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Internet gaming disorder and cognitive failures in daily life among university students: the mediating role of sleep quality and the moderating role of mindfulness

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Abstract
Internet gaming disorder (IGD) refers to sustained, uncontrolled online gaming behavior associated with negative consequences. Previous research has revealed that IGD was a risk factor for daily impaired cognitive outcomes. However, the potential underlying mechanisms are not clear. The present study aimed to examine the mediating role of sleep quality and the moderating role of mindfulness in the link between IGD and daily cognitive failures. Data are from 851 university students using self-reported questionnaires. The results indicated that IGD positively predicted daily cognitive failures and sleep quality partially mediated this association. Furthermore, mindfulness did not regulate the direct pathway between IGD and daily cognitive failures. It moderated the mediating effect of sleep quality, specifically, low mindfulness amplified the positive effect of IGD on daily cognitive failures through sleep quality. This study contributes to a better understanding of the negative influence of IGD on cognitive ability and facilitates the development of targeted prevention strategies aimed at reducing sleep problems and cognitive deficits in daily life for university students with IGD.

Keywords Internet gaming disorder · Daily cognitive failures · Sleep quality · Mindfulness · University students

Introduction

Internet gaming is a ubiquitous recreational activity. Evidence suggests that there are more than 3.7 billion internet gamers across the globe (Intelligence, 2023). However, the excessive use of Internet games may lead to addictive behavior when individuals feel a loss of control, and eventually result in internet gaming disorder (IGD). IGD is defined as persistent and recurrent use of internet games despite negative consequences (e.g. impairment in physical, psychological, and social functioning; American Psychiatric Association, APA, 2013). The APA and the World Health Organization (2019) identified IGD as a tentative disorder or a novel behavioral addiction. Recent meta-analyses have reported that the global prevalence of IGD has reached 3% (Kim et al., 2022; Stevens et al., 2020).

In this context, concerns about the negative consequences of IGD are increasingly prominent, especially in relation to cognition (Jang et al., 2021). A number of studies have found that IGD can lead to a range of cognitive deficits, including impaired inhibitory control (Kraplin et al., 2020), disadvantageous decision-making behavior (Yao et al., 2022), and weakened impulse control (Wang et al., 2017). These cognitive deficits have been observed not only in experimental settings but also extend to daily life, such as forgetting a commitment to someone due to gaming. Recent evidence suggests that daily cognitive functioning by individuals' self-reported data could improve the ecological validity of research into human cognition (Carrigan & Barkus, 2016). Previous research has demonstrated a positive correlation between smartphone addiction, internet addiction, and daily cognitive failures among high school students (Hong et

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al., 2020; Jiang et al., 2022). Internet gaming disorder, as another form of technology addiction may easily engender immersion and disconnect from reality which might affect daily cognitive function. However, its relationship with daily cognitive failures has not been closely examined, and the mechanisms underpinning IGD and daily cognitive failures remain unclear. In addition, most studies have only been carried out among high school students. We need to increase the generalizability of the findings to university students.

To fill these gaps, the current study explored the relationship between IGD and daily cognitive failures. We also explored the roles of sleep quality and mindfulness on this relationship due to their close association with cognitive resource recovery and allocation, respectively (Mason et al., 2021). By advancing our understanding of the relationship between IGD and daily cognitive failures, we may be able to develop more effective interventions to alleviate the potential cognitive adverse effects of IGD in university students' daily lives.

IGD and cognitive failures in daily life

Daily cognitive failures refer to the cognitive-based errors (attention, memory, and behavior) during ongoing tasks that individuals would normally be successful in executing, such as walking into a room only forgetting why you are there, throwing away what you need but retaining what you want to throw away (Broadbent et al., 1982; Wallace et al., 2002). These failures reflect frequent breakdowns in cognitive control. Previous studies have established a significantly positive association between the usage of mobile phones (internet, and social media) and daily cognitive failures (Hadlington, 2015; Hartanto et al., 2023). Furthermore, internet gaming, which is also a significant aspect of mobile phone use, has been shown to intrude on daily life through game-related sensory or cognitive disruptions, known as "Game Transfer Phenomena" (Ortiz de Gortari & Panagiotidi, 2023). For instance, players may continue to recall gameplay experiences even after stopping the behavior, which can intrude upon or disrupt their controlled cognitive processes. Despite extensive discussion of this phenomenon, there remains a paucity of evidence on the impact of IGD on daily cognitive failures and the underlying mechanisms.

Based on the cognitive resource theory, cognitive failures often stem from individuals' limited attentional resources and higher cognitive load (Head & Helton, 2014). Firstly, individuals with IGD show incentive sensitization to game-related cues. This results in impaired attentional disengagement towards game-related cues (Zhou et al., 2022) and difficulties in shifting attention to other tasks (Fauth-Bühler & Mann, 2017), which in turn, cause individuals with IGD to miss instructions from others due to their immersion in gaming. Secondly, processing game-related cues increases the cognitive load for individuals with IGD. Online gaming is a highly demanding recreational cognitive activity that requires constant interactions with the game world and other players in a complicated dynamic online setting (Ang et al., 2007). Thus, it can deplete players' cognitive resources and cause deficits in response inhibition (Liu et al., 2013). This may make them more easily drawn to game cues, which results in forgetting their intended tasks or where they placed items. From an emotional perspective, IGD is positively correlated with negative emotions such as anxiety and depression that could exacerbate cognitive failures in daily life (Jiang et al., 2022). Therefore, we hypothesized that IGD may increase individuals' daily cognitive failures.

