ORIGINAL ARTICLE

Does the Usage Habits of Smart Wireless Devices Affect Educational Status and Sleep Quality? The Results of an Anonymous Questionnaire of Iranian High School Students

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ABSTRACT

Objectives

The increasing popularity of wireless smart devices among adolescents has raised concerns about their possible negative effects on academic performance, phone addiction, and sleep disorders. In particular, this issue is of special importance in Iran because some studies have shown that more than 50% of Iranian adolescents are addicted to mobile phones according to the criteria of the Smartphone Addiction Scale-Short Version (SAS-SV). This study aimed to investigate the relationship between daily use time and/or exposure to wireless smart devices and some educational and psychological factors in high school students.

Materials & Methods

This study was conducted on anonymous Iranian high school students using an online questionnaire. Only students aged 14 to 18 who owned personal smart devices were included in this study.

Results

Twenty-nine participants met the inclusion criteria. The results showed that female students used these devices more frequently than male students, and having multiple devices had negative effects on educational performance, phone addiction, and sleep disorders. Sleeping next to wireless devices also negatively impacts sleep quality.

Conclusion

This study highlights the need to promote healthy device usage habits among adolescents.

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Introduction

The popularity of smartphones, tablets, smartwatches, and other wireless devices among adolescents has grown exponentially in recent years. For instance, a 2018 study showed that 95% of American adolescents had access to a smartphone, and approximately half of them used the Internet regularly (1). This issue transcends the boundaries of a prominent economic superpower like the United States and is pertinent to all countries worldwide. For example, a 2014 study (2) of 5,366 12- to 18-year-old Asian adolescents from six countries (China, Hong Kong, Japan, South Korea, Malaysia, and the Republic of the Philippines) showed that up to 84% of them owned a smartphone. Undeniably, this can cause many concerns about the effects of overuse of these smart devices on the educational status of adolescents, as well as their psychological indicators.

Phone addiction in Iranian adolescents

Statistics on the excessive use of wireless communication devices, such as smartphones and tablets, in Iran are genuinely concerning. For instance, a 2022 study (3) on 585 Iranian adolescents showed that the participants spent an average of 6.85 hours a day on smartphones, and 53.3% of them, according to the criteria of the Smartphone Addiction Scale-Short Version (SAS-SV), were diagnosed with phone addiction.

The adverse consequences of phone addiction in adolescents

Problematic mobile phone use (PMPU) is described with several symptoms, ranging from the risk of being in situations prohibited for under-18 adolescents to frequent and unreasonable checking of the smartphone, sleep disorders or insomnia, decreased interest in other activities, and anxiety (4) — a condition that can disrupt education and affect the academic performance of adolescents. The present study's primary goal in conducting the current research was to find an answer to six specific questions:

1. What is the relationship between the daily usage time of wireless smart devices (mobile phones, tablets, and smartwatches) and the educational status of students, their phone addiction status, and the rate of sleep disorders among them?
2. Are the usage habits of wireless smart devices among high school students dependent on their gender?
3. Is gender effective in the scores related to sleep disorders and phone addiction?
4. Does having more than one smart device affect students' educational status, their phone addiction, and their sleep disorders?
5. Does sleeping next to a mobile phone affect the rate of students' sleep disorders?
6. Does nightly sleeping with a switched-on Wi-Fi router affect the rate of students' sleep disorders?

Materials & Methods

Research strategy

The present study first placed advertisements on Iranian students' social networks and then asked high school students to complete a 35-question online questionnaire anonymously. The procedure was that the students first installed a simple application called "App Usage — Manage/Track Usage" (approved by the Google Play Store) (5), and then, after a one-month break, they completed an online anonymous questionnaire (Table 1 and Figure 1).

No identifying information about the anonymous participants was collected, as clearly communicated when they volunteered to fill out the form—additionally, completing the form

Table 1. Parameters examined in the questionnaire

Parameter	Description
Checking the frequency of the smart device	The average number of daily checks of the phone in the last month was obtained from the participants.
Daily usage time	The average daily usage time in the last month was taken from the participants.
Educational information	Non-sensitive educational information was collected from the participants, including age, gender, high school grade, and GPA of the previous semester.
Information about wireless electronic devices	Non-sensitive information related to wireless communication devices was collected from the participants, including having or not having wireless smart devices (Cell phones, tablets, and smartwatches) and their numbers; having or not having a Wi-Fi router; turning on or off the Wi-Fi router while sleeping at night; placing or not placing wireless devices near the pillow (at a distance of less than one or two meters).
Sleep quality assessment questionnaire	Nine questions from the PSQI questionnaire
Questionnaire to assess the level of mobile phone addiction	Twenty CPDQ questionnaire questions

