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Addictive behaviors among youth and adolescents in the digital age

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Addictive behaviors among youth and adolescents in the digital age

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The effect of mindfulness on social media addiction among Chinese college students: A serial mediation model

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Introduction: The COVID-19 pandemic has exacerbated social media addiction (SMA), making it urgent to find effective interventions for social media addiction. Evidence has shown that mindfulness might be an effective intervention for social media addiction. However, psychological mechanisms by which mindfulness reduce social media use remain unclear. Here, we further addressed this issue to examine whether attentional control and fear of missing out (FOMO) mediate the relationship between mindfulness and SMA.

Methods: We recruited 446 college students from two universities in China and analyzed the data.

Results: The results suggest that there are mediation effects of attentional control and FOMO between mindfulness and SMA through 3 paths: path 1, mindfulness → attention control → SMA (−0.04); path 2, mindfulness → FOMO → SMA (−0.22); and path 3, mindfulness → attention control → FOMO → SMA (−0.05).

Discussion: Therefore, mindfulness-based interventions may be an effective way to alleviate social media addiction, especially mindfulness-based interventions targeting FOMO. At the end of the article, we also discussed the limitations of this study.

KEYWORDS

mindfulness, social media addiction, attention control, fear of missing out, college students

Introduction

Social media use has increased exponentially. The number of social media users is estimated to have reached 3 billion worldwide (1). Social media facilitates social interaction and lowers stress for at least some users, but overuse can lead to serious negative consequences, such as social media addiction (SMA), poor sleep quality, less offline social interaction, and more depression and anxiety symptoms (2–5). The estimated SMA prevalence of college students is around 23% (6). To make matters worse, the COVID-19 outbreak exacerbated social media addiction and its negative consequences, such as sleep problems (7, 8), the negative impact on the well-being of excessive social media users (9), increased daily stress, and an increase in suicide-related outcomes (10, 11). Given its high prevalence and severe negative consequences, the question of how to alleviate social media addiction and reduce the adverse consequences of social media addiction has become very urgent.

Many antecedents leading to social media addiction have been investigated, such as attachment styles (12), self-esteem (13, 14), the need to socialize (15), and social anxiety (13). However, how social media addiction can be systematically controlled or regulated remained unsolved in these studies.

Existing evidence suggests that mindfulness-based interventions may be an effective intervention for social media addiction. Mindfulness helps us to be aware of where we are and what we are doing rather than to be overreacting or being overwhelmed by what is happening around us (16). It is a basic human ability to be fully present and prevalent even among ordinary people who have not been systematically trained in mindfulness (17). The ability to sustain mindfulness is called trait mindfulness (TM) (18), which can be improved by mindfulness training (19). Research interested in mindfulness-based interventions (MBI) has exploded over the past few decades (20). Mindfulness has been shown to be negatively associated with social media addiction (21–24), and has an indirect effect on social media addiction through mediation (25, 26) or moderation (27–29). However, the psychological mechanisms by which mindfulness reduces social media addiction remain unclear. These psychological mechanisms can help us design mindfulness-based interventions more effectively.

Two studies have shown that the influence of mindfulness to reduce social media addiction is mediated by the ability of social pressure self-efficacy (29), positive effects on self-esteem, and negative effects on social anxiety (13). In the present study, based on core features of mindfulness and social media addiction, we focused on the potential role of attentional control and social media-related fear of missing out (FOMO).

The mediating effect of fear of missing out

Currently, the COVID-19 pandemic remains a global challenge. Restrictions on the movement of people are one of the government policies aimed at reducing the spread of COVID-19. In this context, the pandemic dramatically changed one's usual routine and decreased social contacts with each other, ultimately leading to fearful experiences that are particularly relevant to interpersonal interactions, especially the fear of missing out (FOMO). FOMO is defined as a widespread anxiety arising when individuals cannot get the experiences they want to know about, mainly manifested by a persistent desire to know what others are doing (30). In fact, it has been shown that the COVID-19 pandemic increased the fear of FOMO in China (31). During lockdowns, social media use may be one of the most effective and available ways to ease FOMO. The latter has been highlighted in previous literature as an important influencing factor of social media use (32, 33), including problematic social media use (34, 35). Therefore, FOMO may be a significant contributor to social media addiction, especially under the COVID-19 pandemic.

FOMO is likely to distract people from their experiences of in-the-moment. In fact, when one is worrying about what one is missing out, it will become especially difficult to focus on what one is doing now. Conversely, when a person is deeply involved in what they are doing at the moment, they may be less likely to think of alternatives and then will feel less FOMO (36). Mindfulness practice places a strong emphasis on focusing on the here and now. This suggests that the fear of missing out is an important target for mindfulness interventions. In fact, related research has provided direct evidence for the relationship between mindfulness and fear of missing out. For example, less mindful attention was associated with higher levels of FOMO (37). Mindfulness practice has reduced levels of fear of missing out (38). Based on this evidence, we hypothesized that FOMO mediates the effect of mindfulness on social media addiction (H1). To be specific, mindfulness may decrease FOMO of Chinese college students, which, in turn, may decrease social media addiction.

The serial mediating role of attention control and FOMO

The psychological mechanisms by which mindfulness reduces fear of missing out in the context of social media addiction require further exploration. Theoretically, attention is widely regarded as a core aspect of mindfulness (39, 40). And the practice of self-regulation of attention is one common component among various types of mindfulness-based interventions (41). For example, mindfulness meditation typically involves focusing attention on a selected target object and redirecting attention on the same target object in the event of distraction (39). In fact, attentional enhancement is one of the most common outcomes of different types of mindfulness-based interventions (40). For example, 8 weeks of mindfulness practice on novice college students has been shown to improve their alertness (39), attentional orienting (39, 42), and attention executive control (42).

According to the process model of emotion regulation, individuals regulate their emotion in the situation-attention-appraisal-response sequence, and attentional deployment is a cardinal emotion regulation strategy (43, 44). Human attention is usually deployed voluntarily based on observers' goals (top-down) or shifted automatically according to noticeable features of stimuli in the environment (bottom-up). The former is usually called attentional control and is regulated by the anterior system, while the latter is usually called attention orientation, such as attention bias, which is regulated by the posterior system (45). However, a recent study found that there is no attentional bias toward relevant information in social media addiction (46). These evidences suggested that attentional control might be central to FOMO regulation.

Besides, a number of studies have found that reduced attention control ability affected individuals' social media use. For example, attention deficit among college students significantly and positively predicted the severity of social media addiction (47, 48). Cognitive flexibility and sustained attention have been significantly and negatively associated with social media addiction in college women (49). Moreover, attention control deficits have become a risk marker for the anxiety onset and persistence (50, 51). Impaired attention control makes individuals more likely to skew attentional resources toward threatening information in the presence of anxiety (52). As an anxious emotion, the negative association between FOMO and attention control has been verified by previous studies (26, 38, 53).

Furthermore, according to the Interaction of Person-Effect-Cognition-Execution (I-PACE) model proposed by Brand (54), when executive functions (e.g., attention control) are weak, the conditioned learning effects of negative emotions, such as anxiety, can cause social media use to gradually get out of control and deteriorate into compulsive use (55, 56). Thus, we hypothesized that mindfulness may

indirectly influence social media addiction through the paths of attention control (H2) and attention control → FOMO (H3).

The present study

Based on the aforementioned literatures, the present study aimed to explore the psychological mechanisms underlying the effect of mindfulness on social media addiction. First, we recruited Chinese college students and examined the correlation between their mindfulness and social media addiction. Then, we further tested whether attention control and FOMO independently mediate this association. At the end, we investigated whether attentional control and FOMO mediate the relationship between mindfulness and social media addiction in a serial way. In conclusion, we aimed to fill in the gaps in the relationship between these variables, with the hope of providing a theoretical basis for intervention research in this context. We showed the hypothetical model in Figure 1.

Materials and methods

Participants

We conducted online and offline questionnaire surveys at two universities in China: Guizhou and Hunan, respectively. A total of 502 students were enrolled by stratified random sampling. All participants voluntarily filled out the questionnaire to participate in the study, without receiving rewards. All the participants were asked to sign informed consent forms and were told that they were participating in the study voluntarily and could terminate the questionnaire freely throughout the process. To ensure data quality, we excluded the data from two subject groups: (1) those who chose the same answer for greater than or equal to half the length of the total scale (57) and (2) those who did not sign the informed consent form. Finally, data from 446 participants (120 male and 326 female) ranging in age from 18 to 26 years (M = 20.36, SD = 1.40) were analyzed. This research was approved by the Ethics Committee of Guizhou Medical University.

Demographics are shown in Table 1. 26.9% and 73.1% of the participants were males and females, respectively. The ages of the participants ranged from 17 to 26 years (mean = 20.36, SD = 1.40). 22% of the participants came from cities, 27.6% came from towns, and 50.4% came from villages. Among all the participants, "only-child" (i.e., participants who were an only-child) accounted for 18.2%, while "non-only child" accounted for 81.8%; 44.4% were "left-behind child" (i.e., participants who experienced both or one parent relocating elsewhere to work for more than 6 months while the participant was growing up), while the rest, 55.6%, were not "left-behind child."

Measures

Social media addiction

To measure the social media addiction of participants, the Bergen Facebook Addiction Scale (BFAS) was used (58), which was translated into the Chinese version by Yubo Hou (59). These items relate to experiences that have occurred in the past year and are rated on a 5-point scale from 1 (Very rarely) to 5 (Very often; example item: "ignored your partner, family members, or friends because of social media?"). The scale consists of 6 dimensions: salience, tolerance, mood changes, relapse, withdrawal, and conflict. In view of the characteristics of social networking sites in mainland China, we replaced the original scale, namely Facebook, Twitter, Instagram, etc., with those social networking sites that are popular in China: QQ, Weibo, WeChat, etc., in the instructions. The scores of the participant for all the items were added to form a social media addiction score, with higher scores indicating higher levels of social media addiction. Cronbach's α of the whole scale was 0.92 in the current sample.

Mindfulness

To measure mindfulness, the Chinese version of the Mindful Attention Awareness Scale (60, 61) was used. The scale consists of 15 self-rating items on everyday experiences. An example is the item "I tend not to notice feelings grab my attention." Responds rated each item on a 6-point Likert-type scale, with a range from 1 (almost always) to 6 (almost never). Total scores can range from 15 to 90, with higher scores indicating a greater level of mindfulness. In this study, Cronbach's alpha was 0.86.

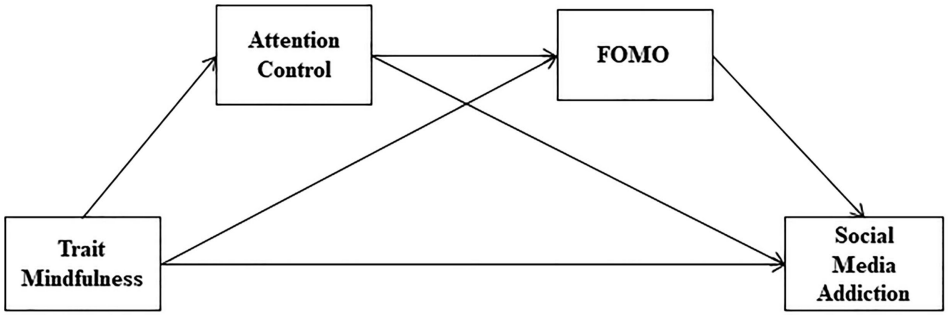

FIGURE 1
The serial mediation model hypothesized in the present study.

TABLE 1 Descriptive statistics.

Variable		*N*	(%)	Variable		*N*	(%)
Gender	Male	326	73.09	Left-behind child	Yes	198	44.39
	Female	120	26.91		No	248	55.61
Residence	City	98	21.97	Only-child	Yes	81	18.16
	Town	123	27.60		No	365	81.84
	Village	225	50.44				

TABLE 2 Descriptive statistics and results of correlational analysis of variables (*N*=446).

	M	*SD*	1	2	3	4
1. Mindfulness	57.43	10.62	1			
2. Attention control	49.87	6.05	0.40**	1		
3. FOMO	54.80	9.44	−0.44**	−0.35**	1	
4. Social media addiction	46.35	12.51	−0.52**	−0.37**	0.67**	1

**$p < 0.01$.

Attention control

To measure attention control, we used the Attention Control Scale (62), which was translated into the Chinese version by Siying He (63). The questionnaire has two dimensions: focusing (9 items) and shifting (11 items). Each item of this scale was rated on a 4-point scale from 1(almost never) to 4 (almost ever; i.e., almost always). In the present study, the Cronbach's alpha of the Attention control Scale was 0.76.

The fear of missing out

To measure FOMO, we used the Fear of Missing Out in the Mobile Social Media Environment Measurement Scale, compiled by Song Xiaokang (64). The scale measures individual FOMO in the context of social media use, and consists of four dimensions: psychological motivation (e.g., "On mobile social media, as soon as I see a hint of what's new, I'm eager to click on it right away."), cognitive motivation (e.g., "Using mobile social media, I was able to get the news, business, or expertise I wanted"), behavioral performance (e.g., "As soon as I have time, such as waiting for the bus or recess, I am used to turning on mobile social media to check for new news or updates"), and emotional dependence (e.g., "If I cannot use mobile social media for a few days, I feel lost"). This scale has 16 items. Each item was rated on a 5-point Likert scale (1 = not at all true to 5 = absolutely true). The total score was between 16 and 80, and the higher the total score, the greater the fear of missing out. The Cronbach's alpha was 0.87, in this study.

Statistical analysis

In the present study, data were analyzed according to how Hayes (65) described the process in his book on the SPSS 26.0. First, descriptive statistics of the investigated variables were calculated. Then, to examine the bivariate correlations between mindfulness, social media addiction, FOMO, and attention control, Pearson's correlation analysis was used. Additionally, we ran PROCESS Macro Model 6 to examine simultaneously all the study hypotheses, as presented in Figure 1. To determine the magnitude of these effects, the bootstrapping method based on 5,000 re-samples of the data was used to produce 95% bias corrected confidence intervals (Cis). When Cis do not overlap with zero, the effect is significant at $\alpha = 0.05$.

Results

Common method biases tests

To exclude common method bias, (66) single-factor test and an exploratory factor analysis were performed, where all items including four variables were included. We found that the first factor accounted for 20.7% of the total variance, which was below the 40% threshold proposed by Podsakoff et al. (67). Therefore, common method biases are unlikely to confuse the interpretation of the data analysis.

Descriptive analysis and correlations between overall variables

Table 2 presents basic descriptive data on mindfulness, attention control, FOMO, and social media addiction. The mean total scores of mindfulness were 57.43 ± 10.62 (range = 25 to 87), the meant total scores for attention control were 49.87 ± 6.05 (range = 28 to 72), the mean total scores for FOMO were 54.8 ± 9.44 (range = 27 to 78), and the mean total scores for social media addiction were 46.35 ± 12.51 (range = 20 to 83).

To test the bivariate correlations of all the variables, we conducted a Pearson's correlation analysis where standard scores for each variable were used. As shown in Table 2, all the variables were significantly correlated with each other, $p < 0.01$. Mindfulness was significantly and positively correlated with attention control ($r = 0.40$, $p < 0.01$), while significantly negatively correlated with FOMO and SMA ($r = -0.44$, $p < 0.01$; $r = -0.52$, $p < 0.01$), respectively. Attention control was significantly negatively correlated with FOMO and SMA ($r = -0.37$, $p < 0.01$; $r = -0.37$, $p < 0.01$), respectively. FOMO was significantly positively correlated with SMA ($r = 0.67$, $p < 0.01$).

Testing the serial mediating effects

Mindfulness, attentional control, FOMO, and social media addiction are all significantly associated, meeting the statistical requirements for a further mediation analysis of mindfulness and SMA (68). With gender, age, place of residence, only-child, and left-behind child as covariates, the mediating role of attention control and FOMO in the relationship between mindfulness and SMA was analyzed by using PROCESS Model 6 in SPSS 26.0 compiled by Hayes (65). The main results are shown in Tables 3, 4. As is shown in Table 3, Mindfulness was a significant predictor of attention control ($\beta = 0.22$, $SE = 0.03$, $p < 0.001$). Mindfulness and attention control are also significant predictors of FOMO ($\beta = -0.31$, $SE = 0.04$, $p < 0.001$;

TABLE 3 Regression coefficients, standard errors, and model summary information for the influence of mindfulness in a model of social media addiction.

Antecedent	Consequent								
	Model 1 (Attention control)			Model 2 (FOMO)			Model 3 (Social media addiction)		
	Coefficient	*SE*	*p*	Coefficient	*SE*	*p*	Coefficient	*SE*	*p*
Gender	0.98	0.60	0.11	−2.09	0.89	0.02	1.25	0.96	0.19
Age	0.13	0.20	0.51	−0.06	0.30	0.83	−0.16	0.32	0.61
Left-behind child	0.42	0.55	0.44	−1.98	0.81	0.02	−1.31	0.87	0.13
Residence	−0.31	0.34	0.37	−1.38	0.51	<0.001	−0.30	0.54	0.58
Mindfulness	0.22	0.03	<0.001	−0.31	0.04	<0.001	−0.30	0.05	<0.001
Attention control	-	-	-	−0.30	0.07	<0.001	−0.19	0.08	0.01
FOMO	-	-	-	-	-	-	0.70	0.05	<0.001
Constant	34.32	4.23	<0.001	95.83	6.68	<0.001	40.20	8.65	<0.001
	$R^2 = 0.17$			$R^2 = 0.26$			$R^2 = 0.52$		
	$F(4, 441) = 22.07, p < 0.001$			$F(5, 440) = 29.58, p < 0.001$			$F(6, 439) = 79.08, p < 0.001$		

TABLE 4 Direct and indirect effects of mindfulness on social media addiction.

Path way	Estimate	*SE*	*p*	95% CI	Relative effect(%)
Total effect	−0.61	0.05	<0.001	−0.70, −0.51	-
Direct effect	−0.30	0.05	<0.001	−0.38, −0.21	48.60
Total indirect effect	−0.31	0.04	<0.001	−0.38, −0.24	51.40
Mindfulness → FOMO → Social media addiction	−0.22	0.03	<0.001	−0.29, −0.16	36.68
Mindfulness → attention control → Social media addiction	−0.04	0.02	<0.001	−0.08, −0.01	6.88
Mindfulness → attention control → FOMO → Social media addiction	−0.05	0.01	<0.001	−0.08, −0.02	7.85

$\beta = -0.31$, $SE = 0.07$, $p < 0.001$). Finally, trait mindfulness and attention control, as well as FOMO, significantly predicted social media addiction ($\beta = -0.30$, $SE = 0.05$, $p < 0.001$; $\beta = -0.19$, $SE = 0.08$, $p = 0.01$; $\beta = 0.70$, $SE = 0.05$, $p < 0.001$). The results of the path coefficient test in the hypothetical model are shown in Figure 2.

