Journal of Behavioral Addictions 4(2), pp. 85–92 (2015)
DOI: 10.1556/2006.4.2015.010

Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students

KADİR DEMİRCİ*, MEHMET AKGÖNÜL and ABDULLAH AKPINAR

Department of Psychiatry, School of Medicine, Süleyman Demirel University, Isparta, Turkey

(Received: December 27, 2014; revised manuscript received: April 26, 2015; accepted: April 26, 2015)

Background and aims: The usage of smartphones has increased rapidly in recent years, and this has brought about addiction. The aim of the current study was to investigate the relationship between smartphone use severity and sleep quality, depression, and anxiety in university students. *Methods:* In total, 319 university students (203 females and 116 males; mean age = 20.5 ± 2.45) were included in the study. Participants were divided into the following three groups: a smartphone non-user group (n = 71, 22.3%), a low smartphone use group (n = 121, 37.9%), and a high smartphone use group (n = 127, 39.8%). All participants were evaluated using the Pittsburgh Sleep Quality Index, Beck Depression Inventory, Beck Anxiety Inventory; moreover, participants other than those in the smartphone non-user group were also assessed with the Smartphone Addiction Scale. *Results:* The findings revealed that the Smartphone Addiction Scale scores of females were significantly higher than those of males. Depression, anxiety, and daytime dysfunction scores were higher in the high smartphone use group than in the low smartphone use group. Positive correlations were found between the Smartphone Addiction Scale scores and depression levels, anxiety levels, and some sleep quality scores. *Conclusion:* The results indicate that depression, anxiety, and sleep quality may be associated with smartphone overuse. Such overuse may lead to depression and/or anxiety, which can in turn result in sleep problems. University students with high depression and anxiety scores should be carefully monitored for smartphone addiction.

Keywords: smartphone, addiction, sleep quality, depression, anxiety

INTRODUCTION

Smartphones are popular devices capable of processing more information than other phones; they include many features such as games, access to the Internet and social networks, messaging, videos, multimedia, and navigation, in addition to their use for communication. Access to the Internet is increasingly easy due to improvements in mobile technology and the prevalence of smartphones. In one study, it was suggested that there are over 1.5 billion smartphone users around the world, and it has been estimated that more than 1 billion smartphones will be sold in 2016 (International Data Corporation, 2013). In a Korean Study, it was reported that 58% of adults owned smartphones, while 84% of college students in Korea used smartphones in 2011 (Park & Lee, 2012). This rate was 56% in 2013 for the United States (Smith, 2013), 79% in 2012 for Switzerland (Willemse, Waller, Süss, Genner & Huber, 2012), and 72% in 2013 for Germany among 12–19-year-olds. (Medienpädagogischer Forschungsverbund Südwest, 2013). The booming use of smartphones and the fact that these phones encompass many features have raised the issue of smartphone addiction (Kwon, Kim, Cho & Yang, 2013). Smartphone addiction is similar in many aspects to Internet addiction (Kim, 2013). Yet, there are also some differences, such as the easy portability, real-time Internet access and easy and direct communication features of smartphones (Kwon, Lee et al., 2013). Behavior addictions, including smartphone addiction, are generally difficult to define because they are related not only to physical, but also to social and psychological factors (Lee, Ahn, Choi & Choi, 2014). The core features of behavioral addiction include the following: sustained engagement in a behavior despite its negative effects, decreased control over participation in the behavior, compulsive participation, and appetitive or craving urges that instantly precede engagement in the behavior (Mok et al., 2014). Official diagnostic criteria for smartphone addiction do not exist. However, based on the definition of Internet addiction, smartphone addiction has been defined as the overuse of smartphones to the extent that it disturbs users' daily lives. Roberts, Yaya and Manolis (2014) found that college students spent almost nine hours daily on their cell-phones. The researchers reported that as the functionality of cell-phones continues to spread, addiction to cell-phone apparently unavoidable piece of technology becomes an increasingly realistic possibility. In a study conducted in South Korea in 2012, the frequency of smartphone addiction (8.4%) was observed to be higher than the frequency of Internet addiction (7.7%). The same study reported that 11.4% of 10- to 20-year-old individuals and 10.4% of 20- to 30-year-old individuals suffer from smartphone addiction (South Korea National Information Society Agency, 2011). Adults often have different schedules than adolescents, and have the luxury to determine their own use of electronic media free of parent-imposed constraints (Fossum, Nordnes, Storemark, Bjorvatn & Pallesen, 2014). These factors may cause higher use of smartphone or electronic media devices among young adults, such as university students.

