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FULL-LENGTH REPORT

Is the I-PACE (Interaction of Person-Affect-Cognition-Execution) model valid in South Korea? The effects of adverse childhood experiences (ACEs) on internet gaming disorder and the mediating effect of stress on adolescents

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ABSTRACT

Background and aims: The purpose of the present study was to investigate the effects of adverse childhood experiences (ACEs) on internet gaming disorder (IGD) and the mediating effect of stress based on the Interaction of Person-Affect-Cognition-Execution (I-PACE) model. *Methods:* The 2017 survey data from one community addiction management center in South Korea were analyzed. A sample of 3,593 adolescents (mean age = 13.75 years, SD = 2.22) were recruited from 23 elementary, middle and high schools and 11 local children's centers. The mediating effect was analyzed by the three-step analysis method. *Results:* Our study found that ACEs had a significant effect on the stress score (B = 1.420, $P < 0.001$) and the stress scale score had a significant effect the IGD score (B = 0.127, $P <$ 0.001). After adjusting for the stress score in the model, ACEs had a significant effect on the IGD score (B = 0.328, $P < 0.001$), and the stress score had partial mediating effects (B = 0.1802, 95% C. I: 0.131–0.239). *Discussion:* We found that ACEs directly affect IGD and that ACEs directly affect IGD through stress in support of the I-PACE model. In the sensitivity analysis, the mediating effect of stress in the low-risk IGD group was significant, but the mediating effect of stress in the high-risk IGD group was not significant. Prior ACEs should be considered when interviewing IGD clients. In addition, enhancing stress management skills would be beneficial to IGD clients with a history of ACEs, and actions reducing exposure to ACEs in childhood are necessary.

KEYWORDS

adverse childhood experiences; internet gaming disorder; youth; mediation; stress

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INTRODUCTION

Although internet games are not problematic for most people, the excessive use of games is a problem. The risk of internet gaming disorder (IGD) has been confirmed such that IGD was included in the latest versions of the Diagnostic and Statistical Manual of Mental Disorders

(DSM-5) (American Psychiatric Association, 2013) and the International Classification of Diseases (ICD-11) (World Health Organization, 2018) (Song, Lee, & Shin, 2019). Recent studies have shown that the increasing use of online games is causing serious problems due to the excessive use of these games, and international research has shown that 10–15% of adolescents in Asia and 1–10% of adolescents in the West experience gaming disorders/addiction (Saunders et al., 2017). The negative effects of excessive engagement with internet games have been found in various studies (Saunders et al., 2017). Previous studies have explained that IGDs rely on similar brain mechanisms as other substance use and behavioral disorders (Saunders et al., 2017). In addition, it has been reported that problematic internet gaming groups have been associated with high levels of emotional symptoms, dysfunctional interpersonal relationships, suicidal behaviors, and stress (Kaess et al., 2017; Strittmatter et al., 2015). A previous study suggested that IGD is caused by the interactions among biological, psychological, and social factors (Chung, 2017). Biological studies related to IGDs have observed similar patterns of brain region activation in the brains of people with internet game use problems and those with alcohol use disorders or gambling addictions (Saunders et al., 2017). In addition, it has been stated that IGDs also appear due to dysfunction in the compensatory circuits, which is an addiction mechanism that underlies substance use disorders, such as alcohol use disorder (Kim et al., 2011). In another previous study, an internet gaming group with problematic use had levels of depression, behavioral disorders, emotional symptoms, hyperactivity/concentration difficulties, interpersonal problems, suicidal behavior, and self-injury behavior that were higher than those in a group with general game usage (Strittmatter et al., 2015). Some studies have shown that the severity of symptoms of IGD is highly related to stress (Canale et al., 2019; Kaess et al., 2017). For example, individuals in a problematic internet use group experienced more daily life stress than those in a control group (Seo, Lee, Lee, Bhang, & Lee, 2021).

In recent years, the most influential model in the gaming studies field has been the Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand, Young, Laier, Wölfling, & Potenza, 2016). The I-PACE model is a theoretical framework for the basic process of developing and maintaining certain uses of the internet, such as gaming, gambling, shopping, communicating, and using specific internet programs. This model provides an integrative theoretical framework concerning internet-related disorders (Brand et al., 2016) and posits that an individual's core characteristics, including personality, biopsychological constitution (e.g., early childhood experiences), social cognition, psychopathology and cognitive reactions in response to a situation (e.g., stress reactivity), constitute etiological factors involved in the development, maintenance, and relapse of different types of internet use disorders (e.g., excessive use of video games). In the I-PACE model, the predisposition factor refers to the core characteristics of the person and includes childhood experiences. In addition, the mediating factor refers to the reactions to situations, and it includes stress. Finally, the executive factor refers to a specific internet use disorder that may result, which includes IGD. Previous studies have suggested that the I-PACE framework is a theoretical framework that will consistently need to be updated based on specific internet use disorders in the future (Brand et al., 2016). The I-PACE model was updated to reflect recent studies and theoretical considerations (Brand et al., 2019), and the recent I-PACE model has undergone further revisions. First, the addiction process was precisely defined by using recent empirical studies (Dempsey, O'Brien, Tiamiyu, & Elhai, 2019; Dong, Wang, Wang, Du, & Potenza, 2019; Ioannidis, Hook, Wickham, Grant, & Chamberlain, 2019; Kaess et al., 2017; Ryu et al., 2018; Schneider, King, & Delfabbro, 2018). Second, the mediating and moderating variables according to the addiction stage (early and later) were described. In particular, the addiction stage gradually increases, the relationship between affective and cognitive responses and addictive behavior becomes stronger, and the affective and cognitive responses evolve into cue reactivity and craving as a consequence of the conditioning process (Brand et al., 2019). The present study applied the updated early stage of the I-PACE model (Brand et al., 2019).

Adverse childhood experiences (ACEs) as a social component have been associated with IGD. ACEs are a concept first introduced by the CDC-Kaiser Permanente Adverse Childhood Experience Study, which studied the association between obesity and ACEs. ACEs include a total of 10 categories of experience as follows: 1) emotional violence; 2) physical violence; 3) physical neglect; 4) emotional neglect; 5) domestic violence; 6) sexual violence; 7) separation/loss; 8) family addiction-related mental disease; 9) family mental illness; and 10) family crimes (Felitti et al., 1998). This framework has been widely studied in various fields. In particular, epidemiological and longitudinal studies have revealed that poor health and common disease risk factors, mental health, sexual and reproductive health, and general health and social issues have relevance to drug use, disease and death (Felitti et al., 1998) and unspecified psychiatric problems and behaviors (Chapman, Dube, & Anda, 2007; Zarse et al., 2019). Widespread exposure to ACEs can cause IGD. People with ACEs have a reported increased sensitivity to stress and decreased brain function evidenced by impaired behavioral control (Briand & Blendy, 2010; Elsey et al., 2015) with a particular emphasis on IGD (Dong & Potenza, 2014; Park B.S & S, 2016). Experiences such as child abuse have emerged as social problems. With a focus on a single ACE or a narrow trauma concept, it is difficult to see ACEs as a social problem. Previous research on IGDs in Korea has studied the associations with single particular events (child abuse, sexual violence, etc.), while the present study utilized ACEs as a social concept. The I-PACE model supports the view not only that ACEs as a contributor to the biopsychological constitution might play a pivotal role in the onset of these disorders but also that these factors are incorporated into the diagnostic criteria for IGD.