The mediating role of sleep quality

Extensive research has shown that IGD is related to sleep quality especially among university students who have the autonomy to manage their own time (Guo et al., 2022). The primary effects of IGD on sleep are delayed sleep duration and reduced sleep quality. In terms of sleep duration, the displacement of sleep hypothesis proposes that gaming directly leads to late bedtimes and shorter sleep duration (Garg et al., 2023b). Studies have identified significant associations between IGD and insomnia symptoms among university students, with addicted gamers exhibiting a notably prolonged time to fall asleep (Alghamdi et al., 2024; Ohayon & Roberts, 2021). One possible explanation for this phenomenon is that individuals with IGD often experience distorted time perception and underestimate the duration of their gaming sessions due to the highly immersive nature of games (Nuyens et al., 2019). For sleep quality, arousal theory emphasizes that the stimulating and interactive nature of gaming increases physiological arousal, which can disrupt the sleep structure or rhythm and result in poor sleep quality. Research has found that individuals with IGD experience reduced slow-wave sleep and shortened rapid eye movement sleep, as well as increased sleep-onset latency and light sleep stage (Dworak et al., 2007; Higuchi et al., 2005). These findings suggest that IGD is closely related to sleep disturbances.

Furthermore, sleeping as an essential mechanism for cognitive resource restoration (Mason et al., 2021), may impact individuals' daily cognitive performance. According to the system consolidation hypothesis of sleep (Diekelmann & Born, 2010), sleep selectively reactivates the neurons involved in learning, thereby facilitating and consolidating declarative and procedural memories (motor skills). Insufficient sleep can impair these memory processes and then

lead to cognitive failures. Meta-analyses have demonstrated that insomnia negatively impacts cognitive performance in attention, memory, and executive functioning (Wardle-Pinkston et al., 2019). Eskildsen et al. (2017) found that poor sleep quality during the last 12 months was positively associated with concurrent and subsequent cognitive failures. At the neurophysiological level, good sleep quality enhances the prefrontal cortex (PFC)'s top-down control over amygdala function and increases bilateral hippocampal gray matter volume. These brain regions are closely associated with learning and memory (Yoo et al., 2007; Taki et al., 2012). In contrast, sleep disruption impairs the optimal functioning of the default mode network and affects the monitoring of both internal and external environments, particularly in adolescents (Tashjian et al., 2018). Finally, individuals with IGD are more likely to have negative self-appraisals and develop negative emotions in the real world (Zhou et al., 2023). These emotional challenges may interact with sleep disorders, impacting their daily cognitive functions. Therefore, the present study hypothesized that sleep quality is a determining factor for daily cognitive failures and may mediate the association between IGD and daily cognitive failures.

Mindfulness as a moderator

Given the aforementioned arguments, sleep quality may play a mediating role between IGD and daily cognitive failures. However, this mediating effect is not always consistent and may vary across individuals' characteristics. Both gaming behaviors and sleep loss can lead to a failure in effectively allocating cognitive resources. Mindfulness, which is closely related to resource allocation, may be an important influencing factor. Mindfulness refers to an individual's ability to maintain conscious, nonjudgmental awareness of present-moment experiences (Brown & Ryan, 2003; Smallwood & Schooler, 2015) and intentionally focus on the present moment with an open, curious, and receptive attitude. It can be considered as an improved focus on and awareness of the present moment. According to the cognitive model of mindfulness (Holas & Jankowski, 2013), mindfulness could reinforce executive functioning by activating meta-awareness processes, reducing the effects of distractors, and improving attentional processes and working memory.

The distraction-conflict theory (DCT) suggests that mindfulness could improve cognitive performance by enhancing self-regulation and diminishing "attentional conflict" caused by game distractions (Brooks et al., 2017; Van Dillen & Papies, 2014). Chiorri et al. (2023) demonstrated that IGD individuals with high mindfulness are less distracted during present-moment activities. Furthermore, the Attentional Control Theory emphasizes that mindfulness can improve attention switching (Prakash et al., 2020). Research has shown that mindfulness could increase cognitive flexibility and reduce reaction times when switching tasks (Jankowski & Holas, 2020). Thus, it has the potential to facilitate a smoother transition between play and non-play activities (Chiorri et al., 2023), ultimately reducing cognitive failures associated with IGD. For example, university student gamers with high mindfulness would interrupt their online gaming to attend classes without forgetting. In addition, mindfulness enhances the ability to maintain visual-spatial information and reduces cognitive failures related to memory or name recall (Jaiswal et al., 2018). In conclusion, mindfulness may be an important individual characteristic that influences daily cognitive failures among individuals with IGD. Thus, the current study examined the moderating effects of mindfulness on IGD and daily cognitive failures.

