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Influence of digital behavior and sleep quality on periodontal status in adolescents: a cross-sectional study

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Abstract

Background Internet addiction (IA) and poor sleep quality are increasingly recognized as behavioral risk factors that may influence adolescents' overall and oral health. Adolescence represents a critical period for establishing lifelong oral hygiene behaviors, and gingival inflammation is highly prevalent in this age group. This study aimed to evaluate the association between IA, sleep quality, and clinical periodontal parameters among adolescents.

Methods This cross-sectional study included 100 systemically healthy adolescents (aged 12–18 years). The sample consisted of both male (47%) and female (53%) participants, predominantly of Turkish ethnicity based on native language, representing middle socioeconomic backgrounds. Data on internet use patterns and sleep quality were collected using the Young Internet Addiction Test (IAT) and the Pittsburgh Sleep Quality Index (PSQI), respectively. Clinical periodontal parameters, including Gingival Index (GI), Plaque Index (PI), Probing Pocket Depth (PPD), and Bleeding on Probing (BoP), were measured by a calibrated examiner.

Results Adolescents with poor sleep quality exhibited significantly higher GI and PI scores ($p=0.025$ and $p=0.024$, respectively). Additionally, the mean IAT score was significantly higher in adolescents with poor sleep quality ($p=0.032$). A high frequency of internet use (> 28 h/week) was more prevalent in this group ($p=0.020$).

Conclusions The findings suggest that poor sleep quality and IA may be associated with poorer periodontal health in adolescents. These results emphasize the importance of considering behavioral factors such as digital media exposure and sleep patterns in the clinical assessment and prevention of periodontal diseases during adolescence. However, due to the cross-sectional design of the study, no causal inference can be made. Future longitudinal studies are needed to validate these associations and improve clinical relevance.

Keywords Adolescent, Internet addiction, Periodontal health, Plaque index, Sleep quality

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Background

Sleep is essential for maintaining systemic balance, including immune responses, hormone regulation, cardiovascular stability, and mental functioning [1]. In adolescents, who are undergoing critical physical and psychological development, adequate and high-quality sleep is particularly essential. However, modern lifestyles—especially those involving prolonged screen exposure and digital media engagement—have led to a growing prevalence of sleep disturbances in this age group [2, 3].

One of the behavioral patterns increasingly associated with poor sleep quality is excessive internet use. Internet addiction (IA), characterized by an inability to control one's internet use despite negative consequences, has been linked to disrupted circadian rhythms, reduced sleep duration, and increased daytime dysfunction [4, 5]. In the present study, this construct was assessed using the Young Internet Addiction Test (IAT), a validated tool widely employed in adolescent populations to evaluate the severity of internet-related behavioral dependency [6]. According to national reports, internet usage among adolescents continues to rise sharply. For instance, the Turkish Statistical Institute reported that the rate of internet use in individuals aged 16–24 was 87.5% in 2016 [7]. This increased to 92.4% in 2019 and reached 96.9% by 2022, highlighting a rapid and ongoing increase in digital media engagement among young people [8, 9].

Importantly, insufficient and poor-quality sleep may also impair self-care behaviors, including oral hygiene practices, dietary routines, and attention to health-related habits. Inadequate sleep has been associated with higher levels of systemic inflammation and may indirectly affect periodontal tissues, making adolescents more susceptible to gingival inflammation and plaque accumulation [10–12]. Furthermore, IA may compound these effects by encouraging sedentary behaviors, delaying meal times, and reducing attention to daily routines such as tooth brushing or dental check-ups [13, 14]. Adolescents are a key population because they experience rapid psychological and behavioral changes during development. These shifts can directly affect their sleep patterns and digital media habits, which in turn may increase their vulnerability to periodontal problems.