Stress has been associated with ACEs and IGDs. Stress can be classified into various types, including positive stress, tolerable stress, and traumatic stress, based on differences in the response of the stress system. In particular, traumatic stress is caused by frequent exposure to powerful and overwhelming stress-inducing factors without adult care, which negatively affect brain development and growth, health, cognition, judgment function, mental health, etc. (Shapiro, Applegate, & Cozolino, 2018). Typical stress-inducing factors include abuse, neglect and sexual violence (Scientific Council, 2014). ACEs are largely related to this type of stress, and toxic or traumatic stress continues to activate the stress response system for long periods of time even if the source of the stress disappears (Anda, Butchart, Felitti, & Brown, 2010). In addition, previous studies have shown that traumatic stress has a negative effect on the developing brain and neuroendocrine system, which makes it easier for individuals to feel stressed, and negatively affects the brain's cognitive and executive functions and indicators related to emotional and mental health (Kalmakis & Chandler, 2015; Shapiro et al., 2018). ACEs, such as childhood trauma, emotional or physical abuse, neglect, and social isolation, have negative effects on the developing brain, which reduce inhibition, memory and control, and studies have reported that certain internet use disorders, such as IGD, can occur (Brand et al., 2016). A previous study showed that children and adolescent ACEs are highly correlated with stress (Lee, Kim, & Bhang, 2020). Various studies have shown that traumatic histories are associated with problematic/addictive internet use (Dalbudak, Evren, Aldemir, & Evren, 2014; Kaess et al., 2017; Kircaburun, Griffiths, & Billieux, 2019). A recent study showed that ACEs have a negative effect on internet addiction through depressive symptoms (Seo et al., 2020). The I-PACE model assumes that stressors play a mediating role between bio-psychological constitution and the induction and development of certain internet use disorders (Brand et al., 2016). The hypothesis in this study is therefore supported by empirical and theoretical studies.

The present study aimed to obtain an understanding of the addiction process that relates to IGD, the number of ACEs, and stress by applying the I-PACE model. The following study hypotheses were tested: (1) the number of ACEs have a direct effect on the severity of IGD; and (2) stress mediates the relationship between the number of ACEs and the severity of IGD. A schematic of these research objectives is shown in Fig. 1.

METHODS

Participants and procedures

This study used survey data from the 2017 smart digital media survey project administered as part of a research project of the Nowon Community Addiction Management Center, which covers one district, Nowon-gu, in Seoul City (the population in Nowon-gu is 532,905 as of December 31, 2019). This survey was conducted from March to October 2017. The Community Addiction Management Center is a community-centered addiction management institution that detects addicts early and supports counseling, treatment, rehabilitation, and rehabilitation, which is consigned and operated by the Ministry of Health and Welfare in accordance with the Mental Health Welfare Act 15.3 of South Korea. Smart digital media survey projects annually reach out at the local schools and Community Child Care Centers to obtain the trend of internet smartphone usage necessary for addiction prevention and then identifies subjects with internet and smartphone addictions for individual intervention. The participants included 3,937 students from 23 elementary, middle and high schools and 11 Community Child Care Centers. An official letter that described the purpose, content and procedure of the study was delivered to all the schools and Community Child Care Centers in the district. The students were asked to respond to the self-report questionnaires before the team delivered neuroscience-based education to every class for internet addiction prevention. We excluded 344 data points with missing values out of 3,937 total respondents. As a result, 3,593 final samples were analyzed.

Measures

ACEs were originally used as a questionnaire for adults about adverse childhood experiences before the age of 18 years (Felitti et al., 1998). However, many previous studies have used ACEs for adolescents (Bomysoad & Francis, 2020; Scully, McLaughlin, & Fitzgerald, 2020; Seo et al., 2020) to measure childhood adversity. Our study used the ACE scale from the CDC-Kaiser ACE study (Felitti et al., 1998). The ACE scale consists of 10 items, namely, verbal/emotional abuse, physical abuse, verbal/emotional neglect, physical neglect, sexual abuse, domestic violence, family mental health, family addiction, crime in the family, and separation/divorce. The number of ACEs was calculated by summing the score, where 'yes' was measured as 1 point, and 'no' was measured as 0 points. When the score was higher, more ACEs had been experienced. The Cronbach's α-level was 0.767 for the total ACE scale (Denholm, Power, & Li, 2013). The Cronbach's alpha was 0.71 in this study.

The severity of IGD was assessed with the Internet Gaming Use-Elicited Symptom Screen (I-GUESS) (Jo et al., 2017), a self-reporting screening measure based on the diagnostic criteria in the DSM-5. For this measurement, nine criteria for diagnosing IGDs were scored from 0 to 3 points depending on the frequency of the experience in the past 12 months, and a combined score of 10 or more indicates a high risk of IGD. Previous studies suggest that this measurement can be performed by using a spectrum-based approach that examines the severity of symptoms rather than the number of symptoms present (Jo et al., 2017). In the study by Jo et al. (2017), which examined reliability and validity, the Cronbach's alpha for the scale showed a high reliability of 0.94, and the coefficients of correlation with the Korean self-reporting Internet Addiction Scale, short-form

