**ORIGINAL PAPER**

# Relationship Between Korean Adolescents' Dependence on Smartphones, Peer Relationships, and Life Satisfaction

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**Abstract**

**Background**  In recent years, the penetration rate of smartphones among Korean teenagers has increased, making it critical to clarify the influence of these devices on adolescents' lives.

**Objective**  This study investigated the effects of smartphone dependence on peer relationships and life satisfaction among Korean adolescents.

**Methods**  Using the middle school panel of the Korean Children and Youth Panel Survey (KCYPS), longitudinal data of 2,250 participants (53.4% boys) at Grade 1 ($M_{age}$ = 14.01, $SD$ = 0.03) in 2018, Grade 2 in 2019, and Grade 3 in 2020 were analyzed to examine the causal relationships between smartphone dependence, peer relationships, and life satisfaction.

**Results**  This study found that smartphone dependence had a longitudinal effect on negative peer relationships. Negative peer relationships had a longitudinal negative effect on early adolescents' life satisfaction. Finally, negative peer relationships in early adolescents longitudinally mediated the relationship between smartphone dependence and life satisfaction.

**Conclusions**  This study showed that early adolescents' dependence on smartphones negatively affects their social relationships and, in turn, negative relationships with peers hindered life satisfaction, suggesting that adolescents' smartphone use should be guided and, when necessary, receive assistance to develop control of their smartphone use.

**Keywords**  Korean adolescents · Smartphone dependency · Peer relationships · Life satisfaction · Longitudinal relationship

## Introduction

In 2020, the United Nations Children's Fund (UNICEF) published the "Innocenti Report Card 16," which analyzed the current status of the well-being of 15-year-olds in 38 Orga-

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nization for Economic Co-operation and Development (OECD) and European Union (EU) countries. Regarding the results of satisfaction with life, a major indicator of mental health, in the "Innocenti Report Card 16," Korean adolescents ranked 34th out of the 38 OECD/EU countries (Gromada et al., 2020). This level of satisfaction with their lives among children and adolescents, who will become Korea's leaders in the future, is an alarming issue requiring greater attention from Korean society.

Life satisfaction is a subjective evaluation of the quality of life in various areas of life and is related to an individual's overall satisfaction with his or her life (Huebner, 2004). Life satisfaction is not a fixed state but a characteristic that changes according to an individual's internal and environmental factors (Danner et al., 2001; Kim & Kim, 2018) and is continuously affected by their situation and environment. Therefore, to increase adolescents' life satisfaction, it is necessary to analyze the factors that affect the life satisfaction of early adolescents.

Recently, excessive use of smartphones has been identified as a key factor in reducing life satisfaction. For example, according to a five-year follow-up study of 500,000 teenagers aged 13–18 in the United States, adolescents who use smartphones longer are more likely to suffer mental health problems such as depression, and adolescents who use smartphones for more than three hours a day are 34% more likely to feel suicidal than those who do not (Twenge et al., 2018). Another study of 1.1 million adolescents reported a sharp decline in adolescents' psychological well-being (self-esteem, life satisfaction, and happiness) since 2012, citing the spread of smartphones and increasing smartphone usage time as the main reasons (Twenge et al., 2018). A study of Korean adolescents also found a similar result: the higher the smartphone addiction index, the lower the subjective happiness (Nam et al., 2013), and the lower the life satisfaction as smartphone usage increased (Ko & Kim, 2020).

Excessive use of smartphones is likely to focus only on enjoyment through devices, which leads to problems such as the inability to control smartphone usage time, resulting in adverse consequences such as conflict with people at home, school, and the workplace (Goodman, 1990; Korea Information Society Agency, 2020)—called dependence on smartphones. Furthermore, if one relies too much on smartphones, it is difficult for them to be interested in engaging in activities (Saunders et al., 2017) and immersing themselves in other things (Park, 2021). As a result, the motivation to continue the desire to belong to the relationship with friends that exists in reality decreases, and the relationship becomes indifferent (Herrero et al., 2019). Similarly, interpersonal damage is a problem that results from Internet addiction (Caplan, 2006) because spending large amounts of time in online interactions lacks sociability and can lead to social isolation (Shensa et al., 2016), which may create obstacles to maintaining social relationships in the real world. These issues related to Internet addiction share many similarities with smartphones, as they both rely overly on forming and activating relationships in the virtual world (Engelberg & Sjöberg, 2004).