* Corresponding author: Kadir Demirci, MD, Assist. Prof. Dr. of Psychiatry; Department of Psychiatry, Research and Training Hospital, School of Medicine, Süleyman Demirel University, Isparta, Turkey, 32200; Phone: +902462119336; Fax: +902462112830; E-mail: kdrdmrc@yahoo.com

ISSN 2062-5871

Excess smartphone use can cause physical health-related problems such as blurred vision and pain in the wrists or neck (Kwon, Lee et al., 2013). Moreover, smartphone overuse may lead to some mental or behavioral problems. It may cause maladaptive behavioral difficulties, interfere with school or work, reduce real-life social interaction, and lead to relationship disorders (Kuss & Griffiths, 2011). In a study conducted on smartphone users, it was found that state anxiety, trait anxiety, and depression were higher in the smartphone overuse group than in the normal use group (Hwang, Yoo & Cho, 2012). Poor sleep quality has emerged as a relevant public health problem in technologically advanced societies (Cheung & Wong, 2011). Existing studies on the association between electronic media use and sleep have largely focused on adolescents. It was reported that problematic Internet use is associated with sleep problems, including subjective insomnia and poor sleep quality (Lam, 2014). Similarly, Song et al. (2010) suggested that adolescents' Internet addiction was correlated with depression and sleep-related problems. However, no study has yet investigated the association between sleep quality, depression, and anxiety, and smartphone overuse or addiction. The aim of this study was to investigate the relationship between sleep quality, depression, and anxiety, and smartphone use severity in university students.

METHODS

Participants

The students of Süleyman Demirel University were the target population of this study. Four hundred randomly selected university students were considered candidates for this study. Fifty-two of the students refused to participate. Twenty-nine students were excluded because their scales were incomplete. Thus, in total, 319 students (203 females and 116 males; mean age = 20.5 ± 2.45) were included in the study.

Procedure

All participants were assessed using the Pittsburgh Sleep Quality Index (PSQI), Beck Depression Inventory (BDI), and Beck Anxiety Inventory (BAI); other than those in the smartphone non-user group, participants were also assessed using the Smartphone Addiction Scale (SAS). Participants were divided into three groups according to smartphone use severity.

Measures

The SAS is a 33-item, six-point likert-type self-rating scale developed by Kwon, Lee et al. (2013) based on the Internet addiction scale and the features of smartphones. The Cronbach's alpha of the SAS is 0.967. The options on this scale range from 1 (definitely not), to 6 (absolutely yes). Higher scores indicate a higher risk of smartphone addiction. The total score on the scale can vary between 33 and 198. A cut-off point was not reported in the original scale (Kwon, Lee et al., 2013). In a reliability and validity study of the Turkish version of the SAS involving 301 university students (Demirci, Orhan, Demirdas, Akpınar & Sert, 2014), the Cronbach's alpha was 0.947. The Turkish version of the SAS consists of seven factors and the explained variance is 66.4% Demirci et al.'s (2014) original 33-item Turkish version of the SAS was used in the present study because it was validated in a young population.

Sleep quality was assessed using the PSQI (Buysse, Reynolds III, Monk, Berman & Kupfer, 1989), which measures subjective sleep quality during the preceding 1-month period. It consists of 19 self-rated questions and 5 questions rated by the bed partner. The 19 items are grouped into scores with the seven following components: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. These component scores were added to a global PSQI score with a range of 0 to 21, with higher scores indicating worse sleep quality. PSQI scores of above 5 were taken as abnormal. Adaptation of the scale to Turkish culture was carried out by Agargun et al. (Agargun, Kara & Anlar, 1996).

The BDI is composed of 21 items that evaluate the severity of depression. Each question inquires about the respondent's particular symptoms and changes in mood over the past week, with a 4-point scale. The degree of depression is indicated by the total score. The Cronbach's alpha of the BDI is 0.91 (Beck, Ward, Mendelson, Mock & Erbaugh, 1961). The validity and reliability study in Turkish was performed by Hisli in 1989, and the cut-off point has been determined as 17 for the Turkish version (Hisli, 1989).

The BAI, developed by Beck et al. in 1988, measures the frequency of one's experiencing anxiety symptoms (Beck, Epstein, Brown & Steer, 1988). The scale, consisting of 21 items, provides Likert-type measurement (0 = none, 3 = intensive) over four points. The validity and reliability study in Turkish was performed by Ulusoy et al. in 1998 (Ulusoy, Sahin & Erkmen, 1998).