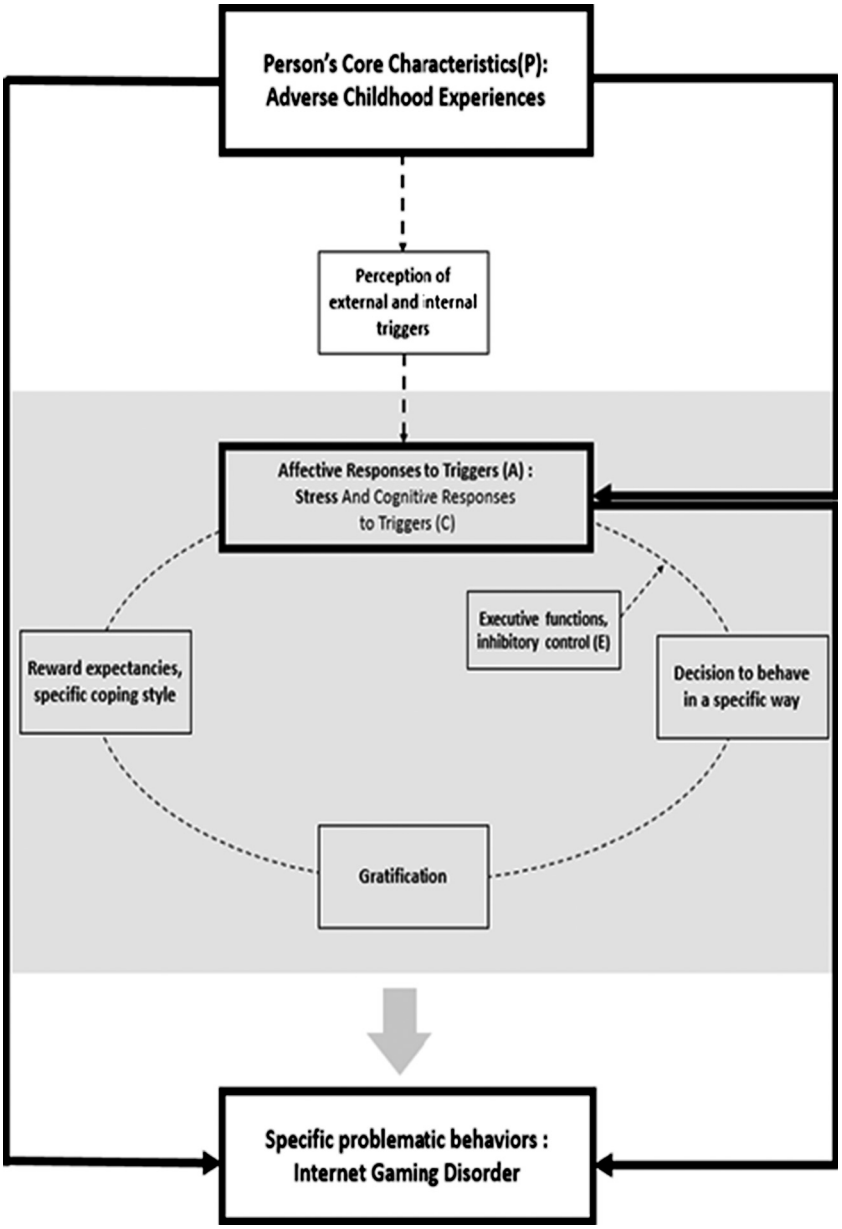

Fig. 1. The present study model

scale and Young's Internet Addiction Test were 0.896 and 0.902, respectively, which indicated that the convergent validity was also stable. The Cronbach's alpha was 0.842 in the present study.

The sum of the 12-item stress scale developed by the Korea Youth Policy Institute was used to assess stress (Choi, Mo, Kang, Kim, & Lee, 2011), which was used as a mediator. This Likert scale with a score of 1 for 'not at all' to 7 for 'very much' measures the stress level that the survey person perceives about their parental relations, sibling relations, appearance, health, family circumstances, friendships, heterosexual relationships, senior relationships, teacher relationships, career problems, and academic problems. The sum of the scores indicates the level of one's perceived stress. The Cronbach's alpha of the scale is 0.903 (Choi et al., 2011). The Cronbach's alpha was 0.874 in the present study.

Gender was used as a dichotomous variable, where boys were recorded as '0', and girls were recorded as '1', and the other variables, specifically, academic achievement ('1' high' ~ '5' 'low'), parents' attitude toward internet/smartphone use ('1' completely restrictive ~ '7' indifferent), number of preventive education experiences about internet/smartphone addiction, and number of cohabitants in the family, were incorporated as continuous variables.

Statistical analysis

All statistical analyses were conducted by using SPSS 25.0 (IBM Corp., Armonk, NY, USA). First, frequency statistics and descriptive statistics were calculated to analyze the general characteristics of the sample. Second, Pearson's correlation analysis was used to examine the relationship

Table 1. Demographic and sociological profiles of the participants (N = 3,593)

Variable	*n*	%
Gender		
Male	1,533	42.7
Female	2,027	56.4
Economic status		
Very high	262	7.3
High	1,025	28.5
Middle	1,892	52.7
Low	300	8.3
Very low	73	2.0
Type of school		
Elementary school (1–6 grade)	1,771	49.3
Middle school (7–9 grade)	1,224	34.1
High school (10~12 grade)	598	16.6
Number of cohabitant(s)		
0	13	0.04
1	131	3.6
2	2,406	67.0
3	595	16.6
4	297	8.3
5 or more	122	3.4
Parents' attitude toward internet/ smartphone use		
Completely prohibited	86	2.4
Mostly prohibited	278	7.7
Mostly prohibited but partially allowed	738	20.5
Partially prohibited but mostly allowed	1,183	32.9
Mostly allowed	937	26.1
Completely allowed	181	5.0
Indifference	155	4.3
Number of preventive education experiences about internet/ smartphone addiction (within a year)		
None	1,120	31.9
1	328	9.3
2	501	14.3
3	650	18.5
4	322	9.2
5 or more	593	16.9

and multicollinearity of the major variables. Third, we conducted a mediation analysis. This mediating effect analysis method is described in Baron and Kenny (1986), and in Zhao, Lynch, and Chen (2010), a three-step method rather than a four-step method was recommended. Fourth, a bootstrap analysis that used Process Macro 3.3 was conducted to statistically examine the mediating effects of the stress scale score.

Ethics

This study was approved by Nowon Eulji Medical Center, Eulji University Institutional Review Board (IRB No. EMCS 2018-06-014). Informed consent was submitted by all institutions before the study procedure. For this analysis, data with non-personally identifiable information (non-PII) were used under IRB approval.

Table 2. Means and standard deviations for the primary variables

Variable	Mean (SD)	N (%)
Adverse childhood experiences	0.43 (1.05)	
0		2,735 (76.1)
1–2		679 (18.9)
3–5		159 (4.5)
I-GUESS score	2.9 (3.5)	
0		1,181 (32.9)
1–3		1,277 (35.5)
4–6		642 (17.9)
7–8		215 (6.0)
9-		278 (7.7)

RESULTS

Descriptive statistics

The results are shown Table 1. The sample included 1,533 (42.7%) boys and 2,027 (56.4%) girls. The mean age was 13.75 (S. D = 2.22) years. Among the participants (n = 3,593), 1,771 were students from elementary school (grades 1–6) (49.3%), 1,224 were students from middle school (grades 7–9) (34.1%), and 598 were students from high school (16.6%). The mean number of ACEs was 0.43 (SD = 1.05); 2,735 (76.1%) of the study participants had no negative childhood experiences at all, 679 (18.9%) experienced 1 to 2, and 159 (4.5%) experienced 3 to 5 (Table 2).

