Gender-Based Multi-Group ARCL Analysis of Adolescents' Smartphone Dependence and Offline and Cyber Delinquency

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Abstract

This study investigates the longitudinal causal relationships among adolescents' smartphone dependence, offline delinquency, and cyber delinquency, focusing on gender differences in their structural dynamics. Using 2018-2022 panel data from the Korean Children and Youth Panel Survey, we applied a multi-group autoregressive cross-lagged model. The results showed significant autoregressive effects of smartphone dependence in both genders, with greater stability among females. Offline delinquency exhibited higher autoregression in females, while cyber delinquency increased sharply in recent waves, especially among female students. Cross-lagged effects revealed gender-specific patterns, such as cyber delinquency strongly influencing offline delinquency in males. These findings highlight the need for gender-responsive interventions and multi-layered strategies that address both real-world and digital forms of adolescent delinquency.

Keywords: Adolescents, Smartphone Dependence, Offline and Cyber Delinquency, Autoregressive Cross-Lagged (ARCL) Model

알기 쉬운 요약

이 연구는 왜 했을까? 요즘 청소년들의 스마트폰 과의존으로 집중력 감소와 현실감 상실 등 다양한 어려움을 겪는 경우가 늘고 있다. 특히 스마트폰 의존이 현실에서의 문제 행동이나 사이버 공간의 비행과 어떤 관련이 있는지, 그리고 이러한 관계가 성별에 따라 어떻게 달라지는지를 살펴보고자 하였다.

새롭게 밝혀진 내용은? 남학생은 사이버 비행이 시간이 지나면서 현실 비행으로 이어지는 경향이 확인되었다. 반면 여학생은 스마트폰 의존이 지속적으로 높게 나타나면서 사이버 비행을 강화하는 위험요인으로 작용하였다. 이처럼 성별에 따라 다른 패턴이 뚜렷하게 나타났다.

앞으로 무엇을 해야 하나? 청소년 비행 예방은 남학생은 디지털 시민성 교육, 여학생은 정서 지원과 상담 개입 등 맞춤형 전략이 요구된다. 이를 국내 교육·상담 현장에 장기적으로 적용할 필요가 있다.

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Ⅰ. Introduction

Adolescence is a period marked by significant physical, psychological, and cognitive changes. It is a time of rapid growth across various domains, including perception, thinking, intelligence, and emotion, and marks the beginning of social interactions aimed at establishing one's identity. Experiences during adolescence signify transformation and growth in life. This process of change and development is Janus-faced, as it involves not only stronger assertions of self, critical thinking, and idealism, but also feelings of frustration, anxiety, and defiance (Lee & Kim, 2014). Another feature of adolescence is the development of cognitive abilities such as numerical and inferential reasoning. Consequently, adolescents become capable of abstract and formal thinking detached from practical experiences. This ability to distinguish between the real and the hypothetical often leads them to challenge reality in pursuit of ideals (Sanghvi, 2020). Adolescence also brings qualitative shifts in moral perspectives, shifting from the egocentric morality of childhood, which relied on parents, to a relative, peer-centered morality (Lawrence et al., 2000).

Given these characteristics, juvenile delinquency has long been a critical social issue, as it can significantly impede key developmental tasks of this period, such as academic advancement, career choices, interpersonal relationships, and identity formation. This has drawn continuous attention from clinicians and researchers. In particular, with the recent expansion of high-speed internet and smartphones, adolescents' offline delinquency (OFDE) has increasingly extended into online environments (Jeon & Nam, 2020). Smartphone use among adolescents has surged because smartphones integrate internet and phone functions, allowing unrestricted communication across time and space with unspecified others (Lee & Kim, 2014). However, this rapid spread of smartphone use has led to not only positive functions but also significant social issues. Among these, cyber delinquency (CYDE) stemming from excessive smartphone dependence (SPDE) has become a serious concern (Sung & Kim, 2022).

Internationally, Nasi et al. (2015) reported that 6.5% of respondents across Finland, the United States, Germany, and the United Kingdom experienced online crime victimization, with defamation and threats of violence being the most common types. Sabin (2023) found that 48% of adolescents in nine EU countries engaged in some form of cybercrime between 2020 and 2021, including hacking (10%), illegal virtual market use (20%), and online money laundering (12.5%). The report highlighted the problem of a generation raised entirely in digital environments becoming involved in cybercrime, prompting the development of prevention programs like Hack_Right in countries such as the Netherlands and the UK.

Domestically, adolescent smartphone dependence was already 11.4% in 2011, which was 3.5% higher than the adult rate of 7.9%. By 2024, the adolescent smartphone overdependence rate had risen to 42.6%, approximately 1.9 times higher than the adult rate of 22.4%. Since 2020, adult smartphone overdependence has stabilized or shown a slight decrease, hovering around 22%, whereas the rate for adolescents has continued to increase from 35.8% to 40.1% and then to 42.6% (Ministry of Science and ICT (MSIT) & National Information Society Agency (NIA), 2025). Excessive smartphone dependence among adolescents can lead to various social problems, with issues related to offline and cyber delinquency being particularly severe (Lee et al., 2023). Recent data (2022-2024) show that while cyber victimization among adolescents initially increased (21.0% to 21.6%) before declining (20.3%), the prevalence of offending rose from 4.1% to 5.7%.

Compared to adults (victimization 8.6%, offending 3.3% in 2024), adolescents showed 2.36 times higher victimization and 1.73 times higher offending rates (Korea Communications Commission (KCC) & NIA, 2025).

Despite the severity of excessive smartphone dependence and cyber delinquency among adolescents, related research is still in its early stages, and national awareness remains insufficient. Moreover, there is no clear theoretical framework to explain these phenomena. Therefore, to enhance the understanding of these phenomena, it is necessary to consult theories and related studies that explain offline delinquency and crime. This study builds its model on existing research informed by the general theory of strain (Agnew, 1992), routine activity theory (Cohen & Felson, 1979), social bond theory (Hirschi, 1969), and the general aggression model (Allen & Anderson, 2017).

