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ORIGINAL ARTICLE

Unpacking the Myth in the Associations Between Self-control and Gaming Disorder in Children and Adolescents: A Comparison Between Traditional and Random Intercept Cross-lagged Panel Model Analyses

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Abstract

Internet gaming is becoming increasingly popular; however, children and adolescents are highly vulnerable to gaming disorder due to the underdevelopment of cognitive control. Longitudinal research providing empirical evidence confirming the stability and direction of the association between self-control and gaming disorder is scarce. This study is aimed at clarifying whether prospective relationships exist between self-control and gaming disorder in children and adolescents or whether they are associated due to common causes. We examined the temporal dynamics of the associations between self-control and gaming disorder symptom severity using a traditional cross-lagged panel model (CLPM; aggregating between- and within-person variance) and a random intercept CLPM (RI-CLPM; disaggregating between- and within-person effects) with three-annual wave data from a large cohort of primary and secondary students ($N = 1359$, mean age 12.67 (SD 1.40), 834 (61.7%) girls). The traditional CLPM indicated a unidirectional negative relationship from self-control to later gaming disorder (B with 95% confidence interval [CI] = −0.12 [−0.19, −0.040]), whereas the RI-CLPM analysis revealed no prospective relationship between self-control and gaming disorder (95% CIs of Bs all contain 0), indicating that self-control was neither the cause nor the result of gaming disorder in children and adolescents. Our study revealed that the nature of the relationship between self-control and gaming disorder tends to be correlational but not causal. The potential common underlying factors for future research are discussed.

Keywords Self-control · Gaming disorder · Cross-lagged panel model · Random intercept cross-lagged panel model · Children and adolescents

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Online gaming has become increasingly popular in recent years. Excessive and uncontrolled gaming is gaining increasing attention worldwide. Internet gaming disorder (IGD) has been included in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) for further study (American Psychiatric Association, 2013). Similarly, in the International Classification of Diseases (ICD-11), gaming disorder (GD) is defined as maladaptive gaming behavioral patterns with impaired control over gaming and the continuation of excessive gaming despite the significant functional impairment and negative consequences as its featured characteristics (World Health Organization, 2018). A recent meta-analysis indicated that among different age groups, the highest prevalence of gaming disorder was in children and adolescents, reaching 6.6% (Kim et al., 2022). Underdevelopment of cognitive control makes children and adolescents highly vulnerable to gaming disorder (Sugaya et al., 2019).

Indeed, an individual's self-control ability has long been suggested to be critical in helping to avoid negative outcomes, such as problematic game use, and difficulty in self-control has been seen to increase the risk of developing gaming disorder (Seay & Kraut, 2007). When comparing problematic massive multiplayer online role-playing game players to non-problematic players, problematic players scored significantly lower in self-control (Collins et al., 2012). Furthermore, studies applying correlational and/or regression analysis methods have shown negative associations between self-control and maladaptive game use (Jeon et al., 2021; Kim et al., 2008), with impulse control problems being linked to the status of pathological gaming for children and adolescents (Choo et al., 2010). The negative associations between self-control and the severity of gaming disorder in young adults seem to be strong and robust to strict Bonferroni correction (Zhou et al., 2023). Moreover, some studies have revealed both the direct and indirect effects of self-control on gaming disorder via factors such as certain gaming motives and maladaptive gaming-related cognition (Cudo et al., 2022; Yu et al., 2021). In addition, when the relationships between other variables and gaming disorder were studied, self-control was always found to play a mediating role and be associated with gaming disorder/pathological gaming itself (Jeong et al., 2020; Mills & Allen, 2020). For example, self-control mediates the relationship between impulsivity and pathological gaming among children and adolescents (Liau et al., 2015). Impulsivity and self-control are regarded as the two core components of the dual-process model of decision-making in risky behaviors (Yu et al., 2021). Thus, the importance of the development of self-control resources has been highlighted, especially for prevention and intervention research on pathological gaming in children and adolescents (Liau et al., 2015).