The relationship between IGD and sleep quality may also be moderated by mindfulness. Individuals with high levels of mindfulness are likely to engage in daily activities consciously and autonomously (Donald et al., 2019). Their self-regulation skill may help mitigate sleep problems such as bedtime delays. The intention-attention-attitude (IAA) model of mindfulness (Shapiro et al., 2006) suggests that mindfulness could facilitate present-moment awareness, break unconscious patterns of behavior or emotion, and enable adaptive behaviors. It helps individuals positively experience internal and external stimuli and reduce negative subjective perceptions of stimuli. As a result, university students with high levels of mindfulness can effectively cope with negative emotions associated with IGD, thereby reducing the impacts on sleep quality. In line with our previous discussion on sleep quality, recent evidence supports the protective effects of mindfulness in college students (Fendel et al., 2024; Smit & Stavrulaki, 2021). Research reveals that the negative impact of mobile phone addiction on sleep quality is weaker in adolescents with high mindfulness (Liu et al., 2017). Further research found that eight-session mindfulness-based intervention could decrease problematic mobile phone use and improve sleep disorders (Liu et al., 2024). Moreover, research on workplace employees indicates that mindfulness can buffer the negative association between cyber leisure during evening and sleep quality, resulting in better performance on the following day (Liu et al., 2021). Hence, mindfulness may reduce sleep disturbances associated with gaming, consequently affecting the relationship between IGD and sleep quality. We assumed that the relationship between IGD and sleep quality would be weaker when mindfulness increases.

The current study

Most studies on the effects of technology addiction on cognitive failures have only focused on high school students or broader age groups (Hong et al., 2020; Hadlington, 2015), but there is a lack of exploration among university students. Moreover, much of the research does not take account of online gaming behaviors, or does not examine the effect of IGD on cognitive failures. To address these gaps, a cross-sectional design was carried out through self-reported questionnaires to investigate the mechanisms underlying the association between IGD and daily cognitive failures in university students. Gender and age were included in the data analysis as covariates. Studies have shown that girls' high sensitivity to negative emotional influences can lead to difficulties in allocating limited cognitive resources under similar pressures, and then increase cognitive failures compared to boys (Zhou et al., 2016). Additionally, cognitive abilities (attention, working memory, and executive functions) typically increase from late childhood to adolescence (Luna et al., 2004). Based on the literature, we hypothesized that mindfulness moderates the direct and indirect (through sleep quality) effects of IGD on daily cognitive failures, with a weaker effect observed for individuals with higher levels of mindfulness (Fig. 1).

Method

Participants

To ensure an adequate sample size for the study, we used G*power 3.1.9.7 to calculate the sample size before data collection (Faul et al., 2007). We chose linear multiple regression and set the significance level of 0.01, the effect size of 0.10, and the statistical level of 99%. The total sample size is estimated to be at least 220.

This study was conducted cross-sectionally using online questionnaires. In order to make the results more representative, we recruited as many subjects as possible. A total of 906 university students agreed to participate in the study and completed the online survey. The response rate was 100%. Seven students on psychiatric sleeping pill treatment along with 48 incorrect and straight-line responses were excluded. Our final sample was 851 students (43% males, 57% females) from 17 to 24 years old with a mean age of 19.14 ± 1.33 years.

The survey was completed in the classroom during a regular class meeting with the presence of the researcher or the trained teachers. Participants were recruited through convenience sampling in four universities with distribution of 145, 156, 489, and 116 participants. We initially informed participants of the study's purpose and only included those who played games recently. As a result, all participants were internet gamers, with non-gamers excluded. They were assured of anonymity and confidentiality, with data being used solely for academic research. Informed consent was obtained from all participants before they completed online questionnaires. The questionnaires included demographic

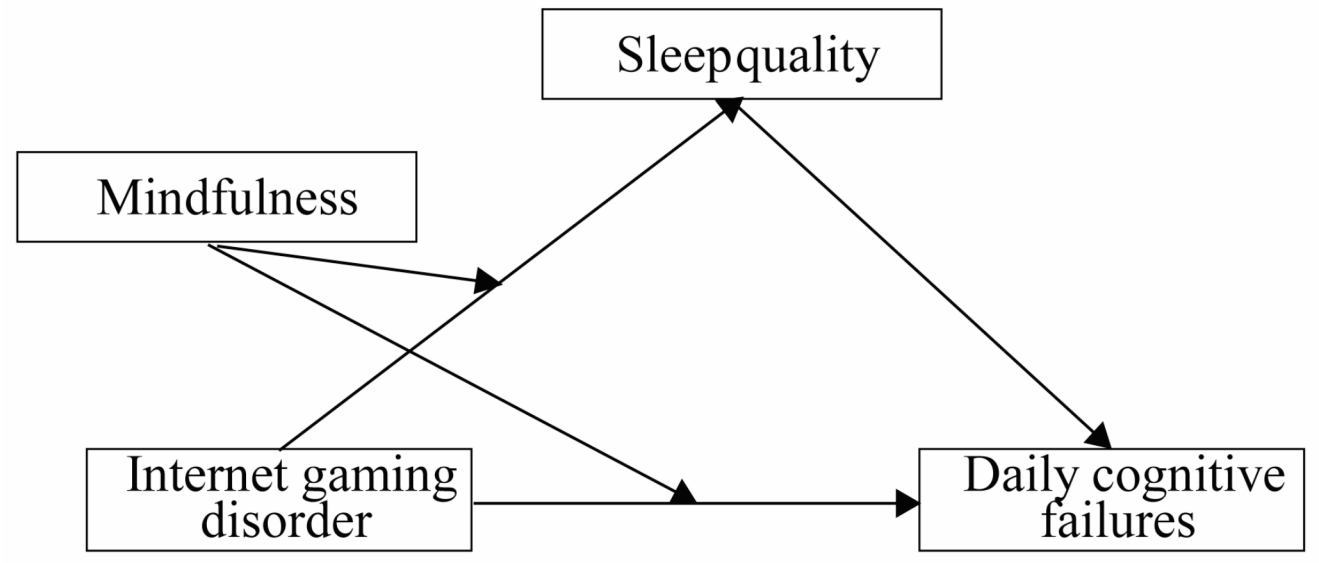

Fig. 1 Conceptual framework of Internet gaming disorder and daily cognitive failures with sleep quality as a mediator and mindfulness as a moderator

information (age, gender, grade, and gaming years) and four measurements. The questionnaire took approximately 15–20 min to complete. Ethical approval was obtained from the Ethics Committee of the first authors' university (No CCNU-IRB-202311008a), and it was in consensus with the Helsinki declarations and Ethical Committee standards (reference to Garg et al., 2023a).