According to the general theory of strain, negative emotions caused by daily strain can lead to delinquency (Agnew, 1992, 2001). Stress, depression, and bullying victimization are major sources of strain that may result in excessive smartphone dependence and cyber delinquency (Patchin & Hinduja, 2011; Shin, 2023). Low self-control is also a key risk factor in cyberspace, as in traditional crime (Lee, 2024). Moreover, experience with offline violence has a strong influence on cyberbullying, a phenomenon explained by the anonymity and accessibility of cyberspace (Guo, 2016). Longitudinal studies have also shown that traditional bullying and cyberbullying mutually influence each other (Ban, 2021). Smartphone overdependence increases aggression and verbal abuse, which mediates and reinforces cyber delinquency (Yoo, 2024). This theory provides a useful framework for understanding how emotional strain resulting from excessive smartphone use may trigger maladaptive coping behaviors, including delinquency.

Aggression, a core factor in school violence and cyber delinquency, refers to intentional harm toward others (Allen & Anderson, 2017). Unlike traditional aggression rooted in power imbalances, cyber aggression leverages digital media (Mladenovic et al., 2021). Social support, including teacher-student attachment and parental relationships, mediates or moderates the links between aggression and cyber delinquency (Lim & Jeon, 2023; Nam et al., 2022).

The social bond theory posits that weakened social bonds lead to delinquency (Hirschi, 1969). Studies have shown that attachment to parents, teachers, and peers helps prevent delinquency (Yoo & Han, 2019; Kim, 2021), and factors like self-control and beliefs significantly affect cyber delinquency (Hoareau et al., 2023). Self-control was found to have a negative effect on both offline and cyber delinquency. In terms of gender, male students were found to have weaker self-control than female students, making them more likely to commit violent delinquency (Lee, 2023).

Routine activity theory (RAT) explains delinquency as emerging from daily life when motivated offenders, suitable targets, and the absence of capable guardians converge (Cohen & Felson, 1979). Adolescents who have grown up in a digital environment use cyberspace as a means of acquiring information and social interaction, making it another sphere of daily life. Cyberspace, with its lack of temporal and spatial constraints and the absence of authority figures like guardians, provides an environment devoid of capable guardianship, thus increasing the likelihood of adolescents becoming suitable targets for crime (Ansary, 2020; Aizeenkot, 2022). In this context, adolescent cyber delinquency centered around social networking services (SNS) can be explained by the main components of RAT, and research that treats cyberspace as a tangible social space

is becoming more prevalent (Ferraresso et al., 2024). This theory further elucidates how the pervasive availability of smartphones facilitates opportunities for cyber delinquency, particularly in contexts characterized by limited supervision and heightened peer influence.

School violence and cyber violence often persist across school years and influence one another over time (Olweus, 1993, 1994; Ban, 2021). Cyber violence, in particular, is highly likely to be repeated or lead to secondary harm due to its characteristics of anonymity, non-face-to-face interaction, widespread dissemination, and lack of physical constraints. These traits cause adolescent offline and cyber delinquency to exhibit a cyclical and persistent pattern (Hinduja & Patchin, 2015).

An important variable to consider in the longitudinal interplay of adolescent school violence is gender. Emotional responses to stressful situations and the forms of violent behavior differ by gender according to adolescent gender roles (Patchin & Hinduja, 2011). Gender differences are also reported in the patterns of school violence, methods of perpetration, and influencing factors (Gini et al., 2022). Gender serves as a key moderator shaping the type and intensity of adolescents' emotional responses under stress. Male adolescents tend to exhibit direct aggression expressing power and dominance, while female adolescents are more prone to indirect aggression through social relationships or language. Greater empathy strongly suppresses violent tendencies (Romero et al., 2024).

Previous studies mainly used cross-sectional data, limiting causal analysis (Park & Lee, 2013). In particular, adolescents with extensive experience in offline delinquency are more likely to commit delinquent acts in virtual spaces. This can intensify smartphone dependence resulting from real-world maladjustment, which in turn can trigger further delinquent behavior, forming a cyclical structure. In this respect, the psychological and behavioral changes of adolescence need to be understood within a long-term temporal flow, highlighting the necessity for longitudinal research that can analyze causal relationships (Yoo, 2024). However, even recent longitudinal studies have often approached school violence from a single dimension or have failed to sufficiently investigate the causality related to the persistence of cyber delinquency (Park & Han, 2018). Cyber delinquency, due to the anonymity and non-face-to-face nature of the digital environment, can cause repetitive and widespread damage without a power imbalance, thus possessing a higher potential for delinquency than offline delinquency (Hinduja & Patchin, 2015). In revising this manuscript, we clarified the theoretical grounding to strengthen the link between the model and the theories employed. Specifically, strain theory and routine activity theory (RAT) were identified as the core theoretical frameworks guiding this study. Smartphone dependence is understood through RAT as reflecting structural changes in adolescents' daily activities, reducing offline social control and increasing immersion in online contexts. Offline and cyber delinquency are explained through strain theory, which highlights delinquency as a coping mechanism for stress and frustration, with gender differences shaping these responses. Social bond theory is used in a supplementary way to account for how differences in family and school attachment by gender influence delinquent behaviors. By restructuring this section, the theoretical justification for the hypothesized relationships among smartphone dependence, offline delinquency, and cyber delinquency has been made more concise and directly aligned with the analytic model.

Accordingly, this study aims to longitudinally examine the cross-lagged causal relationships among adolescents' smartphone dependence, offline delinquency, and cyber delinquency by applying a multi-group

ARCL model. This approach enables the analysis of how these variables interact over time, including the effects of smartphone dependence at one time point on subsequent offline and cyber delinquency, and vice versa, while also identifying gender differences in these structural dynamics. Using five-year panel data from first-year middle school to second-year high school students, the study seeks to provide gender-specific insights for intervention strategies. The specific research questions are: (1) How do adolescents' smartphone dependence, offline delinquency, and cyber delinquency persist over time, and do these patterns differ by gender? (2) How are the longitudinal reciprocal relationships among these variables structured, and are these relationships moderated by gender?