Correlations among the variables

The results of the Pearson's correlation analyses between the major variables are shown as correlation coefficients in Table 3. The stress scale score was positively correlated with childhood experiences (ACEs) (r = 0.224, P < 0.001), and the IGD severity measure was positively correlated with stress (r = 0.221, P < 0.001). In addition, the number of ACEs was positively correlated with IGD severity (r = 0.166, P < 0.001).

Effects of adverse childhood experiences on the stress scale score

The analysis of the effects of ACEs on stress is shown in Table 4. The regression models that included female gender, age, parental attitudes toward internet/smartphone use, the number of preventive education experiences about internet/ smartphone addiction, the number of cohabitants in the family, economic levels and academic achievement resulted in statistically significant explanations of 19.8% of the stress scale score variance (F (8, 3344) = 104.450, P = 0.00). ACEs were positively associated with the stress experienced by the children and adolescents, β = 0.21, P = 0.00, 95% C.I. = [1.213, 1.626] (model 1), and when more ACES were experienced, the stress scale score was higher.

Table 3. Pearson's correlation coefficient between pairs of model variables

Variable	1	2	4	5	6	7	8	9	10	11
1.	1									
2.	0.291***	1								
3.	0.219***	0.104***	1							
4.	0.036**	−0.016*	0.006*	1						
5.	0.050***	0.025*	0.030*	−0.017*	1					
6.	0.163***	0.076***	0.091***	−0.019*	−0.007*	1				
7.	0.313***	0.089***	0.247***	−0.012*	0.045***	0.143***	1			
8.	−0.098***	−0.295***	−0.005*	−0.067***	0.011*	0.081***	0.192***	1		
9.	0.325***	0.152***	0.065***	−0.038**	0.069***	0.212***	0.251***	0.221***	1	
10.	−0.006*	−0.013*	−0.016*	−0.038**	0.019*	0.100***	0.090***	0.166***	0.224***	1

Note: 1) +: $P < 0.1$, *: $P < 0.5$, **: $P < 0.01$, ***: $P < 0.001$ 2) 1. Age 2. Gender (0 = Male, 1 = Female) 3. Parents' attitude toward internet/smartphone use 4. Number of preventive education experiences about internet/smartphone addiction 5. Number of cohabitants 6. Economic status 7. Academic achievement 8. I-GUESS score 9. Stress scale score 10. Adverse childhood experiences.

Table 4. Summary of the hierarchical regression analysis for the variables predicting stress

Stress scale score	Effects of adverse childhood experiences (ACEs) on stress			
	B	S.E.	*β*	95% C.I.
Control variable				
Constant	3.250	0.829		[1.625, 4.876]
Age in years	0.783	0.053	0.255***	[0.678, 0.887]
Female	0.837	0.225	0.060***	[0.396, 1.279]
Parents' attitude toward internet/smartphone use	−0.119	0.088	−0.022	[−0.291, 0.052]
Number of preventive education experiences about internet/smartphone addiction	−0.132	0.061	−0.033**	[−0.251, −0.012]
Number of cohabitants	0.421	0.126	0.052***	[0.173, 0.668]
Economic status	0.920	0.139	0.108***	[0.647, 1.193]
Academic achievement	0.791	0.112	0.122***	[0.571, 1.011]
Independent variable				
Adverse childhood experiences	1.420	0.105	0.210***	[1.213, 1.626]
Model				
R^2			0.200	
adj R^2			0.198	
F-value			104.450	
P			0.00	

Note: 1) B – unstandardized coefficients; 2) *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$; 3) S.E. – standard error; 3) C.I. – confidence interval.

Effects of child and youth stress on the IGD score

The results of the relationship between ACEs and the IGD score are shown in Table 5. The regression model explained 13.8% of the variance in internet gaming addiction severity as measured by I-GUESS (F (8, 3364) = 68.283, $P < 0.001$). ACEs were positively related to the IGD scores, $\beta = 0.148$, $P < 0.001$, 95% C.I. = [0.401 0.620] (Table 5), which indicated that when the number of ACEs was greater, the IGD score was greater. Multiple regression analyses were performed by using the independent variable (ACEs) and the parameter (stress), as shown in Table 3. The regression models that included ACEs and stress explained 18.7% of the variance in internet gaming addiction severity as measured by I-GUESS (F (9, 3343) = 86.614, $P < 0.001$). The stress scale score was shown to be positively related to the IGD score, $\beta = 0.249$, $P = 0.00$, 95% CI = [0.109, 0.144] (Table 5). After adjusting for the stress scale score, ACEs were shown to be positively related to the IGD score, $\beta = 0.095$, $P < 0.001$, 95% CI = [0.219, 0.437] (Table 5), thereby supporting hypothesis 1. The results of this investigation that employed the bootstrapping method with the 95% confidence intervals of the parameter are shown in Table 6. The bootstrapping results were 0.131–0.239 ($\beta = 0.180$, S.E. = 0.027), and the mediating effect was significant because the confidence interval did not include zero. According to the mediated effects analysis, the stress scale score partially mediated the relationship between ACEs and IGD severity; therefore, hypothesis 2 is supported (Fig. 2).

For the sensitivity analysis, we divided the participants into two groups according to the levels of IGD risk (high-risk group for participants with I-GUESS scores ≥10; non-IGD risk group for I-GUESS scores ≤9). Supplementary Tables 1 and 2 show the mediating effects of the stress scale score on the relationship between IGD and ACEs in each of these two groups. First, the effect of ACEs on the stress

Table 5. Summary of the hierarchical regression analysis for the variables that contributing to the severity of internet gaming disorder

I-GUESS score	Effects of adverse childhood experiences on internet gaming addiction severity				Effects of adverse childhood experiences and stress on internet gaming addiction severity			
	B	S.E.	*β*	95% C.I.	*B*	S.E.	*β*	95% C.I.
Control variable								
Constant	5.738	0.438		[4.879, 6.596]	5.309	0.427		[4.472, 6.146]
Age in years	−0.103	0.028	−0.066***	[−0.158, 0.047]	−0.203	0.028	−0.129***	[−0.258, 0.147]
Gender (0 = Male, 1 = Female)	−2.112	0.119	−0.297***	[−2.345, 1.879]	−2.215	0.116	−0.312***	[−2.442, 1.987]
Parents' attitude toward internet/ smartphone use	0.049	0.046	0.018	[−0.041,0.140]	0.065	0.045	0.023	[−0.024, 0.153]
Number of preventive education experiences about internet/ smartphone addiction	−0.109	0.032	−0.054***	[−0.172, 0.046]	−0.093	0.031	−0.046***	[−0.154, −0.03]
Number of cohabitants	0.065	0.066	0.016	[−0.065,0.195]	0.012	0.065	0.003	[−0.115, 0.140]
Economic status	0.234	0.073	0.054***	[0.090,0.378]	0.121	0.072	0.028*	[−0.020, 0.262]
Academic achievement	0.419	0.059	0.127***	[0.303,0.535]	0.321	0.058	0.097***	[0.207, 0.434]
Independent variable								
Adverse childhood experiences	0.510	0.056	0.148***	[0.401,0.620]	0.328	0.056	0.095***	[0.219, 0.437]
Mediator								
Stress scale score					0.127	0.009	0.249***	[0.109, 0.144]
Model								
R^2			0.140				0.189	
adj R^2			0.138				0.187	
F-value			68.283				86.614	
P			0.00				0.00	

Note: 1) B – unstandardized coefficients; 2) $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$; 3) S.E. – standard error; 3) C.I. – confidence interval.

