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Research Article

THE RELATIONSHIP BETWEEN DIGITAL FATIGUE AND ACADEMIC PROCRASTINATION AMONG PRECLINICAL MEDICAL STUDENTS: A TWO-CENTER CROSS-SECTIONAL STUDY

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ABSTRACT

Objective: This study aimed to examine the relationship between digital fatigue and academic procrastination among preclinical medical students and to evaluate learning-related behavioral patterns such as screen time, study habits, break frequency, and perceived academic achievement.

Materials and Methods: This two-center, cross-sectional, quantitative study was conducted among first- to third-year medical students at Çukurova University and İzmir Katip Çelebi University during the 2025–2026 academic year. Data were collected via an online questionnaire. The level of digital fatigue was measured using the *Digital Fatigue Scale (DFS)*, and academic procrastination was assessed with the Turkish short form of the *Tuckman Procrastination Scale (TPS)*. Descriptive statistics, Pearson correlation analysis, independent samples t-test, and one-way analysis of variance (ANOVA) with Tukey post-hoc tests were used for statistical analysis. A significance level of $p < 0.05$ was adopted.

Results: A total of 268 preclinical medical students participated in the study. A strong positive correlation was found between digital fatigue and academic procrastination ($r = 0.595$, $p < 0.001$). Among the subscales, the association between digital dependency and academic procrastination was the strongest ($r = 0.601$, $p < 0.001$). Students from Çukurova University had significantly higher DFS and TPS scores than those from İzmir Katip Çelebi University ($p < 0.01$). Students with regular study habits demonstrated significantly lower levels of digital fatigue ($p < 0.001$). Increasing daily screen time was associated with higher levels of both digital fatigue ($r = 0.292$, $p < 0.001$) and academic procrastination ($r = 0.221$, $p < 0.001$). Lower perceived academic achievement corresponded to higher DFS and TPS scores ($p \leq 0.003$). No significant difference was found based on neuropsychiatric diagnosis or treatment status ($p > 0.05$). Although differences across break frequency groups were not statistically significant, an increasing trend in fatigue and procrastination scores was observed with more frequent breaks.

Conclusion: There is a strong and significant relationship between digital fatigue and academic procrastination among preclinical medical students. Increased screen exposure, irregular study habits, and lower perceived academic achievement appear to be associated with higher levels of both digital fatigue and procrastination. These findings highlight the importance of educational approaches that enhance students' self-regulation skills and promote digital hygiene practices within increasingly digitalized learning environments.

Keywords: Digital fatigue; Academic procrastination; Medical students; Screen time; Self-regulation; Digital learning

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INTRODUCTION

With the rapid advancement of technology and the accelerating pace of digitalization, educational processes have undergone an inevitable transformation. This shift was further catalyzed by the COVID-19 pandemic, which prompted an abrupt transition in higher education from traditional face-to-face learning to online and hybrid instructional formats. Medical education has been profoundly affected by this transformation. Online lectures, video-based materials, synchronous and asynchronous sessions, question banks, and artificial intelligence–assisted learning tools have become central to the academic routines of medical students. In the preclinical phase, the reliance on digital resources for studying and exam preparation has markedly increased students' screen exposure times. Although this digital shift offers advantages such as flexibility, content diversity, and personalized learning pace, the growing dependence on digital technologies has led to the emergence of a new phenomenon among students—digital fatigue.

Digital fatigue is characterized by physical, mental, and emotional exhaustion resulting from prolonged exposure to digital technologies. Its symptoms include decreased concentration, loss of motivation, headaches, neck and eye strain, cognitive overload, sleep disturbances, and stress (1). The increasing complexity of online learning platforms, technological demands, continuous connectivity, and digital overload are among its key determinants. Previous studies have shown that the use of multiple online platforms (e.g., Zoom, Google Meet) contributes to confusion, distraction, and burnout among students (1). Such fatigue negatively impacts learning performance and academic motivation. Moreover, excessive technological demands not only heighten mental fatigue but also exacerbate physical exhaustion, thereby compromising the sustainability of screen-based education. Among high-demand groups such as medical students, the adverse effects of digital fatigue may become even more pronounced. Medical students, who rely heavily on digital tools for studying, practicing preclinical skills, and preparing for examinations, are particularly vulnerable. Recent research has demonstrated that digital fatigue among medical students is associated with depressive symptoms, attention deficits, decreased motivation, and reduced academic performance (2, 3).

The rise of digital fatigue may also be closely linked to another prevalent issue in medical education—academic procrastination. Academic procrastination is defined as the voluntary delay of academic tasks despite awareness of the potential negative consequences and is considered a behavioral manifestation of self-regulatory failure (4, 5). Studies have consistently reported that academic procrastination is widespread among medical students and is associated with technology dependence, irregular sleep, and inadequate self-regulation skills (2, 6-8) It is estimated that between 80% and 95% of university students engage in procrastination, with around half doing so in a persistent or problematic manner. This behavior has been strongly linked to low academic self-efficacy, impulsivity, and task avoidance (Steel, 2007). Given the heavy workload, stress, and anxiety inherent in medical education, students are particularly prone to procrastination. Academic procrastination undermines the ability to initiate and sustain study behaviors, thereby adversely affecting academic success (2, 7-9).

