in young sedentary individuals. While the direct effects of sleep quality and academic stress on exercise capacity were not observed, these factors remain important considerations in the broader context of student health. Strategies aimed at promoting physical activity, improving sleep hygiene, and addressing academic stress are essential for enhancing the well-being and performance of young adults. Implementing integrated health approaches may play a key role in reducing the adverse outcomes associated with prolonged inactivity and academic demands. The study enhances existing knowledge by underlining how physical activity can simultaneously impact educational success and psychological health in student populations.

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Conflict of Interests

The authors declare that there is no conflict of interest in the study.

Financial Disclosure

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Ethical Approval

The study received ethical approval from the Bolu Abant Izzet Baysal University Non-Interventional Clinical Research Ethics Committee (Approval Date: 16.04.2024, Decision No: 2024/93).

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