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ORIGINAL RESEARCH

# Longitudinal Associations Between Sleep Disturbance Trajectories and Internet Gaming Disorder Mediated by Self-Control: A Six-Wave Longitudinal Investigation

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**Objective:** The present study aims to analyze the heterogeneous trajectories of sleep disturbance (SD) among college students and to examine whether self-control mediates the association between sleep disturbance trajectories and Internet gaming disorder (IGD).

**Methods:** A total of 4352 students were initially invited to participate, and 4191 ($M_{age}$ = 19.12, $SD$ = 0.98; 46.9% females) students were included as valid respondents at the first time-point. This study spanned six waves (from 2019 to 2022) with a six-month interval between each wave. Sleep disturbance was measured from Time 1 to Time 4, self-control was measured at Time 5, and Internet gaming disorder was measured at Time 6. Growth mixture modeling (GMM) was applied to identify latent classes of sleep disturbance over the four waves. Mediation analysis was conducted to examine the mediating role of self-control between sleep disturbance trajectories and IGD.

**Results:** The results of growth mixture modelling yielded a four-class solution for sleep disturbance: a stable-low group, an increasing group, a decreasing group, and a stable-high group. Additionally, the results of mediation models showed that increased sleep disturbance is associated with a higher likelihood of individuals becoming more addicted to Internet games due to decreased self-control. Conversely, improved sleep quality may decrease the likelihood of engaging in Internet games via by promoting higher levels of self-control.

**Conclusion:** Future prevention and intervention programs targeted at improving self-control may decrease the possibility of developing IGD.

**Keywords:** Internet gaming disorder, sleep disturbance trajectories, self-control, college students, longitudinal cohort

## Introduction

In recent years, the Internet has witnessed rapid growth alongside the widespread adoption of Internet devices. As a result, an increasing number of young adults have engaged in playing Internet games for entertainment, relaxation, or building new social bonds.[1,2] Internet games are electronic games played through computer networks, especially the Internet, which can be played solo or multiplayer, and on various digital devices that have internet access and game play capabilities. Although moderate play of Internet games might be harmless and even beneficial for improving gamers' mental health and cognitive functions,[3] excessive playing Internet games can lead to the development of Internet gaming disorders (IGD) due to its addictive nature.[4] As one of the most prevalent subtypes of Internet addiction, IGD is defined as the repetitive and excessive use of Internet gaming that contributes to clinically significant impairment or distress.[5] It consists of four main components: (1) excessive use, often related to a loss of sense of time or a neglect of basic drives, (2) withdrawal, including feelings of anger, tension, and/or depression, when the Internet gaming is inaccessible, and (3)



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tolerance that necessitates the need for more hours of use, and (4) negative repercussions, including arguments, lying, poor achievement, and fatigue. Compared to other age groups (eg, children and adolescents), college students are particularly vulnerable to engaging in video games due to ample spare time, limited parental supervision, and the need to cope with various stressors. Thus, it is not surprising that IGD is more common in college students.[6,7] Accumulating evidence has suggested that IGD can lead to various adverse outcomes, including depression or anxiety,[8] impaired executive function or cognitive control,[9] and poor academic performance.[10]

Internet gaming disorder can have a negative impact on gamers' sleep duration and/or deteriorating sleep quality.[10–12] A systematic review in 2021 reported an association between Internet gaming disorder and sleep problems.[13] This review found that Internet gaming disorder was linked to short sleep duration, poor sleep quality, and daytime sleepiness. In addition, the relationship between sleep problems and Internet addiction may be bidirectional. That is, sleep problems may contribute to excessive Internet use and subsequent addiction. According to the biopsychosocial and contextual model,[14] sleep is not solely the consequence of other factors, but has reciprocal relationships with biological, psycho-social, and contextual factors. Previous studies have shown that sleep disturbance (SD) is an important risk factor for developing IGD possibly due to the imbalance between the earlier maturation of brain reward function and the slow maturation of cognitive control.[15,16] To date, only three studies have examined the longitudinal relationship between sleep problems and addiction-related behaviors.[17–19] For example, in a four-wave longitudinal study of 1253 children and adolescents, researchers found a bidirectional dynamic relationship between sleep problems and Internet addiction.[18] Young people with sleep disturbance may resort to using the Internet during their insomnia periods, inadvertently disrupting their circadian rhythm. In addition, some researchers investigated the relationship between the trajectory of insomnia symptoms and addictive behavior, and found that adolescents in the insomnia group had a higher risk of developing IGD compared with the non-insomnia group even after adjusting for covariates.[19]

