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Research Article

Structural Equation Model of Smartphone Addiction Based on Adult Attachment Theory: Mediating Effects of Loneliness and Depression

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SUMMARY

Purpose: This study investigated the mediating effects of loneliness and depression on the relationship between adult attachment and smartphone addiction in university students.**Methods:** A total of 200 university students participated in this study. The data was analysed using descriptive statistics, correlation analysis, and structural equation modeling.**Results:** There were significant positive relationships between attachment anxiety, loneliness, depression, and smartphone addiction. However, attachment anxiety was not significantly correlated with smartphone addiction. The results also showed that loneliness did not directly mediate between attachment anxiety and smartphone addiction. In addition, loneliness and depression serially mediated between attachment anxiety and smartphone addiction.**Conclusion:** The results suggest there are mediating effects of loneliness and depression in the relationship between attachment anxiety and smartphone addiction. The hypothesized model was found to be a suitable model for predicting smartphone addiction among university students. Future study is required to find a causal path to prevent smartphone addiction among university students.© 2017 Korean Society of Nursing Science, Published by Elsevier Korea LLC. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

The Korea Internet and Security Agency reported in 2014 that smartphone usage amongst Korean university students in their twenties was 99.8%, with a daily average of 152.1 minutes, which was the highest rate of any age group [1]. Compared to Korean high school students or office workers, it is easier for Korean university students to access their smartphones because they have more free time and are less under the authority of parents and teachers. In addition, using smartphones might relieve their anxiety about the unpredictable future and stress from interpersonal conflicts, such as romantic relationship breakups [2]. Due to excessive use, therefore, the high smartphone usage rate among university students is apt to lead to smartphone addiction. According to the "Internet Addiction Survey of 2014" from the Ministry of Science, Information and Communication Technology (ICT), and Future Planning, 20.5% of university students are at risk of smartphone addiction, with 3.2% at high risk, and 17.3% at

potential risk [3]. In other words, about one in five university students are at risk of smartphone addiction, which is a serious issue that may interfere with their abilities to live healthy lives. Although both mobile phones and the internet also have a high probability for addiction, the portability of smartphones might put them at greater risk of becoming addictive than either basic mobile phones or the internet.

Some researchers who have examined the relationship between attachment styles and internet or smartphone addiction report that Korean youth or university students who have an insecure attachment style are more likely to become addicted to the internet or smartphone than those with a secure attachment style [4,5]. These young people are apt to use smartphones in order to meet their need for attachment, thus regarding their smartphones as objects of attachment. Other studies have determined that depressed Korean university students have a high tendency to be addicted to smartphones [2]. For Korean university students, depression was found to be the highest predicting factor among other risk factors for addiction, presenting a significantly positive correlation with smartphone addiction [6].

Yet other studies have found that loneliness plays the role of mediator to any addiction [7,8]. In a study by Park [7], smartphone addiction and loneliness presented a significantly positive

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correlation. The study also reported, through multiple regression analysis, that loneliness was a major predictive factor for social networking service addiction [7]. Furthermore, loneliness has been found to be a mediating factor between attachment style and smartphone or internet addiction [8].

Flores [9], in exploring the relationship between insecure attachment style and addiction, suggested that addiction resulted from attachment problems. According to the attachment theory of Bowlby [10], attachment is established between an infant and the infant's primary caregiver through emotional bonds facilitated by physical contact and familiarity. Insecurely attached persons have a negative image of self or others in their internal working models due to their early experiences. As a result, insecurely attached people might either become dependent on or avoidant of others [11]. Brennan et al [12] define "attachment anxiety" as having a fear of rejection and "attachment avoidance" as a fear of closeness and dependency [13].

According to Flores, the reason why substance abusers become addicts is because they experience difficulties with emotional regulation [9]. Addiction is regarded as an alternative to overcoming the difficulties in their relationships, which worsens their attachment capabilities. Those who have insecure attachment styles are likely to become addicted due to their deficiency in regulating their emotions effectively [9]. In a similar vein, Catanzaro and Mearns [14] insist that people who are able to cope with or regulate their negative emotions well are less prone to becoming depressed.