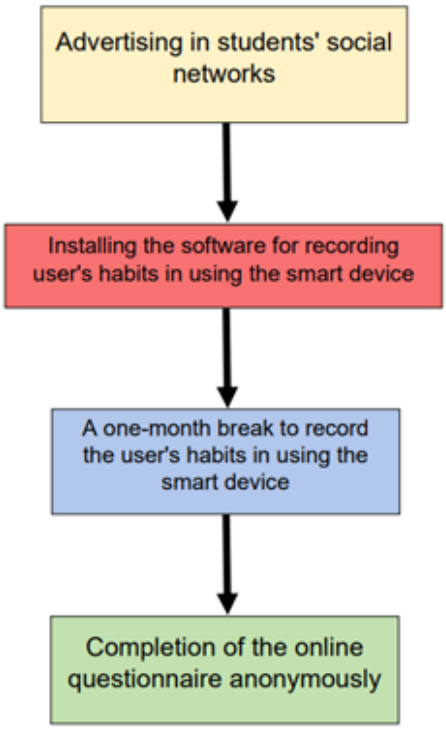

Figure 1. Flowchart of the steps of research

required participants to confirm their consent.
PSQI scale.

The Pittsburgh Sleep Quality Index (PSQI) is a questionnaire designed to assess a person's sleep quality over the past 30 days. In this questionnaire, 19 items are examined in seven separate components, including sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction. Each component has three points that comprise a global score (called the "PSQI global score). This global score ranges from 0 to 21, and the designers have suggested that scores above five are considered significant sleep disorders. Furthermore, PSQI has an internal consistency and reliability coefficient (Cronbach's alpha) of 0.83 for its seven components, indicating high reliability (6).

Modified CPDQ scale

The Cellular Phone Dependence Questionnaire (CPDQ) is a 20-question self-rating questionnaire introduced in 2004 as a helpful scale for rating cell phone dependence. A scoring scale of 0 to 3 is used to answer each question, and a higher overall score indicates more dependence on mobile phones. Besides, the reliability coefficient (Cronbach's alpha) for the CPDQ was reported by its designers as 0.86, indicating its significant reliability (7). Since this questionnaire was designed in 2004 when using mobile phones was mostly limited to simple mobile phones and not smartphones, this study made minor changes after translating it from Japanese while maintaining the general approach. In this way, the results became suitable for today's smart devices. The details of the modified questions are listed in Table 2.

Table 2. Modified CPDQ questionnaire

Number	Question
1	Paying for my mobile phone is more important to me than food and clothes.
2	If I leave my mobile phone, I feel restless all day.
3	I feel more upset about losing my mobile phone than losing my wallet.
4	I have to charge my mobile phone every day.
5	I don't want to go to places with a weak mobile antenna.
6	When I get on the subway or bus, I work on my mobile phone until I get off.
7	I call or answer my calls on the subway or bus.
8	I use my mobile phone when I am in the presence of another person.
9	I work on my mobile device, even late at night.
10	I talk on my mobile for more than an hour a day.
11	It's hard to get along with people who don't have mobile phones.
12	I subconsciously check my mobile phone to see if I have a new notification or not.
13	If I have my cell phone with me, I use it to send messages while working or in the classroom.

Continued Table 2.

14	I send more than ten messages a day.
15	I am happy to receive a new message on my mobile phone.
16	Sometimes, I send messages even though I have nothing to do.
17	When sending messages, I often use emojis.
18	I often reply to messages.
19	I often write long messages.
20	I can express my true feelings through text (rather than over the phone or in person).

Inclusion criteria

The criteria for entering the research included the following:

a. The participant must be studying in high school.

b. The participant must be between 14 and 18 years old.

c. The participant must have at least one personal smart device in his possession.

Participants

Forty-nine participants were required to join the trial during a specific timeframe, known as the Dey month in the Jalali Calendar, to ensure more accurate comparisons of the results. After the end of the one-month period and the completion of the form, screening was done to ensure that only the results that met the entry criteria were included in the research. Accordingly, 29 participants (24 girls and 5 boys) who met the inclusion criteria were finally left.

According to the inclusion criteria, the age range of the participants was between 14 and 18 years (Table 3).

The study sample consisted of Iranian high school students who responded to a call for participation on social networks. Since participants were chosen randomly, no intentional selection was based on the age ranges listed in the relevant table, resulting in a diverse range of participant ages. The most common fields of study in Iranian high schools were Experimental Sciences (ES), Mathematical Physics (MP), and Humanities (H). Table 4 provides information about the participants' fields of study. Table 4. Field of

Table 3. Age range of participants

Age	14	15	16	17	18
Number of participants	2	6	9	11	1

Table 4. Field of study of the participants

Field of study	ES	MP	H	No data
Number of participants	16	8	3	2

study of the participants

Iran's educational system is 3-3-6, consisting of six primary and two high school levels (called first and second high school). The participants of this research were studying in the first (7th to 9th) and second (10th to 12th) grades of high school (Table 5).

