**Smartphone use at bedtime and sleep quality:**

 **The influence of sleep-smartphone hygiene, trait anxiety, and fear of missing out (FOMO) on sleep quality among college students**

The use of mobile information and communication technologies (ICTs) such as smartphones has increased rapidly in recent years (Papaconstantinou, Bartfay, & Bartfay, 2017). In one study, it was suggested that phone companies shipped a total of 347.4 million smartphones worldwide in the first quarter of 2017 alone  (International Data Corporation, 2017). Smartphones are popular devices, capable of processing more information than all other technology; they include many features, such as games, access to the Internet and social networks, messaging, videos, multimedia, and navigation, in addition to their communication function (Demirci, Akgönül, & Akpinar, 2015). The booming use of smartphones and the fact that these phones encompass many features have raised the issue of the smartphone’s effect on the health of the users (Wolniewicz, Tiamiyu, Weeks, & Elhai, 2018). A number of adverse health outcomes associated with high-end users have been identified, such as obesity and decreased physical activity (Kenney & Gortmaker, 2016), reduced user well-being, as reflected in increased anxiety and depression (Banjanin, Banjanin, Dimitrijevic, & Pantic, 2015; Selvaganapathy, Rajappan, & Dee, 2017), and sleep quality (Kenney & Gortmaker, 2016; Papaconstantinou et al., 2017).

The current study focuses on the effect of general smartphone use and its use at bedtime on sleep quality among college students. Studies have reported distinctions between high smartphone users and low smartphone users in sleep quality, as reflected in sleep disturbance and daytime dysfunction (Demirci et al., 2015) and in sleep onset latency and bedtime (Scott & Woods, 2018). All of the cited studies reported poorer sleep quality among college students who are smartphone high users.

College students are known to have poor sleep and inconsistent sleep schedules, with nearly 60% complaining of poor sleep quality and close to 70% reporting sleep problems (Kloss et al., 2016). Insufficient sleep time among college students has been documented to occur in epidemic proportions (Peltzer & Pengpid, 2015), having a substantial impact on their physical and emotional well-being (Eliasson & Christopher, 2017). It has been demonstrated that insufficient sleep and irregular sleep schedules of college students are due in part to social and academic stress, work hours, freedom from parental supervision, and extensive consumption of tobacco, alcohol, and drugs (Cohen, Ben Abu, & Haimov, 2018; Eliasson & Christopher, 2017). All of these lead to an increase in behaviors that impair sleep quality and can be designated by the concept of *poor sleep hygiene*. Sleep hygiene is defined as a collection of behaviors related to the promotion of good sleep (Suen, Tam, & Hon, 2010), such as modifiable environmental (e.g., conducive sleeping environment), scheduling (e.g., consistent sleep-wake schedule), sleep practices (e.g., predictable bedtime routine), and physiological (e.g., reduced caffeine consumption; Martin et al., 2018; Mindell, Meltzer, Carskadon, & Chervin, 2008).

Poor sleep hygiene practices, including increased technology use (i.e., computer, smartphone, MP3 player, tablet), have been identified as increasing the risk for sleep problems in college students (Martin et al., 2018). In the current study, we refer to technology use in the sleep environment (including during sleep time) as *sleep-smartphone hygiene*. This concept refers to behavioral habits of using smartphones at bedtime and includes various uses by students on a smartphone prior to bedtime (e.g., sleeping with the smartphone next to the bed, scrolling up on the smartphone in bed before going to sleep), in the middle of the night (e.g., checking the smartphone during the night and responding to stimuli from one or more of the following applications: email / Facebook / Instagram), or in the early morning (e.g., using a smartphone as an alarm clock, checking your smartphone first upon waking). A new questionnaire was constructed to measure the concept of sleep-smartphone hygiene, with a high score indicating behavioral habits that impair sleep hygiene.

The current study’s main hypothesis is that there will be a relationship between sleep-smartphone hygiene and sleep quality. This hypothesis is based on findings from previous studies that showed that the presence of smartphones in the bedroom (apishly at bedtime) affects sleep (Adams et al., 2017; Papaconstantinou et al., 2017; Scott & Woods, 2018).