Despite strong theoretical and phenomenal support for the association between self-control and IGD, inconsistencies exist. Review studies have acknowledged self-control as a personality trait associated with gaming disorder (Gervasi et al., 2017). In a meta-analysis (Ji et al., 2022) that identified 56 risk and 28 protective factors for gaming disorder and contained children, adolescents, and young adults as the main samples, self-control was found as the only protective factor strongly related to IGD. However, a previous study using multiple linear regression found that self-control did not exhibit significant relationships with pathological gaming in college students, but all other personality trait variables did (Mehroof & Griffiths, 2010). A recent study also found no differences between colleague students with IGD and recreational game users in impulsive and control systems, both at behavioral and neural levels during decision-making tasks (Zhou et al., 2022). These inconsistent results, likely due to methodological differences, underscore the need to examine the association between self-control and gaming disorder using more rigorous methodologies.

More importantly, existing studies examining their relationships have mostly adopted cross-sectional designs (Collins et al., 2012; Kim et al., 2008; Yu et al., 2021), which cannot inform us of how self-control relates to gaming disorder. It is unknown whether low self-control causes gaming disorder, whether gaming disorder causes impaired self-control, or whether they are just associated with common causes. In the few extant longitudinal studies, only the predictive effect of self-control on gaming disorder later has been revealed (Jeong et al., 2019, 2020; Qin & Gan, 2023; Xiang et al., 2022), with no investigation of how gaming disorder might influence individuals' future self-control levels. However, it is highly plausible that individuals with gaming disorder might experience frustration and distress when controlling their game use, which might further damage their ability to exert self-control resources. Indeed, accumulating evidence supports that IGD contributes to impaired response inhibition (Argyriou et al., 2017; Lim et al., 2016). Furthermore, it was found that after a 6-month treatment including pharmacotherapy, individuals with IGD showed improvements not only in IGD severity but also in response inhibition and executive functioning (Lim et al., 2016). Therefore, it is plausible that a bidirectional relationship might exist between self-control (inhibitory and executive control) and gaming disorder.

It is necessary to test the potential causal relationships between the two variables using multiple waves, longitudinal data, and appropriate analytical methods. Moreover, research that systematically addresses the longitudinal reciprocal relationships between self-control and gaming disorder during critical child and adolescent periods may yield significant practical implications. It is particularly meaningful to the development of more directed prevention and intervention strategies to preclude teenagers from gaming disorder and/or self-control deterioration, thus avoiding further deleterious developmental consequences. Thus, to fill this important research gap, this study is aimed at clarifying the temporal dynamics of the link between self-control and gaming disorder, using three-wave longitudinal data on children and adolescents. The research objective was to investigate the potential causal relationship between self-control and gaming disorder and the direction of this causality given its existence. To this end, cross-lagged analyses were used. Beyond the traditional cross-lagged panel model (CLPM), random intercept CLPM (RI-CLPM) analysis separated within-person and between-person effects (Mulder & Hamaker, 2021) in the association between self-control and gaming disorder. As such, this study might yield crucial implications for designing more effective and targeted interventions for gaming disorder by demonstrating whether changes in self-control cause corresponding changes in gaming disorder severity or vice versa within the same person.

Methods

Participants and Procedure

This was a school-based survey of primary and secondary school students in Hong Kong conducted annually in June 2020 (T1), 2021 (T2), and 2022 (T3). Ethics approval was obtained from the Human Subjects Ethics Subcommittee of the authors' university. At T1, the study invitation was sent to 4 primary and 13 secondary schools across the districts of Hong Kong. Students from grades four to six in primary school and seven to eight in secondary school were invited to participate. The invitation letter detailed our research objectives and the possible risks and benefits of participating in this study. Written consent was obtained from parents and respondents before the study. Students were assured that their participation was voluntary, that they could withdraw at any time, and that parents or teachers would not access their responses. The surveys were conducted in classrooms, and one or two research assistants provided guidance and solved queries. Participants could select either the Chinese or the English version of the questionnaire. Once completed, all questionnaires were sealed and returned to the laboratory. All the participants received stationery (worth approximately US$ 5) as compensation after completing each survey.