In Korea, it has been shown that differences in attachment styles have a high correlation with depression or the lack of depression [15,16]. In particular, Kim and Oh [15] found that those who had anxious and avoidant attachment styles were more likely to suffer from depression. Wei et al [13] found that both anxious and avoidant attachment styles had strong associations with increased loneliness and difficulties in interpersonal relationships. Yet another study [16] discovered that an anxious attachment style had direct and indirect effects on loneliness and depression. Based on these previous studies, this study explored the mediating effects of depression and loneliness in the relationship between smartphone addiction and attachment style.

This study sought to build a conceptual framework based on a premise rooted in Flores' theory and attachment theory [9,10]: insecurely attached university students tend to feel loneliness and depression, and cannot regulate their emotions properly. They therefore choose smartphones as self-objects to reduce their pain. By applying Flores' assertion in conjunction with the findings of previous studies [9], the present study aimed to suggest the paths between the risk factors and the mediating effects of depression and loneliness in the relationship between smartphone addiction and attachment style.

Purpose

The purpose of this study was to propose a structural equation model between attachment style and smartphone addiction based on Flores' argument that people become addicted because they experience difficulties with emotional regulation [9]. To do this, we verified the hypothesized structural equation model and examined the mediating effect of loneliness and depression in the relationship between attachment style and smartphone addiction.

Methods

Study design

A cross-sectional research design was employed to explore the causal pathways linking attachment to smartphone addiction in university students.

Study sample

The participants for this research were university students enrolled in a major or elective class at one of the four universities located in cities designated as A, C, S, and P. The age range was 20–30 years old. The reason for choosing this age limit was that the rate of smartphone usage in the twenties was the highest and two times longer than any other working adult group [3]. From the cross-sectional survey, 210 students were recruited, but only data from 200 students were used for the final analysis, due to inconsistent answers. This number satisfied the minimum sample size for the maximum likelihood method, which was commonly used in structural equation modeling analysis [17].

Measurements

Attachment anxiety

Attachment anxiety was assessed using the Experiences in Close Relationships-Revised-Korean instrument, which was developed by Brennan et al [12] and translated by Kim et al [18]. The attachment anxiety measure was composed of 18 items, each rated on a 7-point Likert scale. Higher scores suggested an increased severity of attachment anxiety. The instrument demonstrated good reliability in the research of Brennan et al's [12] ($\alpha = .91$) and Kim et al [18] ($\alpha = .85$). In the current study, internal consistency was strong ($\alpha = .89$). For the study, we followed the instructions of Bae [17], who used the exploratory factor analysis, and did item parceling with three factors extracted from the exploratory factor analysis.

Attachment avoidance

Attachment avoidance was also measured using the Experiences in Close Relationships-Revised-Korean. The attachment avoidance assessment was composed of 18 items rated on a 7-point Likert scale. Higher scores represented an increased severity of attachment avoidance. The instrument had strong reliability in the study of Brennan et al [12] ($\alpha = .91$) and the study of Kim et al [18] ($\alpha = .85$). In our study, internal consistency was satisfactory ($\alpha = .79$). As with attachment anxiety, we followed the instructions of Bae [17].

Depression

Depression was assessed using the Center for Epidemiologic Studies Depression Scale (CES-D) developed by Radloff [19] and translated by Chon et al [20]. The CES-D is a questionnaire composed of 20 items, each rated on a 4-point Likert scale. Higher scores indicated a greater severity of depression. The instrument had strong reliability ($\alpha = .91$) in Chon et al's [20] research, and in the present study internal consistency was strong ($\alpha = .89$). We followed the same instructions of Bae [17] referenced previously.