Statistical analysis

Descriptive statistics were performed to report the analysis of data that were presented as mean ± standard deviation or median (25^{th}–75^{th} percentile). Categorical variables were shown as frequency and percentages. The independent *t*-test was used to compare the parametric variables between the genders. Categorical variables were compared between the groups using the chi-square test. Pearson and Spearman correlations were used to determine the strength of the relationship between the variables. The Kruskal–Wallis test was used to compare more than two independent groups for cases with non-normal distributed variables. In cases where the Kruskal–Wallis test yielded statistical significance, a post hoc analysis was performed to identify the groups that showed differences by using a Bonferroni-corrected Mann-Whitney U test. *P* values <0.05 were regarded as statistically significant. Linear regression analyses were conducted to examine the association between the level of smartphone use and depression/anxiety and sleep quality. The data analysis was performed using SPSS 15.0 for Windows.

Ethics

The study procedures were carried out in accordance with the Declaration of Helsinki. The study was approved by the

local ethics committee. Written informed consent was obtained from all participants.

RESULTS

Three hundred and nineteen students were included in this study. Of all participants, 78% (n = 248) were smartphone users and 22% (n = 71) were not smartphone users. The average SAS score was 75.68 ± 22.46 among smartphone users. We found that SAS scores were significantly higher in females than males (SAS scores were 80.50 and 66.59, respectively, $p < 0.001$). The median value of the SAS scores was found to be 72. According to smartphone use and the median value of SAS scores in this study (Altman & Royston, 2006; MacCallum, Zhang, Preacher & Rucker, 2002), participants were divided into three different groups, as follows: a smartphone non-user group, a low smartphone use group (SAS score < the median value of 72), and a high smartphone use group (SAS score ≥ the median value of 72). Of the participants enrolled in the present study, 71 (22.3%) were in the smartphone non-user group, 121 (37.9%) were in the low smartphone use group, and 127 (39.8%) were in the high smartphone use group. The three groups were similar in terms of age (p = 0.14). The general characteristics of the groups are shown in Table 1.

Depression, anxiety, and the daytime dysfunction component of the PSQI scores were higher in the high smartphone use group than in the low smartphone use group (p = 0.001, $p < 0.001$, p = 0.0011, respectively). Comparisons between the smartphone non-use, low smartphone use, and high smartphone use groups for the scales are given in Table 2.

Table 1. General characteristics of the groups

	Smartphone non-user group n = 71	Low smartphone use group n = 121	High smartphone use group n = 127
Sex, male n (%)	30 (42.3)	61 (51.4)	25 (19.7)
Sex, female n (%)	41 (57.7)	60 (49.6)	102 (80.3)
Age (years) Mean ± SD	20.8 ± 2.11	20.7 ± 2.74	20.2 ± 2.31
SAS Mean ± SD	–	57.1 ± 9.8	93.4 ± 15.8

SAS: Smartphone Addiction Scale, SD: Standard Deviation

Table 2. Comparison between smartphone non-user, low smartphone use, and high smartphone use groups

	Smartphone non-user group n = 71 Mean ± SD	Low smartphone use group n = 121 Mean ± SD	High smartphone use group n = 127 Mean ± SD	p (a/b/c)
BDI	6.0 (3.0–12.0)	5.0 (2.0–9.0)	8.0 (4.0–14.0)	=0.001 (0.05/0.15/<0.001)
BAI	7.0 (3.0–13.0)	5.0 (2.0–10.0)	9.0 (3.0–15.0)	<0.001 (0.02/0.29/<0.001)
PSQI Subscales				
Subjective Sleep quality	1.0 (1.0–1.0)	1.0 (1.0–1.0)	1.0 (1.0–1.0)	0.13 (0.31/0.48/0.04)
Sleep latency	1.0 (0.0–2.0)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	0.58 (0.42/0.89/0.34)
Sleep duration	1.0 (0.0–2.0)	1.0 (0.0–2.0)	0.0 (0.0–1.0)	0.35 (0.61/0.48/0.14)
Sleep efficiency	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.85 (0.58/0.68/0.88)
Sleep disturbance	1.0 (1.0–2.0)	1.0 (1.0–1.0)	1.0 (1.0–1.0)	0.06 (0.02/0.37/0.12)
Use of sleep medication	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.48 (0.43/0.23/0.65)
Daytime dysfunction	1.0 (0.0–1.0)	1.0 (0.0–1.0)	1.0 (0.0–2.0)	0.011 (0.17/0.15/0.003)
PSQI global score	5.0 (4.0–7.0)	4.0 (3.0–6.0)	5.0 (3.0–7.0)	0.179 (0.12/0.93/0.10)

Median (25th percentile–75th percentile)
BDI: Beck Depression Inventory, BAI: Beck Anxiety Inventory, PSQI: Pittsburgh Sleep Quality Index, SD: Standard Deviation
p: p value for Kruskal–Wallis
$p \leq 0.017$ is accepted as statistically significant since Bonferroni correction was applied for two groups comparisons
a: *p* value between smartphone non-user group and low smartphone use group
b: *p* value between smartphone non-user group and high smartphone use group
c: *p* value between low smartphone use group and high smartphone use group