At T1, 4635 students and their parents from 4 primary schools and 13 secondary schools were approached, and we reached our targeted sample size and stopped recruitment after 2863 students filled in the survey (resulting in a response rate of 61.77%; for details, see Zhu et al., 2021). Among the 2863 students, 1448 were excluded because seven secondary schools ($N=1030$) and grades 5 and 6 ($N=418$) were not followed up at T2. We excluded those who reported not playing games at all three time points ($N=55$) as the non-targeted population. One participant was excluded because of invalid data. Thus, 1359 participants from four primary schools ($N=179$) and six secondary schools ($N=1180$) were included in our data analysis. Among the 1359 participants, 706 attended both T2 and T3 assessments, 61 attended T2 but not T3 assessment, 334 attended T3 but not T2 assessment, and 258 (18.98%) were lost to follow-up (Supplementary Fig. 1). The attrition rate was comparable to that of prior studies on similar topics (Beeres et al., 2021; Zhou et al., 2020). The demographic characteristics of the analyzed 1359 participants at T1 are shown in Table 1.

Measures

The measures used in this study are part of a larger-scale survey on children and adolescents' mental health and wellness. We did a pilot test on these measurements to ensure the understandability of the items and confirm the time needed to complete the survey. First, we consulted two social workers and two teachers in two primary schools about the appropriateness of the questionnaires for primary students. Then, we invited students in one class at each school to complete the survey and made sure students could complete the survey within 30 min.

Gaming disorder symptoms were measured using an adapted seven-item Game Addiction Scale (GAS; Khazaal et al., 2016; Lemmens et al., 2009). The GAS was conceptually in

Table 1 Baseline characteristics of participants ($N=1359$)

Variable	*M* (SD) or *N* (%)
Age ($N=1339$)	12.67 (1.40)
Sex ($N=1352$)	
Male	518 (38.3%)
Female	834 (61.7%)
Grade ($N=1359$)	
Grade 4 (primary)	179 (13.2%)
Grade 7 (secondary)	631 (46.4%)
Grade 8 (secondary)	549 (40.4%)
SES ($N=1278$)	
Low family affluence	42 (3.3%)
Medium family affluence	1104 (86.4%)
High family affluence	132 (10.3%)

M, mean; *SD*, standard deviation; *SES*, socioeconomic status line with the diagnostic criteria for IGD in the DSM-5 (Khazaal et al., 2016). We turned the seven items in question format in Khazaal et al. (2016) into "I" statements, based on school social workers' suggestions that "I" statements would be easier for children to relate to themselves, and children would also feel more comfortable responding to "I" statements (than "you" questions) continuously. A sample item is "I have thought all day long about playing a game." Using a 6-point Likert scale (1 = strongly disagree, 6 = strongly agree), respondents were asked to rate the extent to which they endorsed the statements of the seven disorder symptoms (see Supplementary Table 1 for the seven statements) if they indicated they played Internet games usually. A higher average score on the seven items indicates more severe gaming disorder symptoms. The reliability of the scale scores in our sample is Cronbach's alpha (α) = 0.87 (T1), 0.85 (T2), and 0.87 (T3), respectively, and the McDonald's omega (ω) = 0.87 (T1), 85 (T2), and 0.88 (T3), respectively.

Self-control was measured using nine items from the Brief Self-Control Scale (Tangney et al., 2004; Unger et al., 2016). The results of confirmatory factor analysis (CFA) for the Chinese version of Tangney's Self-Control Scale (Unger et al., 2016) showed that the 13 items included in the Brief Self-Control measure belonged to four factors (five items for Factor 1 of general capacity for self-discipline, two items for Factor 2 of deliberate/non-impulsive action, two items for Factor 3 of healthy habits, and four items for Factor 4 of work ethics). We maintained one item that showed the largest loading on Factor 1 to represent the general capacity for self-discipline and kept all eight items on other factors (see Supplementary Table 2 for the nine items, and Supplementary Table 3 for CFA results of the one-factor model of the nine items based on the T3 data of those passing attention checking (N = 759)). Respondents were also asked to rate the nine items (such as, "I am good at resisting temptation") on a 6-point Likert scale (1 = strongly disagree, 6 = strongly agree) to assess individual differences in self-control traits. After reverse scoring some items, a higher average score for the nine items indicated higher self-control ability. The reliability of the scale scores in our sample is α = 0.76 (T1), 0.82 (T2), and 0.80 (T3), respectively, and ω = 0.79 (T1), 83 (T2), and 0.81 (T3), respectively.