Previous studies have examined the association of digital behavior and sleep quality with general and oral health outcomes in adolescents and young adults. For instance, a national survey of 73,238 Korean adolescents reported that IA was linked to poorer self-reported oral health and lower frequency of toothbrushing [15]. Another recent cross-sectional study of Peruvian schoolchildren found that IA negatively affected oral-health-related quality of life, with unhealthy lifestyle behaviors (e.g., poor sleep, irregular diet) acting as mediators [16]. Similarly, a large-scale study in Japan demonstrated that IA was associated with higher dental caries via lifestyle changes [14]. Notably, none of these studies employed clinically assessed periodontal indices in adolescents to evaluate the combined effects of IA and sleep quality.

This unpredictability and the lack of clinical periodontal assessments in previous research underscore the novelty and necessity of our study, which aims to fill this methodological gap by concurrently examining IA, sleep quality, and clinical periodontal health in a Turkish adolescent population.

Methods

This cross-sectional study evaluated patients who visited the Istanbul Medipol University, Faculty of Dentistry, Department of Periodontology for routine dental examinations and periodontal treatment between the dates of September 2019 and September 2024. However, participant recruitment and data collection were carried out only during specific intervals within this timeframe due to disruptions caused by the COVID-19 pandemic. No data were collected during periods of active pandemic-related restrictions (e.g., lockdowns, school closures). Recruitment resumed only after daily life and institutional operations returned to a relatively stable and routine state. Therefore, the potential behavioral and psychological impacts of the pandemic were minimized, and temporal variation was limited. The study population consisted of adolescents aged 12–18 years living in Istanbul, Türkiye, primarily of Turkish ethnicity. The present study was granted ethical approval by institutional ethics committee in accordance with applicable national regulations and conducted in accordance with the guidelines of the Helsinki Declaration of 1975, as revised in 2008. All participants and their parents or legal guardians were informed both verbally and in writing about purpose of the study and their written consent was obtained. Systemically healthy participants who did not use antibiotics in the last 6 months, did not smoke, and had at least 20 teeth in their mouth were included in this study. At the time of study design, no prior clinical studies had evaluated the combined relationship between sleep quality, IA, and periodontal health using objective measures in adolescents. Therefore, a reliable effect size for sample size estimation was not available, and the final sample of 100 participants (50 with poor sleep quality and 50 with good sleep quality) was based on the number of eligible individuals recruited during the data collection period.

Data were collected using a structured questionnaire divided into three sections: sociodemographic information, the Young IAT, and the Pittsburgh Sleep Quality Index (PSQI). Face-to-face interviews were conducted by trained researchers. Participants' general characteristics including age, gender, height/weight, grade were obtained. Perceived family economic status and

perceived academic achievement were assessed with responses classified into "high," "middle," and "low". These data were obtained through self-reported responses provided by the participants. Questions were asked about internet access, such as "do you have a computer?", "do you have internet access at home?", and "weekly internet usage hours." In addition, the purposes for which the participants used the internet and how often they used it were assessed with a 5-point Likert-type question, "never," "rarely," "sometimes," "often," and "always." In order to assess the participants' oral hygiene habits, they were asked about their frequency of brushing their teeth, using dental floss or interdental brushes, their use of mouthwash, and the time they last visited the dentist.

Developed by Young [6], the IAT comprises 20 questions designed to evaluate the frequency of internet-related behaviors. Each item is rated on a 6-point Likert scale, with options ranging from 'never' to 'always.' The total possible score spans from 0 to 100, with higher values indicating greater severity of internet use problems. Scores between 20 and 49 are classified as "average internet user (non-risky user)", scores between 50 and 79 as "internet user who rarely has problems (risky user)", and scores between 80 and 100 as "internet user who often has problems (addicted user)". The Turkish version of the scale was previously applied among adolescents by Bayraktar and Gün, who reported a Cronbach's alpha reliability coefficient exceeding 0.80 [17].

The PSQI is a self-reported instrument that evaluates sleep characteristics and disruptions over a one-month period [18]. The questionnaire contains 24 items in total, with 19 addressed by the respondent and 5 completed by a parent or roommate. Of these, 18 contribute to the final score. Seven distinct domains are scored from 0 to 3, and the cumulative score is calculated by summing the domain scores. A score of 5 or below reflects good sleep quality, while scores above 5 suggest poor sleep quality. The Turkish validity-reliability study of the scale was conducted by Ağargün et al. and Cronbach's alpha internal consistency coefficient was calculated as 0.80 [19].