The smartphone use severity was positively correlated with depression ($r = 0.267$, $p < 0.001$), anxiety ($r = 0.276$, $p < 0.001$), PSQI global scores ($r = 0.156$, $p = 0.014$), the subjective sleep quality component of PSQI ($r = 0.138$, $p = 0.030$), the sleep disturbance component of PSQI ($r = 0.153$, $p = 0.016$), and the daytime dysfunction component of PSQI ($r = 0.244$, $p < 0.001$); meanwhile, it was negatively correlated with age ($r = –0.189$, $p = 0.003$). The correlations between the SAS scores and other scales are demonstrated in Table 3.

Table 3. The correlations between the scores of SAS and the other scale scores

	SAS	
	r	*p*
Age	–0.189	0.003
BDI	0.267	<0.001
BAI	0.276	<0.001
Subjective sleep quality	0.138	0.030
Sleep latency	0.092	0.149
Sleep duration	–0.091	0.153
Sleep efficiency	0.012	0.853
Sleep disturbances	0.153	0.016
Use of sleep medication	–0.016	0.799
Daytime dysfunction	0.244	<0.001
PSQI global score	0.156	0.014

SAS: Smartphone Addiction Scale, BDI: Beck Depression Inventory, BAI: Beck Anxiety Inventory, PSQI: Pittsburgh Sleep Quality Index

A significantly higher proportion of high smartphone users had depression (according to the cut-off level on the BDI scale) than low smartphone users ($p = 0.005$). A comparison of the proportions of smartphone non-use, low smartphone use, and high smartphone use groups having depression and abnormal sleep quality according to the cut-off levels is presented in Table 4.

The results identified age, gender, anxiety, and depression as the determinants of SAS score in the linear regression model (Table 5). Moreover, the regression analyses revealed that depression and anxiety were related to sleep quality ($\beta = 0.325$, $t = 4.725$, $p < 0.01$; $\beta = 0.273$, $t = 3.944$, $p < 0.01$; respectively). There was no direct effect of high smartphone use on sleep quality ($\beta = –0.022$, $t = –0.379$, $p = 0.705$). In addition, high smartphone use and poor sleep quality were also related to depression ($\beta = 0.226$, $t = 4.131$, $p < 0.01$; $\beta = 0.448$, $t = 8.173$, $p < 0.01$; respectively). Finally, high smartphone use and poor sleep quality were also related to anxiety ($\beta = 0.240$, $t = 4.334$, $p < 0.01$; $\beta = 0.424$, $t = 7.673$, $p < 0.01$; respectively) (Table 6).

DISCUSSION

The main findings of our study are as follows. Depression, anxiety, and daytime dysfunctions component of PSQI were significantly higher in the high smartphone use group than in the low smartphone use group. There were significantly positive correlations between the SAS scores and depression levels, anxiety levels, subjective sleep quality, sleep disturbance, daytime dysfunction, and PSQI global scores. The high smartphone use group exhibited higher levels of depression compared to the low smartphone use group according to the BDI cut-off score. Regression analyses indicated that higher levels of smartphone use and poor sleep quality predicted depression/anxiety. In addition, depression and anxiety predicted poor sleep quality. Consequently, depression and anxiety are mediators between the smartphone overuse and poor sleep quality. Moreover, high depression, high anxiety, female sex, and low age were independent predictors of smartphone overuse. To the best of our knowledge, this is the first study to show the relationship between the severity of smartphone use and depression, anxiety, and sleep quality in university students.

A study from South Korea showed that the SAS mean score was 110.02 (Kwon, Lee et al., 2013). We also found that the SAS mean score was 75.76 in a previous study (Demirci et al., 2014). Similarly, the SAS mean score was 75.68 in the present study. Consistent with previous research (e.g., Demirci et al., 2014; Kwon, Kim et al., 2013), the SAS mean score of female students was significantly higher than that of male students in this study. This difference may be related to usage pattern or purpose, such as increased use of social networks. In addition, in our study, a negative correlation was observed between age and SAS score. The findings of the present study confirmed the results of previous studies (e.g., Demirci et al., 2014; South Korea National Information Society Agency, 2011). We also found that female sex and low age were independent predictors of smartphone overuse. Thus, women and younger users may be vulnerable to smartphone overuse or addiction.