Ⅱ. Methods

1. Participants

This study utilized panel data from the Korean Children and Youth Panel Survey (KCYPS 2018) conducted by the National Youth Policy Institute, covering the period from 2018 to 2022. The KCYPS aims to provide foundational longitudinal data to support vision-setting, systematic policy formulation, and implementation regarding youth by comprehensively examining cross-sectional and longitudinal changes in adolescents' developmental environments, consciousness, and attitudes. The middle school 1st grade panel data will be collected over 7 years from 2018 to 2024, but since the subjects of the survey for 2023 and the final year, 2024, are high school 3rd graders and college students, the main subjects of this study were middle and high school students, so only the data for 5 years (2018-2022) from the 1st grade of middle school to the 2nd grade of high school were analyzed. The KCYPS 2018 cohort initially surveyed 2,590 first-year middle school students and their parents, selected through stratified multi-stage cluster sampling. Of these, 1,405 (54.2%) were male and 1,185 (45.8%) were female.

Descriptive statistics (Table 1) showed that males reported significantly higher levels of academic satisfaction (3.56 vs. 3.45), self-esteem (3.04 vs. 2.95), offline delinquency (1.20 vs. 1.11), and cyber delinquency (1.25 vs. 1.17), while females reported higher levels of aggression (1.90 vs. 1.85), depression (1.86 vs. 1.72), and smartphone dependence (2.15 vs. 2.12). No significant gender differences were observed for parental education levels or social relationships.

Table 1. Demographic characteristics of major variables by gender

Variable	Male	Female	Total	t-value
N	1,093	959	2,052	
Parents' education	5.30	5.25	5.28	1.00
Household income	6.76	6.50	6.64	2.50*
Academic satisfaction	3.56	3.45	3.51	5.14***
Self-esteem	3.04	2.95	3.00	6.40***
Aggressiveness	1.85	1.90	1.87	-3.35***
Social relationships	3.03	3.05	3.04	-1.64

Variable	Male	Female	Total	t-value
Depression	1.72	1.86	1.79	-7.64***
Smartphone dependence	2.12	2.15	2.13	-2.36*
Offline delinquency	1.20	1.11	1.16	9.74***
Cyber delinquency	1.25	1.17	1.21	7.71***

Note: Parents' education is 1 for no education, 2 for elementary school graduate, ... , 7 for university graduate; Household income is 1 for no income, 2 for less than 1 million won, 3 for 1-2 million won, ..., 12 for more than 10 million won/month; Academic satisfaction is 6 point scale; Self-esteem, Aggressiveness, Social relationships, Depression, and Smartphone dependence are measured on a 4-point scale; Offline delinquency and cyber delinquency are binary variables (1 and 2).

*p<0.1, **p<0.05, ***p<0.01.

2. Measures

Smartphone dependence was measured using 12 items developed by Kim et al. (2012), rated on a 4-point Likert scale (1=strongly disagree to 4=strongly agree), with higher scores indicating greater dependence. Example items include "I feel anxious if I don't carry my smartphone" and "Without my smartphone, I feel isolated." Factor analysis (varimax rotation, eigenvalue >1) yielded three factors to simplify the model structure.

The items used to measure Offline delinquency were 15 items from Kim et al. (2010). The answers to each item were coded on a 6-point scale: 1=never, 2=1-2 times a year, 3=once a month, 4=2-3 times a month, 5=once a week, and 6=several times a week. Examples include "smoking or drinking alcohol," "truancy or running away from home," and "gambling for money." Responses were dichotomized (1=no experience, 2=any experience) following the approach of prior research (Kim et al., 2010; Lee et al., 2015), since the distribution of delinquent behaviors was highly skewed and the original 6-point scale showed limited discriminative power due to the very small proportion of adolescents reporting such behaviors. Items with prevalence below 0.5% were excluded to avoid statistical instability in factor loadings, and the remaining items were factor-analyzed. As a result, two to three factors were identified each year, typically corresponding to categories such as "school-related delinquency (e.g., truancy, running away)," "substance use and minor deviance (e.g., smoking, drinking)," and "violent/monetary delinquency (e.g., verbal abuse, physical violence, gambling)." This structure was generally consistent with previous findings, supporting the validity of the measurement. Higher values indicate more offline delinquency.

Cyber delinquency was measured using 15 items from Lee et al. (2015), also coded on the same 6-point frequency scale as OFDE. Examples include "sending abusive or offensive messages," "impersonating someone using a stolen ID," and "stealing game money or cyber assets." As with OFDE, responses were dichotomized (1=no experience, 2=any experience) for analysis, and items with prevalence rates below 0.5% were excluded. Factor analysis consistently identified two factors, which largely corresponded to "verbal/psychological aggression" and "cyber fraud/identity misuse," aligning with the factor structures reported in prior research. Higher scores indicate greater cyber delinquency.

Cronbach's alpha values across the years were as follows: SPDE (.886, .884, .901, .893, .889), OFDE (.664, .949, .813, .600, .563), CYDE (.561, .928, .752, .618, .645). Although some years (e.g., OFDE in 2022,

α=.563; CYDE in 2018, α=.561) fell below the conventional threshold of .60, this was primarily due to the very low prevalence of certain delinquent behaviors, which weakened item correlations. Nonetheless, most values exceeded .60, and reliability was further checked using the "α if item deleted" procedure, with items that lowered reliability being removed. This process ensured year-to-year consistency and supports the overall adequacy of the measurement instruments.

3. Analytical Strategy

This study analyzed the longitudinal relationship between adolescents' smartphone dependence, offline delinquency, and cyber delinquency using an autoregressive cross-lagged (ARCL) model, and examined differences by gender using a multigroup analysis. This model is suitable for longitudinal panel data because it allows for analysis of reciprocal causality, control for measurement error, and consideration of temporal precedence between variables. A total of 16 sequentially nested models were compared. Model fit was evaluated using χ^2 difference tests, Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). Good fit was indicated by non-significant χ^2 differences ($p>.05$), TLI and CFI$\geq$.90, and RMSEA<.05 (Kline, 2005; Zheng & Valente, 2022). The gender multigroup analysis was conducted by applying the male and female groups equally to the final model above to test the morphological identity, and then gradually imposing identity constraints on the measurement indicators, path coefficients, and error covariance to compare them. Invariance between the constrained and unconstrained models was supported when the χ^2 difference test was non-significant, and the changes in CFI and TLI were $\leq$.01, and the change in RMSEA was $\leq$.015 (Cheung & Rensvold, 2002). If significant differences were found, constraints on specific paths were relaxed, and revised models were estimated.