Taken together, existing evidence indicates that digital fatigue among medical students has increased in parallel with greater exposure to digital platforms, while academic procrastination has been reinforced by technology dependence, poor sleep, and insufficient self-regulation—factors inherently linked to digitalization. However, studies directly examining the relationship between digital fatigue and academic procrastination remain scarce. Therefore, the primary aim of the present study was to investigate the association between digital fatigue and academic procrastination among preclinical (first to third year) medical students at Çukurova University and İzmir Kâtip Çelebi University. The findings are expected to elucidate the extent to which students' procrastination tendencies are influenced by their exposure to digital learning environments and to provide an integrative perspective by incorporating behavioral variables such as study habits, break frequency, screen time, and perceived academic achievement.

MATERIALS AND METHODS

This study was designed as a two-center, cross-sectional, quantitative investigation aimed at examining the relationship between digital fatigue and academic procrastination. The study population consisted of preclinical (first-, second-, and third-year) medical students enrolled at the Faculties of Medicine of Çukurova University and İzmir Katip Çelebi University during the 2025–2026 academic year. The preclinical phase was specifically chosen because the curriculum at this stage is predominantly screen-based, while confounding factors such as clinical duties, patient interactions, and shift workloads are relatively limited compared to the clinical years.

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The inclusion criteria were (1) being a preclinical medical student at either of the participating universities and (2) completing the online questionnaire in full. Participation was entirely voluntary, and no incentives were offered. Data from 268 respondents who met the inclusion criteria were included in the analysis. The survey was administered via *Google Forms*, distributed through multiple communication channels. All responses were collected anonymously, and researchers did not have access to participants' identifying information.

Ethical approval was obtained from the Çukurova University Faculty of Medicine Research Ethics Committee (Approval No: 53, Date: 12.09.2025) All participants were informed about the study objectives and procedures, and written electronic informed consent was obtained prior to data collection.

Data Collection Instruments

The data collection tool consisted of two sections: (1) questions addressing sociodemographic and academic characteristics, and (2) standardized psychometric scales. Sociodemographic and academic variables included age, gender, university, academic year, total daily screen time, screen time for academic purposes, study habits, the number of breaks taken per hour of study, sleep pattern, and perceived academic achievement.

Digital Fatigue

Digital fatigue was assessed using the *Digital Fatigue Scale (DFS)*, developed by Tutar and Mutlu (10). The DFS is a 28-item instrument designed to measure the multidimensional structure of digital fatigue among individuals with high exposure to digital technologies. It consists of four subscales: *Digital Dependency*, *Psychological Fatigue*, *Physical–Mental Fatigue*, and *Psychosomatic Problems*. Items are rated on a five-point Likert scale, yielding total scores ranging from 0 to 140, with higher scores indicating greater digital fatigue. The internal consistency of the DFS in this study was excellent (Cronbach's $\alpha = 0.95$).

Academic Procrastination

Academic procrastination was measured using the Turkish short form of the *Tuckman Procrastination Scale (TPS)* (5). This 14-item scale employs a five-point Likert response format, with four items reverse-coded. Total scores range from 0 to 70, with higher scores reflecting greater procrastination tendencies. The TPS demonstrated high internal consistency in this sample (Cronbach's $\alpha = 0.90$).

Statistical Analysis

All statistical analyses were performed using *IBM SPSS Statistics for Mac, Version 30.0* (IBM Corp., Armonk, NY, USA). Data were coded and screened for outliers and missing values prior to analysis. The normality of distributions was tested using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Since all variables showed $p > 0.200$, they were assumed to be normally distributed; this was further supported by histograms, Q–Q plots, and standardized z-scores.

Descriptive statistics were reported as mean (X), standard deviation (SD), minimum, and maximum values for continuous variables, and as frequency (n) and percentage (%) for categorical variables. The internal consistency of the DFS and TPS, including their subscales, was evaluated using Cronbach's alpha coefficients.

Group differences were analyzed using the *Independent Samples t-test* for two-group comparisons and *One-Way Analysis of Variance (ANOVA)* for comparisons among three or more groups. When significant results were obtained from ANOVA, *Tukey's post-hoc test* was conducted to determine the direction of differences. Effect sizes were calculated using *Cohen's d* and η^2 *(eta squared)* coefficients.

The relationships among digital fatigue, academic procrastination, screen time, and age were examined using *Pearson's correlation analysis*. Correlation strength was interpreted as follows: $r = 0.10–0.29$ (weak), $r = 0.30–0.49$ (moderate), and $r \geq 0.50$ (strong). All statistical tests were two-tailed, and a significance level of $p < 0.05$ was considered statistically significant.