Despite accumulating evidence establishing the relationship between sleep problems and IGD, there are several limitations in the literature. First, most extant research has examined the directional path from IGD to sleep problems, with limited evidence regarding whether sleep problems affect IGD. Second, most previous studies have relied on cross-sectional or short-term longitudinal designs, which provide limited insight into the long-term dynamic relationship between these variables. Finally, a very limited number of studies explored the potential mechanisms through which sleep problems lead to addiction-related behaviors.

External stressors typically contribute to negative outcomes indirectly through individual internal factors. Therefore, self-control may be an important potential mechanism linking sleep disturbance to IGD. Self-control is defined as the ability that regulate one's behaviors, emotions, and thoughts to avoid impulsive actions and indulgence in pleasure.[20] According to the strength model of self-control,[21] self-control is a limited resource that individuals expend to regulate thoughts, feelings, and actions. This model likens self-control resources to muscles, which can become fatigued after sustained exertion. Similarly, individuals experiencing sleep disturbance may exhaust their self-control resources more quickly, leading to a decline in self-control. Previous neuroimaging studies have provided evidence to suggest that sleep disturbance can have detrimental effects on prefrontal cortical function, potentially compromising an individual's self-control abilities.[22,23] Additionally, sleep health can promote the restoration of positive emotions,[24,25] which in turn enables people to more effectively control their behaviors and affect.[26]

Furthermore, higher levels of self-control might decrease the likelihood of developing addictive behaviors, such as IGD. In a recent meta-analysis, researchers thoroughly reviewed various protective factors against IGD and identified self-control as the strongest protective factor ($r$=−0.31).[27] According to the Interaction of Person-Affect-Cognition-Execution (I-PACE) model for addictive behaviors,[28] the development of addictive behaviors involves heightened sensitivity to cues related to gaming and diminished self-control. As individuals become more accustomed to playing Internet games, their self-control decreases, leading to a higher risk of developing addiction to Internet games. Moreover, the cognitive-behavior model of Internet gaming disorder also postulated that as self-control decreases, individuals find it increasingly challenging to inhibit their craving for gaming, making them more inclined to engage in Internet games.[29,30] Overall, increased sleep disturbance is associated with a higher likelihood of individuals becoming more addicted to Internet games due to decreased self-control. Conversely, improved sleep quality may decrease the likelihood of engage in Internet games via by promoting higher levels of self-control.

Using a six-wave prospective design, we aimed to explore the longitudinal predictive effects of sleep disturbance trajectories on IGD and to examine whether self-control mediates these relationships. Based on previous findings,[31] we hypothesized that distinct patterns of sleep disturbance might be identified, including a stable-low group, an increasing group, a decreasing group, and a stable-high group. Based on the literature, two hypotheses were examined:

**Hypothesis 1**. Self-control at $T_5$ mediated the association between increasing group of sleep disturbance and IGD at $T_6$ (Reference group: stable-low group of SD).

**Hypothesis 2**. Self-control at $T_5$ mediated the association between decreasing group of sleep disturbance and IGD at $T_6$ (Reference group: stable-high group of SD).

# Materials and Methods

## Participants and Procedures

Data in this study were drawn from an ongoing longitudinal study of health-related behaviors of college students. Participants were recruited from first-year students at two technical universities and one comprehensive university in Guangdong, China. Participants were invited to complete an online survey at each of the six time-points. The interval between waves was six months except for the second and the third wave (12 months). The 12-month interval between the second and the third wave was due to the outbreak of the COVID-19 pandemic, as all students were unable to return to school during that time. Detailed sampling and data collection have been described in previous studies.[32,33] In brief, a total of 4352 students were initially invited to participate, and 4191 students were included as valid respondents at the first time-point ($T_1$). Of the $T_1$ participants, 3985 (4.9% attrition rate), 3905 (6.8% attrition rate), 3892 (7.1% attrition rate), 3957 (5.6% attrition rate) and 3068 (26.8% attrition rate) provided valid responses from $T_2$ to $T_6$, respectively. The high attrition rate at $T_6$ was due to some students being away for internships and not present on campus during the evaluation. To facilitate subsequent trajectory analysis, only participants who completed at least two waves of data collection were included in the present study (n = 3861).