The use of smartphones has increased rapidly in recent years. This may result in smartphone addiction, which rep-

Table 4. Comparison among the groups in terms of depression level and sleep quality according to cut-off point

	Smartphone non-user group *n* = 71	Low smartphone addiction group *n* = 121	High smartphone addiction group *n* = 127	*p*
BDI				
BDI < 17	62 (87.3%)	112 (92.6%)	102 (80.3%)	<0.05
BDI ≥ 17	9 (12.7%)	9 (7.4%)	25 (19.7%)	
PSQI				
PSQI < 5	41 (57.7%)	76 (62.8%)	69 (54.3%)	>0.05
PSQI ≥ 6	30 (42.3%)	45 (37.2%)	58 (45.7%)	

BDI: Beck Depression Inventory, PSQI: Pittsburgh Sleep Quality Index

Table 5. Determinants of smartphone addiction severity in a linear regression model

Model	Variables	Standardized coefficients (Beta)	*t*	*p*	R^2	Model *p*
1	Age	.945	45.378	<.001	.893	<.001
2	Age	.488	8.263	<.001	.916	<.001
	Gender	.481	8.154	<.001		
3	Age	.429	7.541	<.001	.925	<.001
	Gender	.447	7.942	<.001		
	Anxiety	.133	5.444	<.001		
4	Age	.426	7.541	<.001	.926	<.001
	Gender	.427	7.524	<.001		
	Anxiety	.094	3.084	.002		
	Depression	.067	2.069	.040		

Table 6: The results of linear regression analyse

	Standardized coeffficients (Beta)	*t*	*p*	R^2	*F*	Model *p*
Model I: Sleep Quality				0.280	31.612	<0.01
SAS	–0.022	–0.379	0.705			
Depression	0.325	4.725	<0.01			
Anxiety	0.273	3.944	<0.01			
Model II: Depression				0.284	48.506	<0.01
SAS	0.226	4.131	<0.01			
PSQI	0.448	8.173	<0.01			
Model III: Anxiety				0.270	45.239	<0.01
SAS	0.240	4.334	<0.01			
PSQI	0.424	7.673	<0.01			

Model I: Smartphone use severity, depression, and anxiety as a predictor of sleep quality; dependent variable = Pittsburg Sleep Quality Index (PSQI)

Model II: Smartphone use severity and sleep quality as a predictor of depression; dependent variable = Beck Depression Inventory (BDI)

Model III: Smartphone use severity and sleep quality as a predictor of anxiety; dependent variable = Beck Anxiety Inventory (BAI)

resents the convergence of existing mobile phone and Internet addiction problems into smartphone addiction (Hwang et al., 2012). Overuse of a smartphone may cause various physical and psychological health problems. Some studies have evaluated the relationship between smartphones, mobile phones, and the Internet on the one hand, and depression, anxiety, and sleep disturbances on the other in adolescents (e.g., Hwang et al., 2012; Lemola, Perkinson-Gloor, Brand, Dewald-Kaufmann & Groby, 2014). Canan et al. (2013) found an association between Internet addiction and impaired sleep. The researchers suggested that both Internet use and the purpose of Internet use are important in terms of sleep duration. In addition, Lemola et al. (2014) evaluated adolescents' electronic media usage at night, along with sleep disturbances and depressive symptoms. The researchers found that smartphone ownership was associated with later bedtimes but was unrelated to sleep disturbance. Park (2014) found a negative association between the level of physical activity and risk of problematic Internet use via the mediation of sleep satisfaction and stress in adolescents. A study investigating the associations between problematic Internet use and adolescents' physical and psychological symptoms showed that excessive Internet use had indirect negative effects through sleep deprivation (An et al., 2014). Our results showed that daytime dysfunction, which is a component of sleep quality, was higher in the high smartphone use group than in the low smartphone use group. This result may be due to sleep dysregulation. There were positive correlations between subjective sleep quality, sleep disturbance, daytime dysfunction, and sleep quality global scores and SAS scores in our study. Moreover, depression and anxiety predicted sleep quality. Smartphone use severity and sleep quality predicted depression. In addition, smartphone use severity and sleep quality predicted anxiety. On the other hand, smartphone use severity was not an independent predictor of sleep quality in our study.

It has been reported that problematic Internet use may affect sleep construction, such as by reducing rapid eye movement (REM) sleep, slow-wave sleep, and sleep efficiency (Dworak, Schierl, Bruns & Strüder, 2007; Higuchi, Motohashi, Liu & Maeda, 2005), or that the bright light of a computer screen may suppress melatonin secretion and delay the onset of sleep (Higuchi, Motohashi, Liu, Ahara & Kaneko, 2003). Cain and Gradisar (2010) suggested some mechanisms concerning the relationship between electronic media use and poor sleep: 1) Electronic media use may dis-