Software used

The online questionnaire form was designed using Bootstrap v4.6.0 and with the help of HTML5, CSS 3, Javascript ES10, jQuery v3.2.1, and Select2.js 4.1.0 technologies and libraries. On the server side, participants' information was saved by PHP 7.4 and MySQL 5.5, and the database was managed with phpMyAdmin 5.2.0. Data was exported from the database for statistical analysis and graphing using Microsoft Office Excel version 2303 and R version 4.2.2. Apexcharts library version 3.36 and Paint.net 4.0 were used to draw graphs.

Results

Reliability

The reliability was calculated based on Cronbach's alpha reliability coefficient for the PSQI and the modified CPDQ, indicating acceptable or appropriate values, respectively (Table 6).

Usage habits, the PSQI global score, and the modified CPDQ score

The participants worked with their smart devices for an average of 6.82 hours per day (6 hours and 49 minutes). Furthermore, each participant checked their smart device 48.31 times on average. Meanwhile, the average global PSQI score of the participants was 9.38 (44.67% of the maximum score), and 93.1% obtained a PSQI score greater than 5. These numbers showed poor sleep quality (< 5) in Iranian students. The mean score of the modified CPDQ was also 29.24 (48.73% of the maximum score), indicating that the participants have a poor condition in terms of phone addiction.

The relationship between usage habits, phone addiction, sleep disorders, and educational status

The present statistical analysis showed no significant relationship between the daily frequency of device checking and educational status, the PSQI global score, or the modified CPDQ mobile phone addiction score. However, participants with more daily usage time scored worse on both the PSQI and modified CPDQ (p-values of 0.19 and 0.08, respectively). The interesting point is that increasing the average

Table 5. Educational level of the participants

Grade	Ninth	Tenth	Eleventh
Number of participants*	2	10	17

*All participants had Iranian nationality

Table 6. Cronbach's alpha for the PSQI and the modified CPDQ

Questionnaire	PSQI	Modified CPDQ
Cronbach's alpha	0.712	0.806

daily usage time improves the educational status (Figure 2).

Gender role

The current study showed that gender is an essential factor in students' smart device habits. For example, females spent an average of 33% (1 hour and 45 minutes) more time on their smart devices daily, and 70% more time was spent checking them (Figure 3).

Regarding indicators related to educational status, the PSQI, and the modified CPDQ, the overall scores of females and males were similar. However, the scores of some components of the PSQI showed noticeable gender differences (Figure 4). For instance, the tendency to take sleeping medication and daytime dysfunction was significantly higher in females, while sleep duration and sleep efficiency in males were clearly more unfavorable.

The effect of the number of personal smart devices

Almost all indicators were worse for participants

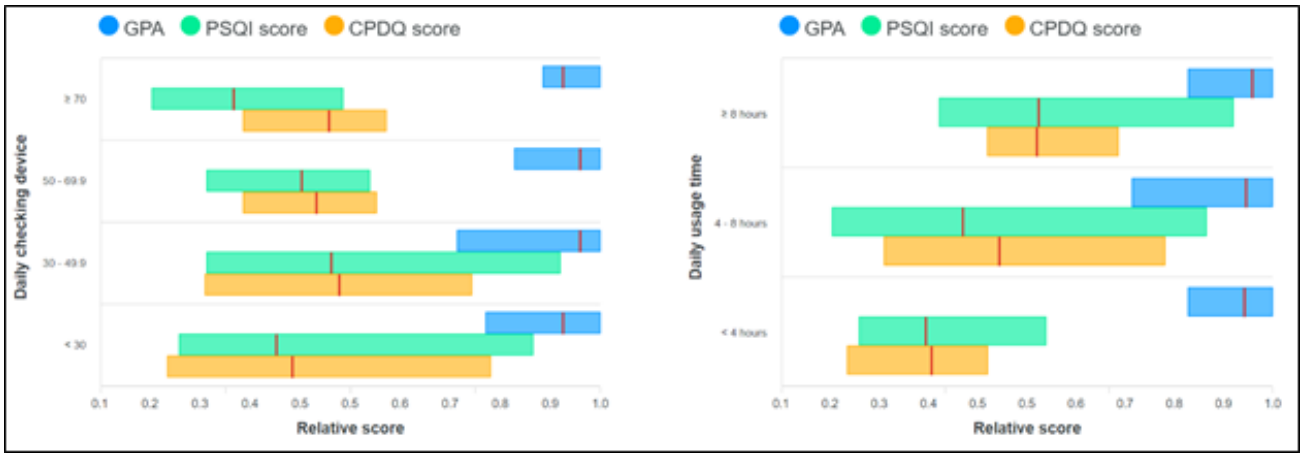

Figure 2. The relationship between students' educational status (GPA of the last semester), PSQI global score, and modified CPDQ score is plotted with smart device usage habits. The red lines show the mean value for each interval