Sociodemographic information (e.g., sex, age, grade, and socioeconomic status (SES)) was collected from the respondents. SES was measured using an adapted version of the Family Affluence Scale (FAS; Currie et al., 1997). Four items were used to measure the family affluence level of the respondents: (1) if the family owns a private car (0: no; 1: yes); (2) the number of learning devices in the house (desktop computer, notebook computer, iPad or other tablets, smartphone, and e-book reader; 1: 1–2 pieces; 2: 3–5 pieces); (3) the number of household appliances (television, refrigerator, washing machine, microwave oven, air conditioner, dishwasher, and audio-visual equipment; 1: 1–3 pieces; 2: 4–7 pieces); and (4) satisfaction level towards the Internet connection at home (0: totally unsatisfied, partially unsatisfied or not sure; 1: basically satisfied or totally satisfied). Family affluence level corresponds to the sum of the four items (range 2–6), with a higher score indicating a higher family affluence level (Zhu et al., 2021). The SES levels of the respondents were classified as low (scoring 2 on the FAS), medium (scoring 3–5 on the FAS), and high (scoring 6 on the FAS).

Attention-checking questions We conducted a digital questionnaire survey in classrooms at T3. Three attention-checking items distributed throughout the questionnaire were used to help screen out those inattentive responses, such as "Please choose 'Disagree (2)' for this item" (Schroder et al., 2015). Students who filled in three items correctly were included in the analysis.

Statistical Analysis

The reliability of the scales used was tested using the R packages including psych (for Cronbach's alpha; Revelle, 2017) and MBESS (for McDonald's omega; Kelly, 2007). Descriptive statistics of sociodemographic variables at baseline and self-control (SC) and gaming disorder symptom severity at all three time points were calculated based on all available data. Repeated-measures ANOVA with post hoc analysis was conducted to describe changes in SC and GAS over time. Pearson correlation analyses were performed to generate correlations between SC and GAS at all time points using SPSS version 26 (IBM Corp.). Three-wave traditional CLPM and RI-CLPM analyses were conducted using the lavaan package in R (Rosseel, 2012).

For both the traditional CLPM and RI-CLPM analyses, structural equation modeling (SEM) with latent constructs was conducted, aiming to partial out measurement errors and simultaneously test all pathways of research interest (Kline, 2015), and maximum likelihood estimation was applied in the SEM. The following criteria were used to evaluate the model fit (Kline, 2015): comparative fit index (CFI; acceptable > 0.90, good > 0.95), root mean square error of approximation (RMSEA; acceptable < 0.08, good < 0.05), and standardized root mean square residual (SRMR; acceptable < 0.08, good < 0.05).

Because we added attention-checking questions in the T3 assessment to ensure data quality, those who did not answer all three attention-checking items correctly ($N = 281$) were regarded as failing attention-checking, their T3 data were treated as missing, and their T1 and T2 data were retained. Missing data were processed using full information maximum likelihood procedures (Acock, 2005). Sociodemographic variables of age, sex, and SES level (ranging from 2 to 6) were added as control variables in the traditional CLPM and RI-CLPM analyses.

Measurement invariance was first established for the traditional CLPM and RI-CLPM analyses (for detailed measurement invariance test results, see the Supplemental file). It turned out that the weak measurement invariance was upheld for both the traditional CLPM (see Supplementary Table 4) and the RI-CLPM analyses (see Supplementary Table 5). Then, traditional CLPM analysis with SC and GAS as latent variables across the three waves was conducted to examine the potential reciprocal relationships between SC and GAS by delineating the temporal directions of the relationships while controlling for autoregressive effects (Fig. 1). As an extension of the traditional CLPM, the RI-CLPM is advantageous for separating within-person effects from stable between-person differences in the association between variables over time by decomposing the variance