Measurements

Internet gaming disorder

University students' degree of internet gaming disorder was assessed by the 20-item Internet Gaming Disorder Test (IGD-20; Pontes et al., 2014). The scale is based on the diagnostic criteria of DSM-5 and consists of 20 items with 6 factors, including salience, mood modification, tolerance, withdrawal, conflict, and relapse. The 5-point Likert scale was used, ranging from 1 (strongly disagree) to 5 (strongly agree). IGD score was calculated by averaging the scores of each item, with higher scores indicating greater severity of internet gaming disorder. The scale is reliable and valid when administered to Chinese college students (Qin et al., 2020). The alpha coefficient in this study was 0.930.

Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) assessed self-reported sleep quality using 19 items (Buysse et al., 1989). It is an effective instrument used to measure the quality and patterns of sleep in the past month. Each component is evaluated using a 4-point Likert scale from 0 to 3. Higher scores indicate worse sleep quality. The Chinese version of PSQI presents good, internal consistency, test-retest reliability, and high construct validity and criterion-related validity in university students (Liu et al., 1996). The alpha coefficient in this study was 0.776.

Daily cognitive failures

The Cognitive Failures Questionnaire (CFQ) is a unidimensional structured questionnaire developed by Broadbent et al. (1982) to measure individuals' cognitive failures in daily life during the last 6 months. It consists of 25 items with each item scored on a 5-point scale (from 1 = never to 5 = always). The Chinese version of the CFQ presents good psychometric properties with satisfactory validity and reliability within Chinese college students (Zhou et al., 2016). The mean score of the 25 items was used in the analyses with higher scores indicating more frequent cognitive failures in daily life. Cronbach's alpha in this study was 0.950.

Mindfulness

The Mindful Attention Awareness Scale (MAAS) is a 15-item scale designed to assess a core characteristic of mindfulness (Brown & Ryan, 2003). Participants were asked to report the frequency of their experience (e.g., "I could be experiencing some emotion and not be conscious of it until sometime later") in the last week. The 6-point Likert scale was used, ranging from 1 (almost always) to 6 (almost never). The MAAS score was calculated by averaging all 15 items, with higher scores representing a higher level of awareness and attention to the present moment in the individual's daily life. The revised version of the scale has high reliability in the Chinese university student population (Chen et al., 2012). The alpha coefficient in this study was 0.943.

Data analysis

The descriptive analysis and correlation analysis were conducted using SPSS 22.0 statistical software. The PROCESS macro (model 4; Hayes, 2017) of SPSS was utilized to examine the relationship between IGD and daily cognitive failures and the mediating effects of sleep quality. Model 8 of the PROCESS macro was selected to test the moderating effect of mindfulness. Indirect effects were examined using 5000 bias-corrected bootstrap samples with 95% confidence intervals (CIs). The demographic variables of the participants including age and gender were controlled for both models.

Results

Common method variance tests

There may be common method variance because the data collection was based on self-reported questionnaires. We tested the common method bias before the model analyses. Harman's single-factor test was performed in SPSS 22.0. The results showed that there was a total of 10 factors with characteristics roots greater than 1. The variance interpretation rate of the first factor was 25.66% (less than the method factor cutoff value of 40%; Podsakoff et al., 2003). This indicated that there is no serious common method bias problem.

Preliminary analyses

Descriptive results and correlation coefficients are shown in Table 1. IGD was positively correlated with sleep quality, and daily cognitive failures. Sleep quality was positively

Table 1 Descriptive statistics and correlations of the measured variables

Variable	M (SD)	1	2	3	4	5	6
1. Age	19.14 (1.33)	-					
2. Gender	1.57 (0.495)	-0.020	-				
3. IGD	2.19 (0.65)	0.110	-0.234**	-			
4. PSQI	4.88 (3.09)	0.161**	0.085*	0.169***	-		
5. MAAS	4.32 (1.02)	-0.048	-0.036	-0.136***	-0.253***	-	
6. CFQ	2.31 (0.68)	0.124**	0.146**	0.336***	0.415***	-0.344***	-