Clinical periodontal parameters were assessed by a single calibrated examiner who was blinded to the questionnaire data. The examiner was calibrated by performing duplicate periodontal measurements on 10 adolescents who were not included in the main study. The measurements were repeated after a 1-week interval to assess intra-examiner reliability. The intraclass correlation coefficients (ICCs) were calculated and found to be above 0.85 for all clinical parameters, indicating high consistency. To determine the periodontal status, the following indices were recorded: Plaque Index (PI), Gingival Index (GI), Probing Pocket Depth (PPD), and Bleeding on Probing (BoP). Measurements were obtained from six sites per tooth for all present teeth using the Williams periodontal probe. PI was used to determine the oral hygiene level of all individuals. The gingival index was used to assess inflammation, ranging from 0 for healthy gingiva to 3 for severe inflammation with spontaneous bleeding. PPD is measured by placing the Williams periodontal probe parallel to the long axis of the tooth into the sulcus and is expressed in millimeters. Following the measurement of PPD, the presence of bleeding at the site was recorded as BoP (+).

Data were analyzed with IBM SPSS V23. The Kolmogorov-Smirnov test was used to examine the conformity of the data to normal distribution. Mann Whitney U test was used to analyze the data that did not follow normal distribution in two groups. Independent samples t test was used to analyze the data that followed normal distribution in two groups. Fisher's Exact test, Pearson chi-square, Yates correction and Fisher-Freeman-Halton Test were used to examine the relationship between categorical data. The significance level was taken as $p < 0.05$.

Results

There was no statistically significant relationship between gender and the groups ($p = 1.000$). In the poor sleep quality group, 52% of participants were female and 48% were male. In the good sleep quality group, 54% of participants were female and 46% were male. The mean age, weight, and height of all participants were 15.6 ± 1.72 years, 57.9 ± 14.5 kg, and 165.2 ± 11.01 cm, respectively. There were no statistically significant differences between groups in terms of age, weight, and height (Table 1).

There was no statistically significant relationship between the groups in terms of tooth brushing, interdental brushing, last dentist visit, gingival bleeding report, smoking, socioeconomic status, and academic success (p=0.363), (p=1.000), (p=0.678), (p=0.266), (p=0,059), (p=0,940), (p=0,603) (Table 2).

There is no statistically significant relationship between the groups and whether there is a computer at home, the frequency of internet access, and the age of internet use (p=1.000), (p=0.809), (p=0.224). There is a statistically significant relationship between the groups and the weekly internet use hours (p=0.020). The rate of those who use the internet more than 28 hours per week in the poor sleep group is 30% and the rate of those who use the internet more than 28 hours per week in the good sleep group is 6%. When the multiple comparison results of the rates are examined, this difference is due to the difference in the rates according to the groups that use the internet more than 28 hours per week (Table 3).

When the total IAT score average value of the participants was compared with their sleep quality, there was a significant difference. Accordingly, the IAT scores of the participants with poor sleep quality were found to be statistically significantly higher than those with good sleep

Table 1 Comparison of participants' demographic characteristics by groups

	Group		Total ($n=100$)	p*
	Poor sleep quality ($n=50$)	Good sleep quality ($n=50$)		
Sex, n (%)				
Female	26(52)	27(54)	53(53)	1.000†
Male	24(46)	23(46)	47(47)	
Age, years (mean ± SD)	15.86 ± 1.71	15.5 ± 1.73	15.6 ± 1.72	0.242*
Weight, kg (mean ± SD)	59 ± 14.1	56.8 ± 14.9	57.9 ± 14.5	0.446*
Height, cm (mean ± SD)	166.6 ± 11.3	163.9 ± 10.7	165.2 ± 11.01	0.233**