Before conducting the survey, we obtained permission from the principals of these universities. Additionally, we obtained electronic informed consent from all participants, and all procedures were approved by the Research Ethics Committee of the corresponding author's institution. For those students who under 18, parents' informed content was also obtained before data collection. To ensure the validity of the survey, the students were instructed to read the instructions carefully before answering the questionnaire. Each survey lasted for approximately 30 min, and students were told that they could withdraw from the study at any time without repercussions.

# Questionnaire Measures

This study was part of a large-scale health-related cohort, which aimed to examine the relationships between sleep problems and various healthy behaviors (eg, mental disease, suicide, aggressive behavior, substance abuse, obesity) among Chinese college students. In the early stage of the survey (from $T_1$ to $T_4$), we paid more attention to some indicators related to sleep and mental health. As the survey progressed ($T_5$ and $T_6$), we found that college students' online game addiction was also more serious. Therefore, in the later stage of the survey, we added some variables related to online game addiction.

## Sleep Disturbance at $T_1$, $T_2$, $T_3$, and $T_4$

Four items from the Youth Self-Rating Insomnia Scale (YSIS) were used to assess sleep disturbance: difficulty initiating sleep (DIS, "During the past month, how often have you had trouble sleeping because you cannot get to sleep within 30 min at night"), difficulty maintaining sleep (DMS, "During the past month, how often have you had trouble sleeping because you wake up frequently during the night"), early morning awakening (EMA, "During the past month, how often have you had trouble sleeping because you wake up very early and could not get back to sleep"), and poor sleep quality (PSQ, "*During the past month, how would you rate your sleep quality overall*").[34] The first three items were responded on a five-point scale from 1 = never, 2 = rarely (<1 time/week), 3 = sometimes (1–2 time/week), 4 = often (3–5 time/

week), to 5 = almost every day (6–7 time/week). The last item was responded on a 5-point response scale from 1 = very good, 2 = good, 3 = fair, 4 = poor, to 5 = very poor. The total score of sleep disturbance ranges from 4 to 20, with higher scores reflecting higher levels of sleep disturbance. These four items have been widely used in prior studies and have demonstrated good psychometric properties in Chinese adolescents and young adults.[35,36] In this study, the Cronbach's alphas of the scale were 0.72, 0.70, 0.74, and 0.75 for $T_1$ to $T_4$, respectively.

### Self-Control at $T_5$

The Brief Self-Control Scale (BSCS) was used to assess the general self-control, which is a short version of the original 36-item Self-control Scale (SCS).[37] BSCS included 13 items (eg, "People would say that I have iron self-discipline") and all items were responded on a 5-point Likert scale from 1 = not at all like me to 5 = very much like me. After recoding the reversed items, all items were summed to get a total score ranging from 13 to 65, with a higher score indicating a stronger self-control ability. High reliability and factorial validity of the BSCS have been reported in previous studies.[38,39] In this study, the Cronbach's alpha was 0.82 at $T_5$.

### Internet Gaming Disorder at $T_6$

The Chinese version of the Internet Gaming Disorder Scale-Short Form (IGDS9-SF) was used to measure the severity of Internet gaming disorder.[40,41] This scale comprises nine items that corresponded to the nine core criteria described in the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5). Items were rated on a 5-point Likert-type scale ranging from 1 (never true) to 5 (very often true). The total scores (ranging from 9 to 45) were calculated, and higher scores reflected a greater severity of Internet gaming disorder. A cutoff score of 21 has been recommended for identifying probable addictive behaviors.[42] Prior studies have shown support for its reliability and validity with the Chinese population.[41,43] In this study, the Cronbach's α was 0.92 at $T_6$.