Table 6. Summary of the bootstrapping analysis of the mediating effect

Effect	Independent variable	Parameter	Dependent variable	B	S.E.	95% C.I.
Mediation effect	Adverse childhood experience	Stress scale score	Internet gaming disorder score	0.1802	0.0278	[0.131, 0.239]

Note: 1) B – unstandardized coefficients; 2) S.E. – standard error; 3) C.I. – confidence interval.

scale score was analyzed, and second, the effect of ACEs on the IGD score was analyzed. Finally, we analyzed the effect of ACEs and the stress scale scores on the IGD scores. ACEs affect the severity of IGD in each of these two populations. However, the mediating effect of the stress scale score was found only in the low-IGD risk group (Figs 3 and 4).

DISCUSSION

The purpose of the present study was to examine the effects of ACEs on IGD severity and to investigate the mediating effects of the stress scale scores on this relationship. We tested how ACEs and stress affect IGD based on the I-PACE framework to determine the factors that can be explained by the theory. We confirmed our hypotheses that (1) as the number of ACEs increased (P in the I-PACE model), the IGD score increased and that (2) stress (A in the I-PACE model) had mediating effects between ACEs and the IGD score. One additional finding from our sensitivity analysis was (3) the difference between the IGD high-risk group and the IGD low-risk group in terms of the mediating effect of stress between ACEs and the IGD scores.

Our results showed that 5.4% of the adolescents in the our sample were at high risk for IGD. The prevalence of IGD in Asia has been reported to range from 9.9% to 15.7 (Gentile et al., 2011; Koo, Han, Park, & Kwon, 2017; Wang et al., 2014). Our results were lower than the prevalence of IGD in most Asian studies and similar to the IGD prevalence of 5.7% in the Wartberg et al. (2017) study and the IGD prevalence of 5.5% in the EUNETADB study in European countries (Müller et al., 2015; Wartberg et al., 2017).

Exposure to adverse experiences has a significant effect on IGD in our results. This is consistent with previous findings that childhood trauma has a significant impact on adolescents' internet gaming behaviors (Shi et al., 2020) In the hypothesis of the I-PACE model, it is argued that negative early childhood experiences such as physical abuse and emotional abuse, as a part of P (Person) in the I-PACE model, make adolescents vulnerable to mental disorders and IGD (Brand et al., 2019). There are several reports on the interaction between trauma and depression or anxiety in IGD/internet addiction (IA). Emotional trauma affected the severity of IGD in 242 online gamers through depression

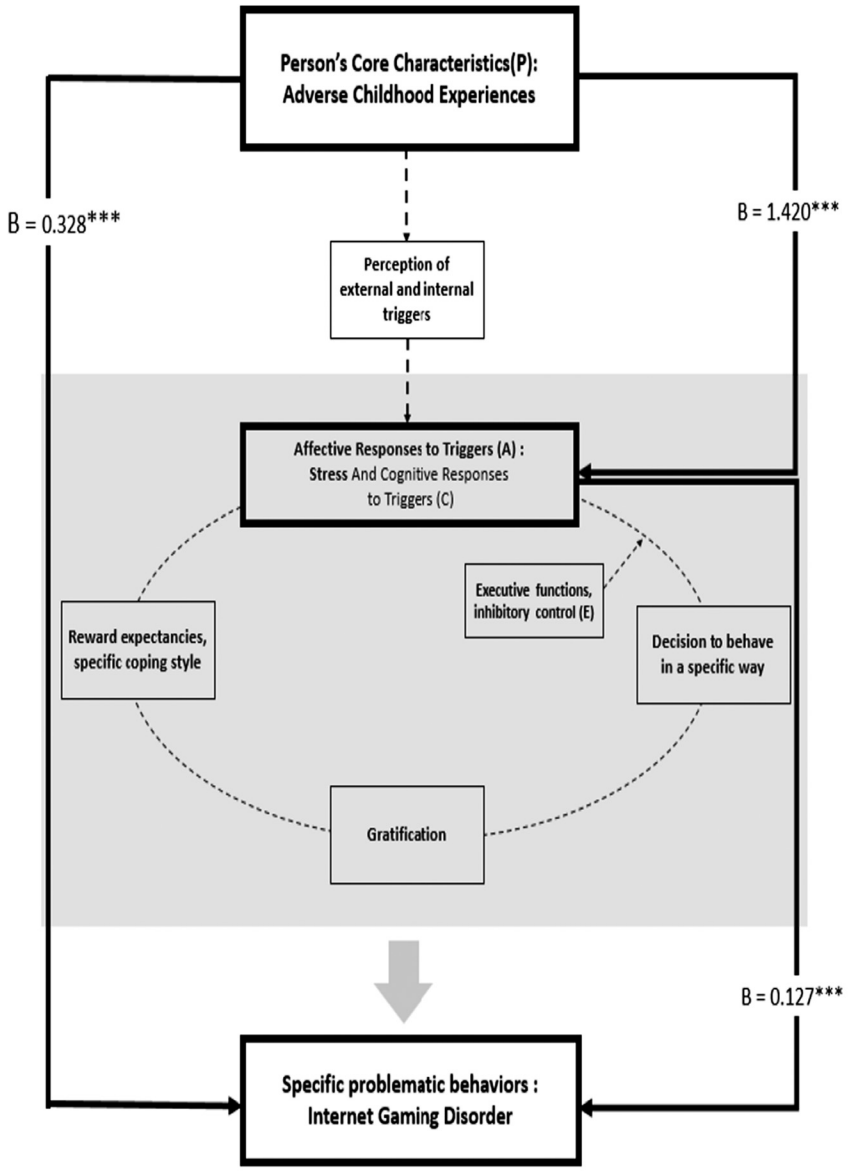

Fig. 2. The Present Study Model: All group. *Note* 1) Fig. 2 shows the analysis results for Table 4 and 5; 2) B – unstandardized coefficients 3) $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$

(Kircaburun et al., 2019). Depressive symptoms had a significant mediating effect on the relationship between IA and ACEs among children and adolescents in the community (Seo et al., 2020). A study of 1,288 gamers reported that ACEs and anxiety affect the severity of IGDs (Grajewski & Dragan, 2020). In addition, a previous study indicated that ACEs are associated with other problematic internet uses, such as IA. In adolescents on probation, ACEs are directly and indirectly associated with internet addiction disorder (IAD) through anxiety (Lee, Chung, Kim, & Lee, 2016). People with a history of traumatic events can use maladaptive coping methods such as internet games (Ehlers & Clark, 2000). Internet gaming addiction may be a coping strategy to reduce the stress caused by ACEs.