Loneliness

The Revised UCLA Loneliness Scale (RULS) was a 20-item Likert scale questionnaire used to measure loneliness. It was developed and revised by Russell et al [21] and translated by Park and Doh [22]. RULS was divided into two subscales: satisfaction with relationships (10 items) and dissatisfaction with relationships (10 items). Scores ranged from 20 to 80. Higher scores showed an increased severity of loneliness. RULS used a 5-point Likert scale with answers ranging from 0 (*never*) to 4 (*very often*). Cronbach α was reported in Park and Doh's [22] study as .90. In this study, Cronbach α for the whole scale was .91, and the two subscales (satisfaction and dissatisfaction) each had a coefficient of .82. In this study, the two subscales (satisfaction and dissatisfaction) were used as factors for item parceling.

Smartphone addiction

Smartphone addiction was measured using the Smartphone Addiction Proneness Scale developed by the National Information Society Agency [23]. It consisted of four subdomains: disturbance of adaptive functioning (5 items), virtual life orientation (2 items), withdrawal (4 items), and tolerance (4 items), equaling a total of 15 items. Each item was scored on a 5-point Likert scale. A higher score represented an increased severity of smartphone addiction proneness. The current study yielded a Cronbach α coefficient of .92. Item parceling was conducted with the four subdomains as factors, as the instrument developers suggested.

Data collection

The researchers received permission from the developers and translators via email to use all instruments of data collection. The participants were university students from Seoul, Chungchung Province, Kangwon Province, and Kyungsang Province. In order to protect the participants, the researchers received permission from the Institutional Review Board (IRB no. PIRB-2015-E006) of Pohang University of Science and Technology before data collection commenced. Data collection lasted from March 15th to May 16th, 2015. In order to participate in the research, participants were informed of the study purpose, the participation procedures, the dangers and benefits of the research, confidentiality, and the option to withdraw from the study at any time.

Data analysis

The collected data were analyzed utilizing SPSS 21.0 (IBM Corp., Armonk, NY, USA) and AMOS 21.0 (IBM Corp., Armonk, NY, USA). In order to examine the characteristics of the participants and the measured variables, descriptive statistics were used. Pearson correlation was used to evaluate the correlations between the latent variables. In order to evaluate the fitness of the hypothesized and modified models, χ^2 , root mean square error of approximation (RMSEA), the goodness of fit index (GFI), the comparative fit index (CFI), the normal fit index (NFI), and the Tucker Lewis index (TLI) were used. Bootstrapping was conducted to examine the statistical significance of the modified model's indirect effects, total effects, and mediated effects. Since the missing values did not have a regular pattern, we decided to use the missing at random method instead of the systematic missing rate. Furthermore, the missing rate was lower than 0.1 per variable, so mean imputation was conducted with the missing data.

Results

General characteristics of study sample

The participants in this study consisted of 200 university students, 126 female (63.0%) and 74 male (37.0%). Their ages ranged from 19 years old to 28 years old ($M = 21.6$, $SD = 2.0$). In terms of religious affiliation, there were 104 nonreligious (52.0%), 60 Protestant (30.0%), 15 Catholic (7.5%), and 21 (10.5%) unidentified students. As for grade, there were 23 freshmen (11.5%), 83 sophomores (41.5%), 56 juniors (28.0%), and 38 seniors (19.0%) (Table 1).

Descriptive statistics of variables, test of normality and multicollinearity

This analysis had the expectation that the observable variables of the hypothesized structural equation model would follow a normal distribution [24,25]. Skewness and kurtosis were to be used in the examination of the assumption of normal distribution if the

Table 1 General Characteristics of Study Sample ($N = 200$).

Characteristics	Categories	<i>n</i> (%)
Gender	Male	74 (37.0)
	Female	126 (63.0)
Age (yr)	$M \pm SD$	21.6 ± 2.0
	19	39 (19.5)
	20	34 (17.0)
	21	31 (15.5)
	22	29 (14.5)
	23	34 (17.0)
	24	11 (5.5)
	25	17 (8.5)
	26	4 (2.0)
	28	1 (0.5)
Religion	Protestant	60 (30.0)
	Catholic	15 (7.5)
	Atheist	104 (52.0)
	Unidentified	21 (10.5)
Grade	Freshmen	23 (11.5)
	Sophomore	83 (41.5)
	Junior	56 (28.0)
	Senior	38 (19.0)

skewness of the variables was less than the absolute value 3 and the kurtosis was less than the absolute value 10, since the distribution would not be far from the assumption of normal distribution [24]. In this study, all the variables fell under the skewness with an absolute value of 1.72 and the kurtosis with an absolute value of 3.4. Therefore, as expected the results of skewness and kurtosis met the assumption of normal distribution.