### Demographic Variables at $T_1$

The participants' age, biological sex (0 = female, 1 = male), and parental education levels (0 = junior high school, 1 = senior high school, 2 = college or above) were considered covariates in subsequent analyses because previous studies have shown that these covariates were significantly associated with Internet gaming disorder.[44,45]

## Data Analysis

The data analysis involved four steps. First, descriptive analyses and Pearson correlation analyses were conducted on the main variables. Second, in order to determine the degree of consistency of measurement across different time periods, we used confirmatory factor analysis (CFA) to evaluate the longitudinal measurement invariance for sleep disturbance across the four measurements. Configural, metric, scalar, and error variance invariance were assessed, respectively. Differences in CFI that did not exceed a threshold of 0.01 ($\Delta$CFI < 0.01) and changes in the RMSEA that did not exceed a threshold of 0.015 ($\Delta$RMSEA < 0.015) were considered indicative of invariant measurements.[46] Third, growth mixture modeling (GMM) was applied to identify latent classes of sleep disturbance over the four waves. Full information maximum likelihood estimation (FIML) was conducted to handle missing values.[47] Unconditional models with one- to five-class were tested for sleep disturbance. Intercepts, linear slope, and quadratic slope were estimated for each latent class.[48] Decisions on the optimal solution of growth trajectories were based on theoretical interpretations and statistical considerations, including lower information criteria fit indices (AIC, BIC, SSBIC), higher entropy values (>0.80), likelihood ratio tests (LRTs; $p < 0.05$ implies c classes fit better than c-1 classes), and the proportion of participants in each class (at least 5%). Finally, after determining the optimal number of classes of sleep disturbance, two separate mediation models were examined to explore the mediating role of self-control at $T_5$ between sleep disturbance trajectories and Internet gaming disorder at $T_6$. In model 1, we used stable-low group of sleep disturbance as the reference group, and examined the mediating role of self-control between increasing group of sleep disturbance and Internet gaming disorder (see Figure 1a). In model 2, we used the stable-high group of sleep disturbance as the reference group, and examined the mediating role of self-control between the decreasing group of sleep disturbance and Internet gaming disorder (see Figure 1b). Mediation analysis was conducted in SPSS using Hayes's PROCESS macro with Model

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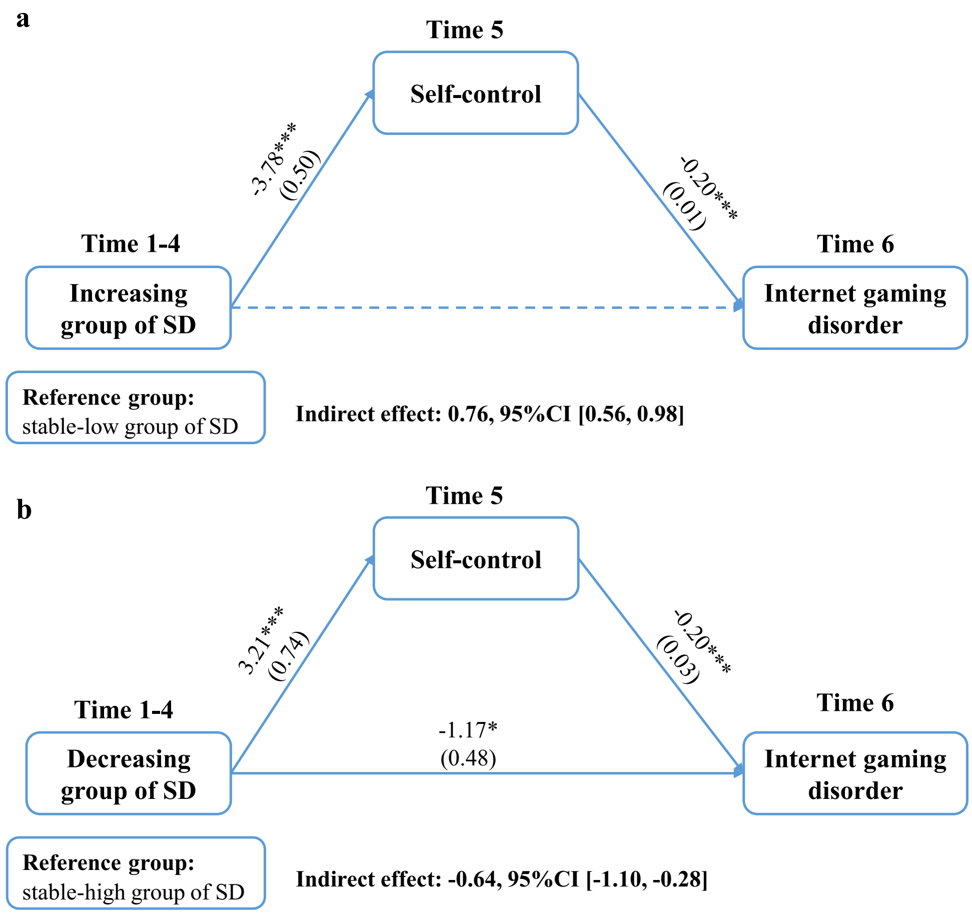