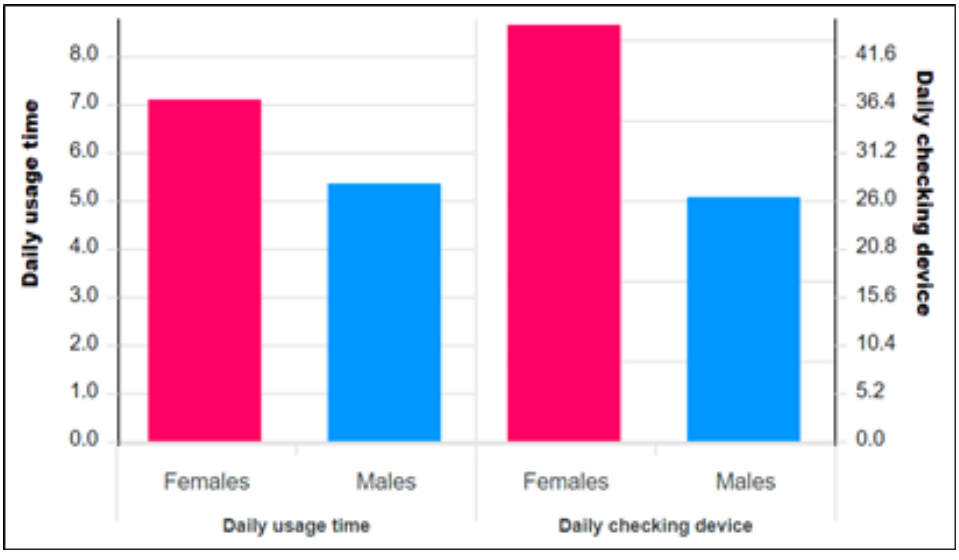

Figure 3. Smart device usage habits by gender

with more than one wireless smart device (8 of 29 participants)(Figure 5). In addition to having a poorer educational status, these participants also had a worse status concerning sleep quality, sleep delay, sleep duration, sleep distribution, tendency to take sleeping medications, decreased daily