However, research directly examining the mechanisms behind the links between sleep-smartphone hygiene and sleep quality is still needed. The current study was designed to address this gap by exploring the mediating effect of psychological factors on this relationship. The research literature has identified two possible psychological factors*: trait anxiety* and *fear of missing out (FOMO)*.

Trait anxiety is the tendency to report negative emotions such as fears, worries, and anxieties in many situations. It is expressed in repeated fears and reports of body symptoms. Trait anxiety can be considered at two levels: at the perceptual level, which includes the tendency to attend closely to threatening stimuli; and at the cognitive level, which includes the tendency to interpret the stimuli in a threatening manner (Woods, 2016). Trait anxiety has been found related both to poor sleep (Rosen, Carrier, Miller, Rokkum, Ruiz, 2015) and to social media use at bedtime (Banjanin et al., 2015; Woods, 2016).

Fear of missing out (FOMO) is a general state of anxiety at missing out on rewarding experiences, a fear that often drives social media engagement (Przybylski, Murayama, DeHaan, & Gladwell, 2013). Individuals report feelings of disconnectedness and missing out in the absence of access to online communication, preferring to keep their phones within reach at night (Vorderer, Krömer, & Schneider, 2016). This desire to be constantly connected and concerned about missing out when offline may make it difficult for highly invested users to disengage from social media at bedtime (Woods, 2016).

In light of this literature, the current study proposes a theoretical mediation model, asserting that psychological factors (i.e., anxiety and FOMO) mediate between the behavioral habits of using smartphones in general (social media engagement) and at the sleeping environment in particular (sleep-smartphone hygiene) and sleep quality.

*Figure 1*. Proposed mediation model for the association between sleep-smartphone hygiene and sleep quality.

The study hypotheses are:

1. Students will report poor behavioral habit of using smartphone in the sleeping environment (sleep-smartphone hygiene).

2. Behavioral habits of using smartphone (sleep-smartphone hygiene and social media engagement) will be related to sleep quality.

3. Psychological factors (anxiety and FOMO) will mediate the link between the behavioral habits of using smartphone and sleep quality.

**METHOD**

**Participants**

Participants were 467 college students from Israel (316 women, 141 men; aged 19-30 years (*M*age = 25, *SD*age = 2.69). The participants were recruited through social networks and on campus; they completed online anonymous questionnaires using Google Forms.

**Instruments**

1. Demographic questionnaire: Participants were requested to provide information regarding their age, gender, religion, marital status, residence, and occupation.
2. Sleep-Smartphone Hygiene Questionnaire (SSHQ): This questionnaire was developed for the current study and contains 10 Likert-type scale items, ranging from 1 (*neve*r) to 5 (*always*). The items examine the habits associated with the smartphone in the sleeping environment (e.g., "I sleep with my smartphone in the bedroom", "I scroll my smartphone while I'm in bed before I fall asleep", "I check my smartphone during the night"). Scores across these items were averaged to create a sleep-smartphone hygiene score for each participant. Reliability of the questionnaire for the current sample was acceptable (Cronbach alpha = .71).
3. Social Media Engagement Questionnaire (SMEQ; Przybylski et al., 2013): Social media engagement was measured with five items assessing the extent to which participants used social media in their daily lives. Participants were instructed to "Please reflect on how you used social media (e.g., Facebook, WhatsApp, Twitter, Instagram, and email) in the past week". Items were presented on an eight-point Likert-type scale, ranging from 1 (*not one day*) to 7 (*every day*). Participants were asked to rate five statements relating to times of use: “within 15 min of waking up,” “when eating breakfast,” “when eating lunch,” “when eating dinner,” and “within 15 minutes of going to sleep’’. Scores across these items were summed to create a social media engagement score for each participant. Cronbach’s alpha coefficient of the SMEQ for the current sample was .85.
4. The Fear of Missing Out Scale (FoMOs; Przybylski et al., 2013) comprises 10 items (e.g., “I get anxious when I don't know what my friends are up to”) presented on a 5-point Likert-type scale, ranging from 1 (*not at all true of me*) to 5 (*extremely true of me*). Item scores were averaged to give an overall score of 1–5. Cronbach’s alpha reliability coefficient for the current sample was .85.
5. The State-Trait Anxiety Inventory (STAI; Spielberger, 1983): The STAI-T is a 20-item inventory measuring trait anxiety as a psychological construct involving self-perception in addition to measuring higher-order factors of negative emotional experience and sub-factors of depression and anxiety. Each item is scored from 1 to 4 points, with potential scores for the STAI-T ranging from 20 to 80. Cronbach’s alpha reliability coefficient for the present sample was .93.
6. Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989): The PSQI is a self-administered questionnaire assessing sleep quality and disturbance over the last one-month interval. The PSQI comprises 19 items divided into seven subscales: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Each of the seven subscales is weighted equally on a 4-point scale of 0 to 3 (0 = no difficulty, 3 = severe difficulty). The subscales are then summed to yield a global PSQI score, ranging from 0 to 21, with higher scores indicating worse sleep quality; a global PSQI score ≥ 5 is consistent with poor sleep quality. For the current study, we used only the global PSQI score.

