

Research paper

Association between smartphone overdependence and generalized anxiety disorder among Korean adolescents

Yeon-Suk Lee^{a,1}, Jae Hong Joo^{b,c,1}, Jaeyong Shin^{c,d}, Chung Mo Nam^{c,d}, Eun-Cheol Park^{c,d,*}

^a Graduate School of Public Health, Yonsei University, Seoul, Republic of Korea

^b Department of Public Health, Graduate School, Yonsei University, Seoul, Republic of Korea

^c Institute of Health Services Research, Yonsei University, Seoul, Republic of Korea

^d Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, Republic of Korea

ARTICLE INFO

Keywords:

Generalized anxiety disorder

Smartphone overdependence

Adolescents

South Korea

ABSTRACT

Background: This study aimed to investigate the association between smartphone overdependence and generalized anxiety disorder among South Korean adolescents.

Methods: Participants were selected from the Korean Youth Health Behavior Survey 2020. The primary dependent variable was the generalized anxiety disorder that was measured based on seven item instrument (GAD-7). The main exposure of interest was the smartphone overdependence using the integrated scale developed by the National Information Society Agency in Korea. Weighted chi-square test and multiple logistic regression were used to assess the association between smartphone overdependence and generalized anxiety disorder.

Results: The final participants comprised of 54,948 middle and high school students. 13,775 students (25.1 %) were classified as the smartphone overdependence group. Of those who reported overly dependent on smartphones, 2803 students (20.3 %) had generalized anxiety disorder. The risk for generalized anxiety disorder were 2.15 folds (95 % CI 2.01–2.30) higher among the overdependence group in compared to their counterparts. Specifically, the risk for generalized anxiety disorder increased when smartphone has negatively affected relationships with friends and colleagues (OR: 2.35, 95 % CI 2.08–2.64). The sensitivity of smartphone overdependence scale was verified and the risk for generalized anxiety disorder increased in magnitude with the severity of smartphone overdependence.

Conclusion: The findings of the study showed significant association between smartphone overdependence and generalized anxiety disorder among South Korean adolescents. The negative changes in social relationships due to excessive smartphone use and the severity of overdependence accounted for the risk for generalized anxiety disorder.

1. Background

Smartphones are becoming indispensable in everyday life for offering variety mobile services for information, communication, education, and entertainment purposes (Ozturk et al., 2017). The portability and accessibility of a smartphone provide additional benefits enabling rapid sharing of information at anywhere for any duration. The mainstream popularity of the smartphone has been spreading around the globe since the past two decades (Škarupová et al., 2016; Cha and Seo, 2018). In 2016, smartphone ownership was reported to be 87 % across 11 advanced economies, including the United States, Canada, major

European nations, and developed Pacific nations (Poushter, 2016). According to the recent finding, South Korea reported the highest number with 88 % of population having smartphones, followed by Australia (77 %) and the United States (72 %) (Cha and Seo, 2018).

Smartphone use is much more prevalent particularly among younger generation (Škarupová et al., 2016). Growth in mobile technology to date provides various qualitative services of smartphones. Young people use smartphones to watch videos, interact on social media, and get access to learning materials (Jeong et al., 2016; Dhir et al., 2015). Whether in advanced or emerging economies, younger people are more likely to be digitally connected using smartphones (Jeong et al., 2016). Despite

* Corresponding author at: Department of Preventive Medicine, Institute of Health Services Research, Yonsei University College of Medicine, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea.

E-mail address: ecpark@yuhs.ac (E.-C. Park).

¹ These authors have contributed equally to this work and share first authorship.

<https://doi.org/10.1016/j.jad.2022.10.018>

Received 23 August 2022; Received in revised form 3 October 2022; Accepted 17 October 2022

Available online 22 October 2022

0165-0327/© 2022 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Table 1

General characteristics of South Korean youth regarding generalized anxiety disorder.