RESULTS

Sociodemographic Characteristics of Participants

A total of 268 preclinical medical students participated in the study, with equal representation from Çukurova University (n = 134) and İzmir Kâtip Çelebi University (n = 134). Among the participants, 50.0% were male and 48.9% were female. The mean age was 20.1 ± 1.3 years (range: 18–23). Regarding class distribution, 42.9% were third-year students, 34.0% were second-year students, and 23.1% were first-year students.

In terms of screen exposure, 78.4% of the participants reported using screens for more than four hours per day, of which 39.2% used screens for 4–6 hours and another 39.2% for more than six hours daily. More than half of the

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Table 1. Mean Scores and Reliability of the Scales

Scale / Subscale	Mean ± SD	No. of Items	Cronbach's α	Reliability Level
Digital Fatigue Scale (DFS) (Total)	77.87±23.39	28	0.950	Excellent
DFS – Digital Dependency	38.07±11.61	12	0.929	Excellent
DFS – Psychological Fatigue	14.74±6.62	7	0.890	High
DFS – Physical–Mental Fatigue	14.44±5.34	5	0.850	High
DFS – Psychosomatic Problems	10.62±4.17	4	0.788	Acceptable
Tuckman Procrastination Scale	41.53±8.73	14	0.900	Excellent

students (52.6%) lived in dormitories, while 24.3% lived with their families.

Reliability of the Measurement Scales

The internal consistency of the instruments used in the study was evaluated using Cronbach's alpha coefficients. For the *Digital Fatigue Scale (DFS)*, the overall Cronbach's alpha was 0.950, indicating excellent internal consistency within this sample. Among the subscales, *Digital Dependency* demonstrated the highest reliability (α = 0.929), classified as excellent. The *Psychological Fatigue* (α = 0.890) and *Physical–Mental Fatigue* (α = 0.850) subscales showed high reliability, while the *Psychosomatic Problems* subscale had an acceptable level of consistency (α = 0.788).

For the *Tuckman Procrastination Scale (TPS)*, the Cronbach's alpha coefficient was 0.900, indicating excellent internal consistency in this sample. This finding supports the reliability of the Turkish short form of the TPS in measuring academic procrastination among medical students.

Overall, both the DFS (total and subscales) and the TPS demonstrated strong internal reliability, confirming that the measurement tools provided a robust foundation for interpreting the study's findings (**Table 1**).

Levels of Digital Fatigue and Academic Procrastination

The mean total score for the *Digital Fatigue Scale (DFS)* was 77.87 ± 23.39. Among its subscales, the *Digital Dependency* dimension had the highest mean score, whereas *Psychological Fatigue* had the lowest. The mean total score for academic procrastination, measured by the *Tuckman Procrastination Scale (TPS)*, was 41.53 ± 8.73, indicating a moderate level of procrastination. These findings suggest that, overall, students experienced relatively low levels of digital fatigue **(Table 1**).

Differences by University

According to the independent samples *t*-test, students from Çukurova University (M = 82.12 ± 22.84) had significantly higher *Digital Fatigue Scale (DFS)* scores compared with those from İzmir Kâtip Çelebi University (M = 73.71 ± 23.26; $t = -2.96$, $p = 0.003$). Similarly, the *Tuckman Procrastination Scale (TPS)* scores were also significantly higher among Çukurova University students ($t = -2.88$, $p = 0.004$). The effect sizes were moderate (Cohen's $d = 0.36$), suggesting that these differences may be related to contextual factors such as curriculum intensity, digital infrastructure, and learning environment conditions.

Gender, Academic Year, and Living Arrangements

No significant differences were found between male and female students in either DFS or TPS scores ($p > 0.05$).

ANOVA results indicated that there were no significant differences in digital fatigue or academic procrastination across academic years ($F(2,260) = 2.07$, $p = 0.128$), although third-year students had slightly higher mean scores (DFS = 80.7 ± 22.9; TPS = 42.5 ± 8.4).

Similarly, no significant differences were observed based on students' living arrangements ($p > 0.05$).

Table 2. Correlations Between Digital Fatigue and Academic Procrastination

Variable	Correlation with TPS (r)	Significance (p)
DFS – Digital Dependency	0.601	**< 0.001***
DFS – Psychological Fatigue	0.418	**< 0.001***
DFS – Physical–Mental Fatigue	0.409	**< 0.001***
DFS – Psychosomatic Problems	0.474	**< 0.001***
DFS Total	0.595	**< 0.001***
Daily Screen Time	0.221	**< 0.001***

*Pearson correlation analysis was used. Bold and *indicates statistical significance.*

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Table 3. Comparison of Digital Fatigue and Academic Procrastination Levels According to Study Habits