Although there are many studies on IGD in community adolescents (Lin, Potenza, Broström, & Pakpour, 2021; Rajab et al., 2020; Schneider et al., 2018; Wartberg et al., 2017), to the best of our knowledge, the effect of ACEs in community adolescents on IGDs has never been fully investigated. Our study is meaningful in that it is a study on the ACEs of community adolescents. We suggest that to reduce the level of internet gaming addiction among youth, it is necessary to prevent ACEs; if ACEs have already been experienced, then early intervention, treatment, and rehabilitation is necessary to minimize the damage (Bomysoad & Francis, 2020). In the future, longitudinal studies on IGD in community youth are needed.

Consistent with previous studies that reported that childhood trauma experiences increase the sensitivity of stress (Kaess et al., 2017; Shonkoff & Garner, 2012), which increases the likelihood of risky behavior such as IGD (Elsey et al., 2015), we demonstrated that ACEs directly and

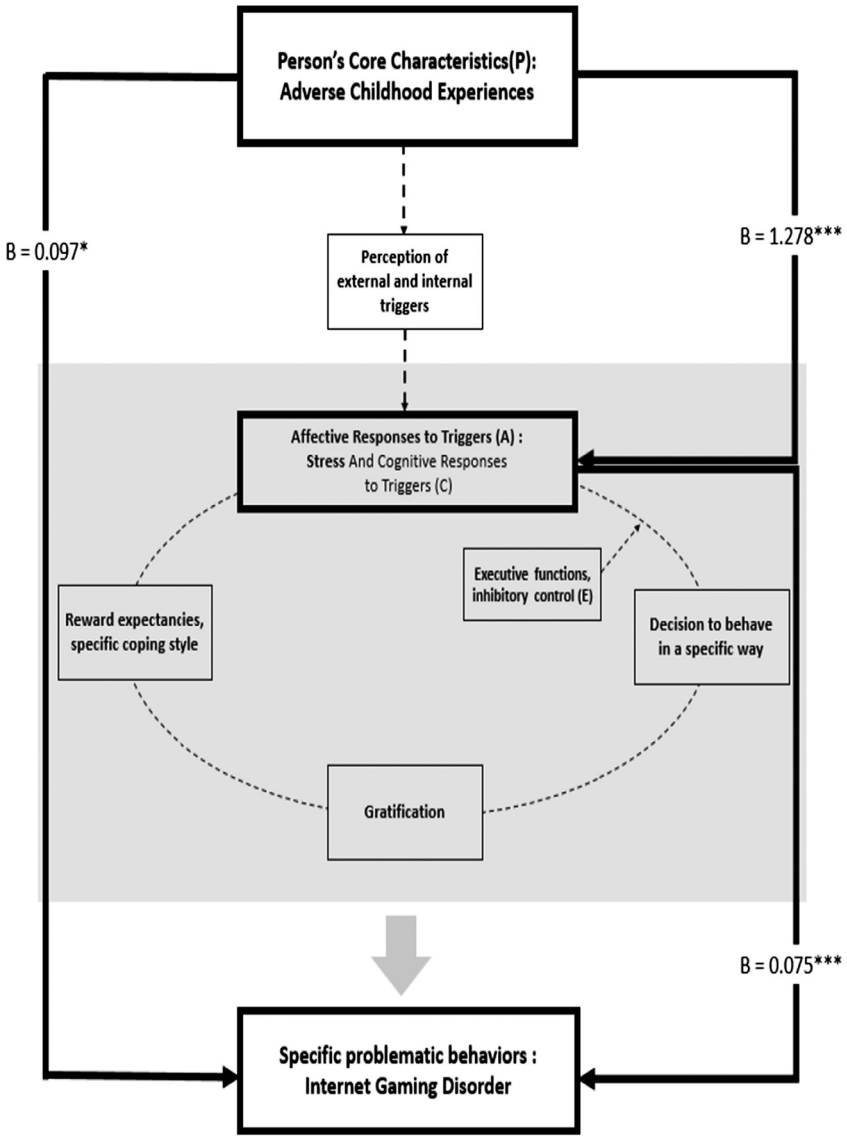

Fig. 3. The Study Model: low- IGD risk group. *Note* 1) Fig. 3 shows the analysis results for Supplementary Table 1; 2) B – unstandardized coefficients; 3) $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$

indirectly affect IGD through stress. Exposure to childhood trauma events increases stress sensitivity through the process of neurobiological change (Nurius, Green, Logan-Greene, & Borja, 2015). In our study, stress was found to affect the IGD scores in community youth groups and high-risk IGD groups. The results of our study, namely, that the stress score affects the IGD score, are similar to those of a previous study showing that, among 2,675 randomly selected students from 40 schools in four Saudi cities, high levels of stress are strongly related to gaming addiction (Rajab et al., 2020). In another study of 469 game-addicted elementary and middle school students, higher levels of ACE were associated with greater stress, and higher levels of stress were associated with lower levels of parent-child positive communication (Kim & Lee, 2015).

The I-PACE model explains that stress influences decisions about addictive behavior as an emotional and cognitive response (Brand et al., 2019). I-PACE (2019) explains neurobiological principles in addition to the I-PACE (2016) for stress (Brand et al., 2016, 2019). The I-PACE (2016) model shows that certain internet use is a coping method that reduces stress and that the subjective stress response affects whether addictive behavior is present (Brand et al., 2016; Tang et al., 2014; Tavolacci et al., 2013; Whang et al., 2003) The participants with IGD had high perceived stress and depression. In addition, individuals with low resilience do not attempt problem-oriented copying (Lin et al., 2021). The updated I-PACE model (2019) indicates that stress determines certain behaviors and that decisions to engage in these behaviors are related to the impulsive/active system (Brand et al., 2019; Kahneman, 2003; Schiebener & Brand, 2015; Strack & Deutsch, 2004) Levels of inattention and hyperactivity problems affect IGD symptoms (Jeong et al., 2020). Lower inhibitory control affects IGD scores after one