place sleep; 2) using electronic media devices may be associated with cognitive, emotional or physiological arousal; 3) light emission of the screen of devices may affect sleep; and 4) mobile phone use in the bedroom may disturb sleep in that received messages may awake adolescents at night. Moreover, Loughran et al. (2005) reported the adverse effect of electromagnetic fields emitted by mobile phones on sleep electroencephalograms. Similarly, Huber et al. (2002) reported that electromagnetic field exposure (mobile phone usage) in the evening influences physiological factors such as sleep quality and the melatonin rhythm, probably by influencing the brain activity – particularly that of the pineal gland; it may also result in altered cerebral blood flow and brain electrical activity. In another study, it was shown that exposure to mobile phone emissions at nighttime could have an effect on melatonin onset time (Wood, Loughran & Stough, 2006). Moreover, Thomée, Härenstam and Hagberg (2010) reported that prolonged use of media can cause physical discomfort, such as muscle pain and headaches, which can negatively affect sleep. In addition, poor sleep quality has been linked with negative consequences for health and performance, such as obesity and lower school grades (Arora, Broglia, Thomas & Taheri, 2014). We think that these mechanisms observed in technology users may be responsible for sleep problems in the case of smartphone overuse or addiction.

Lemola et al. (2014) did not find any relationship between smartphone ownership and symptoms of depression. However, Hwang et al. (2012) found that state anxiety, trait anxiety, and depression were higher in the smartphone overuse group than in the normal use group among college students. A recent study carried out among university students reported that depression and anxiety scores were higher in the case of moderate/high Internet addiction (Dalbudak et al., 2013). Our findings on depression and anxiety are highly consistent with those of previous studies (e.g., Dalbudak et al., 2013; Hwang et al., 2012). The present results showed that depression and anxiety predicted sleep quality. Smartphone use severity and sleep quality also predicted depression. In addition, smartphone use severity and sleep quality predicted anxiety. Young adults tended to be unaware of just how much time they really spent on their smartphone, as well as the effect this might have on their academic performance and social interaction (Meena, Mittal & Solanki, 2012). It is suggested that there may be a correlation between low self-esteem and a sense of social inadequacy and social network addiction (Thadani & Cheung, 2011). Because sleep is a significant biological mechanism related to mood regulation (Thomée, et al., 2011), students whose sleep is disrupted because of technology use may be more likely to experience markers of depression such as loss of energy, concentration problems, and daytime sleepiness (Adams & Kisler, 2013; NSF., 2011).

In our study, depression and anxiety predicted the level of smartphone use independent of sleep quality, age, and gender. When used moderately, a smartphone may contribute to improving emotional and psychological well-being. In addition, smartphone communications can be used to relieve stressful situations (Park & Lee, 2012). Moreover, Adams and Kisler (2013) reported that depressed individuals might have sleep problems and use the technology to pass the time. One plausible reason for our findings on depression and anxiety is that spending time on the smartphone could be an escape from feelings of depression or anxiety. It was reported that the purpose of Internet use is important in terms of sleep duration (Canan et al., 2013). Similarly, the aim of smartphone use may be significant for sleep quality, depression, and anxiety.

Adams and Kisler (2013) suggested that sleep quality is a mediator between technology use after sleep onset and depression and anxiety in college students. Lemola et al. (2014) found that electronic media use at night is related to sleep disturbances and depressive symptoms. The researchers reported that electronic media use at night was associated with depressive symptoms. They suggested that sleep disturbances in turn appear to be a partial mediator of the relationship between electronic media use at night and depressive symptoms. Our findings indicated that depression and/or anxiety acted as a mediator between smartphone overuse and sleep quality. We think that smartphone overuse may lead to depression and/or anxiety, which in turn leads to sleep problems.

Several limitations of the present study should be considered. The relatively small study population was one such issue. Moreover, all of the participants were university students, and may not represent the total population. All subjects were well-educated adults. Longitudinal studies and samples with different educational and age backgrounds are needed. The cross-sectional design, which is not the best way to evaluate causal relations, also limited the results. Furthermore, all of the scales were self-rated. Finally, the literature in this field is not yet rich enough.

In conclusion, our study expanded the literature to include smartphone overuse and depression, anxiety, and sleep quality in university students. Although the effects of behavioral addictions, including smartphone addiction, on our lives are rising, little research has been carried out on these issues. Thus, our study provides an important contribution to the field. Ultimately, depression, anxiety, and sleep quality may be associated with smartphone overuse. Smartphone overuse may lead to depression and/or anxiety, which can in turn result in sleep problems. University students displaying high depression and anxiety scores should be attentively monitored for smartphone addiction.

Funding sources: Nothing declared.

Authors' contribution: Study concept and design: KD and MA, analysis and interpretation of data: KD, statistical analysis: KD and AA, obtained funding: no, study supervision: AA.

Conflict of interest: The authors declare no conflict of interest.