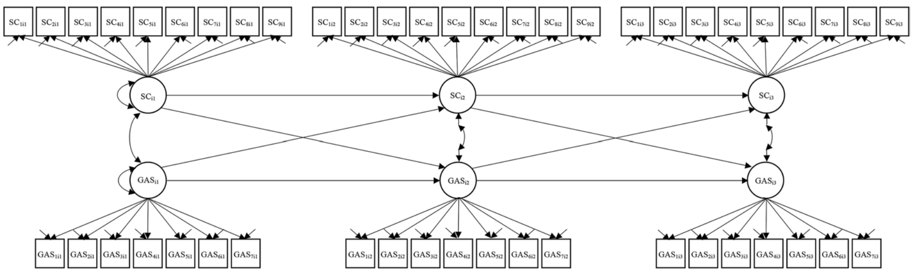

Fig. 1 Graphical representation of our three-wave traditional CLPM. SC, self-control; GAS, gaming addiction scale. SC and GAS are both latent constructs

into between- and within-person components across measurement occasions (Hamaker et al., 2015). As stable, trait-like differences between individuals are accounted for, lagged relations are restricted exclusively to within-person fluctuations (Mulder & Hamaker, 2021), that is, how fluctuations in one variable within an individual impact other variables across time can be explicated. However, the usual way RI-CLPM analyses are conducted using the sum or mean scores has pronounced disadvantages and could lead to bias in the lagged parameter estimates (Mulder & Hamaker, 2021). To construct the latent variables in the RI-CLPM, we followed the procedures proposed by Mulder and Hamaker (2021). In the RI-CLPM analyses, multiple indicators were included for each latent variable (SC and GAS), and the dynamics between the latent variables of SC and GAS over time were formulated. A random intercept was included for each indicator of the SC and GAS, and these random intercepts were free to associate with each other. Additionally, a common factor of multiple indicators was included for each occasion to capture the common within-person variability of the SC and GAS over time (Fig. 2). Thus, the longitudinal reciprocal relationships between self-control and the severity of gaming disorder symptoms were delineated more accurately.

Results

The mean GAS score of the respondents at T1, T2, and T3 was 2.93 (standard deviation, SD 1.09), 2.90 (SD 1.02), and 2.90 (SD 1.03), respectively, all below the midpoint of the scale (3.5). The repeated measures ANOVA with Greenhouse–Geisser correction determined that the mean GAS did not differ significantly between time points ($F(1.90, 1012.96) = 2.42$, $p = 0.092$). Post hoc analysis with Bonferroni correction revealed that the mean GAS did not differ significantly from T1 to T2, T2 to T3, or T1 to T3 (all p values > 0.10). The mean SC levels of the respondents at T1, T2, and T3 were 3.68 (SD 0.83), 3.51 (SD 0.85), and 3.39 (SD 0.78), respectively, around the midpoint of the scale (3.5). The repeated measures ANOVA with Greenhouse–Geisser correction

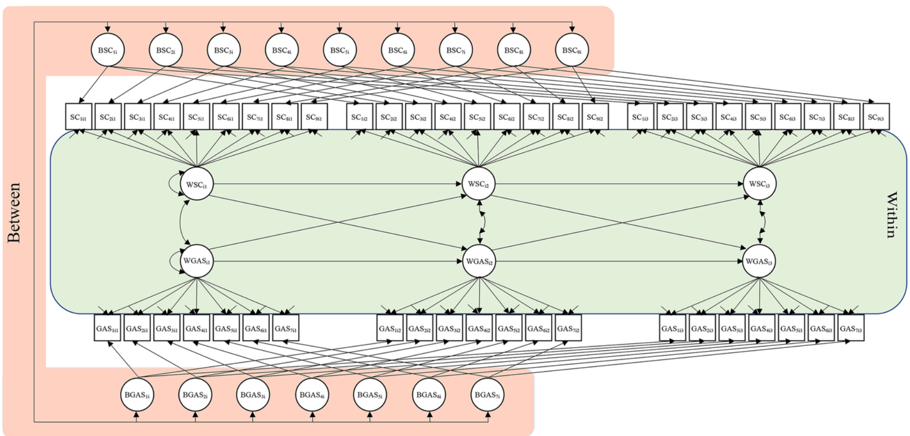

Fig. 2 Graphical representation of our three-wave RI-CLPM. SC, self-control; GAS, gaming addiction scale. SC and GAS are both latent constructs. In the RI-CLPM, the indicator-specific random intercepts capture trait-like differences between individuals (in red), and occasion-specific factors capture the within-individual dynamics (in green)

showed that the mean SC differed significantly between the three time points (F(1.95, 1351.81) = 50.26, $p < 0.001$). Post hoc analysis with Bonferroni correction indicated that the mean SC significantly decreased from T1 to T2 ($p < 0.001$), from T2 to T3 ($p = 0.002$), and from T1 to T3 ($p < 0.001$). Descriptive statistics and Pearson correlations between the SC and GAS across the three waves are shown in Table 2. All the correlations were significant in the expected direction. Higher self-control levels correlated with less severe gaming disorder symptoms at all time points.