The mediating effect sizes of attention control and FOMO in the relationship between mindfulness and SMA are shown in Table 4. As shown in Table 4; Figure 2, the mediating role between the mindfulness and SMA of attention control and FOMO is significant. The total effect value of mindfulness on SMA was −0.61, and the direct effect value of mindfulness on SMA was −0.29, and the total mediating effect accounted for 51.40% of the total effect. The mediating effect consists of three indirect effects: Path 1: Mindfulness → FOMO → SMA (−0.22), Path 2: Mindfulness → Attention Control → SMA (0.04), and Path 3: Mindfulness → Attention Control → FOMO → Social Media Addiction (−0.05). For pathways 1, 2, and 3, the ratios of the three indirect effects to the total effect were 36.68%, 6.88%, and 7.85%, respectively. All three indirect effects reached a significance level, since CIs of the above indirect effects did not include the zero value. Thus, hypotheses 1, 2, and 3 were confirmed.

The above results suggest that mindfulness not only indirectly predicts SMA through the single mediating effects of attentional control and FOMO, but also indirectly predicts SMA through the serial mediating effects of attentional control and FOMO.

Discussion

Mindfulness might be a protective factor, for college students, from social media addiction under the COVID-19 pandemic. However, psychological mechanisms by which mindfulness may reduce social media use remain unclear. The present study analyzed the relationship between mindfulness and social media addiction among Chinese college students *via* a serial mediation model. The results of this study suggest that attention control and fear of missing out partially mediate the relationship between mindfulness and social media addiction. Consequently, in this study, we confirmed a direct link between mindfulness and social media addiction in Chinese college students (38). We found that mindfulness, through three paths, influence social media addiction, and that these three paths are: attention control, fear of missing out, and attention control → fear of missing out. These results help us further our understanding of the relationship between mindfulness and social media addiction, and provide theoretical support for future mindfulness interventions for social media addiction.

Firstly, we demonstrated the mediating role of fear of missing out in mindfulness and social media addiction. Specifically, college students with higher levels of mindfulness had lower FOMO in the mobile social media environment, further reducing their possible

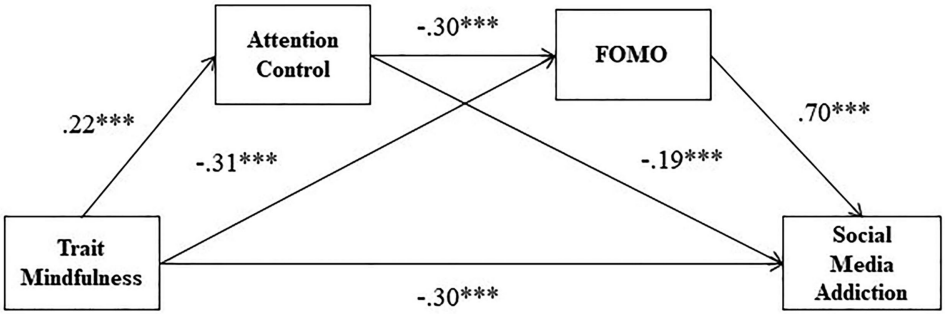

FIGURE 2
Theoretical research model with standard coefficients. Regression coefficients were obtained with gender, age, place of residence, only-child, and left-behind child, in covariates in PROCESS Procedure for SPSS, where *** denotes that $p<0.001$, $N=446$.

SMA. According to the mechanisms of mindfulness (40), college students with higher levels of mindfulness might reduce SMA by allowing FOMO to settle, by identifying and accepting it. SMA and FOMO were found to be negatively related to mindfulness in the southeastern United States (26), India (69), and the Middle East (70) in previous researches. Consistently, similar relationships among SMA, FOMO, and mindfulness were also found in Chinese sample in our present study. Moreover, the effect of mindfulness on social media addiction through FOMO was the highest in this study, up to 36.68%. This percentage underscores the role of FOMO in how mindfulness affects the SMA process. This result suggests that reducing FOMO might be an important mechanism by which mindfulness changes social media addiction. However, no effect of a mindfulness intervention on the FOMO in the Middle East sample was found (70). This may be attributed to the effectiveness of mindfulness intervention program design and implementation. Because they did not design mindfulness interventions specifically for FOMO, and implemented them in the form of psychoeducation rather than group psychotherapy. Social Media Mindfulness Practice had been proposed recently (38).

On the other hand, the correlation between FOMO and SMA in this study is greater than that in previous studies (37, 71). This discrepancy may stem from the COVID-19 pandemic, which indicates that the relationship between FOMO and social media addiction might have become stronger under the COVID-19 pandemic. Whether this pathway is dependent on the COVID-19 scenario deserves further exploration in the future.

Secondly, this study found a significant pathway of mindfulness → attention control → fear of missing out on social media addiction. This model suggests that the serial relationship between attention control and fear of missing out mediates the relationship between mindfulness and social media addiction. Studies have shown that increased mindfulness improves attentional function (39, 72). In our results, the negative correlation between attention control and FOMO is similar to previous results (50, 73). That is to say, in general, the higher the mindfulness of college students, the higher their attention control function might be, which might potentially lead to them producing less FOMO, and their reduced FOMO may further reduce their potential social media addiction. Some evidence from neuroscience suggests that selective attention and the activation of its inhibitory attention-related networks are associated with the suppression of emotions (74). We hypothesize that this may be a continuum: i.e., higher levels of mindfulness may improve individuals' attentional functions such as vigilance, sustained attention, and conflict monitoring, which may help identify some emotional precursors closely related to addictive behaviors and thus reduce the occurrence of addictive behaviors.

In terms of effect size, FOMO alone as a mediating role had the largest effect value, while attention control and FOMO as serial mediating roles has a small effect value. Therefore, the pathway of mindfulness → attention control → fear of missing out on social media addiction appears to play a limited role in mindfulness-based amelioration of social media addiction. On the other hand, these data suggest that mindfulness may reduce fear of missing out through other pathway, such as the non-judgment facet of mindfulness which was strongly and inversely related to negative affect and anxiety (75). Further research is needed in the future.

Finally, we verified the mediating effect of attention control on mindfulness and social media addiction. The results suggest that if college students have higher levels of mindfulness, their ability to control attention may also be higher. Such college students might effectively be able to control their attention, stay away from threatening information related to social media, and consequently reduce possible social media addiction (26). Previous studies have indicated that everyone can be distracted by excessive social media information, which can easily lead to attention fixation on social media information (76). However, a high level of mindfulness enables an individual to spot situations in which attention cannot be taken away in time (16). It seems that college students could also actively improve attention control ability to reduce the risk and behavior of social media addiction through Social Media Mindfulness practice. Because attention to current experiences and states is a core concept of mindfulness and can significantly enhance focused attention, which is one of the components of attention (77). However, the mediating effect size for attention control was small, and such results suggest that there might be more powerful mediating pathways for the effect of mindfulness on social media addiction. Therefore, when we design mindfulness for social media, we should not focus too much on attentional control.

This research has made several theoretical and practical contributions. On the one hand, we revealed that attention control and FOMO mediated the relationship between mindfulness and SMA by three paths, with an emphasis on the mediation of FOMO. On the other hand, our research suggests that mindfulness-based interventions might be an effective intervention to alleviate social media addiction, especially mindfulness-based interventions targeting FOMO.

Limitations

Our study may have some limitations as follows. The first limitation is related to our sample. We only carried out the survey in Guizhou and Hunan provinces in southern China, and therefore, follow-up research should expand the scope of the survey and utilize more representative population data. The proportion of women in this study reached 73.1%. Although we included gender as a covariate to control, future research should avoid imbalances in the gender ratio. Secondly, the present study is a cross-sectional study, only reflecting the degree of correlation between studies. In the future, longitudinal comparison will explain the causal relationship between variables. Thirdly, we only examined the mediating role of attentional control, and other facets of mindfulness will need to be further explored in the future, such as non-judgment, non-reactivity, and acting with awareness. Finally, we did not do any mindfulness intervention, although the conclusions have practical implications, they need to be confirmed by future intervention studies.

Conclusion

Mindfulness was significantly and negatively associated with social media addiction. Attention control and FOMO played mediating roles on the effect of mindfulness on social media addiction in parallel, with a large indirect effect value of FOMO, and a small indirect effect value of attention control. Attention control and FOMO also played mediating roles on the effect of mindfulness on social media addiction serially, but the indirect effect of serial mediating is small. Therefore, special emphasis should be placed on FOMO when designing social media mindfulness interventions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Guizhou Medical University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

CL and HC designed the study. HC, XM, YL, JL, WY, and JN collected and analyzed the data. CL and HC wrote the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Gender differences and left-behind experiences in the relationship between gaming disorder, rumination and sleep quality among a sample of Chinese university students during the late stage of the COVID-19 pandemic

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Background and aims: Studies have shown that gaming disorder (GD) is associated with rumination and poor sleep quality. However, the reciprocal relationship between GD, rumination and sleep quality is unclear. Moreover, the differences between gender and between left-behind experiences in the aforementioned relationship remain unknown. Therefore, the present study examined gender differences and left-behind experiences in the relationship between GD, rumination, and sleep quality among a sample of Chinese university students during the late stage of COVID-19 pandemic using a network analysis approach.

Methods: A cross-sectional online survey of 1,872 Chinese university students was conducted comprising demographic information (age, gender, and left-behind experience), gaming experience, gaming frequency, Gaming Disorder Test (GDT), Short Version of Rumination Response Scale (RRS), and Pittsburgh Sleep Quality Index (PSQI).

Results: Among Chinese university students, the prevalence of (i) GD was 3.5% and (ii) sleep disturbance was 14%. GD had positive and weak connection with rumination and sleep quality in the domain-level relational network. The network structures and global strengths both showed no significant differences between gender and between left-behind experiences. The nodes gd3 (*"continuation or escalation of gaming"*) and gd4 (*"gaming problems"*) had the strongest edge in the network.

Conclusion: The results suggest reciprocal relationships between GD, rumination, and sleep quality. Gender and left-behind experiences did not influence the reciprocal relationship between GD, rumination, and sleep quality during the late stage of COVID-19 pandemic. Using network analysis, the findings provide novel insights that rumination and sleep quality may have interacted with GD among Chinese students during the late stage of COVID-19 pandemic. Reducing

or eliminating negative rumination may decrease GD and improve sleep quality. Moreover, good sleep quality contributes to positive rumination which may decrease the risk of GD among Chinese university students.

KEYWORDS

gaming disorder, rumination, sleep quality, left-behind experience, network analysis

1. Introduction

1.1. Gaming disorder

Gaming disorder (GD) was recently included in the category "disorders due to addictive behaviors" in the 11th revision of the International Classification of Diseases (ICD-11), and comprises both online and offline variants (1). In China, the Disease Prevention and Control Bureau of China reported that most gaming addicts prefer online gaming, such as Massively Multiplayer Online Role-Playing Games (MMORPGs) and Multiplayer Online Battle Arena (MOBA) games (2). Therefore, GD in the present study refers to GD predominantly online [i.e., internet gaming disorder (IGD)]. GD may compromise real-life interpersonal relationships and academic performance, erode family harmony and impair psychological and physical health, resulting in such consequences as anxiety, depression, eye strain, and wrist pain (3, 4). As of December 2021 in China (where the present study was carried out), the number of online gamers was more than 553 million (53.6% of Chinese internet users), an increase of nearly 70 million compared to before the novel coronavirus disease-2019 (COVID-19) outbreak (483 million online gamers in December, 2018) (5, 6).

The COVID-19 pandemic has disrupted global daily life in lots of aspects, including the consumption of gaming (7). During the COVID-19 outbreak, many countries advised or ordered their citizens to stay at home to prevent the spread of the virus. Individuals confined to their home turned to online gaming and other online activities as a source of entertainment or leisure. Some scholars have indicated that gaming activities may have conferred lots of benefits during the COVID-19 pandemic, such as social communication and coping with negative emotion and stress (8). However, other research has suggested that videogame playing and GD has increased significantly among adolescents and emerging adults during the COVID-19 pandemic (9, 10).

1.2. Rumination

Nolen-Hoeksema, Wisco and Lyubomirsky (p. 400) defined rumination as "the process of thinking perseveratively about one's feelings and problems rather than in terms of the specific content of thoughts" (11). Rumination is associated with maladaptive cognition including unreasonable attribution, hopelessness, excessive self-criticism, and pessimism (12–14). Watkins and Roberts proposed a H-EX-A-GO-N model explaining the onset and maintenance of rumination (15). Habit development (H) and the perception of goal discrepancies (GO) lead to trait and state rumination, respectively. Abstract processing (A) and negative biases (N) may influence rumination, while executive functioning deficits (EX) may also cause depressive rumination (15). In addition, rumination and fear of COVID-19 were found to mediate the association between intolerance of uncertainty and mental well-being (16). Co-rumination following COVID-19 was regarded as a form of psychological inflexibility, which was associated with internalizing symptoms (e.g., passive attention and repetitively discussing problems) (17). Rumination may also exacerbate and prolong psychological distress and disturb sleep maintenance (11). In addition, a survey found that female adolescents reported more rumination and depression than males (18).

1.3. Sleep quality

Sleep quality is closely linked to individuals' health in many circumstances. Some scholars have indicated that the COVID-19 pandemic may have increased sleep problems and damaged the immune system function (19). Lockdown and self-quarantine during the COVID-19 pandemic have also changed sleep schedules and deteriorated sleep quality including postponing bedtime and waking time, reducing sleep at night time, and increasing napping during the day time (20). Insomnia induced by stressful events is a common body reaction, especially in the face of the COVID-19 pandemic. A meta-analysis from seven studies reported that the prevalence of sleep disturbance was 23% among Chinese higher education students during the COVID-19 pandemic (95% CI: 14%–32%) (21). A report indicated that sleep quality among university students during COVID-19 was worse than that prior to the pandemic (22). Moreover, depression, anxiety, and poor psychological resilience are associated with poor sleep quality.

1.4. Gender differences

There are significant gender differences in many mental disorders (e.g., anxiety disorders, depressive disorders, eating disorders, and GD) (23–26). In addition, females may experience more rumination than males (27). Lee, McEnany and Weekes reported gender differences in sleep patterns including more daytime sleepiness and large variations between weekday and weekend sleep schedules among young male adolescents compared to female adolescents (28).

1.5. Left-behind experiences

Left-behind experiences refer to individuals in childhood who have experienced the situation of being left behind in a rural region of China at least 6 months under the care of kin members, while

their parents became migrant workers in urban areas (29, 30). Left-behind children have been found to be more vulnerable to GD compared to non-left-behind children due to lack of parental care and supervision (31). In addition, left-behind experiences may influence an individual's mental health including Chinese university students (32, 33). In relation to some of the aforementioned variables, Yang and Liu reported that life events, self-esteem, and rumination were all associated with internalization problems among children with left-behind experiences (34). Moreover, children with left-behind experiences have been found to show more sleep problems and have been found to exhibit a higher prevalence of sleep problems (35).

1.6. The present study

To date, the relationship between gaming disorder, rumination, and sleep quality during the COVID-19 pandemic has not been investigated, especially utilizing network analysis. In addition, gender differences and left-behind experiences in relation to gaming disorder, rumination, and sleep quality among Chinese university students during the late stage of COVID-19 pandemic are also unclear. Therefore, gender differences and left-behind experiences between the aforementioned variables among Chinese university students during the late stage of the COVID-19 pandemic need to be examined.

2. Theoretical background

Based on the Conservation of Resources Theory (CRT) (36), individuals are motivated to retain, protect, and build all kinds of resources for surviving and maintaining well-being (37). The COVID-19 pandemic has changed some individuals' behavioral style, and impacted on their psychological and physical health (38). As for university students, they could not go to university and needed to take online classes at home, which may have made them anxious and depressed due to lack of face-to-face communication. One study surveying 405 Chinese university students reported that 44% had depression symptoms, 42.2% felt anxiety, and 29.4% had experienced stress because of home quarantine during the COVID-19 pandemic (39). Another study reported that 7.3% of Chinese college students had comorbidity of depression and anxiety because of home quarantine during the COVID-19 pandemic (40). Tang et al. reported more severe alexithymia among home-quarantined Chinese university students with depression ($n = 223$) or PTSD ($n = 73$) compared to home-quarantined Chinese university students without depression ($n = 2{,}262$) or PTSD ($n = 2{,}412$) during the pandemic (41). Finally, in a study among 7,800 Chinese college students, Ye et al. indicated the COVID-19 pandemic outbreak might induce acute stress disorder (ASD) due to home quarantine in the epidemic regions and found that the relationship between COVID-19-related stressful experiences (e.g., home quarantine) and ASD were mediated by resilience, better coping strategies, and social support (42).

For protecting and rebuilding various essential resources involving psychological and social resources (e.g., reducing stress and negative emotion due to COVID-19 and increasing social connection through online gaming), some individuals experiencing resource loss may try to escape from stress or increase social communication through engaging in problematic behaviors, such as substance use and gaming (37).

In the Interaction of Person-Affect-Cognition-Execution (I-PACE) model (43), predisposing (within-person) variables involving genetics, early childhood experiences (e.g., being left-behind), coping style (e.g., rumination), psychopathology, needs, motivation, and values, which arouse individuals' perception of external stimulus (online gaming) and demonstrate affective and cognitive responses, increasing gaming behaviors, and perhaps leading to GD in a minority of cases. In addition, based on the Responses Styles Theory (RST) (44), negative rumination as a cognitive bias and coping style may lead to gaming cue-reactivity and craving, further causing or exacerbating GD, while GD may also increase the experience of rumination.

Sleep quality is closely associated with physical, psychological, and social environmental factors, such as insomnia due to a medication or psychoactive substances, poor cognition and/or stress (e.g., rumination, PTSD and COVID-19) (45). For relieving and escaping negative emotion or satisfying social communication need during the COVID-19 pandemic, some adolescents and emerging adults engage in persistent or recurrent gaming behaviors, and ignore negative outcomes, such as poor academic performance and sleep disturbance, which may intensify individuals' reflection (i.e., rumination). Individuals may lose motivation to study hard and be trapped in self-denial anxiety based on the Self-Regulation Executive Function theory (S-REF) (46), which may impact sleep quality and further increase GD.

The power control theory has postulated that sex-role socialization may contribute to (i) taking risks and higher impulsivity among males and (ii) aversion and better self-control among females (47, 48). Gender rooted in social and cultural factors rather than biological, social, political, economic, and cultural differences and may produce different health risks between genders (49). In terms of the theory of children's psychological development, parent–child communication is one of the most important factors in promoting better child development (50). However, for better job opportunities and higher salaries, lots of rural parents in China have to work away from their family and are unable to take care of or supervise their children (i.e., left-behind children) due to lack of face-to-face communication. Consequently, left-behind children may experience poor school achievement, as well as greater physical and psychological health problems (51). Therefore, the gender and left-behind experiences were considered as the moderated variables to influence the interaction of the variables in the present study (i.e., GD, sleep, and rumination).