**Figure 1** Path analysis of the association between sleep disorder trajectories and Internet gaming disorder at $T_6$ through self-control at $T_5$. * $p < 0.05$; *** $p < 0.001$. (**a**): The reference group was stable-low group of SD. (**b**): The reference group was stable-high group of SD.

4, and a bootstrapping approach with 5000 bootstrap samples was used to estimate the 95% confidence intervals (CIs) for the (relative) indirect effects. A significant relative effect was established when the 95% bias-corrected CIs based on 5000 bootstrap samples did not contain 0. Unstandardized regression coefficients for all effects were reported. All analyses in this study were performed using SPSS 25.0 and Mplus 8.3.

# Results

## Sample Characteristics

Of the 3861 participants, 46.9% were females, and the average age at first wave was 19.12 years (range 17 to 28, SD = 0.98). About 41.5% of their fathers and 30% of their mothers had a senior high school or college degree. The overall prevalence of IGD was 4.14%, and males reported a higher prevalence of IGD than females (5.13% vs 3.33%; $\chi^2 = 6.2$, df = 1, $p = 0.013$). Table 1 provided correlations among the main variables. Sleep disturbance at each timepoint was negatively correlated with self-control at $T_5$ and positively correlated with Internet gaming disorder at $T_6$. Self-control at $T_5$ was negatively correlated with IGD at $T_6$.

## Longitudinal Measurement Invariance of Sleep Disturbance

Table 2 presented the longitudinal measurement invariance of sleep disturbance. The results showed that all measures demonstrated error variance invariance, suggesting that observed changes in sleep disturbance over time were meaningful rather than reflecting measurement artifacts.

**Table 1** Descriptive Statistics and Correlations for the Observed Variables (N = 3861)

| Variables | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. SD $T_1$ | 1.00 | | | | | |
| 2. SD $T_2$ | 0.57 | 1.00 | | | | |
| 3. SD $T_3$ | 0.50 | 0.56 | 1.00 | | | |
| 4. SD $T_4$ | 0.46 | 0.53 | 0.66 | 1.00 | | |
| 5. SC $T_5$ | −0.17 | −0.19 | −0.27 | −0.29 | 1.00 | |
| 6. IGD $T_6$ | 0.08 | 0.09 | 0.14 | 0.16 | −0.34 | 1.00 |
| M | 7.59 | 7.83 | 7.78 | 7.64 | 43.49 | 11.29 |
| SD | 2.76 | 2.70 | 2.90 | 2.83 | 7.49 | 4.24 |

**Note**: All correlation coefficients are significant, $p < 0.001$ (two-tailed).
**Abbreviations**: SD, sleep disturbance; SC, self-control; IGD, Internet gaming disorder; T, Time.

**Table 2** Model Fit Statistics for Longitudinal Measurement Invariance

| Variables | Model Tested | CFI | TLI | RMSEA | SRMR | ∆CFI | ∆RMSEA | ∆SRMR |
|---|---|---|---|---|---|---|---|---|
| Sleep Disturbance | Configural Invariance | 0.969 | 0.949 | 0.049 | 0.031 | | | |
| | Metric Invariance | 0.964 | 0.949 | 0.049 | 0.036 | 0.005 | 0 | 0.005 |
| | Scalar Invariance | 0.951 | 0.937 | 0.054 | 0.036 | 0.013 | 0.005 | 0 |
| | **Error Variance Invariance** | **0.946** | **0.938** | **0.054** | **0.045** | **0.005** | **0** | **0.009** |