Variables	Total		GAD-7 score (>10) ^a		P-value
	N	%	N	%	
	54,948	100.0	6099	11.1	
Smartphone overdependence					<.0001
Yes	13,775	25.1	2803	20.3	
No	41,173	74.9	3296	8.0	
Sex					<.0001
Male	28,353	51.6	2191	7.7	
Female	26,595	48.4	3908	14.7	
Educational stage					<.0001
Intermediate school (age 12–14)	28,961	52.7	2945	10.2	
High school (age 15–18)	25,987	47.3	3154	12.1	
School type					<.0001
Co-educational school	36,531	66.5	4074	11.2	
Boys school	9338	17.0	687	7.4	
Girls school	9079	16.5	1338	14.7	
Subjective academic performance					<.0001
Good	20,146	36.7	1974	9.8	
Average	16,585	30.2	1585	9.6	
Poor	18,217	33.2	2540	13.9	
Geographic classification					<.0001
Metropolitan	27,435	49.9	2882	10.5	
City	24,198	44.0	2834	11.7	
Rural	3315	6.0	383	11.6	
Living arrangement					.0018
w/ close relatives (parents, siblings, etc.)	52,332	95.2	5757	11.0	
w/ other relatives	264	0.5	41	15.5	
Others	2352	4.3	301	12.8	
Income level					<.0001
High	21,339	38.8	2024	9.5	
Middle	26,397	48.0	2743	10.4	
Low	7212	13.1	1332	18.5	
Obesity status defined by BMI					.4024
Underweight (≤ 18.5 kg/m ²)	12,756	23.2	1468	11.5	
Normal (< 23 kg/m ²)	25,798	46.9	2836	11.0	
Overweight (< 25 kg/m ²)	7300	13.3	793	10.9	
Obese (≥ 25 kg/m ²)	9094	16.6	1002	11.0	
Physical activity					<.0001
Active	17,707	32.2	1728	9.8	
Inactive	37,241	67.8	4371	11.7	
Drinking experience					<.0001
Yes	18,357	33.4	2636	14.4	
No	36,591	66.6	3463	9.5	
Smoking experience					<.0001
Yes	5630	10.2	916	16.3	
No	49,318	89.8	5183	10.5	
Sources of perceived stress					<.0001
Family environment	6941	12.6	1019	14.7	
School environment	3432	6.2	645	18.8	
Academic performance	27,943	50.9	2858	10.2	
Others	14,614	26.6	1559	10.7	
Not applicable	2018	3.7	18	0.9	
Depressive symptom experience					<.0001
Yes	13,840	25.2	4048	29.2	
No	41,108	74.8	2051	5.0	
Weekday smartphone usage					<.0001
≤ 120 min (2 h)	12,739	23.2	1134	8.9	
121–240 min	18,671	34.0	1791	9.6	
241–360 min	12,286	22.4	1410	11.5	
361–480 min	5234	9.5	741	14.2	
> 480 min (8 h)	6018	11.0	1023	17.0	
Weekend smartphone usage					<.0001
≤ 120 min (2 h)	6960	12.7	612	8.8	
121–240 min	11,662	21.2	978	8.4	
241–360 min	13,348	24.3	1236	9.3	
361–480 min	8439	15.4	975	11.6	
> 480 min (8 h)	14,539	26.5	2298	15.8	

^a Generalized Anxiety Disorder Assessment: When used as a screening tool, further evaluation is recommended when the score is 10 or greater.

the multifaceted conveniences smartphones offer in the modern world, there is a growing concern regarding the overdependence which pertains to smartphone addiction. Specifically, adolescents are strongly attached to their smartphones due to several characteristics of adolescence (Crone and Konjin, 2018). Developmentally, adolescents undergo physical and psychological changes during their transition to adulthood. They are usually dependent on their parents with reference to their life and identity. On the other hand, they try to liberate from parents and create private space for themselves (Ayar et al., 2017; Liu et al., 2020). Online access via smartphone allows adolescents to have a room for one's own, which grants freedom and allows them to exercise control (Crone and Konjin, 2018; de Freitas et al., 2021). In this population, there is greater interest in the operation of new technology with better adaptation to the functioning of smartphones than adults.

Smartphone addiction involves excessive and uncontrollable use accompanied by symptoms resembling substance-related dependence (Darcine et al., 2016). Recently, there is a growing literature suggesting that excessive smartphone use is associated with depression, and to lesser extent anxiety. Smartphone itself creates impulsivity, extraversion, and excessive reassurance seeking which could potentially mediate the relation between self-regulation and problematic smartphone use (Cha and Seo, 2018; Billieux et al., 2015; Elhai et al., 2016; Dhir et al., 2015). Hence, the increased smartphone use frequency may account for poor mental health. Prior research suggests that the use of smartphone is a form of passive coping (Caplan, 2002; Wang et al., 2018). The users rely on smartphone to cope with negative feelings experienced in reality. Given that passive coping strategy is associated with decreased personal well-being, it is reasonable to assume that smartphone overdependence may be related to depression. Empirical studies are in support of this notion (Çağan et al., 2014; Chen et al., 2016; Emirtekin et al., 2019; Gao et al., 2018).

Adolescence is associated with increased need for social connection (Badri et al., 2021). Meanwhile, the global COVID-19 pandemic situation, which began at the end of 2019 and has continued for a long time to the present, has limited people's living radius to homes due to social distancing. This has led to new telecommuting and non-face-to-face classes. In addition, mental health problems such as anxiety and depression have increased due to isolation and loneliness (Jemberie et al., 2020; Gunnell et al., 2020; Wang et al., 2020; Zhu et al., 2020). Depression negatively affects adolescents' growth and development, school grades, and peer-to-family relationships (Shashi and Subhash, 2007). To alleviate infectious disease-related anxiety, people spend more time using smartphones (Király et al., 2020), and are more likely to become addicted.

According to the 2020 Smartphone Overdependence Survey conducted by the Ministry of Science and ICT and the Korea Intelligence Information Society Promotion Agency, adolescents have risen by the largest margin among all age groups (Choi et al., 2020). However, many people do not realize that smartphone addiction among adolescence is a serious problem that can negatively affect their thoughts and behaviors. Subsequently, the Korea Centers for Disease Control and Prevention included general anxiety disorder (GAD-7) questionnaire in the 2020 Youth Risk Behavior Survey to examine the current state of adolescents' mental health (Kim et al., 2022). Therefore, this study aims to by investigating the association between smartphone dependence and generalized-anxiety disorder among South Korean adolescent.