The network analysis approach has been applied widely in many fields of scientific research over the past 20 years. In the field of psychiatric research, network analysis has helped to explain mental disorders' core symptoms, comorbidity issues, the interaction of symptomatic elements, and possible influencing factors (52). Using network analysis, Yuan et al. found that the core symptoms of GD included preoccupation, loss of control (53), and gaming irrespective of negative outcomes using the nine-item Internet Gaming Disorder Questionnaire (54). Collins et al. identified three components of rumination including brooding, reflective pondering, and difficulty trusting positive feelings using a network analysis approach (55). In addition, Marques and de Azevedo proposed the potentialities of network approach for sleep medicine, such as accounting for the psychological structure and relationship between sleep problems, and describing comorbidity conditions (56).

In the motivation-cognition-behavior model of Internet Gaming Disorder (IGD), rumination as a maladaptive cognition is a high-risk factor of IGD (57). Moreover, GD may increase rumination about gaming behaviors and result in a vicious cycle of GD (57). Some studies have reported that the severity of GD is associated with poor sleep quality and greater psychological distress among Hong Kong university students (58). GD may cause negative consequences including sleep disturbance, poor academic performance, and psychological distress (45). In addition, sleep problems may also cause or exacerbate various mental disorders including internet addiction and GD (59, 60). Rumination has been found to be positively associated with subjective sleep quality after controlling variables of negative mood (61). Zoccola, Dickerson, and Lam also indicated that rumination may predict longer sleep onset latency after individuals experience acute psychological stress (62). In addition, the inability to fall asleep after going to bed may trigger ruminative thought (63). Qiu et al. have indicated that online risky behavior including GD and social networking site addiction may impact on sleep quality through rumination and anxiety as mediators among Chinese university students (64). Based on the dysfunctional metacognitions concerning gaming (65), individuals with IGD often tend to ruminate (i.e., thinking out videogames) even when they are not gaming, which may increase sleep disturbance and lead to a vicious cycle (57).

3. Hypotheses

Most studies have indicated that males have higher prevalence of GD than females (26, 66, 67). Some scholars have also indicated gender differences in rumination with females being more likely than males to engage in rumination (27, 68). In addition, female students have been found going to bed and getting up earlier, having longer sleep latency, and poorer sleep quality than males (69). Based on the aforementioned literature, it was hypothesized that there would be gender differences in network structure and global strength of GD and rumination and sleep quality (H_1).

Left-behind experiences are predictive of a greater risk of psychiatric morbidity for university students into early adulthood (70). Individuals with left-behind experiences are more likely to be at higher risk of behavioral addiction (e.g., GD and internet addiction) (31). Left-behind experiences are also associated with rumination and poor sleep quality, respectively (34, 35). Based on the aforementioned literature, it was hypothesized that the network structure and global strength of GD and rumination and sleep quality will be different between those with left-behind experiences and those without left-behind experiences (H_2).

4. Methods

4.1. Participants and procedure

The present study was a cross-sectional survey investigation. Convenience sampling was utilized to collect data from eight universities in four provinces of China (i.e., Heilongjiang, Jiangxi, Liaoning, and Shannxi) from September, 2021 to December, 2021. Participants were recruited with the incentive of gaining course credits. The total of 2,322 participants (Heilongjiang 456, Jiangxi 883, Liaoning 637, and Shannxi 346) completed the online survey. The inclusion criterion for the participants was to have played videogames in the past year. In addition, 440 non-gamers were excluded along with 10 participants due to missing data. Therefore, the remaining sample was 1872 Chinese university students (males = 930, females = 942) ranging from 17 to 24 years (mean = 19 years; SD = 1.7). Participants were informed of the study purpose and completed the survey voluntarily. The whole survey took approximately 10 min for participants to complete.

4.2. Measures

4.2.1. Gaming experience, gaming frequency, and left-behind experience

Gaming experience was assessed with the question "How many years have you played videogames?," and gaming frequency was assessed with the questions "How many days a week do you play videogames?," and "How many hours do you play videogames on weekdays and weekends, respectively?." Left-behind experiences was assessed by the question "Have you experienced the situation of being left behind in a rural region for at least 6 months, while your parent or parents became migrant workers in urban areas?" and answered either "Yes" or "No."

4.2.2. Gaming disorder

The four-item Gaming Disorder Test (GDT) was used to assess the severity of GD, and has been shown to have very good reliability and validity among Chinese university students (71). Items are rated on a five-point scale ("*never*," "*rarely*," "*sometimes*," "*often*," or "*very often*"). Pontes et al. recommended that at least one of items should be answered 4 ("often") or 5 ("very often") to distinguish between potentially disordered and non-disordered gamers (71). In the present study, the Cronbach's alpha and McDonald's ω were 0.833 (CI: 0.821~0.845) and 0.838 (CI: 0.825~0.850).

4.2.3. Rumination

The 10-item short version of Rumination Response Scale (RRS) was used to assess the level of rumination and comprises two factors (i.e., brooding and reflection) (72). The RRS has been shown to have very good reliability and validity among Chinese university students (73). Every item is rated on a four-point scale from 1 ("*never*") to 4 ("*very often*"), with higher scores indicating a higher level of rumination. In the present study, the Cronbach's alpha and McDonald's ω were 0.915 (CI: 0.909~0.920) and 0.916 (CI: 0.911~0.922).

4.2.4. Sleep quality

The 19-item Pittsburgh Sleep Quality Index (PSQI) (74) was used to assess sleep quality. The PQSI has been shown to have very good reliability and validity among Chinese populations (75, 76). The PSQI comprises seven factors including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, used sleep medication, and daytime dysfunction. The PSQI global score ranges from 0 to 21 and a score of more than 7 indicates higher sleep disturbance symptoms or poorer sleep quality (74, 75). In the present study, the Cronbach's alpha and McDonald's ω were 0.646 (CI: 0.623~0.668) and 0.685 (CI: 0.663~0.707).

4.3. Statistical analysis

JASP software (77) was utilized to conduct statistical descriptions including demographic data, gaming experience and frequency, and the prevalence rates of GD and sleep disturbance. Other statistics included *t*-tests (i.e., gender differences and left-behind experiences), Pearson/Bayesian correlation analysis between variables, reliability coefficients of all scales, and EBICglasso network analysis. Cohen's *d* and Bayesian correlation may provide effect sizes of significant difference. RStudio 3.4.4 software including qgraph and bootnet packages were used to calculate bridge centrality (78), edge-weight accuracy, centrality stability, and to test for significant differences (79), while NetworkComparisonTest packages were used to conduct network comparisons (80).

The network model was estimated to show the characteristics of node and edge as the important study variables through the graphic least absolute shrinkage and selection operator (LASSO) method, which is based on the Extended Bayesian Information Criterion (i.e., EBICglasso). The centrality of nodes was calculated through betweenness, closeness, strength and expected influence (81, 82). Bridge centrality was calculated through betweenness, closeness, strength, expected influence (1-step), and expected influence (2-step) to identify bridge symptoms (78), which may display the bridge symptoms between mental health problems. Edge-weight accuracy, centrality stability and testing for significant differences of nodes and edges need to be examined for assessing the network accuracy (79). The non-parametric bootstrap (i.e., 1,000 samples) was utilized to calculate edge-weight accuracy and testing for significant differences of nodes and edges, while the case-dropping subset bootstrap (95% confidence intervals) was utilized to assess the stability of centrality indices (79). The correlation stability coefficient (*CS*-coefficient, at least ≥0.25) indicated the node centrality stability (79). The stronger connection of nodes was indicated by thicker edge. The network comparison test (NCT) was carried out for gender and different left-behind experiences.

4.4. Ethics

The study was approved by the first author's university Ethics Committee (Ref: 20BY184). Informed consent was provided by all participants.

5. Results

5.1. Descriptive statistics and correlation analysis

For GD, 632 participants (33.8%, males = 251, females = 381) chose "never" on all items, 1,174 participants (62.7%, males = 636, females = 538) reported "rarely" or "sometimes" for one item, 39 participants (2.1%, males = 26, females = 13) reported one indicator of GD (i.e., "often" or "very often"), 14 participants (0.7%, males = 9, females = 5) reported two indicators of GD, three participants (0.2%, males = 2, females = 1) reported three indicators of GD, and 10 participants (0.5%, males = 6, females = 4) reported all four indicators of GD (Appendix S1). The prevalence of GD (i.e., at least one indicator on the GDT) was 3.5%. In addition, 1,610 participants (86.0%, males = 801, females = 809) had good sleep quality, while 262 (14.0%, males = 129, females = 133) reported poor sleep quality. The mean number of hours of playing videogames on weekdays and weekends were 2.02 h (SD = 2.31) and 2.71 h (SD = 2.46), respectively. Of all participants, 616 university students had left-behind experience and 1,256 had no left-behind experience. In addition, mean value of rumination was 19.86 out of 40 (SD = 6.01).

The participants' characteristics and the bivariate correlation analysis are presented in Tables 1 and 2, respectively. There were significant differences in GD, gaming experience (number of years spent gaming) and gaming frequency (hours spent gaming daily, number of days a week spent gaming) between gender (all *p*-values < 0.001, Cohen's $d > 0.4$). There were no significant differences in GD, rumination, and sleep quality in relation to left-behind experiences (all Cohen's $d < 0.2$). GD was significantly and positively associated with rumination, PSQI total score, subjective sleep quality, sleep latency, sleep disturbance, and daytime dysfunction (all *p*-values < 0.01, log[BF10] > 3). The frequencies of the seven PSQI factors are shown in Appendix S2. Using sleep medication had the lowest frequency (0.2%), while daytime dysfunction had the highest frequency (9%).

5.2. EBICglasso network analysis

The GD, rumination, and sleep quality networks are shown in Figure 1A (i.e., the domain-level including four items of GD, and the total rumination and PSQI scores) and Figure 1B (i.e., the item-levels including the four GD items, the 10 rumination items, and the seven PSQI factors). GD was connected with rumination and sleep quality. In the 1A network, the strongest edge identified was between node gd3 ("*continuation or escalation of gaming*") and gd4 ("*gaming problems*"; $r = 0.476$; Appendix S3), and gd3 was the strongest central node (betweenness = 1.379, closeness = 1.327, strength = 1.128, expected influence = 1.128; Appendix S4). The edge-weight accuracy and centrality stability are shown in Figures 2A,B, respectively. Most of edge-weights with wide bootstrapped CIs (Figure 2A) indicated that the order of the edges should be interpreted carefully. The CS-coefficient indicated that the node strength performed better [$CS_{(cor=0.7)} = 0.75$; CS > 0.5]. The tests for significant differences are shown in Appendix S5. The edges gd3–gd4, gd1 ("*impaired control*")-gd2 ("*increasing priority*"), and gd2–gd3 were significantly different from one another. All node strengths were significantly different from one another. In the 1B network, gd3 ("*continuation or escalation of gaming*") and gd4 ("*gaming problems*") had the strongest edge ($r = 0.455$). Moreover, sleep duration and habitual sleep efficiency ($r = 0.436$), and r3 ("*Think 'Why do I always react this way?'*") and r4 ("*Go away by yourself and think about why you feel this way*"; $r = 0.424$) also had stronger edges (Appendix S6). The node r3 had the highest strength and expected influence (Appendix S7). The CS-coefficient indicated that the node strength performed better [$CS_{(cor=0.7)} = 0.75$; CS > 0.5]. The edge-weight accuracy, centrality stability, and tests for significant differences are shown in Appendix S8. In addition, the nodes gd3 ("*continuation or escalation of gaming*"), gd4 ("*gaming problems*"), r10 ("*go someplace alone to think about your feelings*"), and DD ("*daytime dysfunction*") were significant bridge symptoms among those with GD (Figure 3). Bridge

TABLE 1 Sociodemographic characteristics.

Variables	Total (n = 1,872)	Gender		t	p	*Cohen's d*	Left-behind experience		t	p	*Cohen's d*
		Male (n = 930)	Female (n = 942)				Yes (n = 616)	No (n = 1,256)			
Age (years)	19.0 ± 1.8	19.0 ± 1.8	19.0 ± 1.7	0.011	0.991	5.271e-4	19.22 ± 1.79	18.88 ± 1.72	3.997	<0.001	0.197
Years spent gaming	5.504.03	6.68 ± 4.06	4.34 ± 3.65	12.926	<0.001	0.607	5.36 ± 3.88	5.58 ± 4.10	1.105	0.269	0.055
Gaming days per week	3.65 ± 2.39	4.43 ± 2.29	2.88 ± 2.23	14.476	<0.001	0.684	3.72 ± 2.41	3.62 ± 2.38	0.809	0.418	0.041
Weekday gaming hours	2.02 ± 2.31	2.48 ± 2.64	1.56 ± 1.84	8.618	<0.001	0.406	2.08 ± 2.27	1.99 ± 2.34	0.777	0.437	0.039
Weekend gaming hours	2.71 ± 2.46	3.48 ± 2.87	1.95 ± 1.65	14.236	<0.001	0.658	2.82 ± 2.32	2.65 ± 2.52	1.369	0.171	0.067
Gaming disorders	6.45 ± 2.60	6.99 ± 2.78	5.93 ± 2.28	9.019	<0.001	0.417	6.73 ± 2.71	6.32 ± 2.53	3.201	0.001	0.157
Rumination	19.86 ± 6.08	20.07 ± 6.25	19.65 ± 5.91	1.472	0.141	0.068	20.12 ± 6.17	19.73 ± 6.03	1.309	0.191	0.064
Sleep quality	4.70 ± 2.67	4.55 ± 2.75	4.84 ± 2.58	2.405	0.016	0.111	5.02 ± 2.66	4.54 ± 2.66	3.619	<0.001	0.178

centrality indices are shown in Appendix S9. The bridge expected influence was 0.595 (0.517~0.672) when the maximum drop proportions retained a correlation of 0.7 in at least 95% of the samples.

5.3. Network analysis for gender and left-behind experiences

EBICglasso models based on the domain and item level network analysis between variables for gender and different left-behind experiences are shown in Appendix S10. In the domain-level network, the strongest edges identified were between node gd3 and gd4 among males (r = 0.454) and among females (r = 0.498; Appendix S11), and gd3 was the strongest central node (for males 1.355 and females 1.078; Appendices S12, S13). In the item-level network, r3 was the strongest node among males (2.566), while gd4 as the strongest node among females (1.40; Appendices S14, S15). In addition, for different left-behind experiences, nodes gd3 and gd4 both had the highest edge weight (for non-left-behind experience 0.492 and left-behind experience 0.424) in the domain-level network. Nodes gd3 and gd2 were the strongest central node among non-left-behind experience (1.166) and left-behind experience (1.010), respectively. Moreover, nodes r3 and used sleep medication (USM) were the strongest nodes among non-left-behind experiences (1.739) and left-behind experiences (3.596) in the item-level network, respectively (Appendices S16–S20).

5.4. Network comparison between gender

As for the NCT, the network structures and global strengths both had non-significant differences between gender at the domain-level (M = 0.085, p = 0.71; 2.09 vs. 1.99, p = 0.19) and the item-level (M = 0.140, p = 0.202; 8.47 vs. 7.88, p = 0.095), respectively.

5.5. Network comparison between different left-behind experiences

The network structures and global strengths also had non-significant differences between different left-behind experiences at the domain-level (M = 0.111, p = 0.38; 2.10 vs. 2.02, p = 0.351) and the item-level (M = 0.080, p = 0.998; 8.27 vs. 8.13, p = 0.777), respectively.

6. Discussion

In the present study, the prevalence of GD was 3.5% among Chinese university students based on Pontes et al.'s recommendation that at least one indicator of GD in the GDT was scored "often" or "very often" (to distinguish between disordered and non-disordered gamers) (71). This rate is similar to previous studies [3.3%, Kim et al. (83); 3.05%, Stevens et al. (26)]. The below-average rate (5%) (2) may be due to lack of a more representative sample of young people (e.g., the present study did not include adolescents at middle schools and high schools, vocational schools, and school-leavers). The prevalence

TABLE 2 Correlation analysis of the study variables.

	GD	Rumination	PSQI	SSQ	SL	SD	HSE	SDD	USM
Rumination	0.192**								
log(BF_{10})	31.687								
PSQI	0.235**	0.25**							
log(BF_{10})	49.613	56.529							
SSQ	0.216**	0.148**	0.713**						
log(BF_{10})	41.052	17.107	660.903						
SL	0.147**	0.137**	0.687**	0.482**					
log(BF_{10})	16.755	14.097	593.622	243.489					
SD	0.071**	0.114**	0.457**	0.154**	0.101**				
log(BF_{10})	1.200	8.732	215.499	18.974	6.071				
HSE	0.021	0.037	0.413**	0.118**	0.122**	0.286**			
log(BF_{10})	−3.114	−2.257	170.725	9.490	10.380	76.190			
SDD	0.170**	0.209**	0.629**	0.415**	0.389**	0.121**	0.054*		
log(BF_{10})	23.849	38.280	467.038	172.646	149.761	10.212	0.773		
USM	0.072**	0.071**	0.251**	0.123**	0.145**	0.060**	0.046*	0.105**	
log(BF_{10})	1.282	1.155	57.047	10.609	16.195	−0.145	−1.598	6.721	
DD	0.207**	0.244**	0.715**	0.433*	0.333**	0.208**	0.025	0.421**	0.099**
log(BF_{10})	37.306	53.945	665.008	190.590	106.537	37.708	−2.966	178.982	5.712

**p <0.01, *p <0.05. GD, Gaming disorder; PSQI, sleep quality; SSQ, Subjective sleep quality; SL, Sleep latency; SD, Sleep duration; HSE, Habitual sleep efficiency; SDD, Sleep disturbance; USM, Used sleep medication; DD, Daytime dysfunction.