*$p<0.05$; **$p<0.01$; ***$p<0.001$

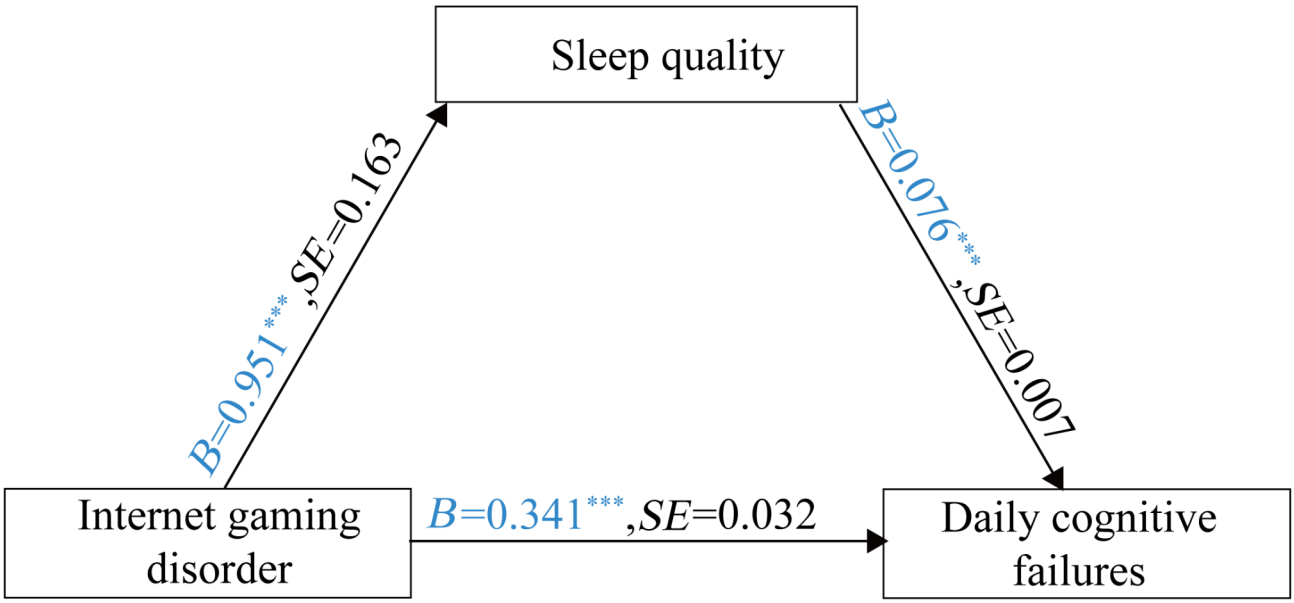

Fig. 2 The mediating effect of sleep quality between IGD and daily cognitive failures. *$p<0.05$; **$p<0.01$; ***$p<0.001$

Table 2 Summary of the moderated mediation model

	PSQI ($R^2=11.06\%$)				CFQ ($R^2=36.41\%$)			
	B	*SE*	*p*	95%*CI*	*B*	*SE*	*p*	95%*CI*
gender	0.718	0.208	<0.001	[0.309, 1.127]	0.252	0.015	<0.001	[0.172, 0.331]
age	0.214	0.076	<0.01	[0.065, 0.362]	-0.008	0.015	0.608	[-0.036, 0.021]
IGD	0.772	0.161	<0.001	[0.456, 1.088]	0.315	0.031	<0.001	[0.253, 0.377]
MAAS	-0.706	0.101	<0.001	[-0. 905, -0.507]	-0.150	0.020	<0.001	[-0.189, -0.110]
IGD* MAAS	-0.362	0.145	<0.05	[-0.647, -0.077]	0.001	0.028	0.99	[-0.055, 0.056]
PSQI					0.065	0.007	<0.001	[0.052, 0.078]

Note: Bootstrap sample size = 5000; *SE* = standard error

correlated with daily cognitive failures. Mindfulness was negatively correlated with IGD, sleep quality, and daily cognitive failures.

Mediation model

To test our hypotheses, we examined the mediation role of sleep quality on the association between IGD and daily cognitive failures using the PROCESS macro (Model 4) with gender and age as control variables. IGD was positively associated with daily cognitive failures ($B=0.341$, $p<0.001$). The partly mediating effect of sleep quality was significant ($B=0.072$, 95% CI [0.043, 0.105]), accounting for 17.43% of the total effect of each variable (Fig. 2).

Moderated mediation model

We then tested the moderating effects of mindfulness on the association between IGD and daily cognitive failures as well as IGD and sleep quality when controlling for the participants' gender and age. In Table 2, IGD was positively significantly related to sleep quality, and mindfulness was

negatively significantly related to sleep quality. Mindfulness negatively moderated the effect of IGD on sleep quality (B = -0.362, $p < 0.05$). The effect of IGD on sleep quality was significant when the level of mindfulness was low ($B = 1.142$, $p < 0.001$), but non-significant at high levels of mindfulness ($B = 0.403$, $p > 0.05$) (see Fig. 3). The predictive power of IGD on sleep quality was strengthened when the level of mindfulness was low.

With regards to the moderating role of mindfulness in the indirect effect of IGD on daily cognitive failures via sleep quality, the moderated mediation results suggested that the indirect effect of IGD on daily cognitive failures through sleep quality was influenced by mindfulness (B = -0.024, $SE = 0.013$, 95% CI [-0.049, -0.000]). Especially, the conditional indirect effect of IGD on daily cognitive failures was significant for users with a low level of mindfulness ($B = 0.074$, $SE = 0.022$, 95% CI [0.034, 0.118]) but nonsignificant for those with a high level of mindfulness ($B = 0.026$, $SE = 0.015$, 95% CI [-0.005, 0.055]) (Fig. 4).

However, the moderating effect of mindfulness on the direct association between IGD and daily cognitive failures was not significant ($B = 0.001$, $p = 0.99$, 95% CI [-0.055, 0.055]).