2. Methods

2.1. Study participants

The data was collected from the 2020 Youth Health Behavior Survey. The Youth Health Behavior Survey, organized by the Korea Centers for Disease Control and Prevention and the Ministry of Education, is an anonymous self-written online survey conducted to identify the health behavior of Korean adolescents and establish and evaluate government

policies accordingly. Starting in 2005, approximately 60,000 middle and high school students (age 12–18) participate annually, and the newest 16th survey was conducted in 2020. Statistical data on the current status and trend of health behavior constructed based on the Youth Health Behavior Survey are used as important evidence for youth health policies, including the National Health Promotion Comprehensive Plan, and for comparison between countries in international organizations such as the WHO. The data used in this study derived from the sampled 400 middle and high schools nationwide, and the survey period was from August 3 to November 13, 2020. With a participation rate of 94.9 %, 54,948 people (28,353 male participants; 26,595 female participants) were selected as the final analysis subjects.

2.2. Variables

The dependent variable is generalized-anxiety disorder which was measured by the Generalized-Anxiety Disorder Experience Survey Tool (GAD-7). It is consisted of 7 questionnaires regarding the severity of anxiety experienced during daily lives and a score of 10 is recommend for evaluation. The optimal sensitivity and validity of GAD-7 scale has been verified in a previous literature and the details are explained elsewhere (Mossman et al., 2017).

The main exposure variable of interest was the smartphone overdependence. The smartphone overdependence scale for adolescents was used to measure the level of smartphone overdependence among the study subjects. This integrated scale developed by the National Information Society Agency in Korea in 2016 is based on the standardized internet dependence scale and smartphone dependence scale developed in 2011. It is designed to measure the level of smartphone overdependence using a self-report 10-item questionnaire considering subareas: failure of accommodation, salience, and problematic outcome. Each score is measured on a four-point Likert scale from 1 to 4, and the total score ranges from 10 to 40 points. A higher score indicates a higher level of smartphone overdependence. Specifically, those scoring above 23 are classified into the overdependence group (Kim et al., 2022).

Demographic-sociological, health-related, psychosocial factors were also assessed. Demographic-social factors included gender, school classification, school type, subjective academic performance, city size, residence type, economic status, health-related factors include obesity, physical activity, drinking, smoking, psychosocial factors include the sources of perceived stress, depressive symptom experience, and smartphone usage time (weekday/weekend).

2.3. Statistical analysis

The general characteristics of the subject and the risk for GAD-7 were expressed as frequency and percentage. Chi-square test was performed to examine the statistical difference within each categorized group. Logistic regression was performed to investigate the association between smartphone overdependence and generalized anxiety disorder, and later, the risk for generalized anxiety disorder was examined according each of the 10-item included in the smartphone overdependence questionnaire. Also, the smartphone overdependence score was stratified according to the levels of severity to checked for the sensitivity of the overdependence scale. The results of logistic regression were expressed as Odds Ratio (OR) with 95 % confidence interval (95 % CI). SAS version 9.4 was used for analysis of the data, and the statistical significance level in all analyses was set to $P < .05$.

3. Results

Table 1 presents the general characteristics of the study population and the result of chi-square tests for independence. Of the total selected sample, 25.1 % (13,775) reported experiencing smartphone overdependence. Of those who reported experiencing smartphone overdependence, 20.3 % (2803) had generalized-anxiety disorders. Of the

Table 2

Result of logistic regression for generalized anxiety disorder.

Variables	GAD-7 score (>10) ^a		P-value
	OR	95 % CI	
Smartphone overdependence			
Yes	2.15	(2.01–2.30)	<.0001
No	1.00		
Sex			
Male	1.00		
Female	1.48	(1.35–1.63)	<.0001
Educational stage			
Intermediate school (age 12–14)	1.00		
High school (age 15–18)	1.07	(0.98–1.16)	.0631
School type			
Co-educational school	1.00		
Boys school	0.92	(0.81–1.04)	.2794
Girls school	0.94	(0.85–1.05)	.3092
Subjective academic performance			
Good	1.00		
Average	0.89	(0.82–0.97)	.0050
Poor	1.02	(0.94–1.12)	.3471
Geographic classification			
Metropolitan	1.00		
City	1.06	(0.98–1.15)	.0906
Rural	0.94	(0.82–1.09)	.6826
Living arrangement			
w/ close relatives (parents, siblings, etc.)	1.00		
w/ other relatives	1.33	(0.86–2.06)	.1532
Others	1.10	(0.93–1.31)	.3545
Income level			
High	1.00		
Middle	1.01	(0.93–1.08)	.8187
Low	1.49	(1.37–1.63)	<.0001
Obesity status defined by BMI			
Underweight (≤ 18.5 kg/m ²)	0.99	(0.92–1.07)	.7259
Normal (< 23 kg/m ²)	1.00		
Overweight (< 25 kg/m ²)	1.07	(0.96–1.19)	.1385
Obese (≥ 25 kg/m ²)	1.14	(1.04–1.24)	.0032
Physical activity			
Active	1.00		
Inactive	1.06	(0.98–1.14)	.2328
Drinking experience			
Yes	1.11	(1.03–1.20)	.0024
No	1.00		
Smoking experience			
Yes	1.05	(0.94–1.17)	.2996
No	1.00		
Sources of perceived stress			
Family environment	7.64	(4.29–13.61)	<.0001
School environment	9.38	(5.20–16.94)	<.0001
Academic performance	6.92	(3.90–12.30)	<.0001
Others	6.99	(3.92–12.46)	<.0001
Not applicable	1.00		
Depressive symptom experience			
Yes	6.07	(5.67–6.49)	<.0001
No	1.00		
Weekday smartphone usage			
≤ 120 min	1.00		
121–240 min	0.94	(0.84–1.04)	.2019
241–360 min	0.88	(0.77–1.00)	.0441
361–480 min	0.87	(0.74–1.01)	.0687
> 480 min	0.90	(0.77–1.04)	.1599
Weekend smartphone usage			
≤ 120 min	1.00		
121–240 min	0.95	(0.84–1.07)	.3951
241–360 min	0.88	(0.76–1.01)	.0593
361–480 min	0.96	(0.83–1.12)	.6223
> 480 min	1.12	(0.97–1.30)	.1200