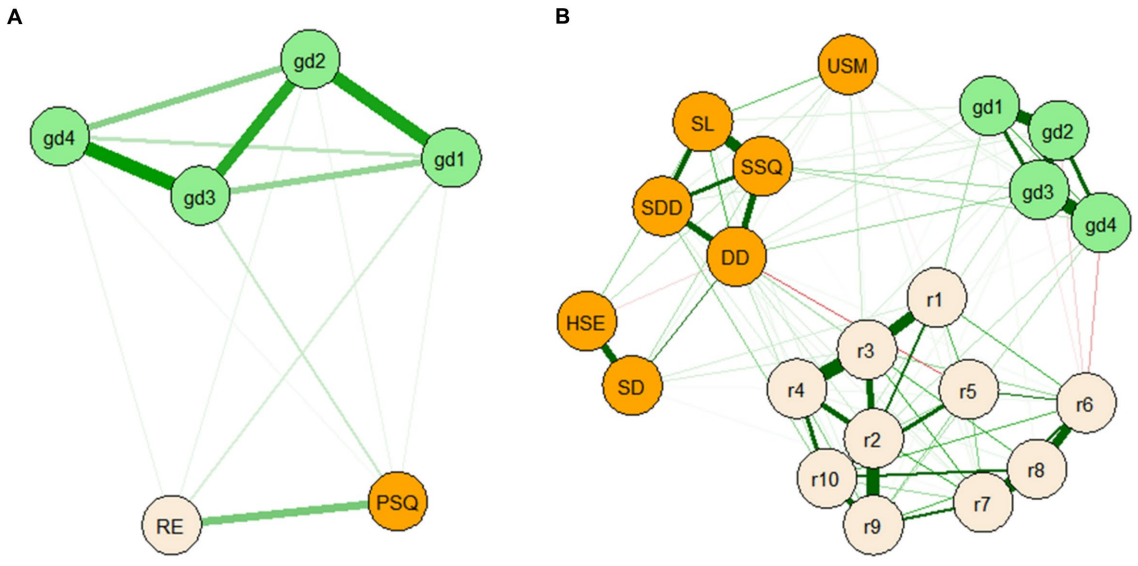

FIGURE 1
EBICglasso model based on the domain-level **(A)** and the item-level **(B)** network analysis according to the relationships between GD, rumination and sleep quality among 1,872 participants. gd1~gd4, Gaming disorder; RE, r1~r10=Rumination; PQSI, Sleep quality; SSQ, Subjective sleep quality; SL, Sleep latency; SD, Sleep duration; HSE, Habitual sleep efficiency; SDD, Sleep disturbance; USM, Used sleep medication; DD, Daytime dysfunction.

of sleep disturbance was 14.0% among Chinese university students during the late stage of COVID-19 pandemic, which was consistent with a previous study (13.93% [PSQI ≥8]) (84). Zhou et al. reported that the prevalence of sleep quality was 18.4% using the same instrument and evaluation criteria (i.e., PSQI >7/≥8) among frontline health professionals during the COVID-19 outbreak (85).

Some studies have indicated poorer sleep quality due to using different assessment tools or the same assessment tool with different cutoff criteria (e.g., PSQI ≥ 5) (86, 87). Most Chinese university students in the present study reported good sleep quality which may be due to when the survey took place. At that time of data collection, there were very few cases of COVID-19 in mainland China and most

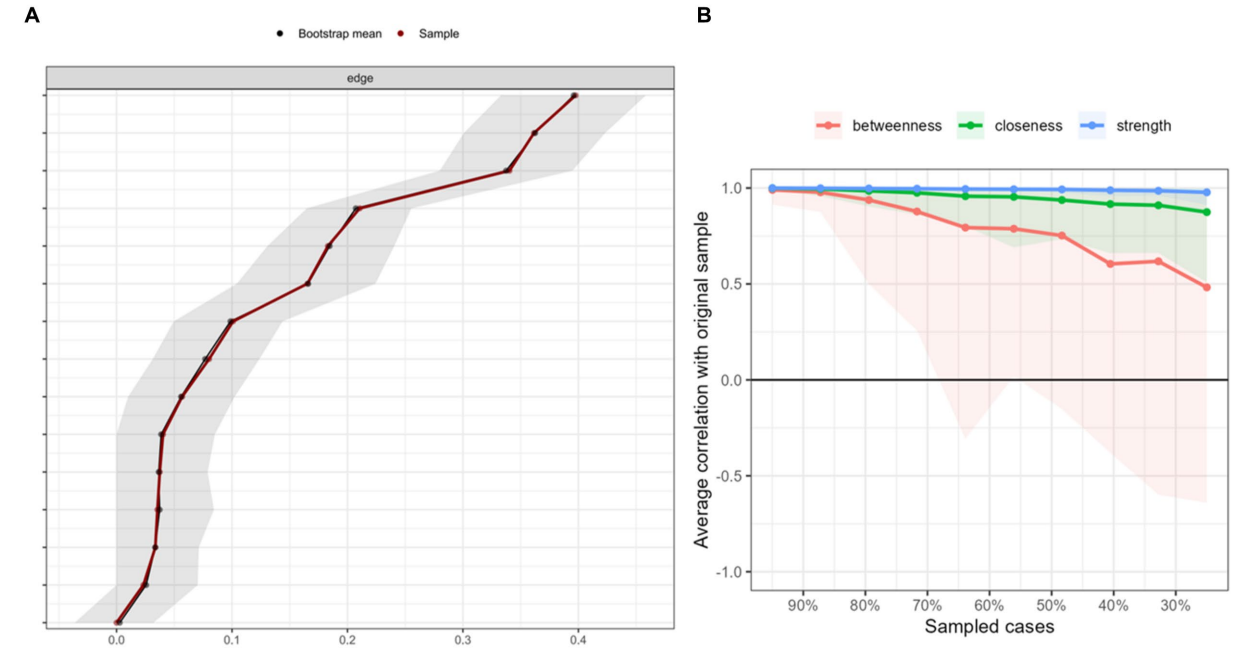

FIGURE 2
Bootstrapped confidence intervals of estimated edge-weights **(A)** and Case-dropping bootstrap procedure for node strength **(B)**.

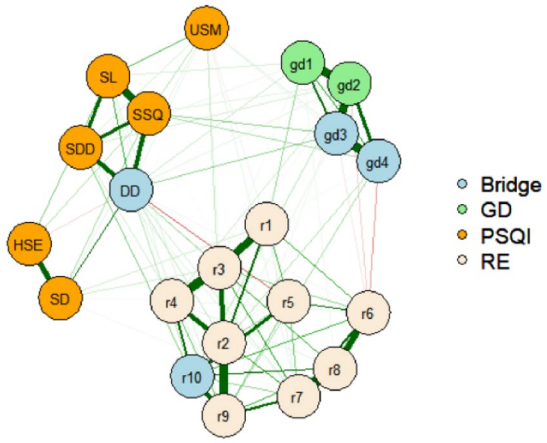

FIGURE 3
The item-level Network structure according to the relationships between GD, rumination and sleep quality among 1,872 participants. gd1~gd4, Gaming disorder; r1~r10=Rumination; SSQ, Subjective sleep quality; SL, Sleep latency; SD, Sleep duration; HSE, Habitual sleep efficiency; SDD, Sleep disturbance; USM, Used sleep medication; DD, Daytime dysfunction. Nodes identified as bridge symptoms are colored in blue.

of those reported were imported cases (total 25 cases of which 20 were imported cases) (88). Therefore, students are likely to have exhibited less sleep disturbance during the late stage of the COVID-19 pandemic compared to earlier stages.

Males were found to be gaming more frequently and at higher risk of GD than females in the present study, and is consistent with the findings from recent meta-analytic studies (26, 66). Males often show internalization problems and adopt maladaptive coping strategies owing to social isolation, achievement, and competition (67, 89), which may increase the risk of GD by escaping negative emotions or satisfying psychological needs. In addition, there were no significant differences in GD, rumination and sleep quality between participants who had left-behind experiences and those who did not (all Cohen's $d < 0.2$). A previous study found that relative deprivation among children with left-behind experiences may predict GD, and that the relationship between relative deprivation and GD was mediated through deviant peer affiliation (90). Therefore, the impact of left-behind experiences on the variables studied here need to be further examined.

Correlation analysis between GD, rumination and sleep quality was consistent with previous findings which reported online risky behavior (e.g., excessive gaming) was positively associated with rumination and sleep quality, and indirectly impacted on sleep quality through the mediation of rumination and anxiety (64).

In the present study, the gd3 node ("*continuation or escalation of gaming*") and gd4 node ("*gaming problems*") had the strongest edge, which indicated that gd3 and gd4 may be considered as the core symptoms of GD diagnosis for psychologists and clinical psychiatrists. In addition, the gd3 node was positively connected with sleep quality, especially subjective sleep quality (SSQ) and daytime dysfunction (DD). The most plausible explanation is that problematic gamers spend so much time playing videogames that they sleep much less and experience poor sleep quality. In addition, r3 ("*Think 'Why do I always react this way?'*") and daytime dysfunction (DD) were the most important nodes in rumination and sleep quality, respectively. The "used sleep medication" (USM) factor connected with GD and rumination in the item-level network. Of all participants, only 2.4% used sleep medication at least once or more a week. The USM factor has been found to have a weaker correlation with the total PSQI than other factors among Chinese individuals without insomnia (75, 76). Some studies have found that online risky behaviors and internet

addiction are associated with sleep quality, but indirectly rather than directly influenced sleep quality through multiple mediation (e.g., rumination and anxiety as mediating factors) (64, 91). Therefore, further research examining the relationship between GD and sleep quality is needed.

In addition, gd4 was connected negatively with r6 ("*Think about a recent situation, wishing it had gone better*") and positively with r9 ("*Analyze your personality to try to understand why you are depressed*"), which indicates the close relationship between rumination and functional impairments of GD. In addition, the nodes gd3 ("*continuation or escalation of gaming*"), gd4 ("*gaming problems*"), r10 ("*go someplace alone to think about your feelings*"), and DD ("*daytime dysfunction*") were significant bridge symptoms among those with GD. This indicates the close association between GD, rumination, and sleep. Rumination accompanied by going someplace alone may increase daytime dysfunction, and lead to GD for a minority of gamers.

In the I-PACE model (43), rumination as a negative coping style (i.e., one of general predisposing variables) may lead to GD and sleep disturbance, while GD may increase positive rumination (e.g., getting gaming rewards and complete gaming tasks) and negative rumination (e.g., poor interpersonal relationship and academic performance), further increasing sleep disturbance. Sleep problems with day and night reversal may also increase rumination and exacerbate GD (60). Wood, Griffiths, and Parke reported that the negative aspects of time loss included loss sleep and a guilt feeling of "wasting time" (i.e., rumination) among videogame players, which also suggests an interaction between GD, rumination, and sleep quality (92). GD, rumination, and sleep quality appear to be connected using the network analysis approach in the present study and appear to display reciprocal interactions between the three variables, which was verified by the analyses of network accuracy and stability.

In the present study, no gender differences in the network structures and global strengths were found. Therefore, H_1 was not supported. Gender differences in GD may be associated with gaming motives and preferences, such as females liking gaming for building intimacy and recreation with males liking gaming for competition and escaping negative emotion (93, 94). More specifically, males prefer Massively Multiplayer Online Role-Playing Games (MMORPGs) and Multiplayer Online Battle Arena (MOBA) games, while females prefer casual games (95, 96). In addition, females have been found to experience greater rumination than males (26), which is inconsistent with the findings of the present study. This may be due to the different sampled populations (i.e., the present study used purely university students whereas the findings reported by Johnson and Whisman are from a meta-analysis with many different sampled populations) (27). More generally, rumination has been found to significantly predict online gaming addiction among Chinese adolescents (97). Moreover, gender has been shown to moderate the relationship between rumination and problematic online gaming, especially for males (98). Some studies from Europe noted that reports of country-specific COVID-19 deaths decreased subjective sleep quality, which predicted greater rumination and somatic complaints (99). Therefore, a longitudinal study examining the relationship between GD, rumination, and sleep quality should be conducted, especially to examine if the COVID-19 pandemic has had a sustained and strong psychological and physical impact on university students.

The numbers of left-behind children and migrant workers are increasing with high-speed economic development in China. Left-behind children report more psychopathology and less pro-social behaviors than non-left-behind children (100), while university students with left-behind experiences also have more mental health problems, such as somatization, depression, and anxiety (33). Therefore, the influence of left-behind experiences to the interaction of the aforementioned variables was examined based on the theory of children' psychological development. However, differences in left-behind experiences in network structures and global strengths were not found in the present study, and did not support H_2. The results indicated a similar network relationship between different left-behind experiences during the late stage of COVID-19 pandemic. Liu and Wang indicated that university students who had left-behind experiences during primary school had more mental health problems than those who had left-behind experiences at middle school (101), while being left-behind by two migrant parents was worse for mental health problems than being left-behind by only one migrant parent. These studies indicated that more complex factors (e.g., time of being left behind and being a single parent) may influence the relationship between left-behind experience and mental health (e.g., negative emotion and coping style), which may increase or decrease GD.

As of 25 November 2021, 2464.33 million doses of COVID-19 vaccine had been administered in China (102). Moreover, the majority of citizens have now had a third COVID-19 vaccine in mainland China. In addition, the government took strict measures to control the spread of COVID-19 coming into China (e.g., cutting off international flights and introducing quarantine measures for individuals entering mainland China from abroad), which provided health protection for Chinese citizens to live in greater peace and contentment. Therefore, during the late stage of COVID-19 pandemic, nearly all Chinese university students had conventional offline classes without quarantine and self-isolation when they took part in the survey. Apart from traveling abroad, life has now gone back to normal in China.

Some limitations need to be considered in the present study. First, the cross-sectional design and convenience sampling (eight universities in four provinces) meant the sample was not representative of all Chinese students and causal relationships between variables could not be determined. Second, sleep quality was not examined using objective and sophisticated experimental equipment but relied on subjective self-report. Self-report more generally is subject to other methods biases. Third, gamers were only defined based on the question *"Have you played video games in the past year?"* ("Yes" or "No"), which did not take into account individual variations in the frequency of gaming which could have impacted on the findings. Fourth, very little information was collected regarding gaming habits. Therefore, the validity of the variables concerning gaming experience and gaming frequency are somewhat restricted. Fifth, the types of videogames played were not examined, which may have limited the correlational analysis that could be conducted with various study variables (e.g., gender). In addition, the gaming genre engaged in and characteristics of left-behind experiences need to be further analyzed, such as investigating the number of parents who migrated to work elsewhere (i.e., mother, father or both), students' age when left-behind, and students' personality and resilience, all of which may have influenced mental health of students with left-behind experiences, as well as impacting GD, rumination, and sleep quality. Therefore, representative and objective assessment, as well as a trajectory analysis needs to be included in future studies.

7. Conclusion

The results suggested that GD was significantly associated with rumination and sleep quality. There were no significant differences found between gender and left-behind experiences in relation to GD in the network structures and global strengths during the late stage of COVID-19 pandemic. The findings provide novel insights that rumination and sleep quality may have interacted with GD among Chinese students during the late stage of COVID-19 pandemic. Reducing or eliminating negative rumination may decrease GD and improve sleep quality. Moreover, good sleep quality contributes to positive rumination, which may then decrease the risk of GD among Chinese university students.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving human participants were reviewed and approved by Gannan Medical university Ethics Committee (Ref: 20BY184). The patients/participants provided their written informed consent to participate in this study.

Author contributions

LLi and LLiu conceived and designed the study. LLi and ZN performed the experiments and wrote the first draft of the paper. LLi and MG analyzed and interpreted the data. SM and HZ contributed reagents/materials/analysis tools. MG edited and contributed to the revised paper. All authors contributed to the article and approved the submitted version.

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Conflict of interest

MG has received research funding from Norsk Tipping (the gambling operator owned by the Norwegian government). MG has received funding for a number of research projects in the area of gambling education for young people, social responsibility in gambling and gambling treatment from Gamble Aware (formerly the Responsibility in Gambling Trust), a charitable body which funds its research program based on donations from the gambling industry. MG undertakes consultancy for various gambling companies in the area of player protection and social responsibility in gambling.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1108016/full#supplementary-material

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The relationship between anxiety and internet gaming disorder in children during COVID-19 lockdown: a network analysis

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Background: Internet gaming disorder (IGD) has become a social problem in children. Evidence from previous studies has proven that anxiety is associated with IGD. However, IGD was always assessed as a whole based on total scores, and the fine-grained relationship between anxiety and IGD was hidden.

Objective: The present study aims to investigate the fine-grained relationship between anxiety and IGD in elementary school students during the COVID-19 lockdown, and to identify potential targets for psychological interventions.

Methods: During the lockdown caused by the COVID-19 pandemic, 667 children from a primary school in China were investigated by the Spence Children's Anxiety Scale-Short Version and Internet Gaming Disorder Scale. R4.1.1 software was used to construct a network model, assess bridge centrality, and test the robustness of the network and conduct a network.

Results: There were 23 cross-community edges (weight ranged from −0.03 to 0.12), and each node of anxiety was connected to different nodes of IGD. The nodes with the top 80th percentile bridge expected influence were A2 "social phobia" (0.20), A3 "panic disorder" (0.21) and IGD5 "escape" (0.22). The robustness of the network was acceptable.

Conclusion: From the perspective of network analysis, the present study explored the correlation pathways between anxiety and IGD in children and identified social phobia and panic disorder as the best targets for intervention to reduce IGD.

KEYWORDS

anxiety, internet gaming disorder, children, COVID-19, network analysis

1. Introduction

The 2020 national research report on internet access by minors shows that with the rapid development of new internet technologies, internet access by minors is becoming increasingly common. By the end of 2019, 175 million Chinese minors were internet users, accounting for 93.1% of the total number of minors, while the internet penetration rate of elementary school students was also high, at 89.4% (1). There is a trend of younger teenagers accessing the internet (2). Meanwhile, the childhood stage is a critical period for psychological development and personality formation (3). Children are curious about new things, good at imitation (4, 5), undisciplined and easily impulsive (6, 7). Therefore, children are more likely to be addicted to the internet than more mature individuals (8), and one of the main types of internet addiction is internet gaming disorder (IGD) (9). IGD is described as being addicted to online games for a long time and developing a strong sense of dependence and continuous craving behavior (10, 11).

The current diagnosis and definition of IGD mainly relies on the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) published by the American Psychiatric Association in 2013 (12), which lists nine diagnostic criteria for IGD: addiction to games; increased tolerance; giving up other activities to play games; reckless disregard for the adverse effects; using games as a way to cope and escape negative emotional experiences; social/occupational disruptions because of playing games; trying and failing to control online game time; deliberately hiding online game-related problems; and becoming irritable and temperamental if they cannot access the internet. During the outbreak of COVID-19, school closures, prolonged isolation at home, and reduced offline interactions increases the risk of IGD (13). IGD causes psychological and physical damage to children (14–17), jeopardizes social skills and academic performance (18), and even leads to suicide and delinquency (19–21). In light of these findings, there is an urgent need to explore the mechanisms of IGD in elementary school students to provide targets for early psychological intervention.