Discussion

The present study tested a moderated mediation model to examine the mechanisms underlying the relationship between IGD and daily cognitive failures. Consistent with previous research on the use of mobile phone or social network sites (Axelsson et al., 2022; Xanidis & Brignell, 2016), the results revealed a positive association between IGD and daily cognitive failures. This association was mediated by sleep quality. In line with our hypotheses, we also found that mindfulness moderated this mediating effect. Specifically, IGD influenced daily cognitive failures through sleep quality among individuals with low mindfulness, but not among individuals with high mindfulness. These findings could help develop more effective interventions tailored to individuals with different levels of mindfulness.

The relation between IGD and daily cognitive failures

In line with our assumptions, the results showed a significant positive correlation between IGD and daily cognitive failures. Specifically, individuals with higher IGD reported more cognitive failures in their daily lives. Our results support the cognitive resource theory, which suggests that IGD overconsumes an individual's cognitive resources and competes with other daily cognitive activities (Billieux et al., 2020). While limited research has focused on this direct relationship, it is noteworthy that cognitive failures are often associated with the depletion of cognitive resources related to attentional control and working memory (Unsworth, 2015). Studies have found that individuals with IGD have reduced attention and memory capacity, which in turn lead to poorer cognitive and academic performance (Farchakh et al., 2020).

Many students escape from uncomfortable feelings or become distracted from real-world pressures through

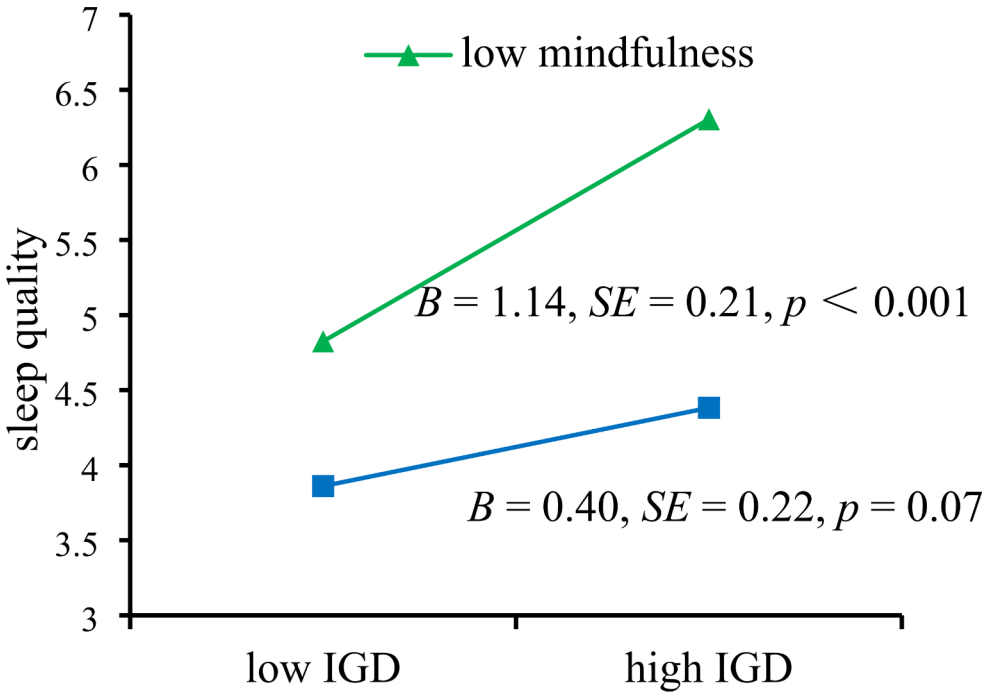

Fig. 3 The moderating effect of mindfulness on the association between IGD and sleep quality