Thus, these negative peer relationships can increase the likelihood of hindering adolescents' life satisfaction. Previous studies have shown that dependence on smartphones affects peer relationships (Kim & Byun, 2015; Kim & Lim, 2012), and peer relationships affect life satisfaction (Konu et al., 2002; Park & Huebner, 2005), suggesting a mediating role of negative peer relationships in the relationship between smartphone dependence and life satisfaction. In addition, Lapierre et al., (2019) investigated whether smartphone dependency might predict depressive symptoms via a lack of social support. Thus, this study aimed to

investigate the relationships between smartphone dependence, negative relationships, and life satisfaction.

## Dependence on Smartphones and Peer Relationships

Many studies have reported that smartphone overuse negatively affects adolescents' social relationships (Choi & Kim, 2017; Lepp et al., 2016; Pera, 2020). Specifically, research has shown that increased smartphone use hinders social development by reducing opportunities for direct interactions with peers (Kim & Lim, 2012). In other words, excessive smartphone use leads to a decrease in interactions in practical relationships, resulting in a lack of conversation and conflict with peers, potentially leading to disconnection or alienation in relationships (De-Sola et al., 2017). Smartphones increase communication with peers in the virtual world but simultaneously increase alienation in the real world, causing relationships to deteriorate (Kim & Byun, 2015). In addition, excessive smartphone use can cause problems in social skill development and control, adversely affecting relationships with peers (Herrero et al., 2019). This result suggests that social development is negatively affected by experiencing difficulties in interpersonal relationships in the virtual world rather than interpersonal relationships in reality (Jang & Jeon, 2016) and by reducing opportunities for interaction with people (Anshari et al., 2016).

## Peer Relationships and Life Satisfaction

Adolescence is a period of forming new social relationships while experiencing rapid physical, psychological, social, and emotional changes. Adolescents' social and interpersonal abilities have a profound influence on psychological adaptations such as life satisfaction (Park & Huvener, 2005) and subjective well-being (van Workum et al., 2013). For example, peer attachment strongly predicts adolescents' life satisfaction (Ma & Huebner, 2008), and adolescents form peer attachments by learning intimacy and sociality through interactions with friends (Lee, 2013; Nickson & Nagle, 2004). If well-formed, peer attachment can help adolescents cope with and overcome problems occurring in adolescence, and the satisfaction of their lives increases significantly due to satisfaction from the relationship (Kim & Paik, 2018; Nickson & Nagle, 2004). Similarly, in adolescence, the higher the level of friend support (Kwak et al., 1998), and the more positive and stable the relationship with peers, the higher the level of perceived happiness (Bae et al., 2015; Gilman & Huebner, 2006; Jung & Cho, 2011; Konu et al., 2002).

## The Present Study

Recently, studies to examine the influence of smartphone have begun to be attempted in various ways. However, to date, this research has examined the correlation between smartphone addiction and life satisfaction (Hale et al., 2020) or only analyzed the correlations between smartphone use, friendship, and emotional loneliness (Erdem & Efe, 2021). Although some studies (Jianfei et al., 2021; Kil et al., 2021) examined the structural relationships between smartphones, psychological and emotional problems, and life satisfaction, the research was primarily relying upon cross-sectional survey data. Cross-sectional research based on data collected at the same time makes it difficult to grasp the relationship between variables

clearly; that is, when analyzing the relationship between variables using cross-sectional data, there is a limitation in that it is difficult to reflect the temporal precedence between variables (Youn & Cho, 2014). Furthermore, when the mediating model is examined with cross-sectional data, causality cannot be identified due to the lack of temporal precedence between variables (Gollob & Reichardt, 1987).

Thus, the current study aimed to clarify the causal relationships between these variables using longitudinal data to investigate the longitudinal effects of smartphone dependence on life satisfaction mediated by adolescents' peer relationships. By investigating the longitudinal effects of smartphone dependence on peer relationships and, in turn, on the life satisfaction of Korean adolescents, who are increasingly dependent on their smartphones, we aimed to identify practical and educational countermeasures that could increase adolescents' life satisfaction.

## Methods

### Research Data

The National Youth Policy Institute conducted the Korea Children and Youth Panel Survey (KCYPS) to provide basic data to guide policy and academic research related to children and adolescents by establishing panel data that can comprehensively grasp changes in the growth and development of children and adolescents. As of 2018, the survey sample of KCYPS 2018 was students enrolled in the fourth grade of elementary school and the first grade of middle school, with the 2017 Education Statistics of the Ministry of Education being used as a sampling frame. The original sample was constructed using a multistage stratified cluster sampling method. Specifically, the size of the allocation sample was calculated by distributing it proportionally to the number of students in the fourth grade of elementary school, and the first grade of middle school in 17 cities and provinces nationwide, from which the schools were selected and students in one class of the school were surveyed.