^a Generalized Anxiety Disorder Assessment: When used as a screening tool, further evaluation is recommended when the score is 10 or greater.

74.9 % (41,173) who are not overly dependence on smartphones, 8.0 % (3296) had generalized anxiety disorders. The distribution of these two classified groups differs from one another with the P-value < .0001.

Table 2 presents the results of multiple linear regression analysis for generalized anxiety disorder. In compared to those who are overly

Table 3

Result of logistic regression for generalized anxiety disorder stratified by smartphone overdependence inventory (10 items).

Variables	GAD-7 score (>10) ^a			P-value
	No	Yes		
	OR	OR	95 % CI	
Smartphone overdependence inventory				
1. Have tried to spend less time on smartphone but have been unsuccessful	1.00	1.64	(1.54–1.76)	<.0001
2. Difficult to control the time spent on smartphone	1.00	1.75	(1.63–1.87)	<.0001
3. Spend longer periods of time on smartphone than intended	1.00	1.79	(1.68–1.91)	<.0001
4. Difficult to focus on other work when smartphone is within reach	1.00	1.79	(1.68–1.92)	<.0001
5. Difficult to keep mind away from smartphone	1.00	2.25	(2.08–2.44)	<.0001
6. Fail to control the impulse to go back on smartphone after being done using it	1.00	2.17	(2.02–2.33)	<.0001
7. Have physical discomfort from spending time on smartphone	1.00	1.90	(1.76–2.05)	<.0001
8. Smartphone has negatively affected relationships with family	1.00	1.74	(1.62–1.87)	<.0001
9. Smartphone has negatively affected relationships with friends and colleagues	1.00	2.35	(2.08–2.64)	<.0001
10. Smartphone has negatively affected schoolwork or job performance.	1.00	2.05	(1.91–2.20)	<.0001

^a Generalized Anxiety Disorder Assessment: When used as a screening tool, further evaluation is recommended when the score is 10 or greater.

dependent on smartphone (served as the reference group), the overdependence group showed increased risk for anxiety disorder by 2.15 folds (95 % CI 2.01–2.30; P-value < .0001).

Table 3 summarizes the result of logistic regression for generalized anxiety disorder stratified by smartphone overdependence questionnaire inventory (10 items). As a result, the odds for generalized anxiety disorder increased by 2.35 folds among those who reported experiencing negative effects of social relationships with friends and colleagues by (95 % CI 2.08–2.64; P-value < .0001).

Fig. 1 demonstrates the result of logistic regression for generalized anxiety disorder according to the different levels of overdependence, with the highest score representing the most severe level of overdependence. The smartphone overdependence cut-off was set to 21–25 points. As a result, the risk for generalized anxiety disorder increased in magnitude with higher score. The odds increased by 3.77 folds among those who scored the most severe level of smartphone overdependence

scale (95 % CI 2.99–4.77; P-value < .0001).

Table 4 presents the result of logistic regression for generalized anxiety disorder stratified by all covariates considered in the analysis. In general, the odds for generalized anxiety disorder significantly increased among male (OR: 2.31; P-value < .0001) and those who are living with other relatives (OR: 3.93; P-value < .0001). Furthermore, the association between smartphone usage time and generalized anxiety disorder was independent.

4. Discussion

This study examined the relationship between smartphone overdependence and generalized anxiety disorders among the South Korean adolescents. In the analysis, demographic and sociological factors, health-related factors, and psychological factors were included to adjust for confounding effects. The findings of this study suggest that smartphone overdependence could potentially increase the risk for anxiety disorder, and the risk is likely to increase in magnitude with greater dependency. Since today's youth are the first generation to grow up surrounded by various forms of high-tech media, they are very receptive to new types of media such as smartphones (Sohn, 2005). However, misuse of technology is caused by social problems in adolescents and young adults at greatest risk (Şaşmaz et al., 2014; Sohn et al., 2019; Cimino and Cerniglia, 2018; Nakayama et al., 2020), and smartphone addiction is stronger in young adults (Haug et al., 2015). Adolescents are more vulnerable to smartphone overdependence because they tend to have a lower level of control over the urge to pursue pleasure than adults (Steinbeis et al., 2016). In addition, the prevalence of mental health problems in children aged 11 or older peaked in their teens (PISA and OECD, 2017). It can be said that mental health is likely to deteriorate from the excessive use of smartphone.