Evidence from previous studies has proven that anxiety is associated with IGD (22, 23). Individuals with anxiety disorders are more likely to socialize online, overuse smartphones and be addicted to online games (24–26). Currently, influenced by all kinds of media information and uncertainty about the perceived risk of the epidemic, people are more anxious in the face of the COVID-19 lockdown. Therefore, the relationship between anxiety and IGD during the pandemic has attracted the attention of researchers. Fazeli et al. (13) found that IGD significantly influenced anxiety and depression symptoms in adolescents during the COVID-19 epidemic. Wang et al. (27) found that adolescents with anxiety disorders were more likely to develop IGD in the presence of fear of missing out. Elhai et al. (28) found that COVID-19 anxiety was strongly associated with smartphone use.

However, in previous studies investigating the relationship between anxiety and IGD, IGD was always assessed as a whole based on total scores (29). Indeed, the DSM-5 diagnostic criteria for IGD contain nine heterogeneous symptoms, and each symptom may be sensitive to specific risk factors and represent a unique risk pathway mechanism. The correlation based on the total score hides the fine-grained relationship between the different symptoms of anxiety and IGD (30). In addition, previous correlation studies cannot provide intervention targets at symptom level because there was no measure that quantifies the relative importance of items.

Network analysis is a promising statistical method to solve these problems. As data-driven processing that does not rely on a priori assumptions about the relationships between variables (31), network analysis helps reveal the relationships between psychological variables at the fine-grained level. The network structure consists of nodes representing psychological variables and lines representing statistical relationships between variables (32). Compared with traditional statistical correlation research, network analysis has the following advantages: (a) the ability to clarify fine-grained relationships between variables (33); (b) the potential to avoid spurious correlations due to a large number of variables (34); (c) visualization of association patterns between different variables (35); and (d) the capacity to assess the relative importance of variables by providing a centrality index (36). The term community is used to denote a theory-based set of psychological variables, and index bridge centrality helps to accurately capture the variables that play a key role in bridging communities (37), these bridge variables are often considered as potential targets for psychological intervention. Thus, network analysis may help deepen our understanding of the relationship between anxiety and IGD and provide targets for psychological intervention.

In summary, based on network analysis, the present study investigated the fine-grained relationship between anxiety and IGD in elementary school students during the COVID-19 lockdown. We developed a network model to explore the correlation pathways between the symptoms of anxiety and IGD and assessed bridge centrality to provide a theoretical basis for identifying effective symptom targets for psychological interventions.

2. Materials and methods

2.1. Participants

In April 2022, during the lockdown caused by the COVID-19 pandemic, a cluster sample of children in Baoding City, China, was investigated. Inclusion criteria: (a) children from the elementary grades of primary school; (b) isolated at home for at least 1 week due to the COVID-19 epidemic; (c) clear consciousness and normal perceptual function; (d) volunteered to participate in the study and provided the informed consent. Exclusion criteria: (a) cognitive dysfunction or communication disorder; (b) incomplete questionnaires. The Spence Children's Anxiety Scale-Short Version (SCAS-S) and Internet Gaming Disorder Scale (IGDS) powered by www.wjx.cn were used to survey the children after explaining the purpose and method

Abbreviations: COVID-19, coronavirus disease 2019; IGD, internet gaming disorder; SCAS-S, Spence Children's Anxiety Scale-Short Version; IGDS, Internet Gaming Disorder Scale; GGM, Gaussian graphical model; LASSO, least absolute shrinkage and selection operator; EBIC, extended Bayesian information criterion; BEI, bridge expected influence; CS-coefficient, correlation stability coefficient.

of the research to the children and their parents. The parents were required to read the questions and response options of each item to their children, and then the children answered according to their own feelings. A total of 722 questionnaires were distributed, and incomplete questionnaires were deemed invalid. Finally, 667 valid questionnaires were collected for an effective recovery rate of 92.38%. The present research followed the Helsinki Declaration and was approved by the Ethics Committee of Xijing Hospital of Air Force Medical University (Project No. CHiCTR1800019761).

2.2. Measures

2.2.1. SCAS-S

The SCAS-S was revised by Ahlen et al. (38) on the basis of the Spence Children's Anxiety Scale (39) to evaluate anxiety symptoms. The SCAS-S contains 19 items and consists of 5 dimensions, namely, separation anxiety, social phobia, panic disorder, physical injury fear and generalized anxiety. The SCAS-S is a Likert 4-point scoring scale: 0 = never, 1 = rarely, 2 = sometimes, 4 = always. The higher the score, the more severe the anxiety. The Cronbach's α of this scale in the present research was 0.80.

2.2.2. IGDS

The IGDS was compiled by Pontes and Griffiths (40) to assess IGD in the previous 6 months. The Chinese version of the IGDS revised by Jiang and Zeng (41) was used in this study. The nine items of the IGDS correspond to the nine diagnostic criteria for online game addiction in DSM-5, namely, preoccupation, tolerance, giving up other activities, continuing despite problems, escape, negative consequences, loss of control, deception, and withdrawal. IGDS is measured on a Likert 5-point scoring scale: 1 = never, 2 = often not, 3 = sometimes, 4 = often, and 5 = always. The higher the score, the stronger the tendency of IGD. The Cronbach's α of this scale in the present research was 0.89.

2.3. Statistical analysis

Statistics of demographic characteristics and scale scores were calculated by SPSS 22.0 software. Network model construction, bridge centrality analysis, and robustness tests were conducted by R4.1.1 software.

2.3.1. Network model construction

The Gaussian graphical models (GGMs) were fitted to the data (32). In the network model, nodes represented variables of SCAS-S and IGDS and were divided into anxiety community (separation anxiety, social phobia, panic disorder, physical injury fear, and generalized anxiety) and IGD community (preoccupation, tolerance, giving up other activities, continuing despite problems, escape, negative consequences, loss of control, deception, and withdrawal). Edges between nodes represented partial correlations after statistically eliminating interference from all other nodes (34). Edge color indicates the nature of the partial correlation, red edges suggest a negative correlation, blue edges suggest a positive correlation, edge saturation indicates the intensity of the partial correlation, and a more saturated edge suggests a larger partial correlation. The combination of least absolute shrinkage and selection operator (LASSO) (42) regularization and extended Bayesian information criterion (EBIC) (43) was used in network model construction to shrink small edges to zero weight and make the network stable and clear (44). To balance the sensitivity and specificity (45), the EBIC hyperparameter γ was set to 0.5. The Fruchterman-Reingold algorithm was used to build the network layout (46). The anxiety-IGD network model was constructed with the qgraph package (47).

TABLE 1 Demographic characteristics of the sample (n = 667).

Variables	Mean (SD), Range, %
Age	7.63 (0.65), 6–10
Male gender	396 (59.37%)
Educational level	
First grade	260 (38.98%)
Second grade	407 (61.02%)
Total anxiety score	13.73 (8.55), 0–46
Total score of IGD	13.59 (6.10), 9–42

2.3.2. Bridge centrality analysis

In the present study, the bridge expected influence (BEI) was estimated. As a kind of bridge centrality index, the BEI of a node is defined as the sum of the edge weights between the node and all nodes from other communities (37). In a bidirectional network, a higher value of BEI indicates a greater likelihood of affecting or being affected by other communities. The bridge centrality of nodes was evaluated by the networktools package (37).

2.3.3. Network robustness test

To test the network robustness, three operations were conducted. First, we estimated the 95% confidence interval of edge weights to evaluate the accuracy by non-parametric bootstrapping (1,000 bootstrapped samples). A relatively narrow 95% confidence interval ensures adequate accuracy of the edge weights (44). Second, we tested the stability of BEI by case-dropping bootstrapping (1,000 bootstrapped samples). We also calculated the correlation stability coefficient (CS-coefficient) to quantify the stability; a value larger than 0.5 of CS-coefficient indicates ideal stability (44). Finally, we tested the difference in the BEI indices of nodes and the difference in the edge weights of node pairs by bootstrapping (1,000 bootstrapped samples, α = 0.05). The network robustness was tested with the bootnet package (44).

3. Results

3.1. Demographic characteristics and descriptive statistics

The demographic characteristics of the sample are displayed in Table 1. The means and standard deviations of the variables in the anxiety-IGD network are displayed in Table 2.

TABLE 2 The means and standard deviations of variables in the anxiety-IGD network.

Variables	Mean (SD)
Dimensions of anxiety	
A1 separation anxiety	3.69 (2.43)
A2 social phobia	3.32 (2.35)
A3 panic disorder	1.05 (1.84)
A4 physical injury fear	2.70 (2.29)
A5 generalized anxiety	2.97 (2.50)
Items of IGD	
IGD1 preoccupation	1.69 (1.05)
IGD2 tolerance	1.78 (1.08)
IGD3 giving up other activities	1.38 (0.83)
IGD4 continuing despite problems	1.50 (0.89)
IGD5 escape	1.33 (0.81)
IGD6 negative consequences	1.38 (0.82)
IGD7 loss of control	1.52 (1.00)
IGD8 deception	1.50 (0.95)
IGD9 withdrawal	1.50 (0.99)

3.2. Fine-grained relationship between anxiety and IGD

The anxiety-IGD network is displayed in Figure 1A. Logically, there was a maximum of 45 edges across the communities in the network; in the present research, there were 23 cross-community edges (weights ranged from −0.03 to 0.12). Overall, positive edges accounted for the vast majority of cross-communities edges (86.96%). The positive cross-community edges contained A1 "separation anxiety"—IGD3 "giving up other activities" (edge weight = 0.04), A1 "separation anxiety"—IGD5 "escape" (edge weight = 0.02), A1 "separation anxiety"—IGD9 "withdrawal" (edge weight = 0.01), A2 "social phobia"—IGD1 "preoccupation" (edge weight = 0.04), A2 "social phobia"—IGD2 "tolerance" (edge weight = 0.04), A2 "social phobia"—IGD3 "giving up other activities" (edge weight = 0.06), A2 "social phobia"—IGD4 "continuing despite problems" (edge weight = 0.01), A2 "social phobia"—IGD6 "negative consequences" (edge weight = 0.04), A2 "social phobia"—IGD8 "deception" (edge weight = 0.02), A3 "panic disorder"—IGD5 "escape" (edge weight = 0.12), A3 "panic disorder"—IGD6 "negative consequences" (edge weight = 0.06), A3 "panic disorder"—IGD7 "loss of control" (edge weight = 0.02), A3 "panic disorder"—IGD9 "withdrawal" (edge weight = 0.01), A4 "physical injury fear" —IGD5 "escape" (edge weight = 0.01), A5 "generalized anxiety"—IGD1 "preoccupation" (edge weight = 0.003), A5 "generalized anxiety"—IGD4 "continuing despite problems" (edge weight = 0.03), A5 "generalized anxiety"—IGD5 "escape" (edge weight = 0.06), A5 "generalized anxiety"—IGD6 "negative consequences" (edge weight = 0.03), A5 "generalized anxiety"—IGD8 "deception" (edge weight = 0.01) and A5 "generalized anxiety"—IGD9 "withdrawal" (edge weight = 0.04). The negative cross-community edges contain A1 "separation anxiety"—IGD6 "negative consequences" (edge weight = −0.01), A4 "physical injury fear"—IGD6 "negative consequences" (edge weight = −0.03) and A4 "physical injury fear"—IGD8 "deception" (edge weight = −0.02). The correlation matrix of the network model can be found in Supplementary Table 1.

The accuracy test of edge weights is displayed in Supplementary Figure 1. The 95% confidence interval of edge weights in the anxiety-IGD network was relatively narrow, indicating that the edge estimation was accurate. The difference test of edge weights is displayed in Supplementary Figure 2.

3.3. Bridges between anxiety and IGD

The BEI is displayed in Figure 1B. The nodes with the top 80th percentile BEI were A2 "social phobia" (0.20), A3 "panic disorder" (0.21) and IGD5 "escape" (0.22). As shown in Supplementary Figure 3, the BEI indices of A2 "social phobia," A3 "panic disorder" and IGD5 "escape" were statistically larger than those of most other nodes. As described in Supplementary Figure 4, the average correlation of BEI indices of the subsample and the original sample showed a relatively gentle downward trend with the reduction of subsample. The value of the CS-coefficient on the BEI was 0.52, which was larger than 0.5, indicating adequate stability.

4. Discussion

Based on network analysis, the present study revealed the correlation pathways between anxiety and IGD in elementary school children during the COVID-19 lockdown and provided suggestions for IGD interventions through the evaluation of the BEI index. The stability and accuracy of the network model were acceptable, which guaranteed the reliability of our conclusion.

4.1. Correlation pathways between anxiety and IGD

The detailed relationships between variables revealed by network analysis can provide indications of the correlation pathways through which different aspects of anxiety affect IGD (48, 49). These correlation pathways may represent underlying interaction mechanisms of anxiety and IGD. In light of this, we discussed the most powerful pathways bridging various aspects of anxiety and contents in IGD.

Among the four pathways through which "separation anxiety" correlated with IGD, the strongest pathway was "separation anxiety"—"giving up other activities," while among the six pathways through which "social phobia" correlated with IGD, the strongest pathway was "social phobia"—"giving up other activities." Separation anxiety is described as the irrational fear or anxiety of being separated from family or close attachment (12, 50). According to Bowlby's attachment theory, the quality of parental care a child receives in early years has profound effects on future mental health (51). Children who do not receive effective care and attention from parents are incapable of dealing with separation anxiety. Many children have been separated from their

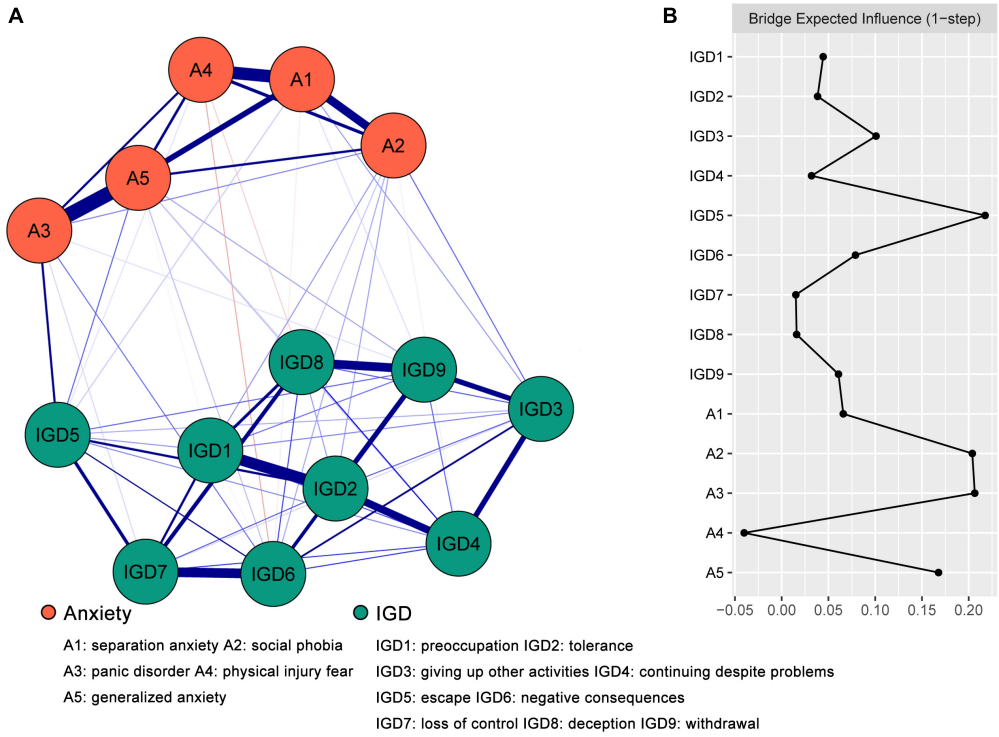

FIGURE 1
The anxiety-IGD network model and bridge expected influence (BEI). **(A)** The anxiety-IGD network model. The red edges suggested a negative correlation, while the blue edges suggested a positive correlation, and a more saturated edge suggested a larger partial correlation. **(B)** The bridge expected influence indices of the nodes in the network (raw score).

relatives and even parents due to the COVID-19 lockdown, and separation anxiety caused by the disruption of close relationships drives children to online games, which may meet their emotional requirements. Social phobia is described as the excessive fear of social occasions and interactions with others and may result in social isolation (52). Baker and Hudson (53) found that children with social phobia had narrower social networks and poorer friendship quality and were more likely to experience social alienation than children with other anxiety symptoms. This may be due to increased sensitivity to social exclusion and social withdrawal in adolescents with symptoms of social phobia leading to deficits in interpersonal skills (54). Therefore, children with social phobia tend to abandon offline social activities and indulge in virtual worlds. The reason is that the internet provides a platform for them to communicate anonymously.

Among the four pathways through which "panic disorder" correlated with IGD, the strongest pathway was "panic disorder"—"escape," while among the six pathways through which "generalized anxiety" correlated with IGD, the strongest pathway was "generalized anxiety"—"escape." Panic disorder is characterized by misinterpretations of explosive sensory and emotion, i.e., heart palpitations, dyspnea, dizziness, and near-death experience (55, 56). Inconsistent with panic disorder, generalized anxiety is characterized by persistent, relatively mild symptoms on most days for at least 6 months, such as nervosity, irritability, fatigue, attention and memory problems, and insomnia (12, 57, 58). Both panic disorder and generalized anxiety lead to evident negative emotional experiences, and when there is no appropriate outlet, such as during the COVID-19 lockdown, children often turn to online games to escape these emotional experiences.

Among the three pathways through which "physical injury fear" correlated with IGD, the strongest pathway was "physical injury fear"—"negative consequences." The symptoms of physical injury fear are similar to those of specific phobia; they all manifest as extreme and persistent fear of a certain object or situation, such as heights, tunnels, darkness, or worms (59). COVID-19 may cause death and sequelae (60), and related reports have led to increased sensitivity to physical injury fear. In addition, the children in the present study were too young to identify the authenticity of information, so they were excessively afraid of dangerous information and were prone to online gaming addiction, which could lead to a series of negative consequences.

4.2. Optimal targets for intervention

Anxiety is comorbid with IGD (61), and the activation of bridge symptoms can increase the risk of transferring from one disorder to another (37). In network analysis, bridge centrality explained the comorbidity and reciprocity of different disorders (62). The current study identified bridge symptoms between anxiety and IGD in children. Bridge symptom identification helps reveal fecund information on comorbidities and provide prioritized clinical targets to prevent co-occurrence (63, 64). The BEI indices of "social phobia" and "panic disorder" were the largest in the anxiety community. From the perspective of the network, the intervention

of "social phobia" and "panic disorder" has a greater impact on IGD than other nodes of the anxiety community, so they are potential best targets for interventions. Previous studies have confirmed the relationship between social phobia and IGD (65). In fact, children with social phobia have more personal space and time, which is a crucial risk factor for IGD (66). Given the acuteness and recurrence of panic disorder symptoms (67), individuals may have persistent worries, and online games may provide a distraction. Gaming online is an escape strategy to alleviate anxious emotions, and people may spend excessive amounts of time on online games as a coping mechanism to escape from the reality of their worries and difficulties (24–26). However, online gaming does not actually solve the problem, and wasting too much time on games makes things worse. A vicious cycle may further exacerbate psychological distress in people with IGD. Therefore, there is a need to implement targeted interventions to improve intervention efficiency and save medical resources.