Scale / Subscale	Study Intensively Before Exams (n = 147)	Study Regularly (n = 69)	No Study Routine (n = 47)	*P* value
DFS–Digital Dependency	39.46 ± 11.03	33.41 ± 11.91	40.55 ± 11.27	**<0.001***
DFS–Psychological Fatigue	14.86 ± 6.50	13.58 ± 6.64	16.09 ± 6.79	0.128
DFS–Physical–Mental Fatigue	14.81 ± 5.32	13.71 ± 5.32	14.36 ± 5.43	0.369
DFS–Psychosomatic Problems	10.91 ± 4.15	9.57 ± 4.18	11.23 ± 4.03	**0.045***
DFS Total	80.04 ± 22.96	70.26 ± 23.53	82.23 ± 22.41	**0.006***
TPS Total	42.20 ± 8.91	38.23 ± 8.16	44.28 ± 7.60	**<0.001***

*One-way ANOVA test was used. Bold and * indicates statistical significance. Post-hoc analyses were performed using Tukey's test, and significant group differences are described in the text.*

Correlation Analyses

Pearson's correlation analysis revealed a positive, moderate-to-strong, and statistically significant relationship between digital fatigue and academic procrastination (r = 0.595, $p < 0.001$). This finding indicates that higher levels of digital fatigue were associated with increased tendencies toward academic procrastination (**Figure 1**).

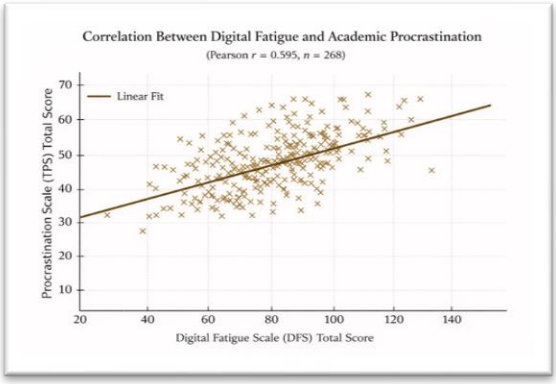


Figure 1. Correlation between Digital Fatigue Scale (DFS) and Tuckman Procrastination Scale (TPS) total scores (r = 0.595, n = 268). The scatter plot illustrates a positive linear relationship, indicating that higher digital fatigue levels are associated with greater academic procrastination tendencies.

When the subdimensions of digital fatigue were examined, all four subscales of the DFS showed significant positive correlations with academic procrastination (**Table 2**). The strongest correlation was found between *Digital Dependency* and academic procrastination (r = 0.601, $p < 0.001$), followed by *Psychosomatic Problems* (r = 0.474, $p < 0.001$), *Psychological Fatigue* (r = 0.418, $p < 0.001$), and *Physical–Mental Fatigue* (r = 0.409, $p < 0.001$). These findings indicate that digital fatigue is a multidimensional construct encompassing physical, mental, and psychosomatic elements that collectively relate to procrastination behaviors.

Furthermore, daily screen time showed a positive and significant correlation with both digital fatigue and academic procrastination. Specifically, total daily screen time correlated with DFS scores (r = 0.292, $p < 0.001$) and TPS scores (r = 0.221, $p < 0.001$), suggesting that increased digital exposure is associated with higher levels of fatigue and procrastination.

No significant correlations were observed between age and the main study variables, indicating that within the narrow age range of the sample, digital fatigue and procrastination levels were not age-dependent ($p > 0.05$).

Distribution of Digital Fatigue Levels

The classification of participants based on their total *Digital Fatigue Scale (DFS)* scores is presented in Figure 2. Accordingly, 17.9% (n = 48) of the participants were in the "very low" category and 42.5% (n = 114) in the "low" digital fatigue category. When these two groups were combined, approximately 60.4% of students exhibited low or very low levels of digital fatigue. This finding suggests

Table 4. Comparison of Digital Fatigue and Academic Procrastination Levels According to Perceived Academic Achievement

Scale / Subscale	1 (Very Low) (n = 7)	2 (Low) (n = 30)	3 (Moderate) (n = 134)	4 (High) (n = 85)	5 (Very High) (n = 7)	*p*-value
DFS – Digital Dependency	50.29 ± 9.72	44.23 ± 8.44	37.75 ± 11.61	35.42 ± 11.24	37.57 ± 15.13	**<0.001***
DFS – Psychological Fatigue	13.71 ± 5.19	17.83 ± 5.80	14.79 ± 6.93	13.75 ± 5.93	13.57 ± 10.01	0.064
DFS – Physical–Mental Fatigue	12.29 ± 5.35	16.47 ± 4.24	14.47 ± 5.73	13.85 ± 4.68	14.57 ± 7.96	0.163
DFS – Psychosomatic Problems	13.14 ± 4.45	12.63 ± 3.77	10.57 ± 4.20	9.71 ± 3.85	11.29 ± 5.74	**0.007***
DFS Total	89.43 ± 15.36	91.17 ± 17.26	77.59 ± 23.99	72.73 ± 22.07	77.00 ± 34.98	**0.003***
TPS Total	49.43 ± 8.36	46.73 ± 8.06	40.84 ± 8.43	40.15 ± 8.85	41.29 ± 5.25	**<0.001***

*One-way ANOVA test was used. Bold and * indicates statistical significance. Post-hoc analyses were performed using Tukey's test, and significant group differences are described in the text.*

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that the majority of preclinical medical students maintain a balanced and manageable relationship with digital technologies.