After receiving IRB approval from the National Youth Policy Institute, the KCYPS contacted the selected school to confirm the assent of children and adolescents to participate in the survey. Next, children and adolescents who agreed to the survey were visited at home, where a face-to-face interview was conducted. Since children and adolescents and their guardians participated in the survey, two interviewers with tablet PCs visited households to administer the surveys to participating children, adolescents, and guardians.

The participants in this study were middle school students in Korea because they are particularly vulnerable to smartphone dependence (National Information Society Agency, 2020), their life satisfaction is very low (Yoo, 2020), and relationships with school friends become very important (Moon & Baik, 2016). Thud, the data were extracted from Year 1 (2018), Year 2 (2019), and Year 3 (2020) of the middle school panel of the Korean Children and Youth Panel Survey 2018 (KCYPS). The middle schools that participated in the study surveyed 2,590 original panels in the first year, 2,438 (94.1% maintained) in the second year, and 2,384 (92.0% maintained) in the third year. The data used in the analyses were limited to students who completed all three sessions and included 2,250 participants comprising 1,199 boys (53.4%) and 1,051 girls (46.6%).

## Research Design

This study investigated the longitudinal relationships between smartphone dependence, negative peer relationships, and life satisfaction. To this end, we utilized three-wave autoregressive cross-lagged design which allows for examination of influences over time of one construct on another, while simultaneously controlling for stability as well as for associations between the three investigated constructs over time (Little et al., 2007). Specifically, we first determined whether the values of smartphone dependence, negative peer relationships, and life satisfaction are affected at each consecutive time point over time. Next, we examined whether smartphone dependence affects negative peer relationships at the next time point and whether negative peer relationships affect life satisfaction at the next time point. Lastly, we examined whether smartphone dependence mediated negative peer relationships and, in turn, whether negative peer relationships affected life satisfaction. To examine this, we utilized three points of longitudinal data (measuring smartphone dependence, negative peer relationships, and life satisfaction at each time point) from Year 1 (2018), Year 2 (2019), and Year 3 (2020) of the middle school panel of the Korean Children and Youth Panel Survey 2018.

## Measures

**Smartphone dependence**. The KCYPS 2018 utilized a short version of the smartphone addiction self-report scale developed by Kim et al., (2012) and was modified to measure adolescents' dependence on smartphones. Smartphone dependence consisted of 15 questions comprising four subscales: daily life disorder (5 questions), virtual world orientation (2 questions), withdrawal (4 questions), and tolerance (4 questions). Each question is scored on a four-point rating scale ranging from 1 point (*not at all*) to 4 points (*very much so*); the higher the score, the greater the dependence on smartphones. The Cronbach's α reliability of Kim et al., (2012) was 0.914, whereas, in this study, it was 0.88, 0.87, and 0.88 for the first, second, and third time points, respectively.

**Negative peer relationships.** KCYPS (2018) used the Peer Relationship Quality Scale developed by Bae et al., (2015) to measure the quality of peer relationships. The measure was largely composed of two factors (positive and negative peer relationships) and six subfactors (mutual intimacy, social support, peer relationship satisfaction, conflict and confrontation, general initiative, withdrawal, and isolation). This study only used questions related to negative peer relationships, which included the subscales of conflict and confrontation, general initiative, withdrawal, and isolation. Each question is scored on a four-point rating scale ranging from 1 point (*not at all*) to 4 points (*very much so*), indicating that the higher the score, the more negative the peer relationships of the adolescent. The internal consistency of the Negative Peer Relationships factor in Bae et al., (2015) was 0.85, whereas the internal consistency of the Negative Peer Relationships factor in this study was 0.73 for the first time point, 0.80 for the second time point, and 0.82 for the third time point.

**Life satisfaction.** In KCYPS 2018, Diener et al., (1985) translated questions into the Satisfaction with Life Scale (SWLS) to measure youth life satisfaction. The scale consists of five questions to measure cognitive judgment on how satisfied an individual is with his or her overall life. A four-point rating scale ranging from 1 point (*not at all*) to 4 points (*very much so*) was used for five questions such as "I am satisfied with my life" and "The situa-

tions of my life are very good." The higher the score, the greater the youth's life satisfaction. Cronbach's α in the original scale development study was 0.87 (Diener et al., 1985); reliability in this study was 0.85 for the first time point, 0.82 for the second time point, and 0.82 for the third time point.