The examination of the assumption of multicollinearity was executed based on tolerance and the variance inflation factor. In this study, tolerance was .42–.62 ($> .10$), and variance inflation factor was 1.68–2.38 (< 10). Therefore, there was no problem with multicollinearity.

Modification and verification of hypothesized model

Verifications of the hypothesized model's fitness are shown in Table 2. Since χ^2 of the hypothesized model was 210.66, which was twice greater than the degree of freedom (GFI = .88, CFI = .93, TLI = .91, NFI = .89, RMSEA = .09), it did not reach the recommended standard. Therefore, on the basis of modification indices, the model's fitness was improved through the covariance set between the measurement error of endogenous variables and the measurement error of exogenous variables. As a result, since χ^2 was 145.76, which was lower than twice the degree of freedom (GFI = .91, NFI = .93, CFI = .96, TLI = .94, RMSEA = .07), it satisfied the model acceptance criteria.

Effect analysis of modified model

Among the nine paths of the modified model, five paths were significant (Figure 1, Table 3). The direct paths from attachment avoidance to smartphone addiction ($\beta = -.37$, $t = -2.56$) and attachment avoidance to loneliness ($\beta = .46$, $t = 5.75$) were statistically significant. The direct path from attachment anxiety to loneliness ($\beta = .55$, $t = 5.99$) was significant, and the paths from loneliness to depression ($\beta = .54$, $t = 2.46$) and from depression to smartphone addiction ($\beta = .34$, $t = 3.06$) were also valid.

The total effect was computed by adding the direct effect of the predictor variable to the outcome variable and the indirect effect, which had rounded at least one mediating variable and had an impact on the variable [17]. The total effect of attachment avoidance on smartphone addiction was $\beta = -.26$, which was significant ($p = .004$), and the total effect of attachment anxiety on

Table 2 Fit Index of Hypothetical Model and Modified Model.

Model	$\chi^2 (p)$	χ^2/df	GFI	RMSEA	NFI	CFI	TLI
Criteria	$p \geq .05$	≤ 2	$\geq .9$.08–.10 (mediocre fit) $\leq .08$ (reasonable fit) $\leq .05$ (close fit)	$\geq .9$	$\geq .9$	$\geq .9$
Hypothetical model	210.66 (< .001)	2.63	.88	.09 (LO .07, HI .11)	.89	.93	.91
Modified model	145.76 (< .001)	1.99	.91	.07 (LO .05, HI .08)	.93	.96	.94

Note. CFI = comparative fit index; GFI = goodness fit index; NFI = normal fit index; RMSEA = root mean square error of approximation; TLI = Tucker-Lewis index.