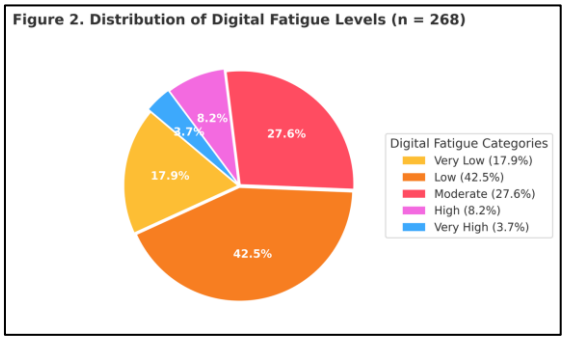


Figure 1. Distribution of participants according to total Digital Fatigue Scale (DFS) scores.

Meanwhile, 27.6% (n = 74) of students were categorized as having a "moderate" level of digital fatigue, representing individuals who display noticeable signs of digital exhaustion that may adversely affect learning performance. More notably, 8.2% (n = 22) and 3.7% (n = 10) of participants were classified as having "high" and "very high" levels of digital fatigue, respectively. When considered together, these groups constitute approximately 11.9% of the sample, indicating that about one in ten students experience substantial digital stress, loss of control, and exhaustion.

Overall, this distribution demonstrates that while most preclinical medical students are able to cope effectively with digital demands, approximately one in four experience moderate levels of fatigue, and roughly one in ten suffer from high or very high digital fatigue. Students within these latter groups may represent an at-risk subgroup characterized by impaired attention, reduced academic functionality, and weakened self-regulation resulting from intensive technology use.

Digital Fatigue and Academic Procrastination According to Study Habits

Significant differences were observed in digital fatigue and academic procrastination scores according to students' study habits (**Table 3**). Comparisons among students who reported "studying intensively before exams," those who "study regularly," and those with "no fixed study routine" revealed statistically significant group differences in the *Digital Dependency* subscale of the DFS ($p < 0.001$). Post-hoc *Tukey* analyses showed that the "study regularly" group had significantly lower mean scores (33.41 ± 11.91) than both the "study intensively before exams" (39.46 ± 11.03) and "no study routine" (40.55 ± 11.27) groups.

No significant differences were found among the groups in *Psychological Fatigue* ($p = 0.128$) or *Physical–Mental Fatigue* ($p = 0.369$); however, in both subscales, students without a study routine showed higher mean scores. A significant difference was observed for the *Psychosomatic Problems* subscale ($p = 0.045$), with post-hoc results indicating that the "study regularly" group had lower mean scores (9.57 ± 4.18), suggesting that regular study habits may help reduce physical stress symptoms associated with digital learning.

A statistically significant difference was also found in total DFS scores ($p = 0.006$). Students with regular study habits (M = 70.26 ± 23.53) had lower levels of digital fatigue compared to those who studied intensively before exams (M = 80.04 ± 22.96) and those without a study routine (M = 82.23 ± 22.41).

Regarding academic procrastination, significant group differences were also observed ($p < 0.001$). Students with no study routine had significantly higher TPS total scores (44.28 ± 7.60) than both of the other groups, indicating a stronger tendency toward procrastination among students lacking consistent study habits.

Table 5. Comparison of Digital Fatigue and Academic Procrastination Levels According to Daily Screen Time

Scale / Subscale	0–2 hours (n=5)	2–4 hours (n=53)	4–6 hours (n=102)	>6 hours (n=103)	p value
DFS – Digital Dependency	26.80 ± 9.73	32.23 ± 12.74	38.28 ± 9.82	41.41 ± 11.37	**<0.001***
DFS – Psychological Fatigue	14.40 ± 6.31	13.58 ± 6.92	14.53 ± 6.14	15.56 ± 6.92	0.346
DFS – Physical–Mental Fatigue	12.20 ± 4.09	12.75 ± 5.38	13.78 ± 4.85	16.07 ± 5.44	**<0.001***
DFS – Psychosomatic Problems	7.60 ± 4.10	8.72 ± 4.15	10.63 ± 3.65	11.73 ± 4.30	**<0.001***
DFS Total	61.00 ± 23.25	67.28 ± 25.57	77.23 ± 19.38	84.77 ± 23.63	**<0.001***
TPS Total	37.20 ± 5.81	39.43 ± 10.24	40.36 ± 7.12	43.98 ± 8.95	**0.002***

One-way ANOVA test was used. Bold and * indicates statistical significance. Post-hoc analyses were performed using Tukey's test, and significant group differences are described in the text.