**Note**: Bold type indicates established model of measurement invariance.

## Identification of Sleep Disturbance Trajectories

In Table 3, the model selection criteria were applied to decide the optimal number of classes of sleep disturbance. The AIC, BIC and SSBIC all decreased from one- to five-class solutions, which indicated improved model fit compared with the base model. The non-significant LRT statistics produced by the five-class model supported rejecting the hypothesis of a five-class trajectory. Additionally, the 4-class model showed a higher entropy value (0.81) than the 3-class model (0.76). Therefore, considering the higher entropy and theoretical meaningfulness of group membership, we decided the 4-class model as the optimal class.

The final model included four trajectory groups. Specifically, the first group (n = 3004, 77.80%), named the "stable-low group of SD" (intercept = 6.70, $p < 0.001$; linear = 0.34, $p < 0.001$; quadratic = −0.09, $p < 0.001$), participants reported low levels of sleep disturbance across four waves. The second group (n = 297, 7.70%), named the "increasing group of SD" (intercept = 7.61, $p < 0.001$; linear = 1.61, $p = 0.027$; quadratic = −0.12, $p = 0.554$), with an initial low level of sleep disturbance and then gradually increasing over time. The third group (n = 175, 4.50%), named the "decreasing group of SD" (intercept = 12.88, $p < 0.001$; linear = −3.70, $p < 0.001$; quadratic = 0.59, $p < 0.001$), which was characterized by a gradual decrease in the level of sleep disturbance over time. The fourth group (n = 385, 10.0%),

**Table 3** Model Fit Statistics for Growth Mixture Models

| Classes | AIC | BIC | SSBIC | Entropy | LRT *p* value | BLRT *p* value | Smallest Group |
|---|---|---|---|---|---|---|---|
| 1-class | 67559.825 | 67,622.412 | 67,590.636 | NA | NA | NA | NA |
| 2-class | 67082.388 | 67,170.009 | 67,125.524 | 0.83 | 0.519 | < 0.001 | 11.5% |
| 3-class | 66781.853 | 66,894.509 | 66,837.313 | 0.79 | 0.015 | < 0.001 | 8.9% |
| **4-class** | **66542.329** | **66,680.020** | **66,610.114** | **0.81** | **0.034** | **< 0.001** | **4.5%** |
| 5-class | 66406.205 | 66,568.931 | 66,486.315 | 0.80 | 0.184 | < 0.001 | 2.2% |

**Note**: Bold indicates final class solution.
**Abbreviations**: AIC, akaike information criterion; BIC, bayesian information criterion; SSBIC, sample size adjusted Bayesian information criterion; LRT, likelihood ratio test; BLRT, bootstrap likelihood ratio test.


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**Table 4** Association Between Sleep Disturbance Trajectories and Internet Gaming Disorder Mediated by Self-Control

| Path | Estimate | S.E. | Est./S.E. | *P*-value | 95% CI | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Sleep disorder trajectories (Ref: Stable-low group) | | | | | | |
| Increasing group of SD | | | | | | |
| Total effect | 1.240 | 0.282 | 4.397 | < 0.001 | 0.688 | 1.793 |
| Direct effect | 0.476 | 0.266 | 1.789 | 0.074 | −0.046 | 0.998 |
| Indirect effect | 0.764 | 0.108 | 7.074 | < 0.001 | 0.557 | 0.983 |
| Sleep disorder trajectories (Ref: Stable-low group) | | | | | | |
| Decreasing group of SD | | | | | | |
| Total effect | −1.812 | 0.490 | −3.698 | < 0.001 | −2.775 | −0.849 |
| Direct effect | −1.173 | 0.478 | −2.454 | 0.014 | −2.112 | −0.235 |
| Indirect effect | −0.639 | 0.220 | −2.905 | < 0.001 | −1.105 | −0.277 |

**Note**: Estimate, unstandardized coefficient.
**Abbreviations**: S.E., standard error; Est./S.E., ratio of unstandardized coefficient to standard error; CI, the confidence interval for the unstandardized coefficient.

named the "stable-high group of SD" (intercept = 11.60, $p < 0.001$; linear = 0.48, $p = 0.466$; quadratic = −0.17, $p$ = 0.280), in which individuals reported a high level of sleep disturbance across four waves.