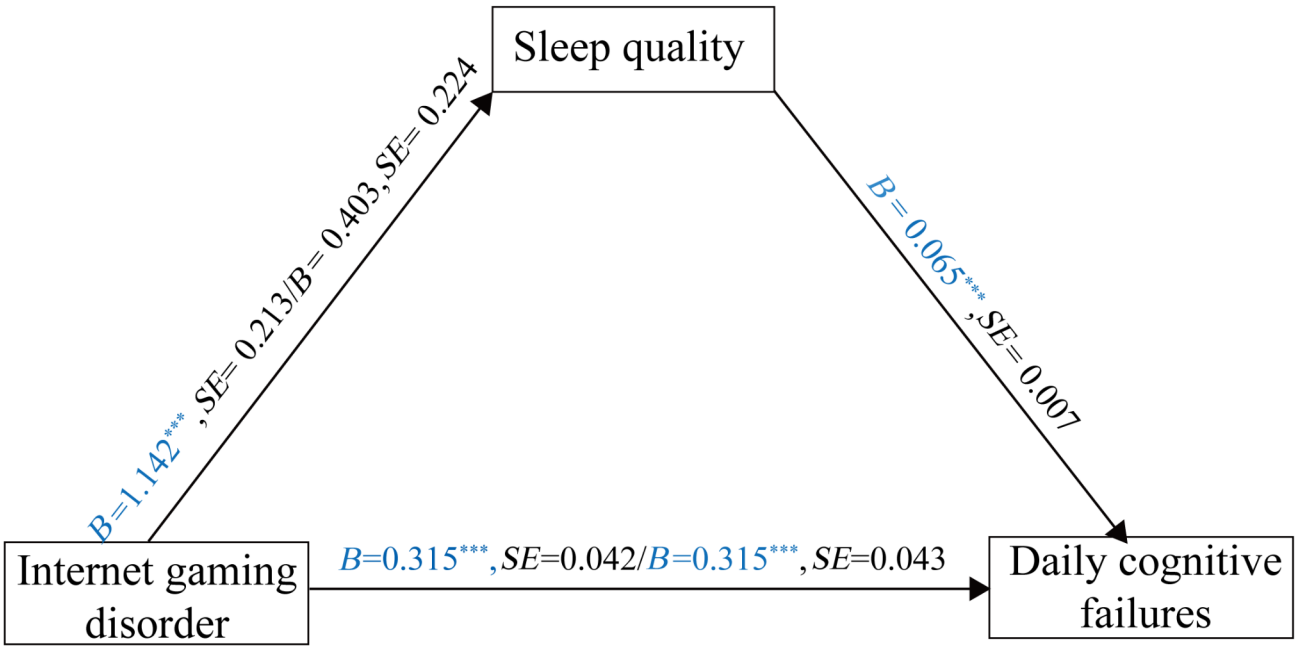

Fig. 4 The mediating effect of sleep quality between IGD and daily cognitive failures in the subgroup. *Note:* the left side of the slash indicated the low mindfulness group, and the right side of the slash indicated the high mindfulness group. $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Internet games (Wang & Cheng, 2022). This leads to the phenomenon of "real world dissociation" (RWD; Jennett, 2010), as internet games offer immersive experiences that enable players to explore and interact within a virtual world. These RWD experiences may cause gamers to exhibit insufficient perception and slow reactions to the real world, and these then result in difficulties with attention, concentration, and cognitive flexibility in their everyday lives. Consequently, they may experience cognitive failures, such as being unable to hear others shouting at them. Furthermore, Park et al. (2020) found that individuals with IGD showed reduced sensitivity to early error monitoring and diminished awareness of errors in the later stage. This impaired error processing may hinder individuals' ability to correct and adapt their behavior, thereby exacerbating daily cognitive failures.

The mediating role of sleep quality

Consistent with our hypothesis, sleep quality mediated the relationship between IGD and daily cognitive failures. This finding can be explained by the displacement of sleep hypothesis (Exelmans & Van den Bulck, 2017). This theory postulated that playing games during nighttime reduces sleep duration. Gaming exposes players to blue light and disrupts circadian rhythms. Heo et al. (2017) reported that users of blue-light smartphones took longer to reach dim light melatonin onset 50% and experienced decreased sleepiness. Research on IGD has also found that playing games for more than two hours per day decreases sleep quality and increases the severity of daytime sleepiness (Akcay & Akcay, 2020). Furthermore, some researchers have proposed that online gaming might impact an individual's sleep through "perceptual after effects". For example, some gamers experience "afterimage effects" and continue to see game-related images after a gaming session, which makes it difficult for them to fall asleep (Ortiz de Gortari et al., 2011). However, further experimental studies are needed to verify the underlying mechanisms because this study was based on qualitative interviews.

Consistent with previous research (Wilkerson et al., 2011), the present study showed that gamers' sleep quality affected their daily cognitive failures. This finding aligns with ego depletion theory (Bratslavsky et al., 1998), which suggests that finite resources depleted by sustained self-control could be replenished through rest. Otherwise, individuals may increase their susceptibility to distractions and impulsive tendencies. For instance, using smartphone for a long time late at night increased depletion the next morning via its effect on sleep, which in turn exacerbated fatigue and diminished daily work engagement (Lanaj et al., 2014). Wolfe et al. (2014) found that the relationship between video gaming and sustained attention performance was fully mediated by sleep duration. Thus, our results suggest that sleep disturbances caused by online gaming prevent players from replenishing depleted cognitive resources, thereby leading to more frequent daily cognitive failures. Furthermore, pre-bedtime video gaming may also increase the risk

of cognitive failures by impacting an individual's sleep architecture. Empirical studies of game use among children (13.45 ± 1.04 years) have found that gaming significantly reduces slow-wave sleep and impairs verbal cognitive performance (Dworak et al., 2007). This suggests that the moderating role of sleep quality in the relationship between IGD and cognitive function might be relatively stable across age groups.

The moderating role of mindfulness

The results showed that mindfulness moderated the first stage of the mediating process of sleep quality. Specifically, IGD could increase daily cognitive failures through the mediation of sleep for individuals with low mindfulness, but this mediation effect was not significant for individuals with high mindfulness. This finding is in line with that of Li et al. (2022), who also found a stronger association between IGD and sleep quality when self-regulation was low, which is significantly correlated with mindfulness (Bowlin & Baer, 2012).

Our study supports the metacognitive model of insomnia (Ong et al., 2012). This theory posits that mindfulness enhances intentional awareness of the present moment, fosters self-compassion and acceptance, and alters outcome-oriented cognition. This helps to balance appraisals and cognitive flexibility in sleep-related metacognitive processes, ultimately reducing sleep-related arousal and easing insomnia. Therefore, individuals with IGD who exhibit higher levels of mindfulness are expected to experience improvements in sleep quality due to a reduction in non-adaptive cognitions. Furthermore, the attention monitoring and acceptance skills of mindfulness can reduce negative emotions (e.g., anxiety, depression, stress) and indulgence in positive experiences (feelings of cravings, addictions). These effects contribute to an improvement in sleep quality (Lindsay & Creswell, 2017). Finally, our results can also be explained by the facilitating effect of mindfulness on task-switching. Individuals with high mindfulness can focus on present-moment experiences (inner feelings and external stimuli) and exhibit greater agility in task-switching (Samuel & Costanzo, 2020). Lee's (2014) study showed that mindfulness training enhances task-switching performance and makes it easier to transition from gaming play to sleep.