SD Standard deviation

†Yates's correction

*Mann Whitney U test, median(min-max)

**Independent sample t testi

Table 2 Relationship between sleep quality and oral health behaviors, dental attendance, smoking, socioeconomic status, and academic performance

	Group			Test statistic	p
	Poor Sleep	Good Sleep	Total		
Tooth brushing					
None	5 (10)	2 (4)	7 (7)	3.859	0.363**
1	19 (38)	18 (36)	37 (37)		
2 or more	13 (26)	20 (40)	33 (33)		
Irregular	13 (26)	10 (20)	23 (23)		
Interdental brushing					
No	47 (94)	48 (96)	95 (95)	-	1.000*
Yes	3 (6)	2 (4)	5 (5)		
Last dental visit					
None	5 (10)	3 (6)	8 (8)	2.314	0.678**
6 months ago	30 (60)	28 (56)	58 (58)		
1 year ago	9 (18)	8 (16)	17 (17)		
2 year ago	4 (8)	6 (12)	10 (10)		
5 year or more	2 (4)	5 (10)	7 (7)		
Gingival bleeding					
No	18 (36)	25 (50)	43 (43)	1.469	0.266***
Yes	32 (64)	25 (50)	57 (57)		
Smoking					
No	43 (86)	49 (98)	92 (92)	-	0.059*
Yes	7 (14)	1 (2)	8 (8)		
Socioeconomic status					
Low	5 (10)	4 (8)	9 (9)	0.124	0.940**
Middle	39 (78)	40 (80)	79 (79)		
High	6 (12)	6 (12)	12 (12)		
Academic performance					
Low	2 (4)	2 (4)	4 (4)	1.011	0.603**
Middle	40 (80)	36 (72)	76 (76)		
High	8 (16)	12 (24)	20 (20)		

*Fisher's exact test

**Pearson chi-square test

***Yates's correction

quality ($p=0.032$). Total IAT score categorical variable does not differ according to the groups ($p=0.074$). While 26.5% of the participants with poor sleep quality were found to be addicted, 5% of the participants with good sleep quality were found to be addicted to the internet (Table 4).

When clinical periodontal parameters were compared between the groups, GI and PI scores were found to be statistically significantly higher in participants with poor sleep quality ($p=0.025$, $p=0.024$). There was no difference between the groups in terms of BoP and PPD mean values (Table 5). Effect sizes (Cohen's d) were calculated

Table 3 Comparison of internet access and usage characteristics between groups

	Group			Test statistic	*p*
	Poor Sleep	Good Sleep	Total		
Availability of a home computer					
No	13 (26)	13 (26)	26 (26)	0.000	1.000*
Yes	37 (74)	37 (74)	74 (74)		
Frequency of internet access					
Always	40 (80)	38 (76)	78 (78)	0.058	0.809*
Occasionally	10 (20)	12 (24)	22 (22)		
Age at first internet use					
< 12 years	32 (64)	26 (52)	58 (58)	1.026	0.224*
≥ 12 years	18 (36)	24 (48)	42 (42)		
Total weekly internet usage time					
1–2 h	2 (4)	7 (14)	9 (9)	11.622	**0.020****
2–7 h	13 (26)	14 (28)	27 (27)		
7–14 h	12 (24)	15 (30)	27 (27)		
21–28 h	8 (16)	11 (22)	19 (19)		
> 28 h	15 (30)[a]	3 (6)[b]	18 (18)		

*Yates's correction Fisher-Freeman-Halton Test

[a–b]Values that do not share the same superscript letter are significantly different ($p < 0.05$), based on post-hoc comparisons

Table 4 Comparison of total IAT scores by groups

	Poor Sleep	Good Sleep	Test statistic	*p*
Total IAT Scores	36.2 ± 19.5	28.2 ± 16,8	2.179	0.032 *
Non-risky user	12 (24.5)	19 (38)	5.207	0.074**
Risky user	24 (49)	26 (52)		
Addicted user	13 (26.5)	5 (10)		