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Digital Fatigue and Academic Procrastination According to Perceived Academic Achievement

Participants' levels of digital fatigue and academic procrastination differed significantly according to perceived academic achievement (**Table 4**). For academic procrastination, the differences among groups were statistically significant ($p < 0.001$). Students with "very low" and "low" perceived achievement had significantly higher TPS total scores (49.43 ± 8.36 and 46.73 ± 8.06, respectively) than those with "moderate" or "high" perceived achievement.

Similarly, significant differences were observed in total DFS scores across perceived achievement levels ($p = 0.003$). Students with low perceived achievement reported higher digital fatigue (91.17 ± 17.26) compared with those who rated their academic achievement as high (72.73 ± 22.07).

Subscale analyses revealed significant group differences for *Digital Dependency* ($p < 0.001$) and *Psychosomatic Problems* ($p = 0.007$). Post-hoc *Tukey* analyses indicated that students with "very low" and "low" perceived achievement had higher scores on these subscales, suggesting greater dependency and psychosomatic distress associated with digital learning. Differences in *Psychological Fatigue* ($p = 0.064$) and *Physical–Mental Fatigue* ($p = 0.163$) were not statistically significant, though mean scores were higher among students with lower perceived achievement in both dimensions.

Digital Fatigue and Academic Procrastination According to Daily Screen Time

Comparisons based on daily screen time revealed that both digital fatigue and academic procrastination levels increased significantly with longer screen exposure (**Table 5**). The total *Tuckman Procrastination Scale (TPS)* score differed significantly among screen-time groups ($p = 0.002$). Post-hoc *Tukey* analysis indicated that this difference was most pronounced between students with more than six hours of daily screen time and those with 0–4 hours of screen time.

Subscale analyses further demonstrated significant differences for *Digital Dependency* ($p < 0.001$), *Physical–Mental Fatigue* ($p < 0.001$), and *Psychosomatic Problems* ($p < 0.001$). Students with more than six hours of screen time scored significantly higher in these three subdimensions, indicating that prolonged digital exposure contributes not only to cognitive strain but also to physical exhaustion. Although the difference in the *Psychological Fatigue* subscale was not statistically significant ($p = 0.346$), mean scores showed an upward trend in line with increasing screen time.

Comparisons by Neuropsychiatric Diagnosis or Treatment Status

Participants' *Digital Fatigue Scale (DFS)* and *Tuckman Procrastination Scale (TPS)* scores were compared according to whether they reported having a neurological or psychiatric diagnosis or receiving treatment. Independent samples *t*-tests revealed no statistically significant differences between groups for either DFS or TPS total scores ($p > 0.05$ for both). The mean TPS score of students receiving treatment (41.42 ± 6.81) was almost identical to that of students without any diagnosis or treatment (41.55 ± 8.98). Similarly, digital fatigue levels did not significantly differ between these two groups (73.70 ± 25.35 vs. 78.47 ± 23.09; $p = 0.274$).

No significant differences were found across any DFS subscales. However, descriptive statistics showed a tendency for students without a diagnosis or treatment to have slightly higher digital fatigue scores across all subdimensions. This suggests that neuropsychiatric treatment status did not play a major role in explaining differences in fatigue or procrastination within this sample.

Digital Fatigue and Academic Procrastination According to Break Frequency During Study Sessions

Analyses based on the number of breaks taken per study hour revealed no statistically significant differences in either digital fatigue or academic procrastination levels across groups ($p > 0.05$ for all variables). Nevertheless, descriptive data indicated a trend toward higher total DFS and TPS scores as break frequency increased.

The *Digital Dependency* subscale approached statistical significance ($p = 0.053$), as did the *Psychosomatic Problems* subscale ($p = 0.063$). Although the overall TPS difference was not statistically significant, the highest mean procrastination score was observed among students who reported taking three or more breaks per study hour (M = 43.75 ± 8.06). This trend suggests that excessive fragmentation of study sessions may correspond with greater fatigue and procrastination tendencies, even if the differences did not reach statistical significance.

DISCUSSION

This study examined the relationship between digital fatigue and academic procrastination among preclinical medical students using a multi-center sample, revealing a strong and significant positive association between the

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two constructs. The findings indicate that as digital fatigue increases, students demonstrate a greater tendency to delay academic tasks—an effect particularly driven by the **Digital Dependency** dimension, which showed the strongest correlation among all subscales. These results suggest that the digitalization of learning environments affects not only the cognitive load of medical students but also their behavioral regulation and learning-related self-control processes. Considering that academic procrastination is widely conceptualized as a behavioral manifestation of **self-regulation failure** (4), the observed association between higher digital fatigue and increased procrastination appears theoretically coherent.