Ⅲ. Results

Table 2 presents the descriptive statistics for the three major latent variables of the study model: Smartphone dependence, offline delinquency, and cyber delinquency tracked over five years from the first year of middle school (Grade 7) to the second year of high school (Grade 11), by gender. The trajectory of smartphone dependence showed an overall increase from Grade 7 to Grade 9, followed by a decline in Grade 10 and stabilization in Grade 11 for girls. In contrast, boys' SPDE declined at Grade 10 but showed an increase again at Grade 11. Offline delinquency decreased from Grade 7 and then remained stable in both genders. Cyber delinquency displayed a decreasing trend from Grade 7 through Grade 10 and remained stable thereafter in both boys and girls. In terms of absolute values, girls exhibited higher levels of smartphone dependence, whereas boys reported higher levels of both offline delinquency and cyber delinquency.

Table 2. Trends in key variables by gender and grade

Variable	Male					Female				
	Grade-7	Grade-8	Grade-9	Grade-10	Grade-11	Grade-7	Grade-8	Grade-9	Grade-10	Grade-11
Smartphone Dependence	2.071	2.136	2.157	2.081	2.142	2.145	2.158	2.175	2.130	2.135
Offline Delinquency	1.255	1.184	1.189	1.177	1.199	1.151	1.106	1.107	1.079	1.088
Cyber Delinquency	1.382	1.287	1.248	1.162	1.163	1.321	1.230	1.135	1.081	1.094

Regarding the rate of change, the increase in smartphone dependence during middle school was greater in boys (from 2.071 to 2.157) compared to girls (from 2.145 to 2.175). During high school, girls showed a decline followed by stabilization (2.175 → 2.130 → 2.135), whereas boys exhibited a sharp decline followed by a notable increase (2.157 → 2.081 → 2.142). The level of offline delinquency decreased during Grade 7 in both genders (boys: 1.255 → 1.284; girls: 1.151 → 1.106) and then stabilized (boys: 1.18~1.20; girls: 1.107~1.109). Similarly, cyber delinquency decreased steadily through Grade 10 (boys: 1.382 → 1.162; girls: 1.321 → 1.081) and then stabilized (boys: 1.163; girls: 1.094).

To examine longitudinal causal relationships among smartphone dependence, offline delinquency, and cyber delinquency, we conducted autoregressive cross-lagged (ARCL) modeling, sequentially testing measurement invariance, structural path invariance, and error covariance invariance. Sixteen models were compared, applying progressively stricter constraints. Model 1 was the baseline unconstrained model, Models 2-4 imposed equality constraints on factor loadings (SPDE, OFDE, CYDE), Models 5-13 tested autoregressive and cross-lagged path invariance, and Models 14-16 tested error covariance invariance. The results are presented in Table 3.

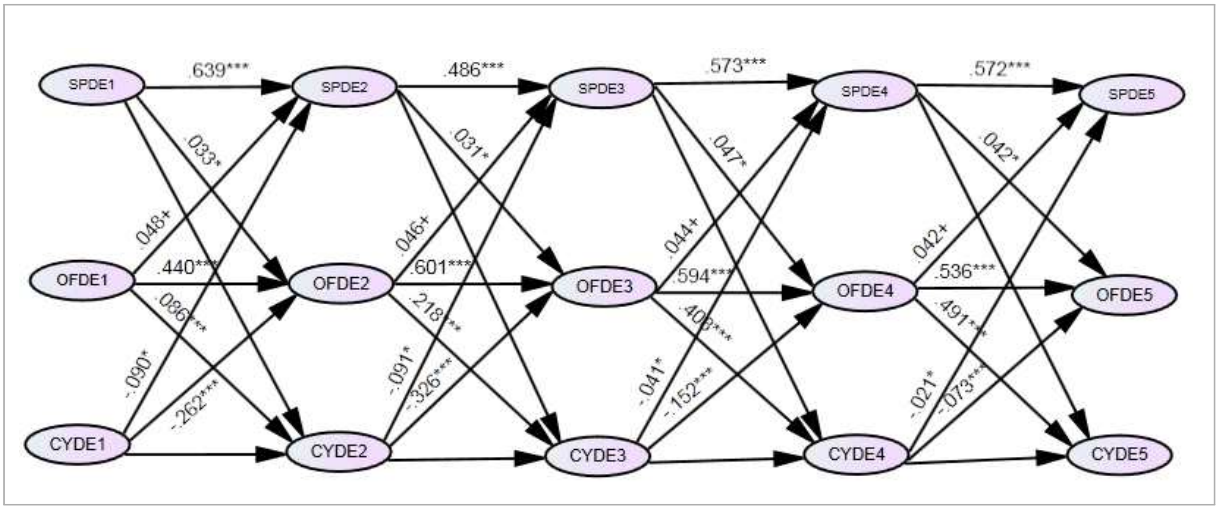
Measurement invariance was supported for smartphone dependence and offline delinquency (Models 2-3), as model fit did not deteriorate compared to the baseline. However, cyber delinquency measurement invariance (Model 4) was not supported, as TLI and CFI differences exceeded .01, and RMSEA difference exceeded .015. Partial measurement invariance was therefore assumed for subsequent tests. Autoregressive path invariance (Models 5-7) and cross-lagged path invariance (Models 8-13) were supported, as model fit indices did not worsen. Error covariance invariance was also supported (Models 14-15), except between offline delinquency and cyber delinquency (Model 16). Model 15 was selected as the final model, with satisfactory fit (CFI=0.870, TLI=0.858, RMSEA=0.049). Estimated path coefficients are shown in Figure 1.