The three-wave traditional CLPM for SC and GAS fit the data adequately, with $\chi^2(1160) = 2796.71$, $p < 0.001$; CFI = 0.91; RMSEA = 0.032, 90% CI = [0.031, 0.034]; and SRMR = 0.084. The traditional CLPM estimates are presented in Table 3. The results indicated that SC and GAS were significantly related at all three time points. All stability paths (from SC at T1 to SC at T2, SC at T2 to SC at T3, GAS at T1 to GAS at T2, and GAS at T2 to GAS at T3) were significant. The cross-lagged paths from SC to GAS at later time points (from SC at T1 to GAS at T2, and SC at T2 to GAS at T3) were significant. In contrast, the cross-lagged paths from GAS to SC at later time points (from GAS at T1 to SC at T2 and from GAS at T2 to SC at T3) were non-significant.

RI-CLPM analysis showed that the model also fit the data well: $\chi^2(1060) = 1994.98$, $p < 0.001$; CFI = 0.95; RMSEA = 0.025, 90% CI = [0.024, 0.027]; and SRMR = 0.041. The random intercepts of each indicator of SC and GAS were significantly associated (all p values < 0.05, see Supplementary Table 6), signifying that higher self-control was related to less severe gaming disorder symptoms at the between-person level. Regarding within-person effects, the concurrent associations between the SC and GAS at all three time points were non-significant at the within-person level. The autoregressive paths, except the one from GAS at T1 to GAS at T2, were all significant, showing that the level of SC within an individual was carried over from T1 to T2 and from T2 to T3 and that the severity of GAS also was carried over within an individual from T2 to T3. The cross-lagged paths between SC and GAS at the within-person level were all non-significant, indicating that the level of self-control was not a predictor of the severity of gaming disorder symptoms after 1 year and that the severity of gaming disorder symptoms was not a predictor of self-control 1 year later. The coefficients of the within-person effects in the RI-CLPM analysis are listed in Table 4.

Table 2 Descriptive statistics and zero-order correlations among self-control and gaming disorder symptoms across three waves

	M (SD)	SC T1	SC T2	SC T3	GAS T1	GAS T2	GAS T3
SC T1	3.68 (0.83)	-					
SC T2	3.51 (0.85)	0.57	-				
SC T3	3.39 (0.78)	0.49	0.64	-			
GAS T1	2.93 (1.09)	−0.50	−0.34	−0.24	-		
GAS T2	2.90 (1.02)	−0.38	−0.48	−0.38	0.52	-	
GAS T3	2.90 (1.03)	−0.30	−0.35	−0.43	0.45	0.62	-

SC, self-control (range 1–6; a higher value means higher self-control); *GAS*, gaming addiction scale (range 1–6; a higher value means more severe gaming disorder symptoms); *M*, mean; *SD*, standard deviation; *T1*, time 1; *T2*, time 2; *T3*, time 3. All correlations were significant at $p < 0.001$ level

Table 3 Summary of the traditional CLPM results

	Covariance/coefficient	p	Correlation/ standardized coefficient
Path between observed variables on each occasion[a]			
SC T1 and GAS T1	**−0.56 [−0.62, −0.51]**	**<0.001**	**−0.56**
SC T2 and GAS T2	**−0.54 [−0.64, −0.45]**	**<0.001**	**−0.54**
SC T3 and GAS T3	**−0.61 [−0.72, −0.50]**	**<0.001**	**−0.61**
Autoregressive paths[b]			
SC T1 to SC T2	**0.56 [0.49, 0.64]**	**<0.001**	**0.47**
SC T2 to SC T3	**0.56 [0.49, 0.64]**	**<0.001**	**0.54**
GAS T1 to GAS T2	**0.50 [0.42, 0.59]**	**<0.001**	**0.43**
GAS T2 to GAS T3	**0.50 [0.42, 0.59]**	**<0.001**	**0.48**
Cross-lagged paths[b]			
SC T1 to GAS T2	**−0.12 [−0.19, −0.040]**	**0.003**	**−0.10**
SC T2 to GAS T3	**−0.12 [−0.19, −0.040]**	**0.003**	**−0.11**
GAS T1 to SC T2	−0.059 [−0.13, 0.008]	0.082	−0.050
GAS T2 to SC T3	−0.059 [−0.13, 0.008]	0.082	−0.056