**Covariates**. In addition to gender, we included parent-reported socioeconomic variables, time spent with parents (weekdays and weekends), and the degree of social withdrawal as covariates. Previous studies have reported that parental relationships affect adolescents' use of smartphones and life satisfaction (Jo & Lee, 2020; Raboteg-Saric & Sakic, 2014; Sanders et al., 2016) and that social withdrawal affects smartphone dependency and peer relationships (Lim, 2022; Panova & Lleras, 2016); thus, we elected to use two variables as covariates. These covariates were assessed at Wave 1.

## Statistical Analyses

This study attempted to clarify the longitudinal, causal relationship to confirm whether smartphone dependence mediates negative peer relationships and causally affects adolescents' life satisfaction. To achieve this, this study utilized the an autoregressive cross-lagged model (ARCLM; Sher et al., 1996). Autoregressive cross-lagged analysis has the advantage of freely grasping the interrelationship between variables with consideration of temporal precedence and is useful for estimating the causal direction between variables over time (MacKinnon, 2008). Autoregressive effects allow us to assess how stable variables remain over time, and parts that are not explained by autoregressive effects can be described as cross-lagged effects between variables (Geiser, 2012).

By analyzing the data, this study first determined associations between time points t and t+1 in smartphone dependence and negative peer relationships and in negative peer relationships and life satisfaction. For the cross-lagged effects, we explored the paths between smartphone dependence at time point t and negative peer relationships at time point t+1 and between negative peer relationships at time point t and life satisfaction at time point t+1. Moreover, the longitudinal mediation effect of negative peer relationships was assessed to determine whether smartphone dependence affects life satisfaction through negative peer relationships (Park & Lee, 2013). The study's criteria for goodness-of-fit were RMSEA (good: ≤ 0.08, acceptable: ≤ 0.10; Browne & Cudeck 1993) and TLI, and CFI (values > 0.90 indicating good fit; Bentler 1990). The analyses were conducted to assess the conceptual model using AMOS.

# Results

## Demographic Characteristics

Information on the participants is presented in Table 1. A total of 2,250 participants ($n$ = 1,199, 53.4% boys) with a mean age of 14.01 ($SD$ = 0.03; at baseline [2018]) years were analyzed in this study. Among them, 2,203 participants (97.9%) possessed their own smartphones and 47 (2.1%) used family member's smartphones. The proportion of possession of own smartphones increased over the year, and 99.1% owned their own smartphones by 2020

**Table 1** *Participants' Demographic Characteristics at the Three Time Points (n=2,250)*

| | 2018 | 2019 | 2020 |
|---|---|---|---|
| Age, *M(SD)* | 15.01 (0.03) | 16.1 (0.03) | 17.1 (0.03) |
| Gender (male) | 1199 (53.4%) | - | - |
| Smartphone possession | | | |
| Owned | 2203 (97.9%) | 2221 (98.7%) | 2230 (99.1%) |
| Using family member's smartphone | 47 (2.1%) | 29 (1.3%) | 20 (0.9%) |
| Hours of Smartphone use | | | |
| Weekdays | | | |
| Never | 36 (1.6%) | 25 (1.1%) | 24 (1.1%) |
| <30 min | 135 (6.0%) | 115 (5.1%) | 60 (2.7%) |
| 30 min–1 h | 351 (15.6%) | 362 (16.1%) | 335 (14.9%) |
| 1–2 h | 695 (30.9%) | 700 (31.1%) | 693 (30.8%) |
| 2–3 h | 563 (25.0%) | 563 (25.0%) | 504 (22.4%) |
| 3–4 h | 227 (10.1%) | 235 (10.5%) | 261 (11.6%) |
| >4 h | 243 (10.8%) | 250 (11.1%) | 373 (16.6%) |
| Weekends | | | |
| Never | 50 (2.2%) | 36 (1.6%) | 16 (0.7%) |
| <30 min | 97 (4.3%) | 56 (2.5%) | 34 (1.5%) |
| 30 min – 1 h | 196 (8.7%) | 173 (7.7%) | 126 (5.6%) |
| 1 – 2 h | 394 (17.5%) | 414 (18.4%) | 493 (21.9%) |
| 2 – 3 h | 585 (26.0%) | 630 (28.0%) | 598 (26.6%) |
| 3 – 4 h | 412 (18.3%) | 423 (18.8%) | 333 (14.8%) |
| >4 h | 516 (22.9%) | 518 (23.0%) | 650 (28.9%) |

*Notes. M*, mean; *SD*, standard deviation

year. The proportion of participants with >3 h of smartphone use increased over the years (from 20.9% to 28.2 on weekdays; from 41.2 to 43.7% on weekends).