Table 3. Results of structural invariance testing for ARCL models

Model	Identity constraints	χ^2	df	TLI	CFI	RMSEA(95% CI)
1	Unconstrained	2748.771	531	.876	.896	.046 (.044-.048)
2	SPDE measurement identity	2880.948	539	.871	.890	.047 (.045-.049)
3	OFDE measurement identity	2949.366	543	.869	.887	.048 (.046-.049)
4	CYDE measurement identity	3457.805	547	.842	.863	.052 (.050-.054
5	SPDE autoregressive identity	2999.052	546	.867	.885	.048 (.046-.050)
6	OFDE autoregressive identity	3044.253	549	.865	.883	.048 (.046-.050)
7	CYDE autoregressive identity	3050.910	552	.866	.882	.048 (.046-.050)

Model	Identity constraints	χ^2	df	TLI	CFI	RMSEA(95% CI)
8	SPDE→OFDE cross-lag identity	3066.385	555	.866	.883	.048 (.046-.050)
9	SPDE→CYDE cross-lag identity	3068.491	558	.867	.882	.048 (.046-.050)
10	OFDE→SPDE cross-lag identity	3091.674	561	.866	.881	.048 (.046-.050)
11	OFDE→CYDE cross-lag identity	3134.620	564	.865	.879	.048 (.046-.049)
12	CYDE→SPDE cross-lag identity	3179.820	567	.863	.877	.048 (.047-.049)
13	CYDE→OFDE cross-lag identity	3290.978	570	.858	.872	.049 (.048-.051)
14	SPDE↔OFDE error covar. identity	3292.541	573	.859	.872	.049 (.048-.051)
15	SPDE↔CYDE error covar. identity	3327.909	576	.858	.870	.049 (.048-.051)
16	OFDE↔CYDE error covar. identity	3571.837	579	.847	.859	.051 (.050-.053)

Figure 1. Final autoregressive cross-lagged model for all adolescents



+p<.15, *p<.05, **p<.01, ***p<.001.

Both smartphone dependence and offline delinquency exhibited significant positive autoregressive effects, indicating stability across time points. Cyber delinquency showed a negative, but non-significant autoregressive effect, suggesting less temporal stability. Cross-lagged paths revealed significant bidirectional positive effects between smartphone dependence and offline delinquency (with stronger SPDE → OFDE influence). It can be seen that the causal relationship between offline delinquency and cyber delinquency is a bidirectional relationship with each preceding the other (α<.001), and the influence is shown to have a positive influence for OFDE→CYDE and a negative influence for CYDE→OFDE. However, the cross-lagged coefficient between smartphone dependence and cyber delinquency was found to be insignificant. Our findings revealed that the autoregressive effect of cyber-delinquency was not significant in the total sample but became significant in both male and female groups. This discrepancy is not a statistical error but rather indicates that gender heterogeneity in the pooled model diluted the effect, while subgroup analyses uncovered its unique patterns. This suggests that gender-specific dynamics are critical in understanding adolescents' deviant behaviors. In order to confirm whether these results differed between male and female adolescent groups, a multi-group analysis was conducted.

Multi-group analysis tested gender differences sequentially: configural, measurement, structural, and error

covariance invariance. The final model (Model 15) was applicable to both groups (Table 4), with acceptable fit (boys: TLI=0.842, CFI=0.856, RMSEA=0.049; girls: TLI=0.860, CFI=0.873, RMSEA=0.054). Therefore, the morphological identity between male and female was tested in the final model.

Table 4. Model fit by gender

Group	χ^2	df	TLI	CFI	RMSEA
Male	2036.811	572	.842	.856	.049(.047-.052)
Female	2073.072	572	.860	.873	.054(.051-.056)

Next, the goodness of fit was tested using the base model that did not impose an identity constraint on the two groups by gender and the constrained model 2-16 that sequentially imposed the identity of measurement, structure, and error covariance. Comparing constrained and unconstrained models (Table 5), measurement and autoregressive path invariance were supported (Models 2-7). Partial cross-lagged invariance was found (Models 8-12), but CYDE → OFDE invariance was not supported (Model 13). However, since models 8-12 support cross-regression identity, a partial cross-regression identity was established, and an error covariance identity test was performed. The three error covariance identity constraint models (14-16) did not show significantly worse fit than the previous models, so model 16 was selected as the final model.

Table 5. Gender invariance testing results

Model	Identity constraints	χ^2	df	TLI	CFI	RMSEA(95% CI)
1	Unconstrained	4714.200	1164	.825	.839	.039(.038-.041)
2	SPDE measurement identity	4729.513	1166	.825	.838	.039(.038-.041)
3	OFDE measurement identity	4793.403	1169	.823	.835	.040(.039-.041)
4	CYDE measurement identity	4786.231	1170	.823	.836	.040(.039-.041)
5	SPDE autoregressive identity	4823.400	1171	.821	.834	.040(.039-.041)
6	OFDE autoregressive identity	4825.200	1172	.822	.834	.040(.039-.041)
7	CYDE autoregressive identity	4826.553	1173	.822	.834	.040(.039-.041)
8	SPDE→OFDE cross-lag identity	4826.591	1174	.822	.834	.040(.039-.041)
9	SPDE→CYDE cross-lag identity	4826.803	1175	.822	.834	.040(.039-.041)
10	OFDE→SPDE cross-lag identity	4828.467	1176	.822	.834	.040(.039-.041)
11	OFDE→CYDE cross-lag identity	4832.153	1177	.822	.834	.040(.039-.041)
12	CYDE→SPDE cross-lag identity	4921.544	1178	.818	.830	.040(.039-.041)
13	CYDE→OFDE cross-lag identity	6077.678	1179	.762	.777	.046(.045-.047)
14	SPDE↔OFDE error covar. identity	4832.220	1179	.823	.834	.040(.039-.041)
15	SPDE↔CYDE error covar. identity	4832.231	1180	.823	.834	.040(.039-.041)
16	OFDE↔CYDE error covar. identity	4865.481	1181	.821	.833	.040(.039-.041)

Table 6 shows the results of testing the moderating effect by gender using the final model. The final multi-group model (Model 16) confirmed significant gender moderation ($\Delta\chi^2$=151.281, df=17, p<.001). In the final model, the autoregression and cross-regression between male and female were estimated as an unconstrained model to examine the difference in coefficients, and the significance of the moderating effect

was tested by checking whether the CRD value was greater than or less than the left and right critical values |1.96| of the 95% confidence interval.

Table 6. Analysis of gender-specific multi-group moderating effects

■ Model comparison

Model	df	CMIN	p	NFI Delta-1	IFI Delta-2	RFI rho-1	TLI rho2
Constraint model	17	151.281	.000	.007	.007	.004	.004

Note: H_0: There is no moderating effect between genders.