**Procedure**

After obtaining consent for the research from the college's Committee of Ethics, participants recruited through social networks and on campus completed online anonymous questionnaires using Google Forms.

**Data analysis**

Assumptions regarding normal distribution were verified. Means, standard deviations, and Pearson’s correlations between study variables were examined. Differences between male and female students were tested via student’s *t*-test.

The hypothesized model was tested with mediation analysis using SPSS 24 (IBM, Chicago, IL, USA) with the PROCESS macro Model 4 (Hayes, 2013). The independent variable was sleep quality (PSQI), the dependent variable was SSHQ, and the mediators were trait anxiety and FOMO. PROCESS produces bias-corrected bootstrap samples (5,000 samples) to generate 95% confidence intervals (CIs) for the indirect effect (IE) of each mediator. A significant indirect effect is found when the confidence intervals do not include zero.

**RESULTS**

Means, standard deviations, and ranges for each measure are presented in [Table 1](https://www.sciencedirect.com/science/article/pii/S0140197118301441%22%20%5Cl%20%22tbl1).

Table 1: *Means (standard deviations) and ranges for study variables*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Mean (*SD*) | Min | Max | Skewness | Kurtosis |
| Smartphone-sleep hygiene (SSHQ)  | 3.82 (0.60) | 1.8 | 5.0 | -0.52 | 0.06 |
| Social media engagement (SMEQ) | 23.16(7.80) | 5 | 35 | -0.13 | -0.85 |
| Fear of missing out (FOMO) | 2.59 (0.70) | 1.0 | 4.9 | 0.29 | -0.13 |
| Trait anxiety (STAI-T) | 39.75 (11.80) | 20 | 77 | 0.63 | -0.8 |
| Sleep quality (PSQI) | 5.21 (2.80) | 1 | 17 | 0.84 | 0.91 |

**Student Sleep-Smartphone Hygiene**

The first hypothesis claimed that students will report on poor behavioral habit of using smartphone in the sleeping environment (sleep-smartphone hygiene). Table 2 presents the frequency (percent) of the responses in each question.

Table 2

*Frequency (percent) of the Responses to the Sleep-Smartphone Hygiene Questionnaire\**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Never | Rarely | Sometimes | Often | Always |
| 1 | Sleeps with the smartphone in the bedroom | 1.7 | 1.5 | 1.3 | 4.8 | **90.7** |
| 2 | Sleeps with the smartphone next to the bed | 7.6 | 6.1 | 8.1 | 14.1 | **63.6** |
| 3 | Leaves the smartphone on during the night | 1.3 | 1.7 | 2.6 | 5.4 | **88.9** |
| 4 | Switches the smartphone to silent mode at night | 23.6 | 11.3 | 15 | 9.5 | **40.6** |
| 5 | Scrolls up on the smartphone when in bed before going to sleep | 3.5 | 8.5 | 14.8 | 23 | **50.0** |
| 6 | Scrolls up on the smartphone when in bed after turning off the lights (after having already planned to sleep) | 10.2 | 14.5 | 18 | 24.5 | **32.8** |
| 7 | Checks smartphone during the night | 20.8 | **23.0** | 21.5 | 18.7 | 16.1 |
| 8 | Responds to one of the following applications: email / Facebook / Instagram during the night | **34.5** | 26.9 | 21.5 | 8.2 | 8.9 |
| 9 | Uses smartphone as an alarm clock | 9.0 | 1.7 | 1.7 | 4.3 | **91.3** |
| 10 | Checks smartphone first upon waking up | 2.2 | 4.8 | 16.7 | 29.5 | **46.9** |

*Note*. \*The mode response for each of the items is highlighted.