The strong positive relationship identified in this study aligns with and extends prior research linking technology-related behaviors to academic procrastination. Previous studies have demonstrated that mobile phone addiction, social media overuse, and problematic technology-dependent behaviors are associated with increased procrastination and poorer academic outcomes among medical students (6, 7). However, much of the existing literature has conceptualized digital overload indirectly through addiction-related constructs, rather than examining **digital fatigue as a multidimensional phenomenon**. In this regard, the present study makes a novel contribution by directly assessing digital fatigue using a validated scale that captures behavioral, psychological, physical, and psychosomatic components. The finding that Digital Dependency was more strongly associated with procrastination than psychological or physical fatigue suggests that **loss of control over digital engagement**, rather than fatigue symptoms alone, may be the primary driver of procrastinatory behavior (2, 7).

This interpretation is supported by recent studies conceptualizing excessive digital engagement as a form of behavioral dependency that undermines attentional control and goal-directed behavior. For example, Zhou et al. (11) describe academic cyberslacking as a dependency-like behavior among medical students, emphasizing how constant online connectivity disrupts sustained cognitive engagement. Similarly, a path analysis by Hamwai et al. (8) demonstrated that smartphone addiction contributes to academic procrastination indirectly through increased daytime fatigue and sleep insufficiency. Taken together, these findings suggest that digital dependency may function as a **behavioral mechanism** through which digital fatigue translates into procrastination, reinforcing a cycle of distraction, fatigue, and delayed task initiation.

When participants were categorized according to overall digital fatigue levels, approximately 60% reported low or very low fatigue, whereas nearly 40% experienced moderate to very high levels. This distribution indicates that digital fatigue is not uniformly experienced among preclinical medical students but rather concentrated within a vulnerable subgroup. Similar patterns have been reported in post-pandemic studies, which highlight the persistence of digital fatigue even after the return to hybrid or face-to-face education (1). More recent evidence suggests that digital fatigue may mediate the relationship between digital overload and academic functioning, amplifying procrastination tendencies particularly among students with lower life satisfaction and diminished recovery opportunities (12).

The inter-university differences observed in this study further underscore the contextual nature of digital fatigue. Students from Çukurova University exhibited higher levels of both digital fatigue and academic procrastination compared with their peers from İzmir Kâtip Çelebi University, suggesting that institutional factors such as curriculum intensity, assessment frequency, instructional design, and digital infrastructure may shape students' digital experiences. This supports the view that digital fatigue is not merely an individual psychological condition but also an **educational systems issue**. Similar conclusions have been drawn in recent multi-institutional studies emphasizing the role of learning environment design in moderating digital stress and academic engagement (13). However, due to the cross-sectional nature of the present study, causal interpretations remain limited and warrant longitudinal investigation.

Consistent study habits emerged as a clear protective factor against both digital fatigue and academic procrastination. Students who reported studying regularly demonstrated significantly lower digital dependency and psychosomatic fatigue, as well as reduced procrastination tendencies. These findings align with self-regulated learning theories, which emphasize structured routines, goal setting, and time management as key buffers against cognitive overload and behavioral disengagement. Recent research in hybrid medical curricula has similarly shown that effective learning strategies are associated with lower procrastination and improved academic resilience (9). Together, these results suggest that promoting structured study routines may reduce unregulated digital engagement and mitigate the adverse effects of digitally intensive education.

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The inverse relationship between perceived academic achievement and both digital fatigue and procrastination further supports this interpretation. Students with lower perceived academic success exhibited higher digital dependency and psychosomatic symptoms, suggesting that diminished academic self-confidence may lead to less purposeful and more fragmented use of digital tools. This pattern is consistent with findings indicating that problematic technology use is associated with reduced academic self-efficacy and poorer perceived performance (2). Given the subjective nature of perceived achievement, future studies should integrate objective indicators such as GPA to clarify these relationships.

Daily screen time also emerged as a significant determinant of both digital fatigue and academic procrastination. Students reporting more than six hours of daily screen exposure exhibited markedly higher levels of digital dependency, physical–mental fatigue, psychosomatic problems, and procrastination. These findings are consistent with recent evidence demonstrating that prolonged screen exposure contributes not only to cognitive exhaustion but also to behavioral disengagement and health-related complaints among medical students (8). Importantly, emerging literature suggests that digital fatigue may act as a **mediator**, intensifying the negative effects of digital distraction on academic performance (14).

Although no statistically significant differences were found with respect to break frequency, the observed trend toward higher fatigue and procrastination with increasing numbers of breaks is noteworthy. Near-significant findings in the Digital Dependency and Psychosomatic Problems subscales suggest that the **quality and content of breaks**, rather than their frequency, may be more influential. Breaks that involve continued screen exposure—such as social media browsing—may fail to provide cognitive restoration and may even exacerbate digital strain. This interpretation is supported by recent studies on Zoom fatigue, which indicate that screen-based breaks do not effectively reduce exhaustion (3). Future qualitative or mixed-method studies should therefore explore the nature of digital versus non-digital breaks in greater depth.