## Mediation Effect of Self-Control

Table 4 and Figure 1a illustrated a significant mediating effect of self-control at $T_5$ on the association between increasing group of SD and IGD at $T_6$ (Reference group: stable-low group of SD). Specifically, compared to the stable-low group of SD, individuals in the increasing group of SD showed lower levels of self-control at $T_5$ ($b = -3.78$, SE = 0.50, $P < 0.001$), and self-control at $T_5$ in turn negatively predicted IGD at $T_6$ ($b = -0.20$, SE = 0.01, $P < 0.001$). Furthermore, bootstrapping analyses indicated that self-control had a significant indirect effect (indirect effect = 0.76, SE = 0.11, 95% CI = [0.56, 0.98]). Table 4 and Figure 1b illustrated a significant mediating effect of self-control at $T_5$ on the association between decreasing group of SD and IGD at $T_6$ (Reference group: stable-high group of SD). Specifically, compared to the stable-high group of SD, individuals in the decreasing group of SD showed higher levels of self-control at $T_5$ ($b$ = 3.21, SE = 0.74, $P < 0.001$), and self-control at $T_5$ in turn negatively predicted IGD at $T_6$ ($b = -0.20$, SE = 0.03, $P < 0.001$). Furthermore, bootstrapping analyses indicated that self-control had a significant indirect effect (indirect effect = −0.64, SE = 0.22, 95% CI = [−1.10, −0.28]).

# Discussion

The present study was used to identify distinct change patterns of sleep disturbance and to examine the mediating role of self-control in the longitudinal association between sleep disturbance trajectories and IGD among Chinese college students. As we expected, college students were classified into four sleep disturbance groups, including a stable-low group, an increasing group, a decreasing group, and a stable-high group. In addition, our mediation analyses supported the hypothesis that self-control mediate the effects of sleep disturbance trajectories on IGD in college students.

## The Prevalence and Gender Differences of IGD

This study found that the overall prevalence of IGD was 4.14% among Chinese college students. Based on DSM-5 criteria, the prevalence for IGD has varied from 1.16% to 5.9% depending upon the sample characteristics and recruitment methods employed.[49] In terms of gender differences, the findings showed that males had significantly higher rates of IGD compared to females, which is consistent with previous studies.[6,50,51] The possible reasons for the higher

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rates of IGD in males are multifactorial. Firstly, the popular styles of online games are mainly role-playing, shooting, multiplayer battles, and action gaming, which are more appealing to males than females.[52] Secondly, males are more likely to engage in Internet gaming as a means to achieve a sense of accomplishment or to build new social bonds.[53,54] Finally, neuroimaging studies have provided evidence that gaming-related cues can elicit stronger desires and activate reward-related brain regions to a greater extent in males.[55]

## The Mediating Role of Self-Control

Consistent with the research hypothesis, we found that self-control mediated the longitudinal relationships between sleep disturbance trajectories and IGD. Specifically, compared to the stable-low group of sleep disturbance, individuals in the increasing group of sleep disturbance had a lower level of self-control, which in turn increased the risk of developing IGD. Conversely, compared to the stable-high group of sleep disturbance, individuals in the decreasing group of sleep disturbance demonstrated higher levels of self-control, which decreased the risk of IGD. These findings extended the literature that has identified self-control as a mediator between sleep problems and addictive behaviors (or other psychological maladjustment).[22,56,57] For example, in a cross-sectional study, researchers found that low self-control and high impulsivity are mediating mechanisms in the association between sleep problems and problematic mobile phone use.[56]

On the one hand, improvements or worsening of sleep disturbances are associated with corresponding changes in individuals' self-control. The strength model of self-control have proposed that self-control is a limited resource that is used when engaging in behaviors or tasks that require overriding or inhibiting a response.[21,58,59] When self-control capacity becomes depleted, exerting self-control becomes increasingly challenging, resulting in poorer performance on subsequent tasks and behaviors. Extending from this model, Barber and his colleagues pointed out that sleep plays a role in replenishing self-control resources, whereas sleep disturbance would contribute to deficits in limited self-control.[58] This viewpoint has also been confirmed by some empirical research.[22,60] In a systematic review and meta-analysis, researchers also revealed a positive association between good sleep quality and self-control both between- ($r$ = 0.26) and within-individual levels ($r$ = 0.35).[23]