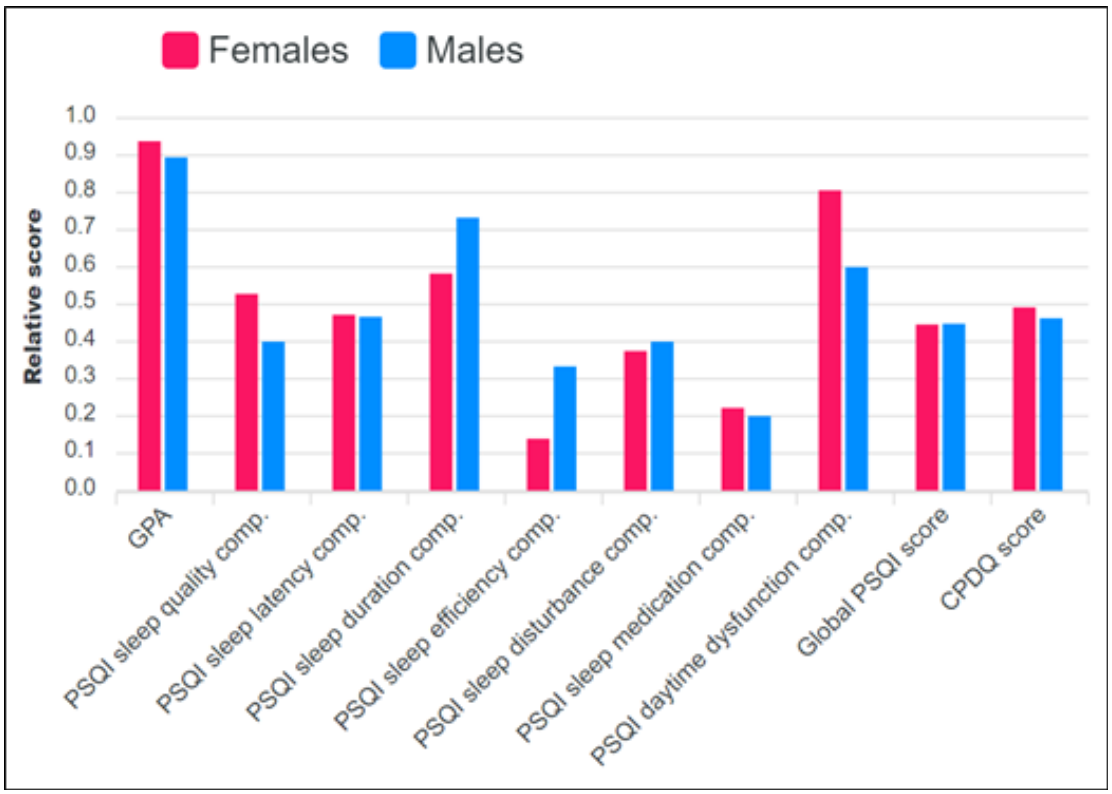

Figure 4. GPA, PSQI sleep indices, and modified CPDQ score by gender

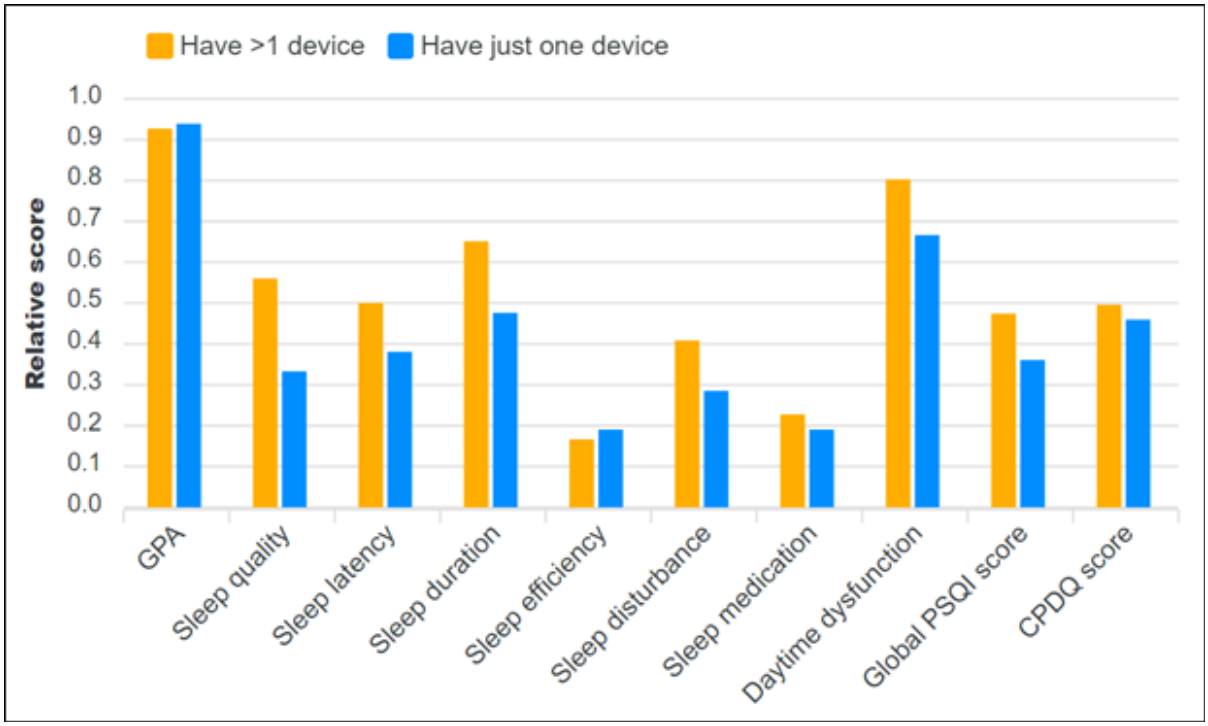

Figure 5. GPA, PSQI sleep indices, and modified CPDQ score by the number of smart devices in personal ownership

performance due to sleepiness, the PSQI global score (p-value = 0.008), and the modified CPDQ score (p-value = 0.035).

Moreover, participants who owned multiple smart devices used their primary devices more than those who only owned one smart device (Figure 6).

The effect of sleeping next to a wireless smart device on PSQI scores

Eighteen (out of 29) participants admitted to keeping their wireless smart devices close to their heads at night without putting them in airplane mode. The PSQI sleep medication score was significantly higher for the participants who slept beside their devices. Furthermore, the PSQI global score for this group was 9.5% worse than the others. However, other indices did not significantly differ (Figure 7).