■ Model fit

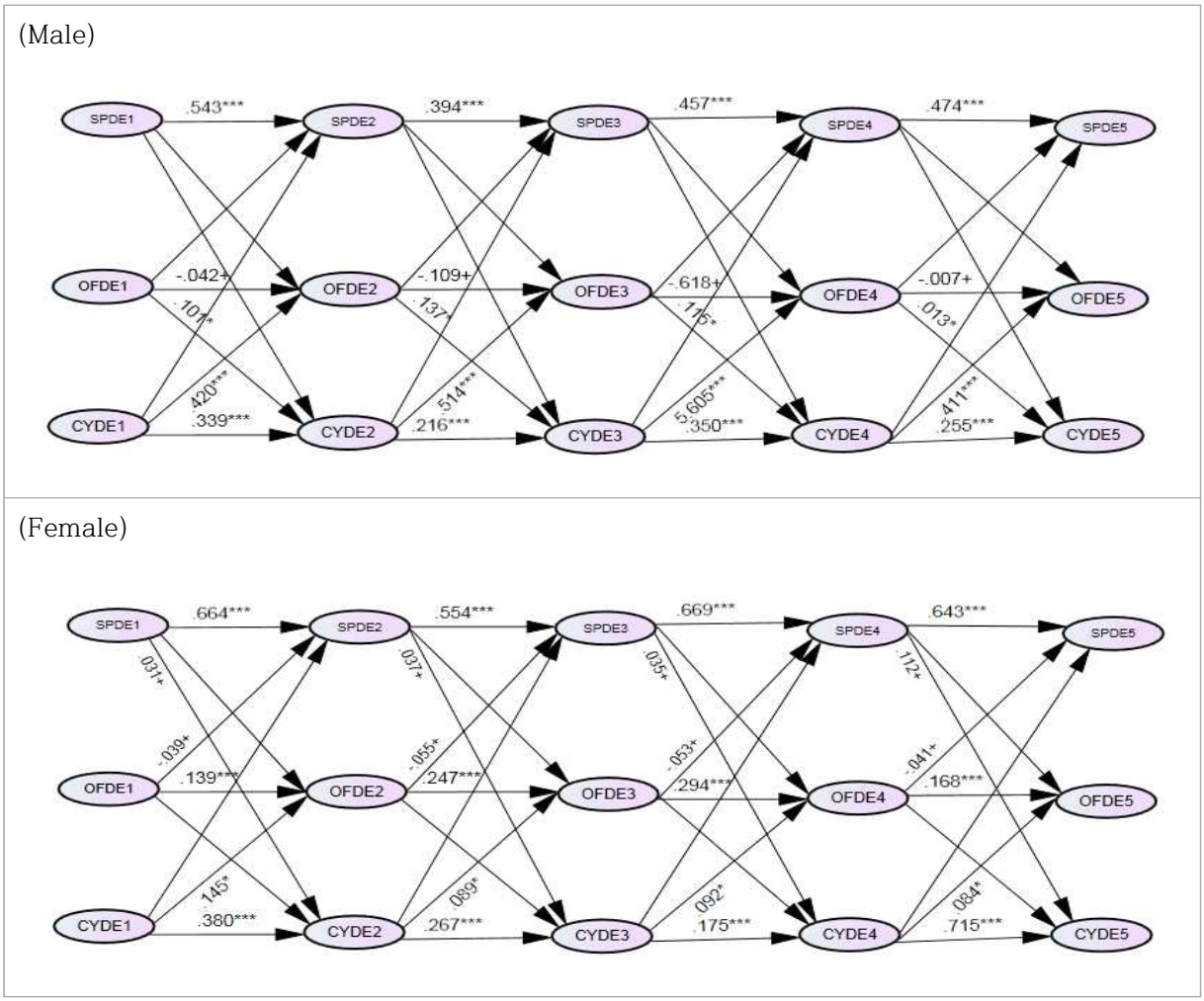
Model	CMIN	df	CMIN/df	TLI	CFI	RMSEA
Unconstrained model	4714.200	1164	4.050	.825	.839	.039 (.038-.041)
Constrained model	4865.481	1181	4.120	.821	.833	.040 (.039-.041)

As shown in Figure 3 and Table 7, the autoregressive effects of smartphone dependence were significant and positive over time for both male and female adolescents, indicating that SPDE is not a transient phenomenon but rather a persistent pattern during adolescence. The standardized regression coefficients for males ranged from b=.394 to .543, while those for females were higher, ranging from b=.554 to .669. The CRD was -6.785, revealing a statistically significant gender difference, with females demonstrating greater stability and stronger autoregressive effects than males. Offline delinquency was 8% higher in males than in females. However, over time, its autoregressive effect showed a very weak negative influence in males, whereas it had a significant positive influence in females. Specifically, the standardized regression coefficients for males ranged from b=-.007 to -.618 (p=.12), while for females, they ranged from b=.139 to .294 (p<.001), indicating a significant gender difference (CRD=-4.608, p<.001). These findings suggest that females exhibited stronger and more stable patterns of offline delinquency over time compared to males. On the other hand, the autoregressive effect of cyber delinquency had a significant positive effect over time for both male and female, indicating that adolescents' cyber delinquency was likely to increase that at the next time point. For males, the standardized coefficients ranged from b=.216 to .350, while for females, they ranged from b=.175 to .715. However, the CRD of 0.697 indicated no significant gender difference in the autoregressive effects of cyber delinquency.

Regarding the cross-lagged effects between smartphone dependence and offline delinquency, in males, both the SPDE→OFDE and OFDE→SPDE paths were negative but not statistically significant. Among females, both paths were also negative; however, the effect of offline delinquency on subsequent smartphone dependence was marginally significant (p=.121), suggesting that increases in offline delinquency slightly reduced subsequent smartphone dependence. The CRDs for these cross-lagged paths were -0.877 and 0.460, indicating no significant gender moderation effects. For the cross-lagged effects between smartphone dependence and cyber delinquency, in males, both the SPDE→CYDE and CYDE→SPDE paths were positive but not statistically significant. Among females, both paths were positive as well, with the SPDE→CYDE path marginally significant (p=.143), suggesting that increases in smartphone dependence slightly increased subsequent cyber delinquency. The CRDs for these paths were -0.707 and 0.958, indicating no significant gender differences

in these relationships. Lastly, the cross-lagged effects between offline delinquency and cyber delinquency revealed significant positive bidirectional relationships among males, indicating a reciprocal and reinforcing dynamic where cyber delinquency promoted offline delinquency over time, and offline delinquency, in turn, reinforced cyber delinquency. In contrast, among females, the OFDE→CYDE path was not significant, whereas the CYDE→OFDE path was significant (p=.022), suggesting weaker mutual influence compared to males. The CRD for OFDE→CYDE was 1.110 (not significant), while the CRD for CYDE→OFDE was 5.912 (p<.001), indicating that males exhibited a stronger and more stable influence in this pathway than females.