The findings of this study is consistent with previous studies (Hussain et al., 2017; Long et al., 2016; Demirci et al., 2015; Tao et al., 2017; Eyvazlou et al., 2016), all of which present significant link between problematic smartphone use and anxiety. Particularly, this study showed that those experiencing negative changes in social relationships with friends were relatively more vulnerable to anxiety. In adolescence, peer relationships become important role models for each other and function as social support. However, negative relationship experiences can seriously affect individuals (Jeong, 2004). If a bad relationship with friends continues in adolescence, it decreases a sense of belonging or competence, causing a problem of social atrophy with anxious and timid characteristics (Lee et al., 2014). The weaker the family or peer relationship, the more difficult it is to communicate face-to-face, making it easier for people to seek social connections on internet (Oetting and Donnermeyer, 1998). It can be used to compensate for the helplessness

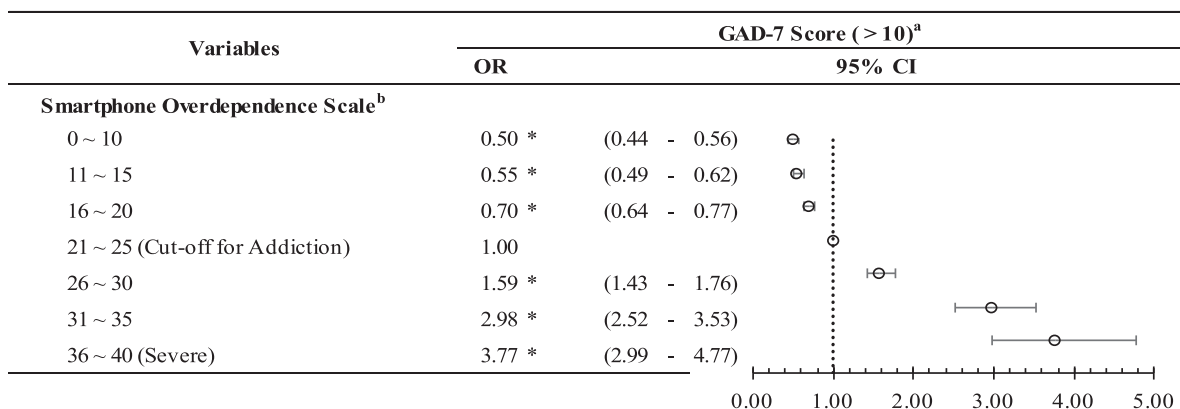


Fig. 1. Result of logistic regression for generalized anxiety disorder stratified by smartphone addiction scale.

^aGeneralized Anxiety Disorder Assessment: When used as a screening tool, further evaluation is recommended when the score is 10 or greater.

*P-value < .05

Table 4

Result of logistic regression for generalized anxiety disorder stratified by general characteristics.

Variables	GAD-7 score (>10) ^a			P-value
	Smartphone overdependence			
	No	Yes		
	OR	OR	95 % CI	
Sex				
Male	1.00	2.31	(2.08–2.57)	<.0001
Female	1.00	2.05	(1.88–2.24)	<.0001
Educational stage				
Intermediate school (age 12–14)	1.00	2.28	(2.07–2.52)	<.0001
High school (age 15–18)	1.00	2.04	(1.86–2.24)	<.0001
School type				
Co-educational school	1.00	2.15	(1.97–2.34)	<.0001
Boys school	1.00	2.31	(1.94–2.74)	<.0001
Girls school	1.00	2.07	(1.81–2.38)	<.0001
Subjective academic performance				
Good	1.00	2.23	(1.98–2.51)	<.0001
Average	1.00	2.13	(1.86–2.43)	<.0001
Poor	1.00	2.10	(1.89–2.32)	<.0001
Geographic classification				
Metropolitan	1.00	2.29	(2.08–2.52)	<.0001
City	1.00	2.04	(1.85–2.26)	<.0001
Rural	1.00	1.86	(1.48–2.33)	<.0001
Living arrangement				
w/ close relatives (parents, siblings, etc.)	1.00	2.15	(2.00–2.30)	<.0001
w/ other relatives	1.00	3.93	(1.49–10.37)	<.0001
Others	1.00	2.06	(1.40–3.03)	<.0001
Income level				
High	1.00	2.10	(1.88–2.36)	<.0001
Middle	1.00	2.22	(2.01–2.45)	<.0001
Low	1.00	2.07	(1.77–2.42)	<.0001
Obesity status defined by BMI				
Underweight (≤ 18.5 kg/m ²)	1.00	2.22	(1.93–2.56)	<.0001
Normal (< 23 kg/m ²)	1.00	2.13	(1.93–2.34)	<.0001
Overweight (< 25 kg/m ²)	1.00	2.27	(1.88–2.73)	<.0001
Obese (≥ 25 kg/m ²)	1.00	2.05	(1.73–2.44)	<.0001
Physical activity				
Active	1.00	2.18	(1.90–2.51)	<.0001
Inactive	1.00	2.14	(1.97–2.33)	<.0001
Drinking experience				
Yes	1.00	2.07	(1.87–2.30)	<.0001
No	1.00	2.18	(2.00–2.38)	<.0001
Smoking experience				
Yes	1.00	1.94	(1.62–2.32)	<.0001
No	1.00	2.19	(2.03–2.36)	<.0001
Sources of perceived stress				
Family environment	1.00	2.14	(1.82–2.52)	<.0001
School environment	1.00	2.34	(1.87–2.93)	<.0001
Academic performance	1.00	2.22	(2.01–2.44)	<.0001
Others	1.00	1.96	(1.70–2.27)	<.0001
Not applicable	1.00	7.15	(3.42–14.94)	<.0001
Depressive symptom experience				
Yes	1.00	1.80	(1.65–1.95)	<.0001
No	1.00	2.75	(2.47–3.06)	<.0001
Weekday smartphone usage				
≤ 120 min (2 h)	1.00	2.37	(2.00–2.80)	<.0001
121–240 min	1.00	1.98	(1.75–2.23)	<.0001
241–360 min	1.00	2.05	(1.79–2.35)	<.0001
361–480 min	1.00	2.39	(1.99–2.89)	<.0001
>480 min (8 h)	1.00	2.39	(1.99–2.87)	<.0001
Weekend smartphone usage				
≤ 120 min (2 h)	1.00	2.45	(1.91–3.13)	<.0001
121–240 min	1.00	2.42	(2.04–2.88)	<.0001
241–360 min	1.00	1.76	(1.52–2.04)	<.0001
361–480 min	1.00	2.22	(1.90–2.59)	<.0001
>480 min (8 h)	1.00	2.27	(2.02–2.56)	<.0001