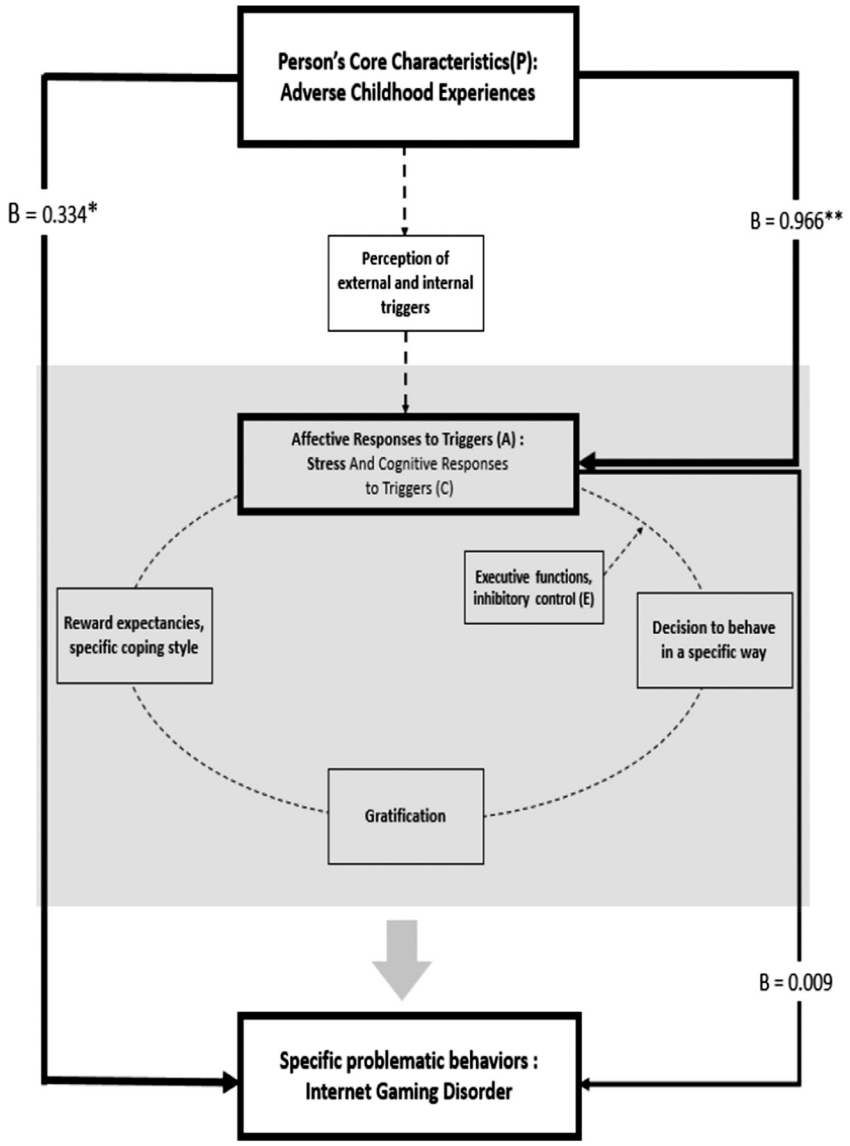

Fig. 4. The Study Model: high -IGD risk group. *Note* 1) Fig 4. shows the analysis results for Supplementary Table 2; 2) B – unstandardized coefficients; 3) $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$

year (Kräplin et al., 2021). The level of general inhibitory control and executive function moderates the relationship between affective and cognitive responses to external or internal triggers and specific addictive behavioral decisions (Brand et al., 2019). In line with this report, our findings support hypothesis 2 that the effect of stress mediates the relationship between ACEs and IGD severity.

In our sensitivity analysis (see Supplementary Tables 1 and 2), the mediating effect was not significant in the IGD high-risk group, but the mediating effect in the IGD low-risk group was significant. ACEs and stress influence IGD in the general adolescent population with many low-risk groups. In particular, stress is more important in the early stage of addiction than in the later stage. Although IGD has no neurotoxic effects on the brain because of the absence of substance use, it may occur because of the conditioning of the changes in reward processing (Kräplin et al., 2021). As an affective response to a certification trigger becomes repetitive, the response becomes automatically linked later (Brand et al., 2019). Previous studies have demonstrated that stress affects the severity of IGD in adolescents in the general community (Lin et al., 2021; Rajab et al., 2020). The I-PACE model (2019) highlights the role of stress on IGD during the early stage (Brand et al., 2019). Meanwhile, in later stages, the connections between affective and cognitive responses and addictive behaviors are reinforced and automatically linked, and cravings and cue reactivity occur. This is associated with the chronic activation of the stress response systems in adolescence and adulthood due to changes in the specific structure of the brain (Gunnar & Quevdo, 2007) Therefore, we need to give more attention to the stressors of adolescents in the early stages of addiction. Indeed, the I-PACE model is dynamic, and the validity of the hypotheses combined with various evidence should be evaluated. A

wider range of factors, such as executive functions (e.g., general inhibitory control) and cognitive responses to trigger (E and C in the I-PACE model, respectively), should be examined (Brand et al., 2019).

In our study, exposure to ACEs had a significant effect on the severity of IGD while stress had a mediating effect on this relationship. We suggest that policies to prevent ACEs should be actively implemented. In Korea, the Child Protection Service Agency is in charge of the services that prevent and intervene in child abuse. However, it is criticized for not functioning effectively for reasons such as excessive work (Cho, Kim, Bae, & Moon, 2017). There is a need to improve integrated child protection policies in the community. The U.S. Centers for Disease Control and Prevention's Guide on Preventing Adverse Childhood Experiences provides useful suggestions (Centers for Case Control and Prevention, 2019). For example, it is necessary to enhance public campaigns to prevent ACEs such that the public becomes aware of the negative effects of ACEs, and to measure the level of child abuse by using a wide conception that includes ACEs, to compare and analyze the actual conditions in other countries, and to plan prevention and intervention measures accordingly. The results of our study that find that stress has a mediating effect between ACEs and IGD severity suggest that stress reduction programs are important for children and adolescents following exposure to ACEs, especially to prevent problems that develop into IGDs. Other studies have suggested that mindfulness-based stress reduction (MBSR) helps to relieve stress and mediate IGD severity, especially in women (Dong & Potenza, 2014). Cognitive behavioral therapy (CBT) is also effective in reducing stress (Varvogli & Darviri, 2011) and can prevent excessive internet use by allowing individuals to recognize and understand the situational, emotional, and cognitive context of internet use behavior (Szász-Janocha, Vonderlin, & Lindenberg, 2021). There is no stress management program for adolescents that considers childhood trauma experiences. It is therefore necessary to develop evidence-based programs in the future.

The limitations of this study are as follows. First, the study is based on the use of nonprobability sampling in restricted areas. Second, the self-report survey often reflects the social desirability of the respondents. Third, a cross-sectional study design cannot determine causality; therefore, longitudinal studies are needed.

Nevertheless, the significance of the present study is as follows. First, the I-PACE framework was applied to IGDs to examine the induction and development process as it relates to IGDs in a Korean community student sample. Second, as a social factor, the role of negative childhood experiences (i.e., ACEs) can be emphasized and applied domestically and abroad. Finally, attention was given to the role of stress in a group with risk factors such as ACEs, which provided foundational evidence regarding early screening and intervention for internet gaming addiction.