Figure 2. Final path models by gender (standardized coefficients)



+p<.15, *p<.05, **p<.01, ***p<.001.

Table 7. CRD test of gender differences in final path model

Item	Path	Male			Female			CRD
		$\hat{\beta}$	S.E.	CR	$\hat{\beta}$	S.E.	CR	
Autoregression	SPDE⟶SPDE	.459	.018	26.06***	.627	.017	36.35***	-6.785***
	OFDE⟶OFDE	-.065	.042	-1.56+	.222	.046	4.85***	-4.608***
	CYDE⟶CYDE	.249	.042	5.97***	.210	.037	5.64***	0.697

Item	Path	Male			Female			CRD
		$\hat{\beta}$	S.E.	CR	$\hat{\beta}$	S.E.	CR	
Cross-lagged regression	SPDE→OFDE	-.005	.004	-1.25	.000	.004	-.01	-0.877
	SPDE→CYDE	.001	.002	.47	.003	.002	1.46	-0.707
	OFDE→SPDE	-.192	.185	-1.04	-.319	.205	-1.55+	0.460
	OFDE→CYDE	.066	.027	2.40*	.022	.029	.76	1.110
	CYDE→SPDE	.384	.289	1.33	.019	.248	.08	0.958
	CYDE→OFDE	.742	.086	8.62***	.132	.057	2.30*	5.912***

Note: $CRD = (b_1 - b2)/\sqrt{SE_1^2 + SE_2^2}$
+p<.15, *p<.05, **p<.01, ***p<.001.

IV. Discussion and Conclusion

Previous studies on adolescents' smartphone dependence, offline delinquency, and cyber delinquency have largely relied on cross-sectional data or limited pathway analyses, constraining insights into longitudinal dynamics. To address this gap, the present study employed a longitudinal cross-lagged panel model with multi-group analysis from middle school to high school, capturing both causal directions and gender-specific differences, and by interpreting significant as well as non-significant pathways, it offers nuanced insights that advance prior research and inform preventive policies. The key findings and interpretations are as follows.

First, the autoregressive effects of smartphone dependence were significantly positive over time for both boys and girls, with gender moderation effects observed; the effect was stronger and more stable among girls. This finding is consistent with Ahn (2023), who reported that female adolescents exhibit greater reliance on smartphone-based emotional communication and the maintenance of social relationships through SNS. The autoregressive effect of offline delinquency was negative but statistically nonsignificant over time among boys (p=.120), whereas it was significantly positive among girls, indicating gender moderation. This suggests that girls exhibit more consistent patterns of offline delinquency over time, while boys' delinquent behavior may fluctuate in response to environmental or external stimuli, aligning with Moffitt's (1993) developmental taxonomy theory. Cyber delinquency showed significantly positive autoregressive effects for both genders, with no significant gender moderation, indicating stable persistence across time. This is consistent with Bae (2017), who highlighted the role of factors such as stress, self-control, and computer usage in the continued increase of cyber delinquency. Notably, the standard autoregressive coefficients for girls sharply increased between the first and second years of high school, suggesting an escalation in deviant behaviors in cyberspace during this transition, consistent with Kwon and Kim (2019), who argued that female adolescents are more likely than males to turn to cyberspace for stress relief and conflict coping during this period. In contrast, this finding diverges from prior studies (e.g., Wissink et al., 2023), which reported that increased parental monitoring and social support could reduce delinquent behavior over time, suggesting the need for further investigation into the role of parental and social interventions.

Second, the cross-lagged effects between smartphone dependence and offline delinquency were negative but statistically nonsignificant for both genders. Among girls, however, offline delinquency appeared to exert

a very weak negative effect on subsequent smartphone dependence, supporting prior claims (Jung, 2022) that strengthened self-control following offline delinquency may reduce smartphone use. The cross-lagged effects between smartphone dependence and cyber delinquency were positive but nonsignificant for both genders, contrasting with prior findings (e.g., Kim, 2021; Yoo, 2023) that smartphone overdependence heightens aggression, verbal abuse, and impulsivity, thereby directly contributing to cyber delinquency. Nevertheless, the weak positive effect of smartphone dependence on cyber delinquency among girls suggests that smartphone dependence may serve as a latent risk factor for cyber delinquency among female adolescents, consistent with Kim et al. (2021), who reported gender differences in the impact of smartphone overdependence on cyber delinquency. The cross-lagged effects between offline and cyber delinquency showed clear gender differences. The effect of offline delinquency on cyber delinquency was significant only for boys, implying that offline delinquency may escalate into cyber delinquency. Conversely, the effect of cyber delinquency on offline delinquency was significantly positive for both genders but stronger among boys, indicating that boys are more likely to extend deviant online behavior into offline delinquency. For boys, bidirectional significant positive effects were found, suggesting a mutually reinforcing relationship over time, where cyber delinquency fosters offline delinquency, and vice versa. This aligns with prior studies (Sung & Kim, 2019) describing a vicious cycle of persistent and interactive school violence among adolescents.

Based on these findings, the study offers several practical implications for interventions targeting smartphone dependence, offline delinquency, and cyber delinquency among adolescents. First, the longitudinal relationships among these variables from early middle school through high school appear to represent enduring interactions rather than transient phenomena, highlighting the need for long-term rather than short-term intervention strategies. Adolescents deeply involved in these problem behaviors often conceal their actions and may lack awareness of the consequences of their behavior (Warden & Mackinnon, 2003).