^a Generalized Anxiety Disorder Assessment: When used as a screening tool, further evaluation is recommended when the score is 10 or greater.

and frustration experienced in real life (Gross et al., 2002; Auhagen, 2000). In addition, the more rewards you receive on the Internet, the more likely you are to rely on it (Gao et al., 2019).

As a result of analyzing the relationship between smartphone overdependence and generalized anxiety disorder according to sex, the likelihood of having anxiety disorder was higher in male students. This is consistent with previous study resembling ours (Oh and Kim, 2014). In addition, in the case of male students, it is like that they are more vulnerable to media and internet addiction (Kim et al., 2013). In terms of household type, students living with other relatives had the increased risk for generalized anxiety disorder. The support of families in adolescents significantly improves the mental health status of smartphone addiction (Jun and Kim, 2015). In addition, a positive relationship with the family can affect psychological aspects such as depression or anxiety associated with an individual's smartphone addiction (Oh and Kim, 2014). It can be seen that in order to prevent smartphone addiction, it is necessary to involve not only youth individuals but also their parents.

Smartphone usage time is a variable that is widely used for evaluating smartphone dependence (Ellis et al., 2018). Interestingly, the findings of this study did not align with the previous literature. When the association between smartphone overdependence and generalized anxiety disorder was stratified by the usage hours, the risk for generalized anxiety disorder increased regardless of the usage time. Given that smartphone usage time has independent association with adolescents' anxiety, guidelines that consider not only smartphone usage time but also the purpose of smartphone use are recommended.

This study had several limitations. First, the data were based on self-reports; hence, the interactions may not have been accurately measured and may be less reliable. Second, although this study attempted to control for numerous covariates that may affect the dependent variable, residual confounding effects from unmeasured variables could not be ruled out.

5. Conclusions

This study analyzed the association between adolescents' dependence on smartphones and generalized anxiety disorders. The findings of the study showed significant association between smartphone overdependence and generalized anxiety disorder among South Korean adolescents. The negative changes in social relationships due to excessive smartphone use and the severity of overdependence accounted for increased risk for generalized anxiety disorder.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Study conception and design was performed by Yeon-Suk Lee. Analysis and interpretation of data was performed by Yeon-Suk Lee, Jae Hong Joo, Chung-Mo Nam, Jaeyong Shin, and Eun-Cheol Park revised and provided feedbacks the paper. All authors approved the final manuscript.

Consent to publish

Not applicable.

Conflict of Interest

The authors have no relevant financial or non-financial interests to declare.

Data availability

The data is publicly accessible on the website of Korea Youth Risk Behavior Web-Based Survey administered by the Korea Disease Control and Prevention Agency (<https://www.kdca.go.kr/yhs/>).

Acknowledgements

We would like to thank the members of the Institute of Health Services Research at Yonsei University for their advice for the further development of this study.