Sleeping at night while the Wi-Fi router is switched on

The present study found a significant effect of

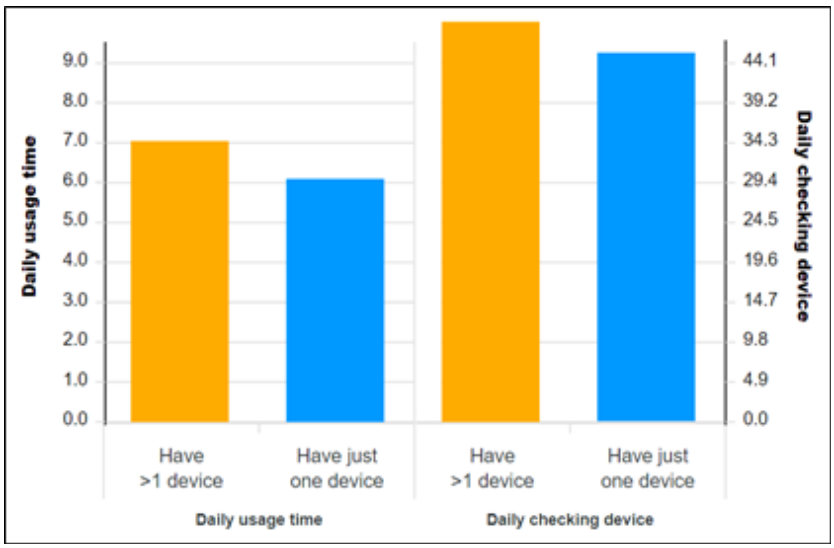

Figure 6. Average daily usage habits of the primary smart device of the participants who had one or more devices

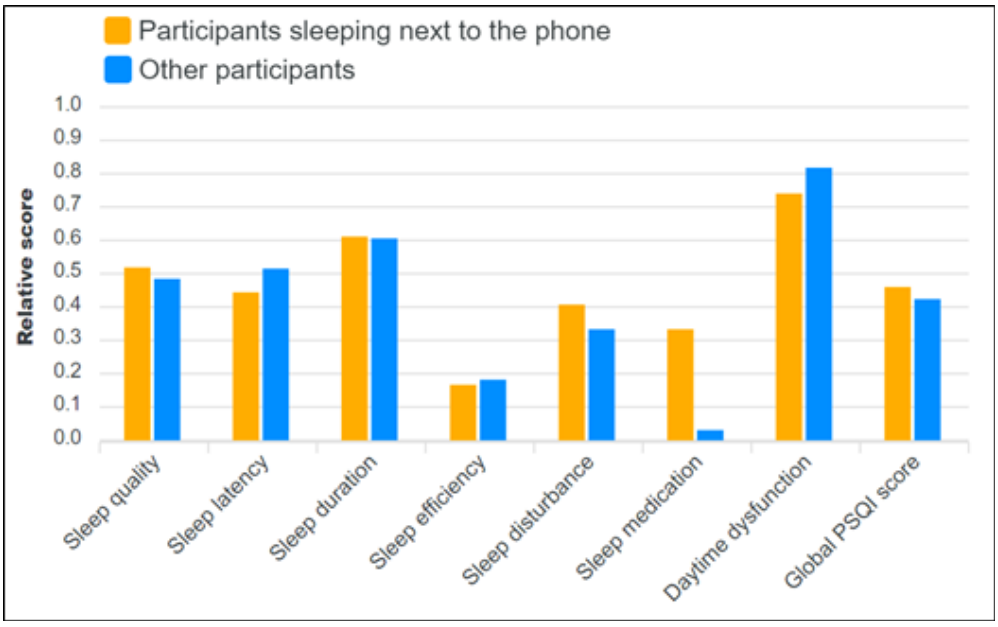

Figure 7. The average PSQI scores for participants who slept next to their device at night, compared to others

switched-on Wi-Fi routers on sleep indicators (Figure 8). Participants who had at least one Wi-Fi router and left it on at night (12 out of 29 participants) scored an average of 19% worse on the global PSQI score than others and had poorer sleep in almost all indicators.

Discussion

An overview of the results

In terms of the average daily usage time, the results of this research show a high degree of agreement with the previous study conducted by Mokhtarinia et al. (2022) (3) (Table 7). This concordance may be considered a factor in validating the other results of both studies.

Research has clearly shown that as phone addiction increases, sleep-related issues tend to worsen (8). Interestingly, the impact of poor sleep quality on mental health indicators is more critical among adolescents who meet the criteria for PMPU (9). Moreover, a 2017 study (10) of 295 Japanese high school students between the ages of 15 and 19 showed that more than five hours of daily cell phone use was associated with insomnia and shorter sleep.