## Correlations and Descriptive Statistics

Table 2 shows the descriptive statistics and significant correlations between the variables at the three time points ($p < .001$). The variables examined in this study satisfied the conditions of normal distribution (skewness$\pm 3$, kurtosis$\pm 10$ or below), a precondition for structural equation modeling (Kline, 2005). The goodness-of-fit of the model was verified using the maximum likelihood estimation method.

## Results of Invariance Test

The present study tested the structural weight invariance and error covariance invariance models compared with the baseline model (Table 3) to test the invariance of the constructs across time points or waves. The structural weight invariance model constrained all path coefficients to be equal across waves; the covariance invariance model constrained all covariances to be equal across waves.

**Table 2** *Correlations and Descriptive Statistics for Study Variables*

| | Smartphone Dependence (SmD) | | | Negative Peer Relationships (NPR) | | | Life Satisfaction (LS) | | |
|---|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T1 | T2 | T3 | T1 | T2 | T3 |
| SmD T1 | -- | | | | | | | | |
| SmD T2 | 0.436*** | -- | | | | | | | |
| SmD T3 | 0.356*** | 0.477*** | -- | | | | | | |
| NPR T1 | 0.285*** | 0.184*** | 0.180*** | -- | | | | | |
| NPR T2 | 0.150*** | 0.317*** | 0.174*** | 0.297*** | -- | | | | |
| NPR T3 | 0.148*** | 0.187*** | 0.256*** | 0.192*** | 0.269*** | -- | | | |
| LS T1 | −0.318*** | −0.210*** | −0.170*** | −0.327*** | −0.179*** | −0.147*** | -- | | |
| LS T2 | −0.164*** | −0.329*** | −0.178*** | −0.201*** | −0.350*** | −0.190*** | 0.440*** | -- | |
| LS T3 | −0.166*** | −0.180*** | −0.260*** | −0.182*** | −0.188*** | −0.308*** | 0.371*** | 0.459*** | -- |
| M | 2.035 | 2.128 | 2.180 | 1.848 | 1.834 | 1.796 | 3.139 | 3.068 | 3.060 |
| SD | 0.488 | 0.467 | 0.492 | 0.514 | 0.561 | 0.562 | 0.541 | 0.476 | 0.455 |
| Skewness | 0.227 | −0.086 | −0.101 | 0.408 | 0.432 | 0.575 | −0.307 | 0.036 | −0.074 |
| Kurtosis | −0.042 | −0.098 | −0.322 | 0.749 | 0.130 | 0.386 | 0.235 | 0.464 | 0.939 |

*Notes*. *M*, mean; *SD*, standard deviation; T1: Time 1; T2: Time 2; T3: Time 3; SmD: smartphone dependence; NPR: negative peer relationships; LS: life satisfaction;
***p < .001

**Table 3** *Model Fit Statistics for Autoregressive Cross Lagged Models*

| Model | $\chi^2$ | df | TLI | CFI | RMSEA | $\Delta\chi^2$ | $\Delta$ df | $\Delta$ TLI | $\Delta$ CFI | $\Delta$RMSEA |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 297.93*** | 41 | 0.896 | 0.926 | 0.064 | - | - | - | - | - |
| 2 | 304.21*** | 42 | 0.898 | 0.928 | 0.062 | 6.28 | 1 | 0.002 | 0.002 | −0.002 |
| 3 | 307.20*** | 43 | 0.901 | 0.931 | 0.060 | 2.99 | 1 | 0.003 | 0.003 | −0.002 |
| 4 | 311.22*** | 44 | 0.901 | 0.933 | 0.059 | 4.02 | 1 | 0.000 | 0.002 | −0.001 |
| 5 | 312.92*** | 45 | 0.903 | 0.935 | 0.057 | 1.70 | 1 | 0.002 | 0.002 | −0.002 |
| 6 | 313.25*** | 46 | 0.905 | 0.936 | 0.055 | 0.33 | 1 | 0.002 | 0.001 | −0.002 |
| 7 | 318.16*** | 47 | 0.907 | 0.938 | 0.054 | 4.91 | 1 | 0.002 | 0.002 | −0.001 |
| 8 | 319.32*** | 48 | 0.911 | 0.938 | 0.053 | 1.16 | 1 | 0.004 | 0.000 | −0.001 |
| 9 | 321.48*** | 49 | 0.913 | 0.939 | 0.051 | 2.00 | 1 | 0.002 | 0.001 | −0.002 |