Many intervention methods have been proven effective for anxiety. Cognitive behavioral therapy is the most experienced and effective psychosocial therapy for treating social phobia in adults and children (68); furthermore, the well-known Gestalt therapy is also effective in reducing anxiety in elementary school children (69). Finally, parent–child interaction therapy can prevent IGD by reducing the child's level of anxiety by establishing a good parent–child relationship (70, 71).

4.3. Limitations

Several limitations should be pointed out in the present study. First, since cross-sectional data were used in our research and the relationships in networks were bidirectional, the determination of causality needs further support from longitudinal research. Second, the sample scope was limited to students in elementary school. Although we aimed to detect and intervene as early as possible, the results may not be suitable for generalization to older children. Finally, there was no control group, and the comparison of networks of students in lockdown and those in school may provide more meaningful findings.

5. Conclusion

In conclusion, the visual network structure provided a delicate description of the correlation pathways between anxiety and IGD; the BEI comparison helped to determine the bridges between anxiety and IGD and recommended social phobia and panic disorder as the potential targets for intervention of IGD. This study represents the first application of network analysis to explore the relationships between anxiety and IGD in children during COVID-19 lockdown and provides a reliable reference for the practice of psychological intervention.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Xijing Hospital of Air Force Medical University (Project No. CHiCTR1800019761). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

TY, SJW, TX, and BW: concept and design. YY, SMW, RD, and ZP: acquisition of the data. TY, JL, and MY: analysis and interpretation of the data. TY, YH, CH, and LW: drafting of the manuscript. XL and SJW: critical revision of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1144413/full#supplementary-material

SUPPLEMENTARY FIGURE 1
Accuracy test of edge weights in the anxiety-IGD network. The red line indicates the sample edge weight values and the gray area indicates the bootstrapped confidence intervals. A1, separation anxiety; A2, social

phobia; A3, panic disorder; A4, physical injury fear; A5, generalized anxiety; IGD1, preoccupation; IGD2, tolerance; IGD3, giving up other activities; IGD4, continuing despite problems; IGD5, escape; IGD6, negative consequences; IGD7, loss of control; IGD8, deception; IGD9, withdrawal.

SUPPLEMENTARY FIGURE 2
Bootstrapped difference test of edge weights in the anxiety-IGD network. The black box indicates that the edge weights of the two corresponding node pairs have a significant difference, the gray box indicates no significant difference. Blue and red boxes on the diagonal correspond to edge weights with positive and negative correlations, respectively. A1, separation anxiety; A2, social phobia; A3, panic disorder; A4, physical injury fear; A5, generalized anxiety; IGD1, preoccupation; IGD2, tolerance; IGD3, giving up other activities; IGD4, continuing despite problems; IGD5, escape; IGD6, negative consequences; IGD7, loss of control; IGD8, deception; IGD9, withdrawal.

SUPPLEMENTARY FIGURE 3
Bootstrapped difference test of bridge expected influences in the anxiety-IGD network. The black box indicates that the bridge expected influences of the two corresponding nodes have a significant difference, the gray box indicated no significant difference. A1, separation anxiety; A2, social phobia; A3, panic disorder; A4, physical injury fear, A5, generalized anxiety, IGD1, preoccupation; IGD2, tolerance; IGD3, giving up other activities; IGD4, continuing despite problems; IGD5, escape; IGD6, negative consequences; IGD7, loss of control; IGD8, deception; IGD9, withdrawal.

SUPPLEMENTARY FIGURE 4
Stability of bridge expected influences in the anxiety-IGD network. The red bar represents the average correlation between bridge expected influences in the full sample and subsample with the red area depicting the 2.5th quantile to the 97.5th quantile.

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Effects of a virtual reality-based motivational reinforcement + desensitization intervention program on psychological craving and addiction memory in female MA-dependent young adults

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Objectives: The aim of this study was to explore the effects of a virtual reality (VR)-based motivational reinforcement + desensitization intervention program on psychological craving and addiction memory in female methamphetamine (MA)-dependent young adults.

Methods: We recruited 60 female MA-dependent young adults in a compulsory isolation drug rehabilitation facility in Sichuan Province, and randomly assigned them to intervention (mean age = 23.24 ± 2.06) and control groups (mean age = 23.33 ± 2.09). The intervention group received a VR-based motivational enhancement + desensitization intervention (total of eight sessions over a 4-week period), while the control group received regular detoxification management during the same period. Assessments were conducted before, immediately after, and 1 month after the intervention, with a visual analogue scale (VAS) being used to assess subjective craving, electronic sphygmomanometer employed to measure physiological parameters, and the Addiction Memory Intensity Scale (AMIS) applied to assess addiction memory intensity.

Results: Generalized estimating equation analysis showed significant main effects of group on changes in heart rate difference, systolic blood pressure difference, VAS and AMIS scores (all $p < 0.01$), and a significant time main effect on changes in diastolic blood pressure difference, VAS and AMIS scores (all $p < 0.01$), and a significant group × time interaction effect on changes in the difference values of three physiological parameters, VAS and AMIS scores ($p < 0.01$ or $p < 0.05$). After the intervention, the differences in three physiological parameters, and the VAS and AMIS scores, were significantly lower in the intervention than in the control group (all $p < 0.05$), and the difference between the two groups remained significant 1 month after the end of the intervention (both $p < 0.01$). VAS scores, heart rate difference, and diastolic blood pressure difference in the intervention group were significantly lower than baseline scores, both at the end of the intervention and 1 month thereafter (all $p < 0.01$); the systolic blood pressure difference in the intervention group was significantly lower at the end of the intervention than at baseline ($p < 0.05$); AMIS scores in the intervention group were significantly lower than the baseline scores 1 month after the end of the intervention ($p < 0.01$).

Conclusion: Our VR-based motivational reinforcement + desensitization intervention program can effectively reduce psychological craving and

physiological reactivity for drugs, and the intensity of addictive memories in female MA-dependent young adults, even after 1 month.

KEYWORDS

MA-dependent, VR, motivational reinforcement, desensitization, psychological craving, addictive memory

1. Introduction

Methamphetamine (MA) has high addiction and dependence potential, and is neurotoxic (1). Prolonged use can lead to adaptive changes in the nervous system and brain, resulting in strong psychological cravings and subsequent relapse. Relapse has always been the main focus and challenge for treating MA dependence. Motivation is closely related to treatment adherence and outcomes (2), but MA-dependent individuals are less motivated than individuals dependent on more traditional drugs of abuse (3). Strengthening motivation is a prerequisite for treatment. The persistence of addiction memories is key to the psychological craving experienced by addicts, and the behaviors that lead to relapse; interventions that target addiction memories have treatment efficacy. Compared with adults, the brains of young adults are more susceptible to psychological craving stimulated by addictive drugs (4), and adolescence is a critical period characterized by increased brain plasticity (5). During this period, it is important to strengthen the motivation of MA-dependent individuals and intervene to address their psychological craving and addiction memory to prevent relapse.

Intensive motivational treatment is a widely used approach in which the therapist employs certain strategies to help patients build and enhance their motivation and goals, and thus address their abusive behavior. Motivational interviewing is the main form of motivational intensive treatment, and can effectively improve the motivation and treatment adherence of MA-dependent individuals (6). According to memory reconsolidation theory, by interfering with the reconsolidation process of the original addiction memory, it is possible to modify or alter it, reduce the craving response after memory arousal, and decrease drug use behavior (7). A growing number of researchers are applying memory reconsolidation theory to addiction interventions. Research has shown that interventions that activate addiction memories and intervene in memory reconsolidation can be effective for reducing cravings and substance use behaviors in addicted individuals (8, 9). Virtual reality (VR) is based on computer technology that generates a three-dimensional environment with high similarity to the real environment in terms of sight, sound, and tactile sensations; the equipment allows people to fully interact with the environment, and generates immersive feelings and experiences (10). Due to the high ecological validity of VR technology, it is superior to traditional stimuli, such as pictures and videos, in terms of activating addictive memories and inducing craving (11). However, few studies have examined the efficacy of interventions that combine VR with memory reconsolidation intervention techniques, and there is even less evidence for the clinical efficacy of integrating motivational reinforcement into this approach.

In this study, we propose the use of motivational interviewing to enhance the motivation of MA-dependent adolescent females to detoxify, and use VR technology to create MA-related scenarios to activate their addiction memories and desensitize them during memory reconsolidation. We also evaluate the effects of this new method on the strength of addiction memories and psychological craving of female MA-dependent young adults.

2. Methods

2.1. Study design and participants

This was a randomized, controlled, single-blind, priority study. Sample size was calculated through the G*Power software, $\alpha = 0.05$, $1 - \beta = 0.95$, the number of levels of the between-group variable is 2, the number of repeated measurements is 3. In order to achieve a medium effect size, the calculated sample size required is 22 people per group. Due to the long study period, a 5% dropout rate was assumed based on the results of previous literature (12). Therefore, we aimed to recruit 30 people for each group.

We recruited 60 MA-dependent female young adults who met the inclusion criteria and exclusion criteria from a compulsory drug rehabilitation center in Sichuan Province, from June 10 to July 10, 2022. The inclusion criteria were as follows: (1) mainly use MA-type drugs; (2) meet the ICD-10 (International Classification of Diseases) diagnostic criteria for amphetamine-type drug dependence; (3) no brain trauma or history of mental illness; (4) normal vision (no color blindness or weak color vision); (5) aged 18–25 years; and (6) fully understand the study content. Exclusion criteria: (1) presence of drug use (e.g., heroin, cocaine); (2) brain injury and coma of more than 30 min; (3) history of mental illness or family history of mental illness; (4) visual acuity or corrected visual acuity of less than 1.0; (5) illiteracy.

After completing the recruitment process, we randomly assigned the eligible MA-dependent young adults to intervention and control groups (30 participants per group). Block randomization was used, with blocks of random length and random changes in block sizes (4, 6, or 8). A random number table was generated by the principal investigator and handed to a research assistant blinded to information relevant to the experiment. The assistant informed each participant of their group assignment. A pretest assessment of psychological craving, physiological parameters, and addiction memory intensity, using a visual analogue scale (VAS), electronic sphygmomanometer, and the Addiction Memory Intensity Scale (AMIS), was then administered to all participants. In the intervention phase, the intervention group received a VR-based motivational reinforcement + desensitization intervention, and the control group received regular detoxification management. We assessed the intensity of addiction memory,

physiological parameters, and psychological craving in both groups, immediately and 1 month after the end of the intervention.

This study was approved by the Medical Ethics Committee of Chengdu Medical College (approval number: 2022NO.23). All subjects voluntarily participated and signed the informed consent form. Subjects who did not want to continue to participate in the study for any reason could withdraw at any time.

2.2. Instruments

2.2.1. Virtual reality tools

This study used the PICO G2 device to create a VR environment. PICO G2 is a VR head-mounted display developed by Bird See Technology Co. (Beijing, China). The device can create VR scenes, including neutral and MA-related scenes. Neutral scenes: starry sky, grass, etc.; MA-related scenes: the whole process of a woman taking MA (Figure 1).

2.2.2. General information questionnaire

We self-designed a general information questionnaire to collect demographic information, including age, education level, marital status, and length and amount of drug use.

2.2.3. Visual analogue scale

A VAS (13) was used to evaluate the participants' subjective psychological craving for drugs. The VAS was initially used clinically to rate pain intensity, and has since been widely used in the field of addiction (14, 15). It has good validity for assessing subjective craving, and was the main outcome measure of this study. The VAS used in this study was a 10-cm line [left endpoint (0), "no craving at all"; right endpoint (100), "very strong craving"]. Subjects placed a mark on the VAS according to their degree of subjective drug craving, and the distance between the marked point and the left endpoint was taken as the craving score. Higher scores indicate higher subjective craving.

2.2.4. Instruments for measuring physiological indicators

Heart rate and blood pressure reflect an individual's altered emotional state and may indirectly reflect the participant's state of craving and addictive memory activation. Heart rate and blood pressure are the primary indicators of cue reactivity and are often considered objective measures of anxiety and craving responses (16). When patients with SUDs are exposed to drug-related cues, their heart rate and blood pressure may increase (17). In this study, heart rate and blood pressure were used as physiological indicators, and the differences in physiological indicators (physiological parameters after the VR experience - physiological parameters before the VR experience), was used as the primary outcome variable. Heart rate and blood pressure were measured using the CK-W356 electronic sphygmomanometer (Zhuochen). During the measurements, the subject's left hand is placed palm up, and the sphygmomanometer is wrapped around the inside of the left wrist, fixed at a distance of 10–15 mm between the base of the palm and the wrist, and kept at the same height as the heart. The subject is told to stay relaxed during the measurement, press the switch, and wait for 20s for the blood pressure and pulse rate recording to begin.

2.2.5. Addiction memory intensity scale

The AMIS was used to assess the addiction memory intensity of the study participants, and the total score of the scale and its dimensional scores were used as secondary outcomes. The AMIS was developed by Chen et al., and mainly measures visual clarity among other sensory aspects of addictive memories (18). The nine AMIS items are scored using a Likert 5-point scale ranging from 1 ("not at all") to 5 ("completely"). Higher scores indicate more intense addictive memories. The Cronbach's α was 0.93 in this study.

2.3. Procedures

2.3.1. Experimental procedure

The experiment consisted of preparation, assessment and intervention phases. During the preparation stage, the experimenter briefly discussed the study purpose and procedure, as well as the concepts of psychological addiction and addiction memory, and the principles of the treatment, so that the participants had a degree of understanding of the treatment process. In addition, the experimenter creates an inclusive and relaxed atmosphere, proactively acquires basic information about the participants. And discusses the participants' experiences of growing up with addiction. The goal is to build relationships and stimulate motivation for recovery. Then, the participants were instructed to sign the informed consent form and complete the general information questionnaire. During the assessment phase, the participants were assessed for craving, physiological parameters, and addiction memory intensity using the VAS, electronic sphygmomanometer, and AMIS, which were administered before, immediately after, and 1 month after the intervention. For the assessment, participants wore VR headsets that presented neutral, MA-related, and neutral scenes in sequence, for a total of 10 min. Before and after presenting the scenes. The participants' heart rate and blood pressure were measured (as physiological indicators). After each scene was presented, the experimenter guided the participants to complete the VAS and AMIS, in that order. In addition, after using the VR equipment, the experimenter conducts a qualitative interview with each participant to assess the VR experience; those who are not comfortable with it can withdraw from the experiment at any time. The interview noted any instances of a sense of vertigo, vomiting, or sense of immersion. During the intervention phase, the intervention group received VR-based motivational reinforcement + desensitization intervention (total of eight sessions for 4 weeks) in addition to routine drug rehabilitation management; the control group received routine drug rehabilitation management during the same period. During the intervention period, the routine drug rehabilitation management consisted of no contact with drugs and some simple manual work. The intervention and evaluation stages were implemented by professionally trained psychology graduate students.

2.3.2. Interventions

The intervention primarily followed a group therapy format, although one-on-one motivational interviews of the participants were conducted by the therapist prior to the start of the group therapy. The group therapy was divided into two stages. The first stage was a motivational reinforcement phase, comprising two sessions completed within 1 week and a single group session 60 min in length. The second stage was VR-based desensitization therapy (two sessions per week;

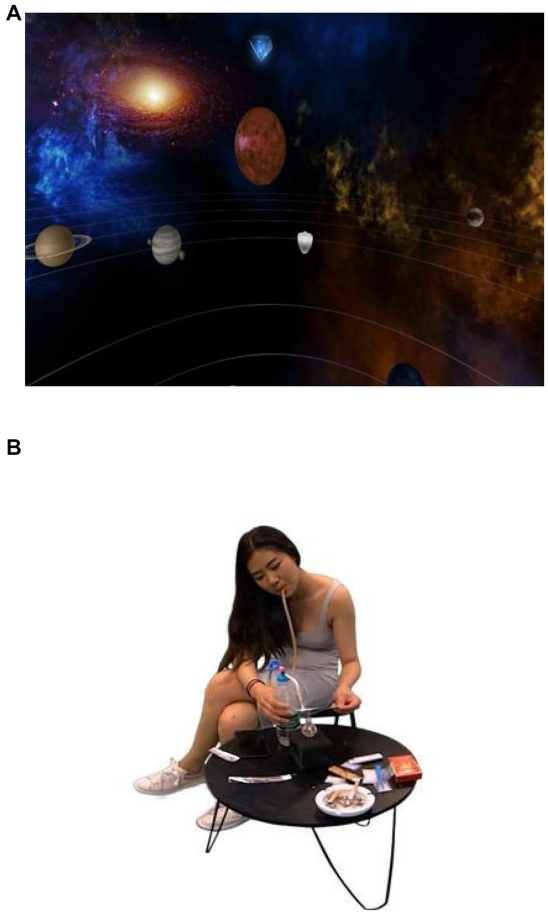

FIGURE 1
VR scenes.

six sessions in total completed in 3 weeks and a single group session 60 min in length). The specific content of each stage of the intervention is shown in Table 1.

2.4. Quality control

Design phase: The experimental protocol was designed on the basis of the first author's extensive reading of the literature, training in psychological techniques, practice of psychological counselling and psychological interventions in drug treatment and in-depth exchanges with peers. The detailed experimental plan was determined after several rounds of revision by the members of the project team.

Implementation phase: The research leader, who is the corresponding author of this paper, provides special training to the psychology postgraduate students, modelling the intervention scenarios, anticipating possible contingencies and formulating practical and effective countermeasures. The entire intervention and evaluation process is carried out by the psychology postgraduate students who have been trained according to the experimental plan.

2.5. Statistics

All of the data were analyzed using IBM SPSS.22.0 software (IBM Corp., Armonk, NY, United States). Descriptive statistics are presented as means ± standard deviations, frequencies, or percentages. An independent sample t-test or Chi-square test was used to compare the demographic characteristics between the intervention and control groups. Using paired samples t-tests to compare differences in physiological indicators before and after entering meth-related VR scenarios for all study participants. Taking psychological craving, differences in physiological indicators (physiological parameters after the VR experience - physiological parameters before the VR experience), and addictive memory strength as the outcome measures, the generalized estimating equation (GEE) was used to analyze the intervention effect. The significance level was set at $p < 0.05$, and the marginal significance level was set at $p < 0.1$. GEE is a semi-parametric statistical method based on likelihood estimation often used for analyzing repeated-measures data. It is applicable to outcome variables that are not normally distributed (19).