Considering the eight to ten hours of daily sleep recommended by the National Sleep Foundation for adolescents aged 13 to 18 (11), Iranian students spend about 43 to 49 percent of their waking hours working with smart devices, a significant percentage. This trend can be quite a double-edged sword. On the one hand, the heightened risk of sleep disorders and smartphone addiction may adversely impact the mental health of individuals within this vulnerable age group. Conversely, if a substantial portion of this screen time is dedicated to educational pursuits, it could raise the overall level of awareness in Iranian society and enhance future generations' academic prospects. Considering the enormous numbers observed in the field of the PSQI results of the participants (average 9.38 and 93.1% with poor sleep quality), it sounds alarming that the prevalence rate of mental disorders in the young Iranian generation may increase in the coming years, even more than previously thought. For instance, another study

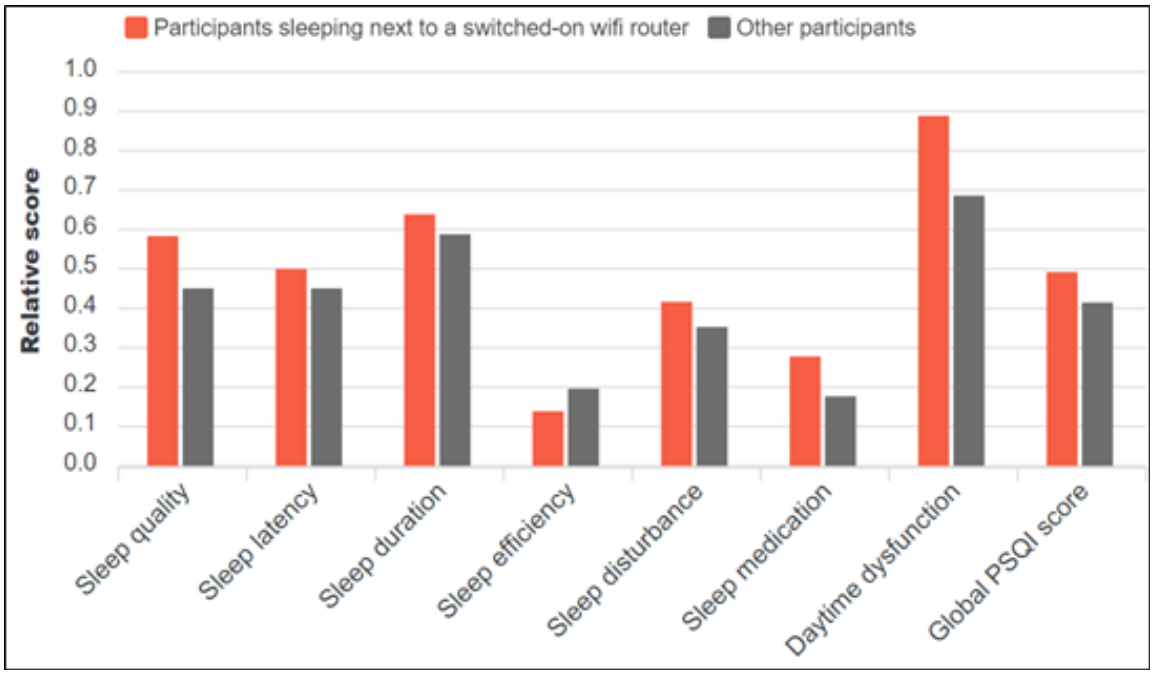

Figure 8. The average PSQI scores for participants who left their Wi-Fi router on at night, compared to others

on Iranian students conducted by Rezaei et al. (2017) has shown that poor sleep quality can be associated with psychological distress (12).

Smart device usage habits and GPA

At first glance, it might not have been expected that the increase in daily usage time is associated with an increase in GPA (mean 0.925, 0.928, and 0.939 relative GPA, respectively, for participants who work less than 4 hours, between 4 and 8 hours, and more than 8 hours daily).

We must acknowledge the significant rise in economic inflation in Iran, which has led to a steep increase in education costs. At the same time, there is a growing demand for affordable online education. As a result, the virtual education sector in Iran is experiencing unprecedented growth. Therefore, perhaps from this direct relationship between usage time and GPA, it can be concluded that a significant part of students' daily usage time is spent on receiving educational content.

Gender

The more excessive use of smart devices by females compared to males (33% more in the average daily usage time and 70% more in the average daily checking of the device) was another noteworthy point in the results. This issue can be considered another example of the inherent differences between sexes (besides their undeniable equality in human rights), but investigating why this significant difference exists is beyond the scope of the results of this research. Moreover, although the average PSQI global score for male and female participants did not show a noticeable difference (9.37 and 9.41 out of 21, respectively), significant differences in the number of PSQI components between sexes (Table 8) can be of interest to psychologists as well as educational activists.