*Note*: Model 1=baseline model; Model 2=structural weight invariance (autoregressive path coefficient of smartphone dependence); Model 3=structural weight invariance (autoregressive path coefficient of negative peer relations); Model 4=structural weight invariance (autoregressive path coefficient of life satisfaction); Model 5=structural weight invariance (cross-lagged path from coefficient of smartphone dependence to negative relation); Model 6=structural weight invariance (cross-lagged path coefficient from negative peer relation to life satisfaction); Model 7=error covariance invariance; Model 8=error covariance invariance; Model 9=error covariance invariance. TLI: Tucker–Lewis index; CFI: comparative fit index; RMSEA: root mean squared error of approximation

The fit of the baseline model (Model 1) was good, $\chi^2(41)=297.93$, $p<.001$, RMSEA=0.064, TLI=0.896, and CFI=0.926, suggesting that the model adequately represented the data. Instead of using the $\chi^2$ difference test, which is sensitive to sample size, this study used RMSEA and CFI indices to compare model fitness. To identify the equivalence assumption, if TLI, CFI, and RMSEA do not become better or worse than 0.01, the equivalence assumption can be satisfied (Chen, 2007).

Model 2's fit was improved compared to Model 1 (the baseline model) but did not become better than 0.01 ($\Delta$RMSEA=−0.002, $\Delta$TLI=0.002, $\Delta$CFI=0.002; Table 2). Model 3 also was an improvement, with the RMSEA, TLI, and CFI all being better than those of Model 2 within 0.01 ($\Delta$RMSEA=−0.002, $\Delta$TLI=0.003, $\Delta$CFI=0.003). Model 4's fit improved both RMSEA and CFI within 0.01 ($\Delta$RMSEA=−0.001, $\Delta$TLI=0.000, $\Delta$CFI=0.002). The fit of Model 5, RMSEA, TLI, and CFI improved within 0.01 ($\Delta$RMSEA=−0.002, $\Delta$TLI=0.002, $\Delta$CFI=0.002). The fit between Models 6 and 5 was changed, and RMSEA, TLI, and CFI improved within 0.01 ($\Delta$RMSEA=−0.002, $\Delta$TLI=0.002, $\Delta$CFI=0.001). The fit of Model 7, RMSEA, TLI, and CFI improved within 0.01 ($\Delta$RMSEA=−0.001, $\Delta$TLI=0.002, $\Delta$CFI=0.002). The fit of Model 8 and both RMSEA and TLI improved within 0.01 ($\Delta$RMSEA=−0.001, $\Delta$TLI=0.004, $\Delta$CFI=0.000). The fit indices of Model 9 were the best, which was confirmed based on the results of the invariance test: $\chi^2(49)=321.480$, $p<.001$, RMSEA=0.051, TLI=0.913, and CFI=0.939.

## Results of the Autoregressive Cross-Lagged Model Analysis

Given that the assumptions of structural weight and error covariance invariance were satisfied by Model 9, the next step was to examine the cross-lagged effects using ARCLM. Before testing the autoregressive cross-lagged model between the primary variables, we analyzed the effects of the covariates on smartphone dependency, negative peer relationships, and life satisfaction in Wave 1. The results showed that gender had a statistically significant effect on smartphone dependency ($\beta=0.079$, $p<.01$), negative friend relationships ($\beta=-0.067$,

$p < .01$), and life satisfaction ($\beta = -0.073$, $p < .01$). Socioeconomic level was found to have a statistically significant effect on smartphone dependence ($\beta = -0.049$, $p < .05$) and life satisfaction ($\beta = 0.067$, $p < .01$), but it did not influence negative peer relationships. It was found that the time spent with parents had a statistically significant effect on smartphone dependency ($\beta = -0.120$, $p < .001$), negative friend relationships ($\beta = -0.058$, $p < .05$), and life satisfaction ($\beta = 0.120$, $p < .001$), and that the level of social withdrawal had a statistically significant effect on smartphone dependency ($\beta = 0.264$, $p < .001$), negative friend relationships ($\beta = 0.270$, $p < .001$), and life satisfaction ($\beta = -0.334$, $p < .001$).

*Notes*. Paths that are not statistically significant are indicated by dotted lines.

T1, Time 1; T2, Time 2; T3, Time 3; SmD, smartphone dependence; NPR, negative peer relationships; LS, life satisfaction * $p < .05$, **$p < .01$, ***$p < .001$.