References

- Auhagen, A.E., 2000. On the psychology of meaning of life. *Swiss J. Psychol.* 59 (1), 34.
- Ayar, D., Bektas, M., Bektas, I., et al., 2017. The effect of adolescents' internet addiction on smartphone addiction. *J. Addict.* 28 (4), 210–214.
- Badri, M., Khaili, M.A., Bahar, M.A., et al., 2021. Social connection and self-perceived depression among adolescents: a path analytic model for Abu Dhabi. *J. Child Fam. Stud.* 30 (1), 146–157.
- Billieux, J., Maurage, P., Lopez-Fernandez, O., et al., 2015. Can disordered mobile phone use be considered a behavioral addiction? An update on current evidence and a comprehensive model for future research. *Curr. Addict. Rep.* 2 (2), 156–162.
- Çağan, Ö., Ünsal, A., Çelik, N., 2014. Evaluation of college students' the level of addiction to cellular phone and investigation on the relationship between the addiction and the level of depression. *Procedia Soc. Behav. Sci.* 114, 831–839.
- Caplan, S.E., 2002. Problematic internet use and psychosocial well-being: development of a theory-based cognitive-behavioral measurement instrument. *Comput. Hum. Behav.* 18 (5), 553–575.
- Cha, S.-S., Seo, B.-K., 2018. Smartphone use and smartphone addiction in middle school students in Korea: prevalence, social networking service, and game use. *Health Psychol. Open* 5 (1), 2055102918755046.
- Chen, L., Yan, Z., Tang, W., et al., 2016. Mobile phone addiction levels and negative emotions among Chinese young adults: the mediating role of interpersonal problems. *Comput. Hum. Behav.* 55, 856–866.
- Choi, D.J., Kim, Y.S., Um, N.R., et al., 2020. The Survey on Smartphone Overdependence [Internet]. Annual Report. Ministry of Science and ICT, National Information Society Agency, Seoul. Dec. Report No.: NIA V-VER-C-20017. Available from: https://www.nia.or.kr/site/nia_kor/ex/bbs/.
- Cimino, S., Cerniglia, L., 2018. A longitudinal study for the empirical validation of an etiopathogenic model of internet addiction in adolescence based on early emotion regulation. *Biomed. Res. Int.* 2018, 4038541.
- Crone, E.A., Konjin, E.A., 2018. Media use and brain development during adolescence. *Nat. Comm.* 9 (1), 1–10.
- Darcine, A.E., Kose, S., Cemal, C.O., et al., 2016. Smartphone addiction and its relationship with social anxiety and loneliness 35 (7), 520–525.
- de Freitas, B.H.B.M., Gaíva, M.A.M., Bernardino, F.B.S., et al., 2021. Smartphone addiction in adolescents, part 2: scoping review—prevalence and associated factors. *Trends Psychol.* 29 (1), 12–30.
- Demirci, K., Akgönül, M., Akpınar, A., 2015. Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. *J. Behav. Addict.* 4 (2), 85–92.
- Dhir, A., Chen, S., Nieminen, M., 2015. Predicting adolescent internet addiction: the roles of demographics, technology accessibility, unwillingness to communicate and sought internet gratifications. *Comput. Hum. Behav.* 51, 24–33.
- Elhai, J.D., Levine, J.C., Dvorak, R.D., et al., 2016. Fear of missing out, need for touch, anxiety and depression are related to problematic smartphone use. *Comput. Hum. Behav.* 63, 509–516.
- Ellis, D.A., Kaye, L.K., Wilcockson, T.D., et al., 2018. Digital traces of behaviour within addiction: response to Griffiths (2017). *Int. J. Ment. Heal. Addict.* 16 (1), 240–245.
- Emirtekin, E., Balta, S., Sural, İ., et al., 2019. The role of childhood emotional maltreatment and body image dissatisfaction in problematic smartphone use among adolescents. *Psychiatry Res.* 271, 634–639.
- Eyvazlou, M., Zarei, E., Rahimi, A., et al., 2016. Association between overuse of mobile phones on quality of sleep and general health among occupational health and safety students. *Chronobiol. Int.* 33 (3), 293–300.
- Gao, T., Li, J., Zhang, H., et al., 2018. The influence of alexithymia on mobile phone addiction: the role of depression, anxiety and stress. *J. Affect. Disord.* 225, 761–766.
- Gao, X.M., Zhu, B., Zhang, X.M., 2019. The relationship between adult attachment and mobile phone addiction in college students: the mediating role of interpersonal alienation. *J. Yangtze Univ.* 42 (6), 107–109.
- Gross, E.F., Juvonen, J., Gable, S.L., 2002. Internet use and well-being in adolescence. *J. Soc. Issues* 58 (1), 75–90.
- Gunnell, D., Appleby, L., Arensman, E., et al., 2020. Suicide risk and prevention during the COVID-19 pandemic. *Lancet Psychiatry* 7 (6), 468–471.
- Haug, S., Castro, R.P., Kwon, M., et al., 2015. Smartphone use and smartphone addiction among young people in Switzerland. *J. Behav. Addict.* 4 (4), 299–307.
- Hussain, Z., Griffiths, M.D., Sheffield, D., 2017. An investigation into problematic smartphone use: the role of narcissism, anxiety, and personality factors. *J. Behav. Addict.* 6 (3), 378–386.