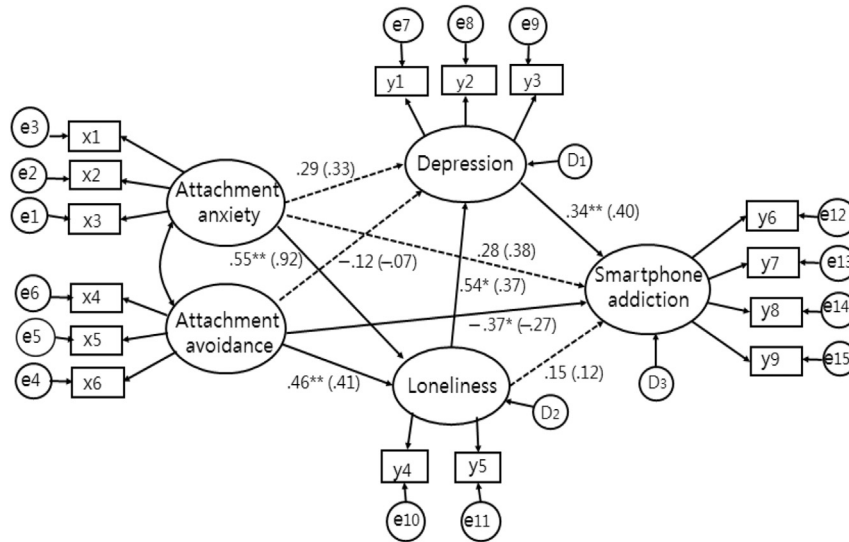


Figure 1. Path diagram of the modified model. Note. e1–e15 means measurement error and it is common symbols in AMOS; x1–x3 refer to parcels of attachment anxiety; x4–x6 refer to parcels of attachment avoidance; y1–y3 refer to parcels of depression; y4–y5 refer to parcels of loneliness; y6–y9 refer to parcels of addiction; * $p < .05$, ** $p < .01$.

Table 3 Effects of Exogenous Variables in Modified Model.

Endogenous variables	Exogenous variables	β	t	R^2	Standardized direct effects (p)	Standardized indirect effects (p)	Standardized total effects (p)
Loneliness	Attachment avoidance	.46	5.75	.78	.46 (< .001)		.46 (.012)
	Attachment anxiety	.55	5.99		.55 (< .001)		.55 (.012)
Depression	Attachment avoidance	-.12	-0.95	.50	-.12 (.344)	.25 (.035)	.13 (.270)
	Attachment anxiety	.29	1.91		.29 (.057)	.30 (.018)	.59 (.007)
	Loneliness	.54	2.46		.54 (.014)		.54 (.037)
Smartphone addiction	Attachment avoidance	-.37	-2.56	.31	-.37 (.011)	.11 (.360)	-.26 (.004)
	Attachment anxiety	.28	1.70		.28 (.089)	.28 (.139)	.56 (.009)
	Loneliness	.15	0.62		.15 (.534)	.18 (.039)	.33 (.272)
	depression	.34	3.06		.34 (.002)		.34 (.043)

smartphone addiction was .56, which was statistically significant ($p = .009$). Attachment avoidance, attachment anxiety, loneliness, and depression explained 31.0% of the variance. The result of bootstrapping on the mediating effect between attachment avoidance and depression was significant ($\beta = .25, p = .035$), and the mediating effect between attachment anxiety and depression was also significant ($\beta = .30, p = .018$).

Examination of dual mediating effect

The model of this research found a dual mediating effect of loneliness and depression on the relationship between attachment avoidance and smartphone addiction, and between attachment anxiety and smartphone addiction. In the case of a multiple mediating model, which has more than two mediating effects, bootstrapping provides total effects, including mediating effects but not specific indirect effects, according to the path of each mediating effect. Thus, the setting of a conversion model using

phantom variables and examination was employed [17,26]. Phantom variables as virtual variables do not have an effect on a model's fitness or the parameters of the original model. In this research, as presented in Figure 2, the path from attachment anxiety to smartphone addiction via loneliness and depression was set as $p1 \rightarrow p2 \rightarrow p3$. The indirect effect of the path showed that the coefficient of the nonstandardized indirect effect was .135; it was computed by multiplying the coefficients from the adjusted model of the nonstandardized direct effect of three paths: attachment anxiety on loneliness, loneliness on depression, and depression on smartphone addiction (Figure 2, Table 4). In addition, the path from attachment avoidance to smartphone addiction via loneliness and depression was set as $p4 \rightarrow p5 \rightarrow p6$. The result of this indirect effect was .061, and it was computed by multiplying the coefficients from the adjusted model of the nonstandardized direct effect of three paths: attachment anxiety on loneliness, loneliness on depression, and depression on smartphone addiction (Figure 2, Table 4). Also, the fitness between the adjusted model and the phantom