CLPM, cross-lagged panel model; *SC*, self-control; *GAS*, gaming addiction scale; *T1*, time 1; *T2*, time 2; *T3*, time 3. The traditional CLPM analysis was conducted by controlling for age, sex, and socioeconomic status (SES) level. Equality constraints were added to the unstandardized regression coefficients. 95% CIs [lower, upper] are given in brackets in the covariance/coefficient column. Bold values represent significance at $p < 0.05$

[a]The values represent the covariance/correlation coefficients

[b]The values represent the regression coefficients/standardized regression coefficients

Discussion

To our knowledge, this is the first attempt to elucidate the temporal dynamics of the association between gaming disorder and self-control. The results of the traditional CLPM, which aggregated between-person and within-person variances, indicated a unidirectional negative relationship from self-control to later gaming disorder. However, the RI-CLPM analysis, which disaggregated the between-person and within-person variances, revealed no prospective relationship between self-control and gaming disorder, indicating that self-control was neither the cause nor the result of gaming disorder in children and adolescents.

Notably, our findings highlight the importance of disaggregating between-person and within-person effects in estimating the link between self-control and gaming disorder to understand their potential causal relationships more accurately. In contrast to the traditional CLPM, the RI-CLPM separates the between-person variance (random intercepts) from the within-person variance (person-centered fluctuations from one's mean over time) in their association. By doing this, we learned how changes in self-control are associated with corresponding changes in gaming disorder symptom severity and vice versa within an individual (within-person effects) with controlling for between-person effects. The longitudinal associations between self-control and gaming disorder found in the traditional CLPM analyses diminished when the RI-CLPM analyses were applied. From a methodological perspective, this study corroborates the growing body of research underscoring the necessity

Table 4 Summary of the within-person effects of the RI-CLPM

	Covariance/coefficient	*p*	Correlation/ standardized coefficient
Path between within components on each occasion[a]			
SC T1 and GAS T1	−0.016 [−0.039, 0.007]	0.17	−0.52
SC T2 and GAS T2	−0.011 [−0.028, 0.005]	0.18	−0.47
SC T3 and GAS T3	−0.009 [−0.021, 0.004]	0.17	−0.46
Autoregressive paths[b]			
SC T1 to SC T2	**0.23 [0.034, 0.43]**	**0.022**	**0.25**
SC T2 to SC T3	**0.23 [0.036, 0.43]**	**0.020**	**0.27**
GAS T1 to GAS T2	0.13 [−0.12, 0.39]	0.30	0.15
GAS T2 to GAS T3	**0.40 [0.15, 0.64]**	**0.001**	**0.41**
Cross-lagged paths[b]			
SC T1 to GAS T2	−1.57 [−4.49, 1.36]	0.29	−0.16
SC T2 to GAS T3	0.72 [−1.65, 3.10]	0.55	0.071
GAS T1 to SC T2	0.001 [−0.015, 0.017]	0.92	0.010
GAS T2 to SC T3	−0.012 [−0.037, 0.013]	0.35	−0.15

RI-CLPM, random intercept cross-lagged panel model; *SC*, self-control; *GAS*, gaming addiction scale; *T1*, time 1; *T2*, time 2; *T3*, time 3. The RI-CLPM analysis was conducted by controlling for age, sex, and socio-economic status (SES) level. 95% CIs [lower, upper] are given in brackets in the covariance/coefficient column. Bold values represent significance at $p < 0.05$

[a]The values represent the covariance/correlation coefficients

[b]The values represent the regression coefficients/standardized regression coefficients

and importance of disaggregating between-person variance from within-person variance to clarify the reciprocal processes of experience and development (Berry & Willoughby, 2017; Cao et al., 2021).