Table 7. Comparison of the results of the study by Mokhtarinia et al. (2022) and the present study

Study	Daily usage time (hour)	Phone addiction
Mokhtarinia et al. (2022)	6.85	53.3% *
Present study	6.82	48.7% †

* The prevalence rate of smartphone addiction according to SAS-SV criteria

† The average score of the modified CPDQ test among the participants

Table 8. Comparison of GPA and different indicators for the two sexes

GPA	PSQI sleep quality	PSQI sleep latency	PSQI sleep duration	PSQI sleep efficiency	PSQI sleep disturbance	PSQI sleep medication	PSQI daytime dysfunction	Global PSQI score	Corrected CPDQ score
Males*	Females	Females	Males	Males	Males	Females	Females	Males	Females
(4.6%)	(32%)	(1.1%)	(25.7%)	(139.6%)	(6.7%)	(11.1%)	(79.9%)	(0.4%)	(6.3%)

* In each case, the sex with a worse situation is written, and the numbers in parentheses are the relative percentage of the indicator being worse than the opposite sex

Number of smart devices

Of the ten indicators examined regarding the influence of the number of smart devices (GPA, PSQI components, PSQI global score, and modified CPDQ score), nine indicators were worse for students who owned more than one smart device (including GPA, PSQI global score, and modified CPDQ score).

Besides, considering that the statistics provided by the participants were related to the installation of the software on their primary smart device, the unexpected result is that the participants who had more than one smart device also worked more with their primary smart device.These results clearly show that families should be more careful when buying unnecessary electronic devices for their children.

Sleeping next to a wireless smart device

Another notable result of this study was an increase of approximately 10% in the global PSQI score for participants who placed their smart devices near their heads without activating airplane mode. Cell phone use at night can be related to disturbances in the natural circadian cycle (13). This has been specifically attributed to the suppression of melatonin levels just before sleep due to the blue light emitted from smart electronic devices, which makes it more difficult to fall asleep and can potentially cause insomnia (13, 14).

Moreover, using a smart device in bed can lead to a person falling asleep with a phone placed near the pillow. A 2020 (15) study of 1,925 17- to 23-year-old Saudi students found that the average time spent using a mobile phone screen in bed was about 25–50 minutes. Additionally, while less than a fifth of students put their phones on airplane mode, 70 percent kept their phones near their pillows while sleeping. Finally, this study showed that long-term use of mobile phones in bed after turning off the lights directly affects low-quality sleep, daytime sleepiness, and increased sleep delay unless the device has a blue light filter. Furthermore, placing a smart device near the pillow has increased daytime sleepiness, nighttime sleep disorders, and sleep delay.

In this context, it is important to highlight two key points: Firstly, this subject may attract the attention of researchers investigating the impact of mobile waves on overall human health. Secondly, we must take into account the potential that these effects could stem not from the waves emitted by the devices themselves but rather from the behavior of individuals who use their devices right up until they go to sleep, making them more likely to place their devices close to their heads during the night. This suggests we might observe a correlation rather than a direct causal relationship. Leaving the Wi-Fi router switched on at night.

Another factor that could have an impact is the effect of waves emitted by Wi-Fi routers on human mental health. In this field, previous research has presented different results. For instance, a sham-controlled 2020 study (16) on 34 healthy young male subjects kept in a sleep laboratory for five nights failed to affect sleep quality. Meanwhile, a 2021 questionnaire study (17) suggested that Wi-Fi routers can negatively affect various health indicators, including sleep quality, by up to 30%. In the present study, unlike putting the phone next to the head while sleeping, it is difficult to consider the negative effects of leaving the Wi-Fi router on at night as a correlation. Therefore, the considerable effect of the switched-on Wi-Fi routers at night on the PSQI indicators observed in this study should be carefully considered by

researchers who work in the field of the effect of electromagnetic waves on the human brain.

In Conclusion

The present study concludes that 1) Iranian students have an inappropriate situation regarding working with their smart devices (mobile phones, tablets, and smartwatches); 2) They spend almost half of the recommended waking hours using these devices; 3) The prevalence of sleep disorders and phone addiction among Iranian students is alarmingly high; 4) Iranian female students, on average, check their phones significantly more frequently than male students and work much longer hours, while in terms of overall sleep quality, they are not significantly different from each other; 5) Having more than one smart device negatively affects educational status, and almost all indicators related to sleep quality are associated with an increase in average phone addiction; 6) Sleeping next to a phone is associated with a significant increase in overall sleep quality; 7) Leaving the Wi-Fi router on at night causes a significant drop in almost all indicators related to sleep quality.

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Authors’ Contribution

Arsalan Heidarpanah conceptualized and developed the methodology.

Hossein. Zamaninasab. programmed the internet questionnaire, collected data, and drafted the article. Arsalan Heidarpanah also analyzed and interpreted data, revised the manuscript, and gave final approval.

Conflict of Interests

None.

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