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APPENDIX

Supplementary Table 1. Summary of the Mediating Effects by the Hierarchical Regression Analysis for the low-IGD risk group

Stress scale score	Effects of adverse childhood experiences (ACEs) on stress			
	B	S.E.	*β*	95% C.I.
Control variable				
Constant	2.00	0.825	–	[0.391, 3.626]
Age in years	0.825	0.533	0.276***	[0.720, 0.930]
Female	1.063	0.226	0.77***	[0.618, 1.508]
Parents' attitude toward internet/ smartphone use	−0.082	0.088	−0.015	[−0.255, 0.090]
Number of preventive education experiences about internet/ smartphone addiction	−0.077	0.061	−0.020	[−0.197, 0.042]
Number of cohabitants	0.434	0.126	0.054***	[0.186, 0.683]
Economic status	0.885	0.140	0.105***	[0.609, 1.161]
Academic achievement	0.714	0.113	0.111***	[0.490, 0.936]
Independent variable				
Adverse childhood experiences	1.278	0.0111	0.182***	[0.391, 3.626]
Model				
R^2	0.454			
adj R^2	0.206			
F-value	102.71(8,3164)			
P	0.00			

	Effects of adverse childhood experiences on internet gaming addiction severity				Effects of adverse childhood experiences and stress on internet gaming addiction severity			
	B	S.E.	*β*	95% C.I.	*B*	S.E.	*β*	95% C.I.
Control variable								
Constant	4.716	0.319		[4.08, 5.37]	4.559	0.314		[0.490, 0.936]
Age in years	−0.081	0.021	−0.073***	[−0.12, −0.04]	−0.143	0.021	−0.129***	[−0.184, 0.101]
Female	−1.593	0.088	−0.315***	[−1.78, −1.42]	−1.662	0.068	−0.329***	[−1.832, 1.492]
Parents' attitude toward internet/smartphone use	0.011	0.034	0.006***	[−0.06, 0.08]	0.017	0.033	0.008	[−0.048, 0.083]
Number of preventive education experiences about internet/smartphone addiction	−0.060	0.024	−0.042*	[−0.11, −0.02]	−0.054	0.023	−0.038*	[−0.100, −0.01]
Number of cohabitants	0.057	0.049	0.019	[−0.05, 0.17]	0.024	0.048	0.008	[−0.070, 0.119]
Economic status	0.231	0.054	0.074***	[0.12, 0.35]	0.159	0.053	0.051**	[0.054, 0.265]
Academic achievement	0.225	0.044	0.095***	[0.13, 0.31]	0.172	0.043	0.073**	[0.087, 0.258]
Independent variable								
Adverse childhood experiences	0.193	0.043	0.074***	[0.11, 0.31]	0.097	0.043	0.037*	[0.012, 0.182]
Mediator								
Stress scale score					0.075	0.006	0.203***	[0.061, 0.08]
Model								
R^2	0.357				0.398			
adj R^2	0.127				0.159			
F-value	58.017(8,3182)				66.45(9,3163)			
P	0.00				0.00			

Note: 1) B – unstandardized coefficients; 2) $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$; 3) S.E. – standard error; 4) C.I. 5) ACEs have a significant effect on stress ($B = 1.278$, $P < 0.001$), and stress has a significant effect on IGD ($B = 0.075$, $P < 0.001$). In addition, ACEs affect IGD ($B = 0.097$, $P < 0.05$). That is, stress showed a significant partial mediating effect.

Supplementary Table 2. Summary of the Mediating Effects by the Hierarchical Regression Analysis for high-IGD Risk Groups.

Stress scale score	Effects of adverse childhood experiences (ACEs) on stress			
	B	S.E.	*β*	95% C.I.
Control variable				
Constant	28.443	4.857	–	[18.854, 38.031]
Age in years	−0.249	0.296	−0.064	[−0.833, 0.033]
Female	2.126	1.155	0.135	[−0.153, 4.406]
Parents' attitude toward internet/ smartphone use	−0.951	0.402	−0.174*	[−1.746, −0.157]
Number of preventive education experiences about internet/ smartphone addiction	−0.807	0.314	−188*	[−1.427, −0.186]
Number of cohabitants	−0.183	0.611	−0.022	[−1.390, 1.023]
Economic status	0.677	0.615	0.079	[−0.538, 1.892]
Academic achievement	0.749	0.473	0.118	[−0.185, 1.684]
Independent variable				
Adverse childhood experiences	0.966	0.335	0.210**	[0.303, 1.629]
Model				
R^2			0.403	
adj R^2			0.162	
F-value			4.145(8,171)	
P			0.00	

I-GUESS score	Effects of adverse childhood experiences on internet gaming addiction severity				Effects of adverse childhood experiences and stress on internet gaming addiction severity			
	B	S.E.	*β*	95% C.I.	*B*	S.E.	*β*	95% C.I.
Control variable								
Constant	11.629	2.238	–	[7.78, 15.07]	11.442	2.464	–	[6.577, 16.308]
Age in years	−0.198	0.136	−0.113***	[−0.43, 0.08]	−0.199	0.137	−0.114	[−0.471, 0.071]
Female	−0.741	0.529	−0.104	[−1.74, 0.32]	−0.768	0.540	−0.107	[−1.834, 0.297]
Parents' attitude toward internet/smartphone use	0.502	0.184	0.204	[0.08, 0.95]	0.527	0.189	0.213**	[0.153, 0.900]
Number of preventive education experiences about internet/smartphone addiction	0.239	0.144	0.124**	[−0.05, 0.52]	0.259	0.148	0.133	[−0.033, 0.552]
Number of cohabitants	0.511	0.282	0.136	[−0.06, 1.05]	0.520	0.283	0.138	[−0.038, 1.079]
Economic status	−0.176	0.281	−0.046	[−0.76, 0.39]	−0.226	0.286	−0.058	[−0.791, 0.338]
Academic achievement	0.345	0.218	0.120	[−0.09, 0.84]	0.338	0.220	0.117	[−0.097, 0.774]
Independent variable								
Adverse childhood experiences	0.335	0.154	0.161*	[0.01, 0.81]	0.334	0.159	0.160*	[0.020, 0.648]
Mediator								
Stress scale score					0.009	0.035	0.021	[−0.060, 0.079]
Model								
R^2								
adj R^2			0.356				0.360	
F-value			0.127				0.130	
P			3.141(8,173)				2.820(9,170)	

Note: 1) B – unstandardized coefficients; 2) $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$; 3) S.E. – standard error; 4) C.I. 5) ACEs have a significant effect on stress ($B = 0.996$, $P < 0.01$), and stress has no significant effect on IGD ($B = 0.009$, $P = 0.788$). That is, stress does not have a significant mediating effect.