3. Results

3.1. Demographic data

The recruitment process is shown in Figure 2. In total, 60 MA-dependent young adults participated in this study, and all of them completed measurements before, immediately after, and 1 month after the intervention. During the intervention, one member of the intervention group missed four treatment sessions for work reasons and was not included in the analysis. Ultimately, 29 and 30 valid samples were obtained for the intervention and control groups, respectively.

There was no significant difference in demographic characteristics between the intervention and control groups (Table 2). All of the participants were female. The mean age was 23.24 ± 2.06 in the intervention group and 23.33 ± 2.09 in the control group. Among all subjects, 36 (61%) lived in cities, 15 (25.4%) lived in towns, and 8 (13.6%) lived in rural areas. In total, 45 (76.2%) subjects had a primary or junior high school education, and 14 (23.8%) had a senior high school education or above. In total, 33 (55.9%) subjects were the only child, while 26 (44.1%) were not the only child in the family. Furthermore, 32 (54.2%) subjects were from single-parent families and 27 (45.8%) were from non-single-parent families. There were 41 (69.5%) unmarried subjects, 12 (20.3%) married subjects, and 6 (10.2%) divorced subjects. Twenty-three participants (38.9%) were employed before admission, and 36 (61.1%) were unemployed. In all participants, the shortest duration of drug use was 1 year and the longest was 10 years. The average duration of drug use was 4.90 ± 2.65 years in the intervention group and 4.70 ± 1.71 years in the control group, and the average amount of drug use per occasion was 0.70 ± 0.42 g in the intervention group and 0.56 ± 0.38 g in the control group.

TABLE 1 Virtual reality-based motivation reinforcement-desensitization therapy.

Stage	Aims	Main contents
One-on-one motivational interviews:	**One-on-one motivational interviews:** 1. Building therapeutic relationships and forming therapeutic alliances. 2. Motivating participants to detoxify.	**One-on-one motivational interviews:** 1. The therapist conducts individualised psychological interviews based on each participant's personal attributes to explore the participant's motivation and available inner resources to activate motivation for recovery.
Group therapy: motivational reinforcement phase:	**1st group meeting:** 1. Forming a group, establishing group norms and familiarising each group member with each other. 2. Clarifying group aims and motivations for group participation. **2nd group meeting:** 1. Becoming aware of the causes and effects of drug addiction and exploring the expectations of recovery and the meaning of life. 2. Reinforcing motivation for detoxification.	**1st group meeting:** 1. The therapist forms the group and clarifies group norms (including: specific timing of group meetings, active expression of ideas, respectful listening, privacy and confidentiality, etc.). 2. Group members introduce themselves, giving their name and a story about their name or what their family expects of them after their name. 3. Each group member talks about their motivation for participating in the group and the therapist leads the group in setting goals together. **2nd group meeting:** 1. The therapist leads the group to review the previous group summary. 2. Group members discuss the effects of drug use on themselves in the group. 3. The therapist leads the group in a discussion about the meaning of life and the relationship between drug use and the meaning of life. 4. Group members write down their expectations of recovery and hand them to the therapist for safekeeping. 5. Assignment: Think about "Are there other possibilities for my life if I do not take drugs?"
Group therapy: VR-based desensitization treatment	**3rd ~ 7th group meeting:** 1. Activating addictive memorie and inducing psychological craving through exposure to MA-related scenarios in a virtual reality environment. 2. Reducing addictive memorie and psychological craving through relaxation exercises within an effective time window. 3. Sharing of therapeutic experiences and personal insights in a group to reinforce the effects of therapy and gain group support. **8th Group Meeting:** 1 ~ 3.Same as the previous five group meetings. 4. Summarising the gains and say goodbye to the group.	**3rd ~ 7th group meeting:** 1. The therapist leads the group in reviewing the last group summary and discussing reflections on the last assignment. 2. The group members entered a virtual MA-related scene through a VR headset and were exposed to it for 3–5 min. 3. After the group members took off their helmets, the therapist played relaxing music and guided them in the performance of relaxation exercises. 4. The group members shared their experience of treatment and reported their subjective psychological craving. 5. The therapist summarized the session, and guided the group members in terms of reviewing the treatment process and applying relaxation skills. 6. Assignment: Think about "What methods can you use to reduce your craving for drugs when and after a tip is exposed?" "How should you respond to drug-related clues in the future?" **8th Group Meeting:** 1 ~ 5.Same as the previous five group meetings. 6. The group members share what they have learned and how they have grown personally after participating in the eight groups and how they feel about the other group members. The therapist guides the group to say goodbye to the group.

3.2. Effects of VR environments on physiological indicators

Comparing the physiological indicators of all subjects before and after entering the MA-related VR scenes, a significant increase in heart rate and blood pressure was found (all $p < 0.0001$). The results are shown in Table 3.

3.3. Treatment effects

The effect of the intervention was analyzed by a 2 (group: intervention and control) × 3 (test time: baseline, immediately post-test, and 1-month post-test) GEE, and the results are shown in Tables 4, 5.

3.4. Psychological craving

The results of the GEE showed that: (1) the main effect of group was significant (Wald$\chi^2 = 7.063$, $p = 0.008$, Partial $\eta^2 = 0.105$); (2) the main effect of time was significant (Wald$\chi^2 = 40.026$, $p < 0.000$, Partial $\eta^2 = 0.356$); (3) and the group ×time interaction effect was significant (Wald$\chi^2 = 27.832$, $p < 0.0001$, Partial $\eta^2 = 0.278$).

At baseline, there was no significant difference in VAS score between the intervention and control groups (36.72 ± 3.13 vs. 30.17 ± 4.14, $p = 0.222$). The VAS score was significantly lower in the intervention than in the control group, both immediately after the intervention (7.59 ± 1.65 vs. 27.67 ± 3.99, $p < 0.0001$) and 1 month thereafter (10.17 ± 2.42 vs. 27.67 ± 3.58, $p < 0.0001$).

After the intervention, the VAS score decreased significantly (7.59 ± 1.65 vs. 36.72 ± 3.13, $p < 0.0001$) and remained low after

1 month (36.72 ± 3.13 vs. 10.17 ± 2.42, $p < 0.0001$). There was no significant difference in VAS score among the three test times in the control group ($p > 0.05$).

3.5. Physiological parameters

3.5.1. Heart rate difference

The results of the GEE showed that: (1) the main effect of group was significant (Wald$\chi^2 = 10.918$, $p = 0.001$, Partial $\eta^2 = 0.195$); (2) the main effect of time was not significant (Wald$\chi^2 = 5.232$, $p = 0.073$, Partial $\eta^2 = 0.039$); (3) and the group × time interaction effect was significant (Wald$\chi^2 = 19.820$, $p < 0.0001$, Partial $\eta^2 = 0.114$).

At baseline, there was no significant difference in heart rate difference between the intervention and control groups (5.07 ± 1.30 vs. 5.23 ± 1.04, $p = 0.921$). The difference value in heart rate was significantly lower in the intervention than control group, both immediately (1.21 ± 0.37 vs. 6.47 ± 0.92, $p < 0.0001$) and 1 month after the end of the intervention (1.45 ± 0.36 vs. 6.36 ± 0.76, $p < 0.0001$).

In the intervention group, the difference value in heart rate was reduced significantly after the intervention compared to baseline (1.21 ± 0.37 vs. 5.07 ± 1.30, $p < 0.0001$), and remained low after 1 month (1.45 ± 0.36 vs. 5.07 ± 1.30， $p = 0.002$). In the control group, the heart rate difference was significantly higher at posttest than baseline (6.47 ± 0.92 vs. 5.23 ± 1.04, $p = 0.002$) and was not significantly different from baseline at 1 month after the intervention (6.36 ± 0.76 vs. 5.23 ± 1.04, $p = 0.11$).

3.5.2. Diastolic blood pressure difference

The results of the GEE showed that: (1) the main effect of group was not significant (Wald$\chi^2 = 3.067$, $p = 0.08$, Partial $\eta^2 = 0.064$); (2) the main effect of time was significant (Wald$\chi^2 = 10.1$, $p = 0.006$, Partial $\eta^2 = 0.067$); and (3) the group × time interaction effect was significant (Wald$\chi^2 = 8.104$, $p = 0.017$, Partial $\eta^2 = 0.051$).

At baseline, there was no significant difference in diastolic blood pressure difference between the intervention and control groups (9.17 ± 2.32 vs. 8.53 ± 1.66, $p = 0.823$). The diastolic blood pressure difference was significantly lower in the intervention than control group, both immediately (2.66 ± 0.85 vs. 8.20 ± 1.49, $p = 0.001$) and 1 month after the end of the intervention (3.17 ± 0.89 vs. 8.20 ± 1.49, $p = 0.007$).

After the intervention, the difference value in diastolic blood pressure decreased significantly (2.66 ± 0.85 vs. 9.17 ± 2.32, $p = 0.002$) and remained low after 1 month (3.17 ± 0.89 vs. 9.17 ± 2.32, $p = 0.006$). There was no significant difference in diastolic blood pressure difference among the three test times in the control group ($p > 0.05$).

3.5.3. Systolic blood pressure difference

The results of the GEE showed that: (1) the main effect of group was significant (Wald$\chi^2 = 4.503$, $p = 0.034$, Partial $\eta^2 = 0.078$); (2) the main effect of time was not significant (Wald$\chi^2 = 4.231$, $p = 0.121$, Partial $\eta^2 = 0.037$); and (3) the group × time interaction effect was not significant (Wald$\chi^2 = 5.558$, $p = 0.062$, Partial $\eta^2 = 0.024$).

There was no significant difference in the systolic blood pressure difference between the intervention and control groups at baseline (7.21 ± 2.44 vs. 7.66 ± 1.66, $p = 0.876$). The systolic blood pressure difference was significantly lower in the intervention than control group, both immediately (2.17 ± 0.61 vs. 9.50 ± 2.44, $p = 0.004$) and 1 month after the end of the intervention (2.31 ± 1.10 vs. 6.83 ± 1.53, $p = 0.016$).

In the intervention group, the systolic blood pressure difference at the posttest decreased significantly compared to baseline (2.17 ± 0.61 vs. 7.21 ± 2.44, $p = 0.025$). After 1 month it remained below the baseline value (2.31 ± 1.10 vs. 7.21 ± 2.44, $p = 0.052$), but not significantly. There was no significant difference in systolic blood pressure difference among the three test times in the control group ($p > 0.05$).

3.6. Addiction memory intensity

3.6.1. Addiction memory intensity score

The results of the GEE showed that: (1) the main effect of group was significant (Wald$\chi^2 = 7.009$, $p = 0.008$, Partial $\eta^2 = 0.107$); (2) the main effect of time was significant (Wald$\chi^2 = 9.703$, $p = 0.008$, Partial $\eta^2 = 0.047$); (3) and the group ×time interaction effect was significant (Wald$\chi^2 = 15.559$, $p < 0.0001$, Partial $\eta^2 = 0.097$).

At baseline, there was no significant difference in AMIS score between the intervention and control groups (3.02 ± 0.16 vs. 3.13 ± 0.12, $p = 0.586$). The AMIS score was significantly lower in the intervention than in the control group, both immediately (2.81 ± 0.14 vs. 3.25 ± 0.10, $p = 0.037$) and 1 month after the end of the intervention (2.55 ± 0.11 vs. 3.22 ± 0.12, $p < 0.0001$).

In the intervention group, the AMIS score was reduced after the intervention compared to baseline, but there was no significant difference (2.81 ± 0.14 vs. 3.02 ± 0.16， $p = 0.19$). However, 1 month after the intervention, the AMIS score was significantly lower than that at baseline (2.55 ± 0.11 vs. 3.02 ± 0.16, $p < 0.0001$). There were no significant differences among the three test times in the control group ($p > 0.05$).

3.6.2. Visual clarity score

The results of the GEE showed that: (1) the main effect of group was significant (Wald$\chi^2 = 7.038$, $p = 0.008$, Partial $\eta^2 = 0.108$); (2) the main effect of time was not significant (Wald$\chi^2 = 5.697$, $p = 0.058$, Partial $\eta^2 = 0.028$); and (3) the group ×time interaction effect was significant (Wald$\chi^2 = 18.008$, $p < 0.0001$, Partial $\eta^2 = 0.103$).

At baseline, there was no significant difference in visual acuity score between the intervention and control groups (3.17 ± 0.17 vs. 3.26 ± 0.12, $p = 0.678$). The visual clarity score was significantly lower in the intervention than in the control group, both immediately (2.97 ± 0.16 vs. 3.40 ± 0.10, $p = 0.027$) and 1 month after the end of the intervention (2.71 ± 0.13 vs. 3.43 ± 0.09, $p < 0.0001$).

In the intervention group, the visual clarity score at the posttest decreased compared to baseline, but not significantly (2.97 ± 0.16 vs. 3.17 ± 0.17, $p = 0.260$). However visual clarity 1 month after the intervention was significantly lower than at baseline (2.71 ± 0.13 vs. 3.17 ± 0.17, $p < 0.0001$). There was no significant difference in visual clarity among the three test times in the control group ($p > 0.05$).

3.6.3. Other sensory aspects score

The results of GEE showed that: (1) the main effect of group was significant (Wald$\chi^2 = 7.079$, $p = 0.008$, Partial $\eta^2 = 0.107$); (2) the main effect of time was not significant (Wald$\chi^2 = 1.012$, $p = 0.603$, Partial $\eta^2 = 0.007$); and (3) the group ×time interaction effect was significant (Wald$\chi^2 = 6.191$, $p = 0.045$, Partial $\eta^2 = 0.046$).

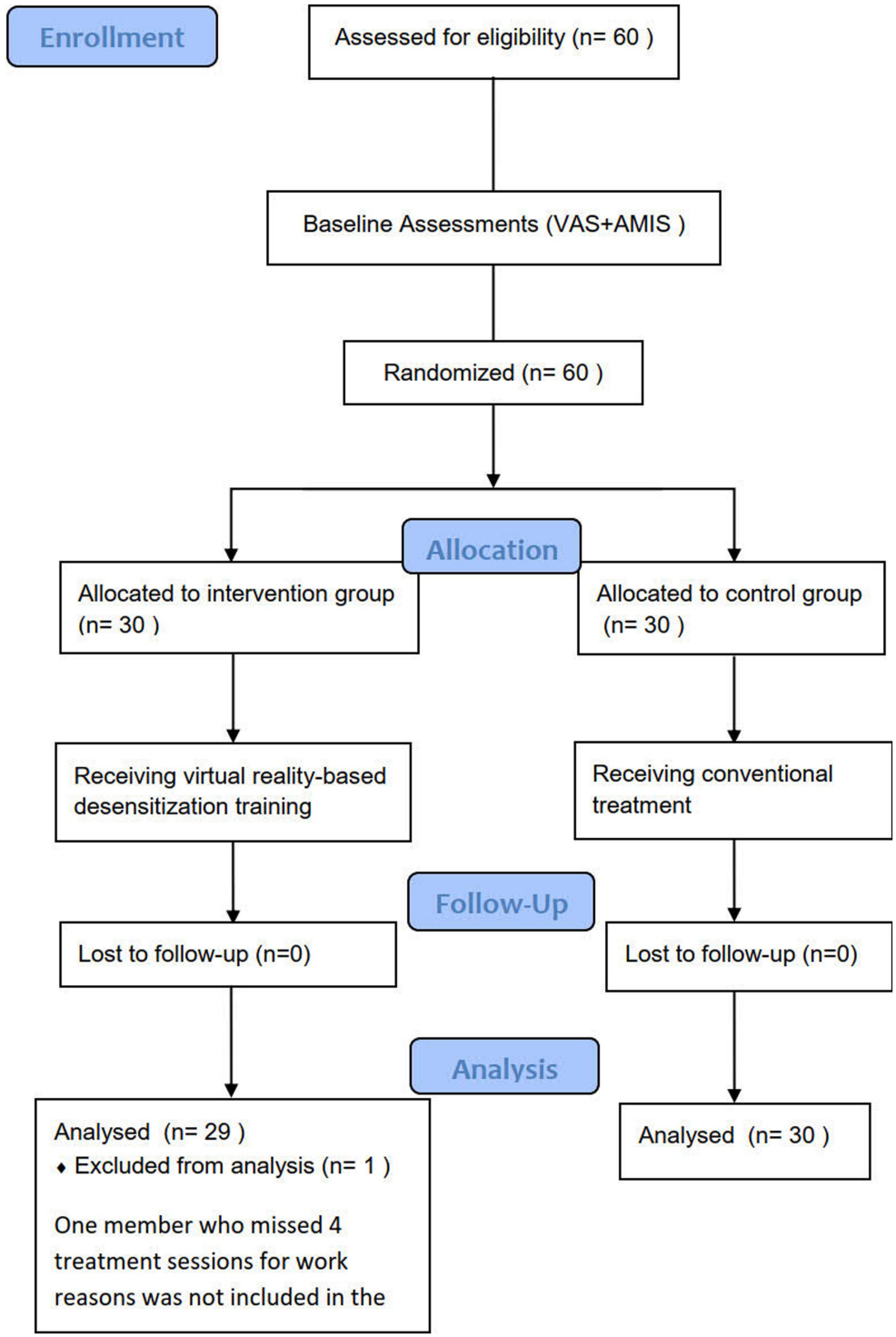

FIGURE 2
Flow diagram.

There was no significant difference in the intensity of other sensory aspects between the intervention and control groups at baseline (2.67 ± 0.18 vs. 2.86 ± 0.16, $p = 0.448$). The intensity of other sensory aspects was significantly lower in the intervention than in the control group, both immediately (2.47 ± 0.16 vs. 2.94 ± 0.15, $p = 0.015$) and 1 month after the end of the intervention (2.29 ± 0.12 vs. 3.02 ± 0.14, $p < 0.0001$).

In the intervention group, the intensity of other sensory aspects at the posttest decreased compared to baseline, but not significantly (2.47 ± 0.16 vs. 2.67 ± 0.18, $p = 0.330$). However, the intensity of other sensory aspects 1 month after the intervention was significantly lower than at baseline (2.29 ± 0.12 vs. 2.67 ± 0.18, $p < 0.0001$). There was no significant difference in the intensity of other sensory aspects among the three test times in the control group ($p > 0.05$).

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TABLE 2 Participants'socio-demographic characteristics at baseline.