Second, the persistence and interplay of smartphone dependence, offline delinquency, and cyber delinquency differ by gender, suggesting the need for gender-specific interventions. For male students, offline delinquency is more likely to fluctuate depending on external conditions, and cyber delinquency is more likely to escalate into offline delinquency, indicating the need for focused interventions such as digital citizenship education and cyber delinquency prevention programs (Althibyani & Al-Zahrani, 2023). For girls, the strong persistence of smartphone dependence and cyber delinquency, and the potential of smartphone dependence as a latent risk factor for cyber delinquency, point to the effectiveness of emotional support, SNS usage regulation programs, and counseling interventions (Hong et al., 2015).

Third, existing domestic youth cyberbullying and delinquency prevention programs are short-term and lecture-oriented compared to long-term, multi-layered interventions abroad, and thus require improvement (Yoon et al., 2014; Kim et al., 2025). For example, the ConRed program in Spain (Del-Rey et al., 2016) aims to prevent cyberbullying and internet addiction by enhancing ICT literacy and applying a multi-tiered intervention model involving teachers, parents, counselors, and external experts. Schultze-Krumbholz et al. (2016) proposed the Media Heroes program, a school-based intervention developed in Germany for adolescents aged 11 to 17, aimed at enhancing empathy and preventing cyberbullying. Focusing on the perpetrators' low levels of empathy, the program employed a multi-layered strategy combining emotional and cognitive empathy training with media literacy education to promote responsible online behavior. The

curriculum included topics such as the definition of cyberbullying, its legal and psychological consequences, the formation of online norms, and coping strategies. Using activity-based approaches such as role-playing and group discussions, the program aimed to foster empathy and digital citizenship.

To address youth delinquency in Korea, multi-layered intervention models (e.g., ConRed, Media Heroes) should be adapted. Key strategies include integrating digital citizenship into curricula, strengthening teacher-parent capacity, and linking schools with community counseling systems. Gender-specific approaches, such as peer/offline activities for boys and emotional support with SNS regulation for girls, are essential. Utilizing national and local infrastructures will enhance the long-term feasibility and sustainability of these programs.

This study contributes to understanding the dynamic interactions among adolescents' smartphone dependence, offline delinquency, and cyber delinquency by analyzing their longitudinal causal relationships by gender. Nevertheless, several limitations warrant consideration. First, the self-reported survey data may be subject to social desirability bias, particularly for aggressive or deviant behaviors, possibly leading to underreporting. Moreover, panel attrition, which tends to be higher among youth with stronger delinquent tendencies (Thornberry et al., 1993), may have biased the sample toward those with lower levels of delinquency.

Second, while measurement invariance across time was confirmed for smartphone dependence and offline delinquency, it was not established for cyber delinquency, indicating potential inconsistency in its measurement structure over time (Millsap & Yun-Tein, 2004). Additionally, multi-group analysis showed that while most autoregressive and cross-lagged paths were invariant across genders, invariance was not supported for the cross-lagged paths between cyber and offline delinquency. This indicates possible gender differences in the transition of problem behaviors (Meeus, 2016) and limits the generalizability of the findings. Future studies should consider additional group characteristics beyond gender.

Third, to improve model fit in the structural equation modeling using AMOS, certain error covariances between latent and observed variables were added based on modification indices. Future studies should consider using more sophisticated missing data handling techniques, such as multiple imputation, to enhance the validity of the analyses.

Finally, the study assumed uniform developmental trajectories across adolescents except for gender differences. However, distinct subgroups may exist based on combinations of high or low levels of smartphone dependence, offline delinquency, and cyber delinquency. Chen et al. (2005) noted that individual traits such as negative emotionality may be key underlying mechanisms in these groups. Lee and Lee (2023) used JTM, a statistical longitudinal approach, to classify groups in which the dynamic trajectories of two factors combined as they progressed through grades were combined and distributed in an imbalanced and diverse manner according to individual characteristics, identified vulnerable groups, and suggested intervention measures. Therefore, in follow-up studies, it is necessary to examine how offline delinquency and cyber-delinquency appear differently in the process of adolescent growth, and classify risk groups in which OFDE and CYDE coexist, and identify their unique psychological characteristics and predictive variables.

이종형은 미국 University of Illinois-Urbana Champaign에서 지리학 석사학위를 받았고, Virginia Commonwealth University에서 역학박사학위를 받았다. 현재는 동 대학 가정의학연구소에서 선임자료분석가로 일하고 있다. 주요 관심 분야는 보건의료통계 분야이며, 스트레스성 치사율과 사회적 비용을 GIS와 공간 베이지안으로 추정하는 연구를 하고 있다.

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이준배는 미국 Texas Tech University에서 경제학 박사학위를 받았으며, 충북대학에서 계량경제 및 다변량 통계학에 관한 강의와 연구를 했다. 현재는 명예교수로 보건복지 분야에 관심을 가지고, 노인 정신건강과 청소년 비행에 미치는 동태적 영향을 분석하고 예방대책을 제시하는 연구를 하고 있다.

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청소년 스마트폰 의존과 현실 및 사이버 비행에 대한 성별 다집단 ARCL 분석

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| 초 록 |

본 연구는 청소년의 스마트폰 의존, 현실비행, 사이버비행 간의 종단적 인과관계를 성별에 따라 비교 분석하고, 이들 간의 관계 구조에서 성별 차이가 어떻게 나타나는지를 규명하는 데 목적이 있다. 이를 위해 한국청소년정책연구원의 KCYPS 2018~2022 (중1-고2) 패널자료를 이용해서 자기회귀 교차지연 모형에 기반한 다집단 분석을 하였다. 분석 결과, 스마트폰 의존은 남녀 학생 모두에게서 유의미한 자기회귀 효과를 보였고, 여학생은 남학생보다 더 높은 안정성과 지속성을 나타냈다. 현실비행은 남학생보다 여학생에게서 자기회귀 계수가 더 높았으며, 사이버비행은 특히 여학생의 경우 최근 시점에서 자기회귀 계수가 급증하였다. 교차지연 분석에서는 남학생의 사이버비행이 현실비행에 강한 정적 영향을 미치는 등 성별에 따른 인과구조의 뚜렷한 차이가 확인되었다. 이러한 연구결과를 바탕으로 성별에 따른 특화된 중재 및 예방 전략의 필요성과 현실과 사이버 공간을 아우르는 다층적 대응 방안 마련의 필요성을 제시하였다.

주요 용어: 청소년, 스마트폰 의존, 현실 및 사이버비행, 자기회귀교차지연 모형