*Independent samples t-test, mean ± standard deviation

**Pearson chi-square test

Table 5 Comparison of clinical periodontal parameters according to groups

Variables (mean ± SD)	Poor Sleep	Good Sleep	Test statistic	*p**
GI	1.25 ± 0.52	1.03 ± 0.42	2.276	0.025
PI	1.34 ± 0.41	1.14 ± 0.44	2.294	0.024
PPD	1.81 ± 0.33	1.74 ± 0.27	1.207	0.230
BoP	40.62 ± 21.95	33.24 ± 16.94	1.882	0.063

SD Standard deviation

*Independent samples t-test

for the comparisons between the sleep quality groups. The effect sizes were 0.47 for GI, 0.47 for PI, and 0.44 for IAT scores, indicating moderate group differences.

Discussion

In this cross-sectional study, we evaluated the relationship between internet use, sleep quality, and periodontal health among adolescents. Our findings demonstrated that poor sleep quality was significantly associated with higher scores of GI and PI, as well as elevated IAT scores and longer weekly internet usage. These findings contribute to the growing body of literature indicating that lifestyle habits influenced by IA may indirectly impact oral health outcomes.

Our study revealed that adolescents with poor sleep quality spent significantly more time on the internet, with 30% exceeding 28 h per week, compared to only 6% in the good sleep quality group. These findings align with those of Ahmed et al. (2022), who demonstrated that children who spent more than 6 h per day on internet gaming had the poorest sleep quality (75%) and showed more emotional symptoms and hyperactivity [20]. This supports the hypothesis that excessive digital engagement during late hours may impair sleep and emotional regulation, further reinforcing the risk of IA in adolescents. This aligns with another study conducted in 2023, which found a link between social media use and poor sleep quality among adolescents [21]. Furthermore, participants with poor sleep had higher mean IAT scores, indicating a greater risk of IA. One plausible explanation for higher internet use and IAT scores in adolescents with poor sleep may be the displacement of sleep time by late-night screen exposure. Blue light emitted by digital devices can disrupt circadian rhythms, delay melatonin secretion, and reduce sleep efficiency [22]. Such physiological disruptions, combined with interrelated emotional and behavioral patterns, may not only reinforce each other but also contribute to neglect in daily self-care routines, including oral hygiene. Previous studies by Lam [23] and by Do and Lee [15] have supported this relationship, showing a bidirectional association between IA and sleep disturbances. These disruptions have also been shown to impact oral health outcomes through both direct and indirect pathways.

Research suggests that adequate sleep contributes to the regulation of the immune system and inflammatory pathways, including those affecting oral tissues. When

sleep is disrupted, the body may produce higher levels of inflammation-related molecules, potentially contributing to the development of periodontal diseases [1]. Our findings support this biological plausibility, as participants with poor sleep quality showed significantly higher levels of GI and PI, reflecting increased gingival inflammation and plaque accumulation. Consistent with our results, a nationally representative U.S. study by Alqaderi et al. found that adults who slept more than seven hours per night were significantly less likely to exhibit severe periodontitis [24]. Notably, this relationship was stronger in individuals with diabetes, indicating that sleep duration may modulate systemic inflammation pathways that impact periodontal health. Although the differences in PPD and BoP were not statistically significant, this may be attributed to the early-stage nature of periodontal disease in adolescents, where clinical signs such as PPD and bleeding may not yet be pronounced. Additionally, the duration of exposure to risk factors such as poor sleep and digital overuse may have been insufficient to cause measurable periodontal breakdown at this stage. As age increases and these behavioral exposures persist, periodontal inflammation may progress, potentially leading to alveolar bone destruction and more pronounced differences in these parameters over time.