As shown in Fig. 1, the autoregressive effects of smartphone dependence (SmD), negative peer relationships (NPR), and life satisfaction (LS) were significant. Therefore, SmD, NPR, and LS at time t+1 significantly predicted SmD, NPR, and LS at time t. These results indicate that SmD, NPR, and LS increased more gradually in participants with higher SmD, NPR, and LS at the initial point. Additionally, a statistically significant cross-lagged effect was found between SmD at one time (t) and NPR at the next time (t+1). The path from SmD at T1 to NPR at T2 was significant, with a standardized path coefficient of 0.090 ($p < .001$). The path from SmD at T2 to NPR at T3 was significant, with a standardized path coefficient of 0.084 ($p < .001$). Additionally, a statistically significant cross-lagged effect was found between NPR at one time (t) and LS at the next time (t+1). The path from NPR at T1 to LS at T2 was significant, with a standardized path coefficient of $-0.043$ ($p < .01$). The path from NPR at T2 to LS at T3 was significant, with a standardized path coefficient of $-0.048$ ($p < .01$). The results of the bootstrapping analysis verified the full mediation effect of NPR at T2 on the relationship between SmD at T1 and LS at T3. SmD affected LS through NPR, with a standardized path coefficient of $-0.043$ (95% CI [-0.082, $-0.020$], $p < .01$).

## Discussion

This study examined the longitudinal causal relationship of smartphone dependence perceived by Korean adolescents on life satisfaction and whether negative peer relations mediated the relationship in which smartphone dependence affects life satisfaction. To achieve this, this study used a longitudinal analysis to investigate the relationships between three factors: smartphone dependence, negative peer relationships, and life satisfaction, using three waves of longitudinal data.

**Fig. 1** Results of Autoregressive Cross-Lagged Model
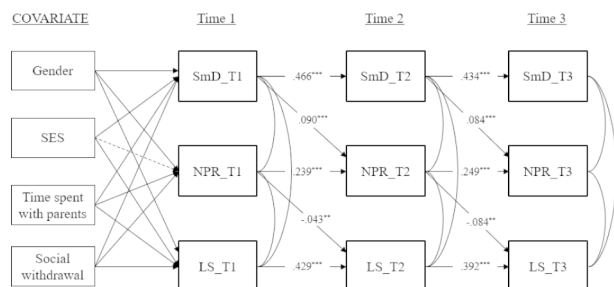
First, this study found that smartphone dependence affected negative peer relationships, supporting previous research showing that the greater adolescents' smartphone usage or addiction level, the lower their peer attachment or positive peer relationships (Choi & Kim, 2017; Lepp et al., 2016). These results suggest that excessive smartphone use and dependence worsen peer relationships (Pera, 2020). Adolescence is important for social development and social skills through friendship (Kang, 2005). Establishing social relationships during this developmental stage helps adolescents learn how to engage in appropriate behaviors in different social environments and establish healthy relationships with different individuals. However, if adolescents experience challenges in developing appropriate social skills, antisocial behaviors may emerge. Furthermore, adolescents may experience problems establishing their personal identity due to role confusion, leading to social maladjustment (Lee & Mo, 2004). The current results show that smartphone dependence negatively affects adolescents' friendships, which hinders social development, a critical developmental task in adolescence that can negatively affect academic performance, identity development, and social adjustment. Therefore, our findings suggest that smartphone use should be controlled and supervised to promote social development through positive peer relationships among adolescents.

Second, it was found that more negative peer relationships led to poorer life satisfaction, similar to the results of studies that reported positive relationships between peers and life satisfaction among adolescents (Konu et al., 2002; Park & Huebner, 2005). Thus, the results of this study show that social relationships with peers are of paramount importance for life satisfaction. Peer relationships play an important role in adolescent development and emotions, and friendships are especially important in explaining adolescents' life satisfaction and happiness. Our results suggest that adolescents must cultivate social skills, such as establishing friendships and maintaining positive relationships, to increase their life satisfaction. Thus, educational interventions and support at the school level are necessary, along with students' efforts.

Third, the longitudinal mediating effect of negative peer relationships between smartphone dependence and life satisfaction was significant. This finding suggests that the greater the dependence on smartphones, the worse the quality of peer relationships becomes, and as peer relationships worsen, adolescents' level of satisfaction with their lives lowers over time. These results are consistent with Kim et al., (2016), who reported that middle school students' dependence on mobile phones negatively affected peer relationships, resulting in depression. In addition, the more time adolescents spend using a smartphone, the more difficulty they have in learning the necessary social skills to establish relationships with others (Kim & Lim, 2012). Thus, adolescents cannot maintain positive relationships with their peers, which has a negative impact on their mental health.