As Table 2 indicates, the students reported poor sleep-smartphone hygiene. Most of the students (90.7%) report that they sleep with the smartphone in the bedroom with 88.9% leaving the smartphone on during the night; 50% scroll the smartphone at bed before falling asleep and 32.8% scroll it after turning off the lights. Most of the students 'never used' or 'rarely used' the smartphone during the night (43.8%). However, 34.8% reported that they 'often' or 'always' check the smartphone during the night. In addition, 76.4% reported checking the smartphone the first thing they do when they wake up.

*The mediation model: The link between behavioral habits of using smartphone (SSHQ, SMEQ), psychological factors (STAI-T, FoMOs), and sleep quality (PSQI)*

No statistically significant gender difference was found in sleep quality, as reflected in the total score of the PSQI tested, *t*(459) = 0.6, ns. Therefore, all subjects were treated as a single group.

Table 3

*Pearson Correlations Between Study Variables*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Sleep-Smartphone hygiene (SSHQ) | Social Media Engagement (SMEQ) | Fear of missing out (FOMO) | Trait Anxiety (STAI-T) | Sleep Quality (PSQI) |
| Sleep-smartphone hygiene (SSHQ)  |  |  |  |  |  |
| Social media engagement (SMEQ) | 0.53\*\* |  |  |  |  |
| Fear of missing out (FOMO) | 0.15\*\* | 0.18\*\* |  |  |  |
| Trait anxiety (STAI-T) | 0.14\*\* | 0.15\*\* | 0.51\*\* |  |  |
| Sleep quality (PSQI) | 0.17\*\* | 0.11 | 0.18\*\* | 0.43\*\* |  |

***Note.* \*\**p* < .01** after Bonferoni adjustment

Pearson correlations between the study variables were consistent with expected associations, based on the proposed model with SSHQ, FOMO, and trait anxiety positively correlated with sleep quality. SMEQ positively correlated with FOMO and trait anxiety but not with sleep quality therefore we did not include him in the following analyses.

Multiple regression test was conducted to predict sleep quality (PSQI), based on the Sleep–Smartphone Hygiene Questionnaire (SHSQ), Social Media Engagement Questionnaire (SMEQ), trait anxiety (STAI-T), and FOMO. Table 4 presents the main findings.

Table 4:

*Simultaneous Regression for Sleep Quality as a Function of Sleep–Smartphone Hygiene, Social Media Engagement, Trait Anxiety, and FOMO*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Predictive Variable | Β | *t* | R2 | *F*(4,456) |
| Trait anxiety | 0.45 | 9.32\*\*\* | 0.20 | 29.59\*\*\* |
| FOMO | 0.06 | 1.38 |
| Sleep – Smartphone Hygiene (SHSQ) | 0.12 | \*\*2.79 |
| Social media engagement (SMEQ) | -0.01 | -0.28 |

***Note****.* \*\**p* < .005, \*\*\* *p* < .001.

As Table 4 indicates, the regression model was significant, *F*(4, 456) = 29.59, *p* < .001. That is, sleep quality (PSQI) can be predicted by trait anxiety, FOMO, social media engagement, and sleep–smartphone hygiene (SHSQ). The four variables explained 20% of the variance in sleep quality (PSQI). Table 4 also reveals that trait anxiety offered the highest unique contribution (β = 0.45, p < .001), followed by sleep–smartphone hygiene (SSHQ; β = 0.12, *p* < .005). The contribution of social media engagement (SMEQ) and FOMO to predict sleep quality (PSQI) was not found to be significant (β = -0.01, β = 0.06, ns).

In light of the above results, a model including SSHQ as an independent variable and sleep quality (PSQI) as a dependent variable was tested, with psychological factors (trait anxiety and FOMO) as mediators.