REFERENCES

Adams, S. K. & Kisler, T. S. (2013). Sleep quality as a mediator between technology-related sleep quality, depression, and anxiety. *Cyberpsychology, Behavior, and Social Networking, 16*(1), 25–30.

Agargun, M. Y., Kara, H. & Anlar, Ö. (1996). Validity and reliability of the Pittsburgh Sleep Quality Index in Turkish sample. *Turkish Journal of Psychiatry, 7,* 107–115.

Altman, D. G. & Royston, P. (2006). The cost of dichotomising continuous variables. *BMJ, 332*(7549), 1080.

An, J., Sun, Y., Wan, Y., Chen, J., Wang, X. & Tao, F. (2014). Associations between problematic Internet use and adolescents' physical and psychological symptoms: Possible role of sleep quality. *Journal of Addiction Medicine, 8*(4), 282–287.

Arora, T., Broglia, E., Thomas, G. N. & Taheri, S. (2014). Associations between specific technologies and adolescent sleep quantity, sleep quality, and parasomnias. *Sleep Medicine, 15*(2), 240–247.

Beck, A. T., Epstein, N., Brown, G. & Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology, 56*(6), 893–897.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J. & Erbaugh, J. K. (1961). An inventory for measuring depression. *Archives of General Psychiatry, 4*(6), 561–571.

Buysse, D. J., Reynolds III, C. F., Monk, T. H., Berman, S. R. & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193–213.

Cain, N. & Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: A review. *Sleep Medicine, 11*(8), 735–742.

Canan, F., Yildirim, O., Sinani, G., Ozturk, O., Ustunel, T. Y. & Ataoglu, A. (2013). Internet addiction and sleep disturbance symptoms among Turkish high school students. *Sleep and Biological Rhythms, 11*(3), 210–213.

Cheung, L. M. & Wong, W. S. (2011). The effects of insomnia and Internet addiction on depression in Hong Kong Chinese adolescents: An exploratory cross-sectional analysis. *Journal of Sleep Research, 20*(2), 311–317.

Dalbudak, E., Evren, C., Aldemir, S., Coskun, K. S., Ugurlu, H. & Yildirim, F. G. (2013). Relationship of Internet addiction severity with depression, anxiety, and alexithymia, temperament and character in university students. *Cyberpsychology, Behavior, and Social Networking, 16*(4), 272–278.

Demirci, K., Orhan, H., Demirdas, A., Akpınar, A. & Sert, H. (2014). Validity and reliability of the Turkish Version of the Smartphone Addiction Scale in a younger population. *Bulletin of Clinical Psychopharmacology, 24*(3), 226–234.

Dworak, M., Schierl, T., Bruns, T. & Strüder, H. K. (2007). Impact of singular excessive computer game and television exposure on sleep patterns and memory performance of school-aged children. *Pediatrics, 120*(5), 978–985.

Fossum, I. N., Nordnes, L. T., Storemark, S. S., Bjorvatn, B. & Pallesen, S. (2014). The association between use of electronic media in bed before going to sleep and insomnia symptoms, daytime sleepiness, morningness, and chronotype. *Behavioral Sleep Medicine, 12*(5), 343–357.

Higuchi, S., Motohashi, Y., Liu, Y. & Maeda, A. (2005). Effects of playing a computer game using a bright display on presleep physiological variables, sleep latency, slow wave sleep and REM sleep. *Journal of Sleep Research, 14*(3), 267–273.

Higuchi, S., Motohashi, Y., Liu, Y., Ahara, M. & Kaneko, Y. (2003). Effects of VDT tasks with a bright display at night on melatonin, core temperature, heart rate, and sleepiness. *Journal of Applied Physiology, 94*(5), 1773–1776.

Hisli, N. (1989). Reliability and validity of Beck Depression Inventory among university students. *Journal of Turkish Psychology, 7,* 3–13.

Huber, R., Treyer, V., Borbely, A. A., Schuderer, J., Gottselig, J. M., Landolt, H. P., Werth, E., Berthold, T., Kuster, N., Buck, A. & Achermann, P. (2002). Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG. *Journal of Sleep Research, 11*(4), 289–295.

Hwang, K. H., Yoo, Y. S. & Cho, O. H. (2012). Smartphone overuse and upper extremity pain, anxiety, depression, and interpersonal relationships among college students. *The Journal of the Korea Contents Association, 12*(10), 365–375.

International Data Corporation (IDC). (2013). Third quarter report 2013. Retrieved from http://www.idc.com/getdoc.jsp?containerId=prUS24418013.

Kim, H. (2013). Exercise rehabilitation for smartphone addiction. *Journal of Exercise Rehabilitation, 9*(6), 500–505.