On the other hand, the finding that low self-control is positively related to IGD is consistent with current theoretical perspectives and empirical evidence,[61–63] which highlight the association between problem behaviors and low self-control. The cognitive-behavior model of Internet gaming disorder emphasizes self-control is a key factor in understanding the pathophysiology and treatment of addictive behaviors.[30] Individuals with poor self-control tend to gravitate towards behaviors that offer immediate rewards and pursue short-term goals,[61] such as excessive gaming on the Internet. However, individuals with stronger self-control are better equipped to monitor their behaviors and engage in activities aligned with long-term goals,[64] which helps prevent the development of Internet game addiction. Similarly, the I-PACE model for addictive behaviors also suggests that reduced executive function/inhibitory control is a central mechanism by which core personal characteristics influence specific Internet-use disorders.[28] Overall, self-control may be a potential mediating mechanism linking sleep disturbance and IGD.

## Clinical Implications

The present study has several significant clinical implications for theory, practice, and policy. First, using a person-centered approach, this study explored the association between sleep disturbance trajectories and IGD, and revealed the mediating role of self-control, thereby extending previous studies on the links between sleep problems and addictive behaviors. Secondly, from a practical perspective, future research should evaluate the impact of targeting self-control in prevention/intervention for IGD. Self-control was considered a construct that encompasses various subconstructs,[65] and interventions can be effectively implemented on specific cognitive factors related to self-control, such as attention control and a future-oriented perspective. For example, in a randomized control study, researchers examined the effectiveness of emotional working memory training (e-WMT) in addressing problematic Internet use and found that significant improvements in executive functions among participants who received e-WMT compared to the placebo group.[66] In addition, results from the meta-analysis have indicated that inhibitory control training is an effective technique for enhancing an individual's ability to overrule impulsive reactions.[67]

Finally, from a policy perspective, increasing evidence has shown that delayed school start time (from 8:00 to 8:30 AM) could help improve sleep health, academic performance, and mental health.[68] Therefore, policymakers may need to realize the crucial role of sufficient sleep for students, as it can help improve their self-control and reduce addictive behaviors.

### Strengths, Limitations, and Future Research

The current study had several important strengths, including a large sample size, a prospective design with long-term follow-up, and a novel statistical technique.

Despite these strengths, there were some limitations that should be addressed. First, self-report questionnaires were used to assess all study variables, which may lead to reporting bias. The combination of multi-method assessments should be considered in the future to provide more comprehensive insights. For example, future research may include objective sleep measurement (eg, actigraphy), allowing the assessment of typical sleep habits over a long period of time and also considering the use of ecological momentary assessment to assess internet gaming activities, so as to obtain real-time data and direct interaction with same day sleep. Second, we did not collect data on self-control and IGD in the first four waves. Cross-lagged panel models (CLPM) could be used in the future research to explore the interrelationships between these variables. Third, sleep disturbances were assessed by four items. Well-structured questionnaires should be used in the future work. Fourth, although the study had a large sample size, the participants are mainly college students, which may limit the generalizability of these findings to different populations and contexts. These findings should be replicated in more diverse samples.

## Conclusion

To summarize, this study demonstrated distinct trajectories of sleep disturbance in college students. We also found that self-control played a mediating role in the associations between sleep disturbance trajectories and IGD. These results have important implications for intervention and prevention efforts targeting college students. Implementing school-based sleep health interventions and self-control improvement programs can be effective in reducing the risk of IGD among university students.

## Data Sharing Statement

The data are not publicly available due to privacy and research ethical restrictions.

## Statement of Ethics

This study complies with the Declaration of Helsinki. The present study protocol was reviewed and approved by the Research Ethics Committee of Hebei University.

## Informed Consent Statement

All participants provided written informed consent prior to their study enrolment.

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## Disclosure

The authors declare no conflicts of interest in this work.

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