**Model 1:** Sleep–smartphone hygiene (SSHQ) as independent variable, trait anxiety and FOMO as the mediators, and sleep quality (PSQI) as the dependent variable: SSHQ was found to be a significant predictor of PSQI (b =.8360, se =.222, *t*(459) = 3.78, *p* < .001), explaining 3% of the variance of PSQI (R2 = 0.030). In addition, SSHQ was found to be a significant predictor of trait anxiety (b =2.8590, se =.9094, *t*(459) = 3.14, *p* < .002) and FOMO (b =.1906, se =.0558, *t*(459) = 3.42, *p* < .007). With trait anxiety and FOMO in the model, SSHQ remained a significant predictor of PSQI (b =.5704, se =.2040, *t*(457) = 2.80, *p* < .005). Trait anxiety was a significant partial mediator of SSHQ (indirect effect =.3173, se =.1042, 95% CI: .1266 to .5309), while FOMO was not a mediator of SSHQ (indirect effect = -.0514, se = .0449, 95% CI: -.1527 to .0258) {since 0 falls in the CI}. This model predicted 20.3% of the variance (R2 = 20.26%).

An additional analysis was conducted to examine whether FOMO is a mediator in the model when it is presented in the absence of trait anxiety.

**Model 2:** Sleep–smartphone hygiene (SSHQ) as independent variable, FOMO as mediator, and sleep quality (PSQI) as dependent variable: With FOMO in the model, SSHQ remained a significant predictor of PSQI (b =.7158, se =.2217, *t*(458) = 3.23*, p* < .001). FOMO was a significant partial mediator of SSHQ (indirect effect =.1206, se =.0538, 95% CI: .0310- .2384). This model predicted 5.5% of the variance (R2 = 5.47%).

**DISCUSSION**

The purpose of this study was to examine the relationship between behavioral habits of using smartphones (sleep-smartphone hygiene, social media engagement) and sleep quality among college students and to examine whether this relationship can be explained by a psychological mechanism. The research hypotheses were partially confirmed. The results revealed that behavioral habits affect sleep quality only when they measured smartphone use in the sleeping environment (by the Sleep-Smartphone Hygiene Questionnaire) but not as a factor of general smartphone use (as measured by the Social Media Engagement Questionnaire). In addition, this relationship was mediated by two psychological factors: trait anxiety and fear of missing out (FOMO).

*Behavioral habits of using smartphones in the sleeping environment: Sleep-Smartphone hygiene*

Sleep-smartphone hygiene is a novel concept, developed for the current study. It is based on concepts introduced in sleep research (i.e., sleep hygiene; Suen et al., 2010). Sleep-smartphone hygiene comprises behavior such as using the smartphone before bedtime, during the night, and in early morning at waking. To measure sleep-smartphone hygiene a new questionnaire was constructed.

The first hypothesis of the study suggests that students will report poor sleep-smartphone hygiene. This hypothesis was supported by the current findings. In all measures, students reported performing behavioral habits that impair sleep-smartphone hygiene. Most of the students reported sleeping with their smartphones in the bedroom, in proximity to their bed, and report scrolling through it until the moment they fall asleep. Most participants also reported that the first thing they do when they wake up is to check their smartphone. Smartphone use during the night was reported in lower percentages.

These findings are consistent with other studies examining student's behavioral habits of using smartphones in the sleeping environment (Fobian, Avis, & Schwebel, 2016; Jennifer Falbe et al., 2015; Li, Lepp, & Barkley, 2015). For example, in one study examining student athletes (Monma et al., 2018), 70.2% reported scrolling through their smartphone after turning off the lights. The findings of this and other cited studies illustrate that student's behavioral habits of using smartphones in their sleeping environment are characterized by poor sleep-smartphone hygiene.

The second hypothesis suggested a relationship between behavioral habits of using smartphones (i.e., sleep-smartphone hygiene, social media engagement) and sleep quality. This hypothesis achieved partial support. Behavioral habits found to affect sleep quality were found to be related to the use of smartphones in the sleep environment (as measured by the Sleep-Smartphone Hygiene Questionnaire) but not to the general use of smartphones during daytime hours (as measured by the Social Media Engagement Questionnaire).