An unexpected finding is that mindfulness did not moderate the direct association between IGD and daily cognitive failures. The Dual Processing Theory of Addiction suggests that individuals with IGD exhibit impairments in executive functioning, increased impulsivity, and reduced response inhibition (Yu et al., 2024). While mindfulness might improve attention diversion from online gaming, it inadequately suppresses impulsive behaviors and dominant responses, resulting in behavioral inhibition failures. Besides, prolonged involvement in online gaming can lead to neural impairment, specifically within the prefrontal cortex, significantly impacting cognitive functions (Wang et al., 2017). Extended mindfulness training is necessary to facilitate neuroplasticity in the brain (Bauer et al., 2020). However, the efficacy of trait mindfulness may be limited and unable to fully mitigate the cognitive failures associated with IGD. Therefore, a consistent link between IGD and daily cognitive failures was observed independent of mindfulness levels. This is similar to the role of self-regulation in Hong et al. (2020)'s research. While Hong did not find that self-regulation moderated the first stage of the mediating process of sleep quality. We speculate that this discrepancy may stem from the unique features of various addictions. Online gaming primarily affects immersion in the game, where mindfulness can boost awareness of the present moment and reduce its impact on sleep.

In summary, our research suggests that mindfulness mitigates the detrimental effects of IGD on daily cognitive failures by alleviating sleep disturbances, and the mediating role of sleep quality between IGD and daily cognitive failures was only observed in individuals with low mindfulness. Our findings indicate that mindfulness acts as a protective factor against sleep disturbances among individuals with IGD, which aligns with previous research (Liu et al., 2021). Specifically, individuals with higher levels of mindfulness exhibit enhanced awareness of their circumstances (Smallwood & Schooler, 2015), which then leads to reduced sleep disruptions caused by immersive gaming, and ultimately aids in their recovery from cognitive depletion related to excessive gaming.

Implications

This study has both theoretical and practical implications. Theoretically, our study contributes to the limited research on the association between media use and daily cognitive failures, particularly focusing on online gaming behaviors. Additionally, our study adds to the existing findings on IGD-induced cognitive impairment by revealing that IGD could influence daily cognitive failures via sleep quality, with mindfulness potentially moderating this relationship.

For clinical practice, this study provides more information about guiding university students to play games rationally and reducing their daily cognitive failures. Our findings highlight the associations between IGD, sleep quality, and frequent occurrences of cognitive failures. It indicates that university students need sufficient self-control when engaging in online gaming as a recreational activity, especially during the university stage when they have more autonomy and fewer external regulations. Therefore, prevention

strategies targeted at effectively managing gaming activities and maintaining a balanced schedule are essential in ensuring adequate rest to promote optimal daytime functioning and fulfill academic responsibilities among students. To achieve this, interventions could involve collaboration between universities and students. For example, teachers could provide activities aimed at reducing gaming behavior and educate students on how to maintain a balanced schedule. Moreover, our study revealed that mindfulness can mitigate the adverse effects of IGD on sleep problems through improving individuals' sleep quality. This suggests that individuals with IGD should enhance their capacity to maintain high levels of mindfulness when engaging in game playing. Although mindfulness was a stable disposition in our study, previous research has shown that mindfulness training can enhance its levels to some extent (Sousa et al., 2021). Thus, regular mindfulness practices may be a targeted intervention to help individuals with IGD improve their sleep quality and prevent daily cognitive failures.

Limitations and future studies

While the current study can aid our understanding, several potential limitations should be noted. First, we are unable to satisfactorily address the issues of causality through a cross-sectional study based on self-report measures. Future research could use a longitudinal study or an experimental design that manipulated IGD abstinence. Furthermore, self-reported data may cause response bias, although our data does not indicate significant common method bias. Second, the use of retrospective self-reports in our study is constrained by the participants' memory, which can introduce potential recall biases, particularly considering the involvement of memory-related issues in daily cognitive failures. We recommend that in the future, data could be collected using real-time self-report measures (e.g., using ecological diary methods to reduce memory bias and increase ecological validity) and objective measures (e.g., using actigraphy devices to assess sleep patterns). Third, while daily cognitive failures based on individuals' self-reported questionnaires are more ecological for studying cognition, their relationship with objective cognitive domains via performance on lab-based tasks needs to be comprehensively examined in future studies. Fourth, the measurements in our study were inconsistent in the time period they assessed, potentially leading to biased results. Although existing studies used similar questionnaires (Hong et al., 2020; Garg et al., 2023b), more caution should be paid in future research to ensure that measurements accurately capture participants' psychological states within the same period.

Conclusions

Drawing on the cognitive resource theory, this study indicated that IGD directly increases daily cognitive failures in university students and indirectly raises the risk of daily cognitive failures by impairing sleep quality. Moreover, mindfulness can alleviate the impact of IGD on sleep quality, indirectly improving cognitive performance. Overall, this study contributes to the field by exploring the mechanisms through which IGD affects daily cognitive failures. The findings also have practical implications and provide guidance for developing targeted interventions to mitigate cognitive deficits.

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Data availability The datasets generated and/or analyzed in the current study are available from the corresponding author on reasonable requests.

Declarations

Conflict of interest The authors declare no conflicts of interest including any financial, personal relationship that could influence the work reported in this paper.

Ethics approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Committee of the School of Psychology, Central China Normal University.

Consent to participate Informed consent was obtained from all individuals participating in the study.

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