Our findings from the RI-CLPM analyses revealed no causal effect of self-control on gaming disorder symptom severity, or vice versa, in the studied age group. Regarding between-person effects, the random intercepts of each indicator of self-control and gaming disorder symptom severity were significantly associated, suggesting that children and adolescents with lower self-control have more severe gaming disorder symptoms. This aligns with many extant findings in this field (Gervasi et al., 2017; Ji et al., 2022; Zhuang et al., 2023) and demonstrates a close relationship between the two constructs. In addition, the non-significant concurrent correlations found at the within-person level show that the previously observed concurrent associations between self-control and gaming disorder were entirely due to common causes induced by time-invariant between-person differences and/or unobserved heterogeneity.

There are some speculations about what may serve as the common underlying cause of low self-control and gaming disorder. First, personal characteristics, such as personality traits and genetics linked to these traits, may serve as common causes. For instance, those individuals with high impulsivity traits are likely to be more responsive to gaming cues and less able to inhibit their impulses against addictive behaviors, including Internet gaming (Yu et al., 2021). Thus, they are also the group of people who tend to exhibit low self-control and gaming disorder. Second, chronic intrapersonal and environmental factors may account for the currently identified stable between-person associations between self-control and gaming disorder. A previous study on self-determination theory found that basic needs frustration undermines self-control, increasing the gaming disorder severity (Mills & Allen, 2020). Adolescent inattention/hyperactivity problems have also been found to affect their self-control and lead to more severe gaming disorder (Jeong et al., 2020). Moreover, environmental factors, such as excessive interference from and lack of communication with parents, increase young adolescents' academic stress, damaging their self-control and accelerating their pathological gaming (Jeong et al., 2019). Although it was beyond the scope of the current study to identify the specific stable or chronic factors that might have been operative as common causes, future research is required to address this pressing issue.

Our findings have practical implications for future interventions. Some current intervention programs aim to enhance youths' self-control to reduce their behavioral problems (see reviews, Pandey et al., 2018; Zhuang et al., 2023). The non-existent within-person effects between self-control and gaming disorder suggest that interventions to improve self-control alone might not stop or prevent the development of gaming disorder among youths. Other common factors or comorbidities are worth noting. This implication has unique value, as previous studies have mainly centered on between-person correlations without separating between- and within-person effects. Although between-person correlations can provide insight into the associations between self-control and gaming disorder across individuals, they constitute little evidence of whether changes in self-control within a person might result in corresponding changes in gaming disorder development (Zhou et al., 2020).

The limitations of this study and future directions merit attention. First, we should be cautious in making a full causal inference because of the correlational nature of the data. However, the longitudinal design of this study and the cross-lagged analyses are valuable in informing us of the temporal dynamics of the associations between self-control and gaming disorder. Second, the measures were based on self-reported data and adapted scales, and the lack of objective evaluation and further validation of the adapted scales may have led to information bias and restriction on the generalizability of our research conclusions. Hence, future research should benefit from multiple-informant, multiple-method designs. More studies on this topic are also needed to consolidate the findings of our study. Moreover, this research field will benefit from more established and standard measures to facilitate comparisons between studies. Third, the data collection interval of one year might be a bit too long, as the RI-CLPM was suggested to better suit short-term studies which contained shorter time lags and induced fewer long-term changes in the studied variables (Lüdtke & Robitzsch, 2021; Takahashi et al., 2022). Fourth, our data were collected from a limited age range and region (Hong Kong), which might have restricted the generalizability of the findings. Future studies with more elaborate designs, such as an expanded span of targeted ages, more representative samples, and consideration of factors that might influence our findings, are warranted.

Conclusions

This study is aimed at clarifying the longitudinal reciprocal relationships between self-control and gaming disorder in children and adolescents using longitudinal data across two years. A unidirectional effect was found from self-control to gaming disorder with the traditional CLPM mixing the between-person and within-person effects. However, using the RI-CLPM, which disaggregates the between-person and within-person effects, we did not find a prospective relationship between self-control and gaming disorder. These findings suggest that there are common causes for low self-control and gaming disorder. Further research is needed to reveal the common underlying factors.

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Data Availability Data and material are available upon reasonable request.

Declarations

Ethics Approval Ethics approval was obtained from the Human Subjects Ethics Sub-Committee of the Hong Kong Polytechnic University (Ref: HSEARS20210414004-02). Parental and respondents' consent were both acquired before the study.

Informed Consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all participants and their parents for being included in the study.

Conflict of Interest The authors declare no competing interests.

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