Interestingly, while the present study did not find statistically significant differences in oral hygiene behaviors such as brushing frequency or interdental cleaning between groups, previous literature indicates a possible association between excessive internet use and deterioration in oral health habits. For instance, Do et al., in a large-scale national survey of Korean adolescents, found that those with high internet use were significantly less likely to engage in preventive oral hygiene behaviors, including post-lunch tooth brushing [25]. Supporting this, a study by Al-Ansari et al. demonstrated that IA was associated with reduced tooth brushing frequency and poorer self-perceived oral health among young adults [26]. One possible explanation for this discrepancy may lie in the behavioral patterns associated with excessive internet use, particularly the increased desire to return to social media platforms. This digital engagement may lead to more hurried or less effective tooth brushing routines. Although no statistically significant differences were observed in tooth brushing frequency between groups, we observed significantly higher GI and PI scores in the poor sleep quality group, which may reflect the quality or thoroughness of oral hygiene practices. These discrepancies may also stem from differences in sample characteristics, cultural practices, or how oral hygiene behaviors are operationalized across studies. Moreover, our findings may suggest that while overt hygiene behaviors such as brushing frequency appear unaffected, other mediating factors—such as psychological stress, behavioral regulation difficulties, sleep disruption, or immune dysregulation—could play a more pivotal role in influencing periodontal outcomes.

The lack of significant differences in socioeconomic status, academic achievement, and smoking status between groups strengthens the argument that internet use and sleep quality themselves are likely the major contributing factors in the observed differences in periodontal health. These findings also highlight the importance of multidisciplinary approaches, integrating dental, psychological, and behavioral assessments when addressing adolescent health. A notable strength of our study lies in the use of clinical periodontal examination rather than relying solely on self-reported measures. This enables a more objective assessment of oral health status, filling a notable gap in the current literature. Previous studies evaluating IA and oral health often lack clinical verification of periodontal status, thereby limiting the accuracy of their findings.

Conclusion

In conclusion, our findings suggest a significant relationship between internet usage, sleep quality, and periodontal health in adolescents. Poor sleep quality, which was found to be associated with higher internet usage and addiction risk, was also associated with poorer periodontal outcomes, particularly increased PI and GI scores. These findings highlight the importance of awareness and preventive strategies targeting digital behavior and oral hygiene in adolescents as part of comprehensive oral health promotion efforts.

This study has certain limitations. As it was designed cross-sectionally, it precludes the ability to determine causal relationships. Additionally, several unmeasured behavioral and physiological factors—such as stress levels, dietary patterns, and physical activity—may have influenced both sleep quality and periodontal outcomes, potentially confounding the observed associations. For example, increased stress may worsen sleep and impair immune response, while dietary habits and physical inactivity are known to affect both systemic inflammation and oral health. The absence of these variables in the present analysis should be considered when interpreting the results. In addition, perceived family economic status and academic achievement were based on self-reported data, which may be subject to reporting bias or misclassification. Furthermore, participant recruitment was interrupted during periods of COVID-19-related restrictions, and resumed only after daily routines normalized. Although this minimized the pandemic's acute impact, some degree of temporal variation could not be completely excluded. Future longitudinal and multi-centered studies including broader behavioral assessments are recommended to confirm and expand upon these results.

Abbreviations

BOP	Bleeding on probing
GI	Gingival index
IA	Internet addiction
IAT	Internet addiction test
PI	Plaque index
PPD	Probing pocket depth
PSQI	Pittsburgh sleep quality index

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Authors' contributions
N.A. contributed to conceptualization, investigation, methodology, and writing (original draft and review & editing). S.Ş. contributed to conceptualization and investigation. E.Y. contributed to methodology and writing (review & editing). All authors have read and approved the final version of the manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. Requests for data access should be directed to Dr. Nurcan Aksaka (Istanbul Medipol University, School of Dentistry, Department of Periodontology, TEM Avrupa Otoyolu Göztepe Çıkışı No. 1, 34214 Bağcılar, Istanbul, Turkey; email: [naltas@medipol.edu.tr]).

Declarations

Ethics approval and consent to participate
This study was approved by the Istanbul Medipol University Ethics Committee (approval no: 679, approval date: 25.09.2019). Written informed consent was obtained from all participants included in the study. In the case of participants under the age of 16, informed consent was obtained from their parents or legal guardians. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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