- Jemberie, W.B., Stewart Williams, J., Eriksson, M., et al., 2020. Substance use disorders and COVID-19: multi-faceted problems which require multi-pronged solutions. *Front. Psychiatry* 11, 714.
- Jeong, N.U., 2004. Construction of the circumplex scales for Korean version of the Interpersonal Adjective Scales (KIAS-40). *Korean J. Couns. Psychother.* 16 (1), 37–51.
- Jeong, S.-H., Kim, H., Yum, J.-Y., et al., 2016. What type of content are smartphone users addicted to? SNS vs. games. *Comput. Hum. Behav.* 54, 10–17.
- Jun, D.S., Kim, D.W., 2015. The effects of smart phone addiction on mental health of adolescents and adults-focusing on the moderating effect of family support. *Soc. Sci. Res. Rev.* 31 (3), 172–174.
- Kim, D.I., Lee, Y.U., Kang, M.C., et al., 2013. A multi-level meta-analysis on the relations between mental health problems and internet addiction. *Korea J. Couns.* 14 (1), 285–303.
- Kim, H., Kim, S.H., Jang, S.I., et al., 2022. Association between sleep quality and anxiety in Korean adolescents. *J. Prev. Med. Public Health* 55 (2), 173.
- Király, O., Potenza, M.N., Stein, D.J., et al., 2020. Preventing problematic internet use during the COVID-19 pandemic: consensus guidance. *Compr. Psychiatry* 100, 152180.
- Lee, Y.K., Chang, C.T., Lin, Y., et al., 2014. The dark side of smartphone usage: psychological traits, compulsive behavior and technostress. *Comput. Hum. Behav.* 31, 373–383.
- Liu, Q., Wu, J., Zhou, Z., et al., 2020. Parental technofence and smartphone addiction in Chinese adolescents: the mediating role of social sensitivity and loneliness. *Child Youth Serv. Rev.* 118, 105434.
- Long, J., Liu, T.Q., Liao, Y.H., et al., 2016. Prevalence and correlates of problematic smartphone use in a large random sample of Chinese undergraduates. *BMC Psychiatry* 16 (1), 1–12.
- Mossman, S.A., Luft, M.J., Schroeder, H.K., et al., 2017. The Generalized Anxiety Disorder 7-item scale in adolescents with generalized anxiety disorder: signal detection and validation. *Ann. Clin. Psychiatry* 29 (4), 227–234A.
- Nakayama, H., Ueno, F., Mihara, S., et al., 2020. Relationship between problematic internet use and age at initial weekly internet use. *J. Behav. Addict.* 9 (1), 129–139.
- Oetting, E.R., Donnermeyer, J.F., 1998. Primary socialization theory: the etiology of drug use and deviance. *Subst. Use Misuse* 33 (4), 995–1026.
- Oh, H.H., Kim, H.J., 2014. The mediating effects of family communication between parent attachment and the internet and smartphone addiction of middle and high school students. *Stud. Korean Youth* 25 (4), 35–57.
- Ozturk, S., Cakin, H., Kurtuldu, H., et al., 2017. Smartphones and programmable shunts: are these indispensable phones safe and smart? *World Neurosurg.* 102, 518–525.
- PISA, OECD, 2017. Results: Students' Well-being. Vol. III. PISA.
- Poushter, J., 2016. Smartphone ownership and internet usage continues to climb in emerging economies. *Pew Res. Cent.* 22 (1), 1–44.
- Şaşmaz, T., Oner, S., Kurt, A.Ö., et al., 2014. Prevalence and risk factors of internet addiction in high school students. *Eur. J. Public Health* 24 (1), 15–20.
- Shashi, K.B., Subhash, C.B., 2007. Childhood and adolescent depression. *Am. Fam. Physician* 75 (1), 73–80.
- Škařupová, K., Ólafsson, K., Blinka, L., 2016. The effect of smartphone use on trends in European adolescents' excessive internet use. *Behav. Inform. Technol.* 35 (1), 68–74.
- Sohn, S., 2005. Competition and substitution of digital media: usage patterns of news, sports, and adult content. *J. Cybercommun.* 16, 273–308.
- Sohn, S.Y., Rees, P., Wildridge, B., et al., 2019. Prevalence of problematic smartphone usage and associated mental health outcomes amongst children and young people: a systematic review, meta-analysis and GRADE of the evidence. *BMC Psychiatry* 19 (1), 1–10.
- Steinbeis, N., Haushofer, J., Fehr, E., et al., 2016. Development of behavioral control and associated vmPFC-DLPFC connectivity explains children's increased resistance to temptation in intertemporal choice. *Cereb. Cortex* 26 (1), 32–42.
- Tao, S., Wu, X., Zhang, Y., et al., 2017. Effects of sleep quality on the association between problematic mobile phone use and mental health symptoms in Chinese college students. *Int. J. Environ. Res. Public Health* 14 (2), 185.
- Wang, P., Wang, X., Wu, Y., et al., 2018. Social networking sites addiction and adolescent depression: a moderated mediation model of rumination and self-esteem. *Personal. Individ. Differ.* 127, 162–167.
- Wang, S., Zhang, Y., Ding, W., et al., 2020. Psychological distress and sleep problems when people are under interpersonal isolation during an epidemic: a nationwide multicenter cross-sectional study. *Eur. Psychiatry* 63 (1), e77.
- Zhu, Z., Liu, Q., Jiang, X., et al., 2020. The psychological status of people affected by the COVID-19 outbreak in China. *J. Psychiatr. Res.* 129, 1–7.