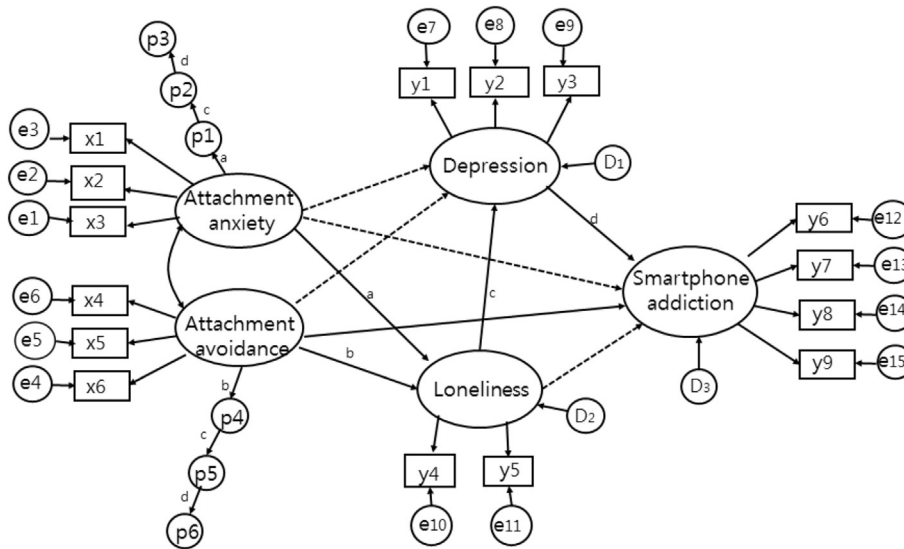


Figure 2. Mediation model by using phantom variables. Note. e1–e15 means measurement error and it is common symbols in AMOS; x1–x3 refer to parcels of attachment anxiety; x4–x6 refer to parcels of attachment avoidance; y1–y3 refer to parcels of depression; y4–y5 refer to parcels of loneliness; y6–y9 refer to parcels of addiction; p1–p6 refer to phantom variables; a denotes path from attachment anxiety to loneliness; b denotes path from attachment avoidance to loneliness; c denotes path from loneliness to depression; d denotes path from depression to smartphone addiction.

Table 4 Specific Indirect Effects.

Effect	Estimate	SE	95% CI (Bias corrected)	p
Indirect effect of attachment anxiety on smartphone addiction through loneliness & depression	.14	0.09	0.02, 0.52	.026
Indirect effect of attachment avoidance on smartphone addiction through loneliness & depression	.06	0.04	0.01, 0.22	.028

Note. CI = confidence interval; SE = standard error.

conversion model was identical, indicating that the phantom conversion model was converted from the adjusted model properly.

As a result of examining the dual mediating effect through bootstrapping analysis, the dual mediating effect of loneliness and depression on the relationship between attachment anxiety and smartphone addiction was statistically significant ($b = .14, p = .026$), and their effect on the relationship between attachment avoidance and smartphone addiction was also found to be statistically significant ($b = .06, p = .028$) (Table 4).

Discussion

In this study, we examined the significance of the dual mediating effects of depression and loneliness in relationship to a hypothesized structural equation model based on Flores' claim [9] and findings from previous studies. Our results show that attachment anxiety and attachment avoidance have a direct effect on loneliness and an indirect effect on depression through loneliness. These findings support Flores' claim [9] that those who have insecure attachments cannot regulate their emotions completely, and they may feel lonely since they do not have any healthy attachments. In addition, attachment anxiety and attachment avoidance both have effects on smartphone addiction through the mediating effects of loneliness and depression. This result is consistent with the findings of previous studies [4,5,9] that have determined that insecure attachment has an effect on smartphone addiction. Attachment

anxiety and attachment avoidance are closely related to smartphone addiction because, according to Flores' assertion [9], smartphone usage is an alternative for a person's lack of secure attachment.