Kuss, D. J. & Griffiths, M. D. (2011). Online social networking and addiction—a review of the psychological literature. *International Journal of Environmental Research and Public Health, 8*(9), 3528–3552.

Kwon, M., Kim, D. J., Cho, H. & Yang, S. (2013). The smartphone addiction scale: Development and validation of a short version for adolescents. *PloS One, 8*(12), e83558.

Kwon, M., Lee, J. Y., Won, W. Y., Park, J. W., Min, J. A., Hahn, C., Gu, X., Choi, J. H. & Kim, D. J. (2013). Development and validation of a smartphone addiction scale (SAS). *PloS One, 8*(2), e56936.

Lam, L. T. (2014). Risk factors of Internet addiction and the health effect of Internet addiction on adolescents: A systematic review of longitudinal and prospective studies. *Current Psychiatry Reports, 16*(11), 1–9.

Lee, H., Ahn, H., Choi, S. & Choi, W. (2014). The SAMS: Smartphone Addiction Management System and Verification. *Journal of Medical Systems, 38*(1), 1–10.

Lemola, S., Perkinson-Gloor, N., Brand, S., Dewald-Kaufmann, J. F. & Grob, A. (2014). Adolescents' electronic media use at night, sleep disturbance, and depressive symptoms in the smartphone age. *Journal of Youth and Adolescence,* 1–14.

Loughran, S. P., Wood, A. W., Barton, J. M., Croft, R. J., Thompson, B. & Stough, C. (2005). The effect of electromagnetic fields emitted by mobile phones on human sleep. *Neuroreport, 16*(17), 1973–1976.

MacCallum, R. C., Zhang, S., Preacher, K. J. & Rucker, D. D. (2002). On the practice of dichotomization of quantitative variables. *Psychological Methods, 7*(1), 19.

Medienpädagogischer Forschungsverbund Südwest. (2013). *JIM 2013. Jugend, Information,* (*Multi*-) *Media. Basisstudie zum Medienumgang 12- bis 19-Jähriger in Deutschland*.

Meena, P. S., Mittal, P. K. & Solanki, R. K. (2012). Problematic use of social networking sites among urban school going teenagers. *Industrial Psychiatry Journal, 21*(2), 94.

Mok, J. Y., Choi, S. W., Kim, D. J., Choi, J. S., Lee, J., Ahn, H., Choi, E. J. & Song, W. Y. (2014). Latent class analysis on Internet and smartphone addiction in college students. *Neuropsychiatric Disease and Treatment, 10,* 817–827.

NSF. (2011). *Depression and sleep*. Arlington, VA: National Sleep Foundation.

Park, N. & Lee, H. (2012). Social implications of smartphone use: Korean college students' smartphone use and psychological

well-being. *Cyberpsychology, Behavior, and Social Networking, 15*(9), 491–497.

Park, S. (2014). Associations of physical activity with sleep satisfaction, perceived stress, and problematic Internet use in Korean adolescents. *BMC Public Health, 14*(1), 1143.

Roberts, J. A., Yaya, L. H. P. & Manolis, C. (2014). The invisible addiction: Cell-phone activities and addiction among male and female college students. *Journal of Behavioral Addictions, 3*(4), 254–265.

Smith, A. (2013). *Smartphone ownership—2013 update*. Washington, DC: Pew Research Center.

Song, H. K., Jeong, M. H., Sung, D. J., Jung, J. K., Choi, J. S., Jang, Y. L. & Lee, J. S. (2010). Internet addiction in adolescents and its relation to sleep and depression. *Sleep Medicine and Psychophysiology, 17*(2), 100–108.

South Korea National Information Society Agency. (2011). *Internet Addiction Survey 2011.* Seoul: National Information Society Agency, pp. 118–119.

Thadani, D. R. & Cheung, C. (2011, January). Online social network dependency: Theoretical development and testing of competing models. In *System Sciences (HICSS), 2011 44th Hawaii International Conference on* (pp. 1–9). IEEE.

Thomée, S., Härenstam, A. & Hagberg, M. (2011). Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults – a prospective cohort study. *BMC Public Health, 11*(1), 66.

Ulusoy, M., Sahin, N. H. & Erkmen, H. (1998). Turkish version of the Beck Anxiety Inventory: Psychometric properties. *Journal Cognitive Psychotherapy, 12,* 28–35.

Willemse, I., Waller, G., Süss, D., Genner, S. & Huber, A.-L. (2012). *JAMES – Jugend, Aktivitäten, Medien – Erhebung Schweiz*. Zürich: Zürcher Hochschule für Angewandte Wissenschaften.

Wood, A. W., Loughran, S. P. & Stough, C. (2006). Does evening exposure to mobile phone radiation affect subsequent melatonin production?. *International Journal of Radiation Biology, 82*(2), 69–76.