No statistically significant differences were observed in DFS or TPS scores between students with and without a neuropsychiatric diagnosis or treatment history. However, the absence of statistical significance should not be interpreted as definitive evidence of no association. This finding may reflect limited statistical power due to subgroup sizes, potential heterogeneity within diagnostic categories, or the self-reported nature of psychiatric history. Therefore, rather than indicating a true lack of difference, these results should be interpreted cautiously within the context of measurement and sampling limitations (8). Future studies with larger and clinically stratified samples, as well as verified diagnostic data, are warranted to clarify whether specific neuropsychiatric conditions differentially influence digital fatigue and procrastination patterns.

Although no statistically significant differences were observed based on break frequency during study sessions, the trend toward higher digital fatigue and procrastination scores with increasing number of breaks is noteworthy. Near-significant results for the *Digital Dependency* and *Psychosomatic Problems* subscales suggest that the *quality* of breaks, rather than their quantity, may be more influential. Breaks that involve continued screen exposure—such as browsing social media or messaging—may fail to provide the expected restorative effects and could even exacerbate digital strain. Therefore, future qualitative or mixed-method studies should explore the content and experience of so-called "digital breaks" to better understand how they influence recovery and self-regulation in technology-intensive learning contexts.

Study Limitations

This study has several limitations that should be acknowledged. The cross-sectional design restricts causal interpretations of the observed associations between digital fatigue and academic procrastination. In addition, the data were based on self-report measures, which may introduce bias, particularly regarding variables such as screen time and perceived academic achievement. Furthermore, the sample was limited to two universities, which may constrain the generalizability of the findings to broader medical student populations.

Despite these limitations, the study also presents notable strengths. Its multicenter design enhances external validity, and the use of psychometrically validated instruments ensures the reliability of the findings. Importantly, this research is among the few to conceptualize and assess *digital fatigue* as a multidimensional construct—encompassing physical, psychological, and behavioral aspects—rather than relying on indirect measures such as social media or smartphone addiction.

Future research should adopt longitudinal designs to examine directional relationships and potential causal

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pathways. Objective measurement of screen time, such as through device tracking data, would improve data accuracy. Moreover, incorporating objective academic indicators like grade point average (GPA) could complement self-reported academic performance. Experimental and interventional studies focusing on self-regulation, time management, digital hygiene, and learning environment design are particularly recommended to evaluate their potential to mitigate digital fatigue and procrastination in medical education settings.

CONCLUSION

This study demonstrated a significant and strong relationship between digital fatigue and academic procrastination among medical students, emphasizing the need to consider digital fatigue as a critical variable in sustaining the quality and well-being of learning experiences within increasingly digitalized medical education environments. The findings highlight that higher levels of digital dependency and prolonged screen exposure are closely associated with stronger tendencies toward academic procrastination.

The inter-university differences observed in this study may reflect contextual and institutional variations; however, the present data do not allow direct conclusions regarding the specific mechanisms underlying these differences. Although factors such as curriculum intensity, assessment structure, instructional design, and digital infrastructure are plausible explanatory variables, these interpretations remain speculative and should be considered hypothesis-generating rather than evidence-based conclusions. Future multi-center studies incorporating objective institutional indicators are needed to examine how structural characteristics of medical education environments may influence digital fatigue and academic procrastination.

Collectively, these findings underscore the importance of implementing educational strategies that foster self-regulation skills and digital hygiene practices to help students manage their cognitive and behavioral engagement with digital learning tools. Integrating such competencies into medical education may enhance students' resilience and efficiency in digitally intensive academic environments.

Future research should employ longitudinal designs to clarify the directionality and underlying mechanisms linking digital fatigue and academic procrastination. Additionally, intervention studies evaluating the effects of targeted educational approaches—such as self-regulation training, digital hygiene programs, and curriculum designs aimed at reducing cognitive load—would provide valuable evidence to inform medical education practices and promote sustainable digital learning.

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Authorship contributions
Study conception and design: ÇO, DBS, FİT;
Data Collection and processing: ÇO, DBS, ZYÖ, FİT, SY;
Analysis and interpretation of results: ÇO, DBS, ZYÖ, FIT, SY;
Literature Search: ÇO, DBS, ZYO, FIT, SY;
Writing: ÇO, DBS, ZYÖ, FİT, SY. All authors reviewed the results and approved the final version of the manuscript.

Data availibity statement
The data supporting the findings of this study are available from the corresponding author upon reasonable request

Declaration of competing interest
The authors declare no competing interests.

Ethics
This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Çukurova University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee (Meeting No: 158, Decision No: 53, Date: 12.09.2025). Participation in the study was voluntary, and informed consent was obtained from all participants prior to data collection. The confidentiality and anonymity of participants were strictly maintained throughout the study, and all collected data were used solely for scientific research purposes.

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