Using longitudinal analysis, this study showed that increased smartphone usage and excessive smartphone dependence can negatively affect peer relationships, a critical competence of social development during early adolescence, and that such negative relationships with peers hinder satisfaction. The study's results not only support previous findings using cross-sectional data (Chui, 2015; Kil et al., 2021) but also empirically support the causal relationship between variables, that dependence on smartphones can negatively affect adolescents' social relationships and lives over time. Specifically, the dependent use of smartphones by early adolescents can have a detrimental effect on life satisfaction through negative relationships with peers.

These results suggest that interventions are necessary to control the overdependent use of smartphones to improve adolescents' social relationships. Furthermore, guidance and education are required to prevent smartphone dependence from hindering adolescents' life satisfaction. Several practical suggestions can be made based on these results. First, education on the supervision and prevention of the misuse and addictive use of smartphones is needed to reduce adolescents' dependence on smartphones. For this, schools need to facilitate interventions such as providing opportunities to talk regularly with students about smartphone overuse, providing education on proper usage habits, and educating students on the problematic consequences of uncontrolled smartphone use. In addition, since smartphones are used not only at school but also at home, parents' roles should be prioritized. Accordingly, schools need to provide parental support services, such as supervising children and implementing parental education for children's counseling, to prevent smartphone addiction. Furthermore, schools should pay attention to students' friendships to increase their life satisfaction. Within Korea's educational environment, there is a lack of leisure time and play culture due to excessive achievement-oriented competition centered on private education and entrance exams beginning in elementary school, which may lead to students preferring to communicate and play on their smartphones. This cycle creates an environment that can lead to smartphone addiction. Therefore, adolescents need opportunities to actively develop their social skills, such as through improved friendship programs at school or friendship counseling programs to help establish friendships. Thus, schools need to provide social welfare services, such as encouraging a play culture and creating systematic friendship development programs that generate interest among adolescents.

This study has several limitations. First, we used data that were collected from 2018 to 2020. The data from 2020 could have been significantly impacted by COVID-19 (Hafstad et al., 2021). Although the study analysis estimated the cross-lagged value while controlling the autoregressive value by using the autoregressive cross-lagged analysis method, statistical analyses alone are limited since it does not control the confounding influence of the COVID-19 pandemic on adolescents' daily lives and the psychological aspects of the event on the respondents. Therefore, the effects of the COVID-19 pandemic should be considered when interpreting the results. Second, this study showed a mediating effect of social relationships in the relationship between early adolescents' dependence on smartphones and life satisfaction. As mentioned earlier, these results suggest that other variables could mediate the relationship between smartphone problems and life satisfaction. For example, two variables that are reported to have an immediate impact on smartphone problems are anxiety and depression (Chung & Lee, 2017). Therefore, subsequent studies need to comprehensively examine the various paths that mediate the relationship between smartphone dependence and life satisfaction. Finally, since most studies on smartphone-related problems have been conducted with adolescents or college students, smartphone issues are becoming more prevalent among younger people, so it is necessary to research the excessive use of smartphones at various developmental stages.

## Conclusions

To date, research examining the effects of smartphone use on adolescents' social, emotional, and school lives has not been able to provide evidence of the directionality of the causal

relationship between key variables due to the reliance on cross-sectional data. However, this study is significant in that it verified the direction of the causal relationship between the effect of excessive smartphone use on adolescents' lives and life satisfaction through longitudinal analysis using longitudinal data. In other words, unlike previous studies that have difficulty verifying the direction of causal relationships, this study is significant in that it empirically identifies the effect of smartphone dependence on adolescents' lives by statistically verifying the causal relationship between variables over time while controlling for measurement errors.

This study has several research implications. First, the influence of middle school students' smartphone dependence on negative peer relationships and life satisfaction over time was found, highlighting the need for interest in and intervention for adolescents' dependence on smartphones. Second, this study confirmed the role of social relations as a mechanism to explain the relationship between smartphone dependence and life satisfaction through negative peer relationships, showing indirect paths in the relationship between adolescents' smartphone dependence and life satisfaction. This result suggests that appropriate guidance and education at home and school are needed to prevent social relations from deteriorating through the proper use of smartphones to improve adolescents' life satisfaction.

## Statements and Declarations

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