The results of the present study also show that attachment avoidance has a direct negative effect on smartphone addiction. In other words, higher attachment avoidance scores correlated with lower smartphone addiction scores. This finding did not fully support the results of previous studies [4,5], although insecure attachment was shown to have a positive correlation with smartphone addiction. As Wei et al [13] stated, attachment avoidance was a fear of closeness and dependency, so those who were attachment avoidant might not be interested in other people or objects, such as smartphones. In contrast, the main characteristics of people with attachment anxiety were that they had negative images of themselves and positive images of others. Those who had the trait of attachment anxiety strived for an object to serve as a "secure base", were always anxious, and wished to gain the approval of others. Therefore, they might be overly attached to other people or objects like smartphones. However, having a tendency toward attachment anxiety and feeling lonely did not always lead to smartphone addiction. Only when people had attachment anxiety, felt lonely, and had negative thoughts about themselves and their environments that led to depression were they highly likely to become addicted to smartphones.

In our modified structural equation model, attachment anxiety, attachment avoidance, loneliness, and depression explained 30.7% of smartphone addiction among the university students we studied. Our findings showed that attachment, depression, and loneliness were the predictive variables of smartphone addiction. However, other variables also might predict smartphone addiction. For example, Park and Lee [27] suggested that shyness and self-esteem might be predictive variables for smartphone addiction in addition to depression and loneliness. Wei et al [13] explained the mediating effect of self-efficacy in the relationship between attachment anxiety, loneliness, and depression and the mediating effect of self-exposure in the relationship between attachment avoidance, loneliness, and depression. In addition, Wei et al [13] examined the relationship between interpersonal difficulties and

loneliness. Therefore, interpersonal relationships, shyness, self-esteem, self-efficacy, and self-exposure might be confounding factors having an impact on the mediating variables (loneliness and depression) and on the outcome variable (smartphone addiction). Since these potentially confounding factors can function as estimation errors, future research is needed for verification of their influences.

To date, there has been no research on the mediating effect of loneliness and depression in the relationship between attachment and smartphone addiction for university students in Korea. However, there have been recent studies examining the mediating effects of loneliness and impulsivity in the relationship between attachment anxiety and smartphone addiction [28], and the mediating effects of loneliness and university adjustment in the relationship between attachment and smartphone addiction [29]. Although there is recognition that loneliness affects addiction, there are limited studies that examine the dual mediating effect of loneliness and depression on the relationship between adult attachment and smartphone addiction. The results of the current study suggest that those who have insecure attachment may feel depressed due to their negative views toward self and others. Their depression and negative emotions may lead them to retreat into their own world and feel lonely. Then, they may fall into smartphone addiction.

Furthermore, rarely do studies target university students with regard to this subject. Since the number of university students addicted to smartphones is increasing, study of the risk factors for and the protective factors preventing smartphone addiction is timely and appropriate in order to offer meaningful suggestions and ways to thwart addiction.

In terms of smartphone addiction among university students, determining who is in a high-risk group and offering preventive intervention, solutions, and recovery paths is necessary. The present study confirms that those who have attachment anxiety want to feel security through involvement in cyberspace. Therefore, those who have traits of attachment anxiety need help establishing healthy and secure relationships in the offline world, rather than the online world, which is an artificial space.

Conclusion

This research examined the mediating effects of loneliness and depression in the relationship between attachment anxiety and smartphone addiction. In addition, the hypothesized model in the present study was indicated as a suitable model for predicting smartphone addiction among university students. Since smartphone addiction affects various areas of people's lives, including interpersonal relationships, studies, emotions, and health, the establishment of strategies to preclude loneliness and depression is absolutely necessary.

The limitations of this study and recommendations for further research are as follows: First, since the participants in this study were located in Seoul, Chungchung Province, Kangwon Province, and Kyungsang Province, the results of this research cannot be generalized to other university students in other locations. While this study indicated that smartphone addiction can be reduced through interventions to prevent loneliness and depression, it was only a cross-sectional study. Thus, longitudinal research is recommended to confirm the causal path of this study's findings.

Conflicts of interest

The authors have no conflicts of interest to declare.

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