Demirci et al. (2015) examined the impact of smartphone addiction on sleep quality. The researchers showed that addiction to a smartphone, manifested by its intensive use, did not affect participants’ sleep quality. However, specific measures related to smartphone addiction, attesting to the use of smartphones in the sleeping environment (e.g., the presence of the smartphone in the bedroom, scrolling in the smartphone before lights out), were associated with sleep quality.

It is important to note that the current study did not employ the terminology of addiction, nor did it rank the subjects on the intensity of addiction, but chose to examine the subject from the behavioral viewpoint without labeling those behaviors as addiction behaviors. This determination facilitated the revelation that the behavioral habits of smartphone use that affect sleep quality are limited to those performed in the sleep environment. In accordance with these findings in the final model, only the variable sleep-smartphone hygiene was considered.

*The mediation model: psychological factors (trait anxiety and FOMO) as mediators between behavioral habits of using smartphones in the sleeping environment (sleep-smartphone hygiene) and sleep quality*

Based on the literature, two psychological factors have been identified as mediating variables in the relationship between sleep-smartphone hygiene and sleep quality. The findings supported the assumptions of the model, showing that trait anxiety is related to both sleep-smartphone hygiene. In addition, trait anxiety was found to be a mediated variable in the relationship between the two; this mediation model explained 20% of the variance of sleep quality. The other psychological factor examined in the study, FOMO, was also found to be a mediating variable in the relationship between sleep-smartphone hygiene and sleep quality; FOMO explained 5% of the variance in sleep quality. Of the two psychological factors examined, trait anxiety was found to be a more significant variable in predicting sleep quality than was FOMO. A possible explanation for this finding relates to the fact that FOMO is a specific aspect of trait anxiety, in that individuals with high trait anxiety are also likely to be characterized by high FOMO. However, high levels of FOMO may also occur in those unafflicted with high trait anxiety (Elhai, Levine, Dvorak, & Hall, 2016).

As all sleep-smartphone hygiene measures have demonstrated behaviors characterized by intense use of smartphones in the sleeping environment, it is reasonable to assume that these behavioral habits alone do not explain the impairment of sleep quality. The finding that two psychological factors were found to mediate this relationship is important. The presence of the smartphone in the bedroom does not necessarily affect sleep quality, but sleep quality will be impaired if the smartphone’s presence increases trait anxiety or FOMO, which in turn will affect sleep quality. These findings are in line with other studies showing that psychological factors such as trait anxiety (Demirci et al., 2015; Woods, 2016) and FOMO are related to intense use of smartphones in the sleeping environment and to various measures of sleep (Scott & Woods, 2018).

The relationship between sleep-smartphone hygiene and sleep quality is important for those seeking effective practices for coping with the impairment of sleep quality among students. Recommendations for behavioral change, as suggested in programs, encourage sleep hygiene (Whipps, Byra, Gerow, & Hill Guseman, 2018) alone are insufficient. Simply removing the smartphone from the bedroom will not necessarily improve sleep quality. Recommendations should also address intra-personal aspects, such as trait anxiety and FOMO. Accordingly, the recommendations should be incorporated into behavior that encourages a hygienic sleep environment (including removing the smartphone from the bedroom) and techniques shown to reduce anxiety, such as CBT (Suh, Cho, & Zhang, 2018) or mindfulness (Lau, Leung, Wing, & Lee, 2018; Scott & Woods, 2018).

**Limitations**

The current study had several limitations. First, the results of the study were based on self-report questionnaires, and showed that students have sleeping problem (the PSQI average score was 5.21). Previous studies have already discussed the gap between subjective reporting of sleep quality and its objective measurement (Cohen et al., 2018). In a follow-up study, the Sleep Quality and the Smartphone Usage Index should be examined using objective measurements (actigraphy). Second, the study was conducted on Israeli students; due to the characteristics of life in Israel, most undergraduate students are older than their counterparts in the United States or Europe. In the context of smartphone use, age plays a significant role, and therefore, this issue should be examined at younger ages such as adolescents and children.

Despite these limitations, the findings have important implications for understanding the impact of smartphone use on sleep quality and the ability to present a research-based intervention program.

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