Variables		Intervention group (n = 29)	Control group (n = 30)	χ^2/t	p
Age(Years) ±s		23.24 ± 2.06	23.33 ± 2.09	−0.170	0.866
Habitation n (%)	City	15 (25.4)	21 (35.6)	4.751	0.093
	Town	11 (18.6)	4 (6.8)		
	Country	3 (5.1)	5 (8.5)		
Education n (%)	Primary or junior high school	24 (40.7)	21 (35.5)	1.326	0.249
	High school or above	5 (8.5)	9 (15.3)		
Only children n (%)	Yes	18 (30.5)	15 (25.4)	0.871	0.351
	No	11 (18.6)	15 (25.4)		
From single-parent family n (%)	Yes	16 (27.1)	16 (27.1)	0.020	0.887
	No	13 (22.0)	14 (23.7)		
Martial status n (%)	Unmarried	23 (38.9)	18 (30.5)	5.166	0.056
	Married	3 (5.1)	9 (15.3)		
	Divorced	3 (5.1)	3 (5.1)		
Working condition n (%)	Employed	14 (23.7)	9 (15.3)	2.071	0.150
	Unemployed	15 (25.4)	21 (35.5)		
Duration of drug abuse (Years) ± s		4.90 ± 2.65	4.70 ± 1.71	0.340	0.735
Amount of drug use (per occasion) (g) ± s		0.70 ± 0.42	0.56 ± 0.38	1.327	0.190

TABLE 3 Comparison of physiological indexes before and after entering the MA-related VR scene.

Variables	before entering the MA-related VR scene	after entering the MA-related VR scene	t	p
HRD	70.95 ± 10.12	76.16 ± 9.32	6.480	0.000**
DBPD	102.07 ± 11.54	110.90 ± 10.40	6.068	0.000**
DBPD	70.41 ± 10.04	77.83 ± 11.81	4.922	0.000**

HRD, heart rate difference; DBPD, diastolic blood pressure difference; SBPD, systolic blood pressure difference. *p < 0.05, **p < 0.01.

4. Discussion

This study used VR technology, combined with motivational reinforcement therapy and addiction memory reconsolidation theory, to design an intervention program aimed at reducing psychological craving and decreasing the intensity of addiction memories in MA-dependent female young adults. This is the first intervention program to be implemented in an MA-dependent female adolescent population. Furthermore, we evaluated its effectiveness based on memory strength, psychological craving and physiological response. The results showed that, after the intervention, psychological craving and the difference values of physiological parameters significantly decreased and remained at a low level for 1 month. However, patients who did not receive the intervention showed no significant change in psychological craving or physiological response. Meanwhile, the intervention effectively reduced the addiction memory intensity of the MA-dependent female young adults, and a consistent decrease in addiction memory intensity, visual clarity, and the intensity of other sensory aspects were seen over time. These results suggest that the VR-based motivation enhancement+desensitization treatment is effective for reducing the psychological craving of MA-dependent female young adults and reducing the intensity of their addiction memories.

According to memory reconsolidation theory, researchers extracted addicts' original addiction memories, activated them to induce an unstable state, and then intervened within a specific time window (10 min ~ 6 h) to change or eliminate the original memory connections (20). The key to this process is that the original memory is activated to induce an unstable state (21). In this study, addictive memories were activated to an unstable state by exposure to meth-related cues in a virtual reality environment, followed immediately by relaxation exercises to interfere with the memory reconsolidation process during an effective time window, thereby abating addictive memory and reducing psychological craving. Female MA-dependent young adults experienced a significant increase in heart rate and blood pressure upon entering the meth-related virtual reality environment, suggesting that immersion in the MA-related virtual reality environment successfully elicited a physiological response in MA-dependent individuals. This result is similar to that of a study conducted with cocaine-dependent patients (22). After cocaine-dependent patients entered the cocaine-related virtual reality environment, the patients' subjective emotional responses, heart rate and electrodermal indicators showed that the stimulus-rich and standardised virtual reality scenario was effective in eliciting subjective psychological craving and physiological response. This was a key point in making the intervention effective, indirectly reflecting the effectiveness of the manipulation in activating addiction memories and inducing

TABLE 4 VAS score and the difference value in physiological parameters, and differences between groups and times according to the Generalized estimating equation (GEE) analysis.

		Intervention group (n = 29)				Control group (n = 30)					
Variables	Time	±s	Difference between times (95%CI)	Waldχ^2	p	±s	Difference between times (95%CI)	Waldχ^2	p	Difference between groups (95%CI)	p
VAS	Baseline	36.72 ± 3.13				30.17 ± 4.14				6.56 (−3.62,26.74)	0.222
	Immediately post-test	7.59 ± 1.65	29.14 (22.65,35.62)	77.582	0.000**	27.67 ± 3.99	2.5 (−5.51,10.51)	0.38	0.54	−20.08 (−28.54,11.62)	0.000**
	1-month post-test	10.17 ± 2.42	26.55 (20.60.32.50)	76.452	0.000**	27.67 ± 3.58	2.5 (−4.52,9.52)	0.49	0.49	−17.49 (−25.96,-9.02)	0.000**
HRD	Baseline	5.07 ± 1.30				5.23 ± 1.04				−0.16 (−3.43,3.10)	0.921
	Immediately post-test	1.21 ± 0.37	3.86 (1.71,6.01)	12.402	0.000**	6.47 ± 0.92	−1.23 (−2.00,-0.47)	9.97	0.002**	−5.26 (−7.21,-3.31)	0.000**
	1-month post-test	1.45 ± 0.36	3.62 (1.34,5.90)	9.715	0.002**	6.36 ± 0.76	−1.13 (−2.53,0.26)	2.53	0.11	−4.92 (−6.56,-3.27)	0.000**
DBPD	Baseline	9.17 ± 2.32				8.53 ± 1.66				0.64 (−4.95,6.22)	0.823
	Immediately post-test	2.66 ± 0.85	6.52 (2.31,10.73)	9.199	0.002**	8.20 ± 1.49	0.33 (−0.49,1.16)	0.63	0.43	−5.54 (−8.92,-2.17)	0.001**
	1-month post-test	3.17 ± 0.89	6.00 (1.76,10.24)	7.692	0.006**	8.30 ± 1.68	0.23 (−1.62,2.09)	0.06	0.81	−5.13 (−8.86,-1.40)	0.007**
SBPD	Baseline	7.21 ± 2.44				7.66 ± 1.66				−0.46 (−6.25,5.33)	0.876
	Immediately post-test	2.17 ± 0.61	5.03 (0.63,9.44)	5.026	0.025*	9.50 ± 2.44	−1.83 (−5.49,1.82)	0.97	0.32	−7.33 (−12.25,-2.40)	0.004**
	1-month post-test	2.31 ± 1.10	4.90 (−0.04,9.84)	3.776	0.052	6.83 ± 1.53	0.83 (−1.64,3.31)	0.44	0.51	−4.52 (0.83,8.22)	0.016*

VAS, visual analogue scale; HRD, heart rate difference; DBPD, diastolic blood pressure difference; SBPD, systolic blood pressure difference. CI, confidence interval, *$p < 0.05$, **$p < 0.01$.

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TABLE 5 AMIS, VC, and OSA scores and differences between groups and times according to the Generalized estimating equation (GEE) analysis.

		Intervention group ($n = 29$)				Control group ($n = 30$)					
Variables	Time	±s	Difference between times (95%CI)	Waldχ^2	p	±s	Difference between times (95%CI)	Waldχ^2	p	Difference between groups (95%CI)	p
AMIS	Baseline	3.02 ± 0.16				3.13 ± 0.12				−0.11 (−0.50,0.28)	0.586
	Immediately post-test	2.81 ± 0.14	0.21 (−0.10,0.52)	1.722	0.19	3.25 ± 0.10	−0.12 (−0.33,0.07)	1.48	0.22	−0.45 (−0.79,-0.10)	0.037*
	1-month post-test	2.55 ± 0.11	0.47 (0.23,0.70)	14.592	0.000**	3.22 ± 0.12	−0.09 (−0.27,0.08)	1.132	0.29	−0.67 (−0.99,-0.35)	0.000**
VC	Baseline	3.17 ± 0.17				3.26 ± 0.12				−0.09 (−0.50,0.32)	0.678
	Immediately post-test	2.97 ± 0.16	0.20 (−0.15,0.56)	1.259	0.26	3.40 ± 0.10	−0.14 (−0.34,0.06)	1.833	0.18	−0.43 (−0.79,-0.68)	0.027*
	1-month post-test	2.71 ± 0.13	0.47 (0.24,0.70)	15.599	0.000**	3.43 ± 0.09	−0.18 (−0.39,0.06)	2.14	0.14	−0.72 (−1.03,-0.41)	0.000**
OSA	Baseline	2.67 ± 0.18				2.86 ± 0.16				−0.19 (−0.66,0.29)	0.448
	Immediately post-test	2.47 ± 0.16	0.20 (−0.20,0.59)	0.947	0.33	2.94 ± 0.15	−0.09 (−0.42,0.24)	0.281	0.60	−0.47 (−0.90,-0.05)	0.015*
	1-month post-test	2.29 ± 0.12	0.37 (0.01,0.73)	3.952	0.047*	3.02 ± 0.14	−0.16 (−0.46,0.14)	1.085	0.30	−0.72 (−1.08,-0.36)	0.000**

AMIS, addiction memory intensity scale; VC, visual clarity; OSA, other sensory aspects. CI, confidence interval, *$p < 0.05$, **$p < 0.01$.

psychological craving. The use of VR to construct drug-related scenarios has higher ecological validity, is more realistic, and can be used to present composite cues that help activate addiction memories and facilitate the goal of eliminating or changing addiction memories. The effectiveness of an intervention comprising VR combined with memory reconsolidation was demonstrated by Maples-Keller et al. (23). The physiological response to fear was effectively suppressed in patients treated by the VR combined with memory reconsolidation intervention. Additionally, VR is advantageous for inducing craving (24), which can enhance the effect of extinction interventions to better achieve craving reduction. Studies have reported significant reductions in nicotine and alcohol craving in addicts using VR interventions (25–29). Some researchers have also combined VR with extinction interventions and cognitive behavioral therapy for nicotine addicts, and reported a decrease in subjective cravings and reduced smoking behavior (30). Liu et al. confirmed the effectiveness of VR combined with cue exposure for memory extinction in MA-dependent patients (31). The training attenuated the patients' craving for drugs and responsivity to cues. Interventions for addiction memory and psychological craving in the VR environment have important implications for relapse prevention. Although the patient's symptoms can be improved in a therapeutic environment, the most important change is not in the laboratory or during treatment, but rather in the world in which the patient lives (32). The advantage of VR for addiction interventions is that it provides a variety of environments that resemble real-life scenarios, including meth-dependent persons, thus allowing for better transfer of intervention effects to real life. Our study used VR to present drug cues that effectively activated addiction memories and induced psychological craving. Our results are similar to previous studies that used craving to assess a VR-based craving-abatement intervention. This intervention protocol was effective for reducing craving in MA-dependent female young adults. Furthermore, the results of this study provide direct evidence that this intervention protocol can reduce addiction memory intensity, visual clarity, and sensory intensity in MA-dependent female young adults. More notably, the effect of the intervention persisted for 1 month.

In this study, we included a one-on-one interview and motivational reinforcement phases before the formal desensitization training, which also played a key role in the efficacy of the motivational interview. According to the motivation-based integrative theory of addiction, motivational interviewing is an individualized, comprehensive treatment technique that stimulates internal motivation for, and guides, sustained behavior changes (33). In the one-on-one motivational interview phase of our intervention, the therapist established a good therapeutic alliance with the patient. During this phase, the therapist stimulated the patient's internal drive for sustained change, which was consolidated during the subsequent desensitization training. In the motivational reinforcement phase, the patient's motivation to quit was further enhanced.

Through group discussions about the consequences of addiction, expectations of recovery, and the meaning of life, therapists helped their patients probe inner conflicts associated with their addictive behaviors more deeply. Through this process, patients accrue important resources to help them maintain long-term detoxification. Every time a memory is extracted, we automatically process it according to the present-day context, after which the modified memory replaces the original one and is stored in long-term memory (34). By providing the VR-based desensitization training after the motivational reinforcement phase, the patients are motivated during the memory extraction-reconsolidation process. Thus, during the memory reconsolidation phase, not only has the present-day context changed, but also its psychological context relative to the original memory. Wang evaluated the effects of a "motivation enhancement-desensitization-neurotransmitter regulation" intervention in patients with MA dependence. The results showed that an intervention model combining motivational reinforcement and desensitization increased patients' motivation to detoxify and reduced the intensity of their addiction memories (12). Our findings also suggest that motivational reinforcement prior to desensitization training is effective for reducing the intensity of addiction memories and psychological craving in MA-dependent female young adults.

The present study also had some limitations. First, it was an exploratory intervention that only included female MA-dependent young adults, which limits the generalizability of the results. In the future, we plan to conduct a multicenter, large-scale study to validate the efficacy of this protocol in a larger group, and further analyze and explore specific intervention mechanisms. Second, although the intervention in this study had a specific operational procedure, the results may have been biased to some degree due to its psychotherapeutic nature, which precluded blinding of the subjects. Finally, although the results of this study demonstrate the effectiveness of the intervention for reducing the intensity of addiction memory and psychological craving 1 month after the end of the intervention, further follow-up studies are needed to determine the long-term effects of the intervention.

In conclusion, this study first combined VR technology with a memory reconsolidation intervention, and added an element of motivational reinforcement, to devise a novel protocol for intervening in psychological craving and addiction memory; the results were highly promising. This study not only promotes the development and application of memory reconsolidation-based clinical treatments and interventions for addiction, but also provides new evidence that could aid the further development of addiction treatment theory.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Chengdu Medical College Biomedical Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

Author contributions

XJ and LJ designed the experiment XJ performed it. YT analyzed the experimental data and participated in the paper writing. XJ drafted the manuscript and prepared the published works. LJ reviewed and edited the manuscript. LZ provided the experimental equipment. BW, YD, SZ, and YY assisted in recruiting subjects, and participated in the implementation of the experiment. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Mediating effects of attention problems on the link between parenting style and internet gaming disorder in adolescents

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Background: Positive and negative parenting styles as well as psychiatric comorbidities including attention deficit hyperactivity disorder (ADHD) have been associated with internet gaming disorder (IGD) in children and adolescents. We hypothesized that ADHD and parenting style would be associated with IGD in adolescents. In addition, psychological status could mediate the link between parenting style and the severity of IGD.

Methods: A total of 256 adolescents with IGD and 211 healthy internet game players and their mothers participated in the current study. Demographic data, gaming patterns, and psychological status including ADHD were recorded for all adolescents. The parenting style of each adolescent's mother was assessed using the Maternal Behavior Research Instrument (Korean version).

Results: There were significant differences in the internet game play patterns, psychological status, and parenting styles between the IGD group and healthy internet game players. In the hierarchical logistic regression analysis, higher ADHD scores, less affective parenting styles, and less autonomous parenting styles, were significant predictors of IGD. In the mediation test, the ADHD score was found to mediate the association between affective and autonomous parenting styles and the severity of IGD.

Conclusion: Attention problems could directly and indirectly mediate the relationship between positive parenting styles and the severity of IGD. Our findings have the potential to aid in the development of treatment plans for IGD and ADHD as well as to contribute to the development of educational resources regarding parenting styles.

KEYWORDS

internet gaming disorder, attention deficit hyperactivity disorder, parenting style, mediation effect, gaming pattern

Introduction

Parenting style and child and adolescent behavior

Parenting style is defined as the manner in which parents rear their children (1–3). Parenting behaviors are known to be associated with adolescents' emotional and problem behaviors (1, 2). Schaefer et al. (3) suggested two independent parenting styles of emotion and control. The emotion dimension involves parents' emotional attitude toward the child (affection vs. rejection), while the control dimension involves parents' exerting control over the child's behavior (autonomy vs. control) (3). According to Baumrind (4), with the combination of these two dimensions, four parenting styles can be derived: authoritative (highly supportive and flexible), authoritarian (lack of support and rigid control), permissive (lack of control), and neglecting (lack of support and control). Each parenting style is associated with children's behavioral patterns and symptoms, and these are related to various socialization processes and emotional aspects. The authoritative parenting style is associated with positive outcomes including emotional adjustment and healthy self-esteem as well as low aggression, anxiety, and depression (5–7). In contrast, the other three styles are associated with negative outcomes including emotional lability, low sociality, and unstable attachment (7, 8). Children of authoritarian parents commonly exhibit withdrawn and hostile behavior. Children of permissive parents often encounter difficulties in regulating their behaviors and emotions and may struggle academically due to the low level of parental control. However, they tend to possess positive self-perception and demonstrate relatively lower levels of depressive symptoms. Finally, the neglecting parenting style is associated with the poorest outcomes in various developmental, behavioral, emotional, and social aspects in children. They often feel emotionally detached and report the highest levels of depression (4). While the authoritative parenting style is typically associated with positive outcomes, these findings do not universally apply to all of society. Gonzalez et al. (9) reported that in African-American college students, the authoritarian parenting style was related to seeking challenges and being competent. Similarly, McBride-Chang and Chang (10) reported that in students in Hong Kong, the authoritative parenting style was actually associated with negative outcomes such as low emotional autonomy.

Parenting style and adolescent with internet gaming disorder

Several studies have suggested that parent–child relational problems in the family are related to internet use patterns in adolescents (11–14). Trumello et al. (14) reported that excessive internet use was negatively associated with maternal care. Mother's avoidance and father's anxiety were also found to be directly associated with problematic internet use in adolescents (13). Furthermore, in a longitudinal study of 1,153 Taiwanese students, low family support, a less protective parenting style, and high attention deficit hyperactivity disorder (ADHD)-related symptoms were associated with problematic internet use (12). In addition, Arikan et al. (11) suggested that maternal attachment anxiety indirectly predicted the overuse of a social network service (SNS) in young adults via young adult attachment anxiety.

Among popular internet-related activities, internet game playing is also known to be associated with family functions and parenting style (15–18). In a study involving 682 Iranian adolescents, parenting style was significantly associated with the prevalence of internet gaming disorder (IGD) (15). A dominant permissive parenting style was associated with symptoms of IGD in children (17). Bonnaire and Phan (16) suggested that parental close monitoring the process of an adolescent's internet use activity could decrease the risk of developing IGD. Throuvala et al. (18) reported that parental rejection could predict IGD through the mediating effect of core self-evaluation in adolescents.

Parenting style and adolescents with attention deficit hyperactivity disorder

ADHD is a prevalent mental disorder that impacts approximately 3 to 5% of students and is characterized by symptoms such as hyperactivity, inattention, and impulsive actions (19). Previous studies have shown that parents of children with ADHD are less authoritative and show an authoritarian parenting style. This parenting style is characterized by high expectations and strict rules set by the parents, and verbal communication is usually one-sided and lacks an emotional response. This can cause their children to feel isolated and depressed and increase their negative symptoms of ADHD (20).

Previous studies have also shown that the parents of children with ADHD have a greater tendency to use punishment to control children with hyperactivity than other parents, meaning they employ a more authoritarian parenting style. On the other hand, permissive parenting styles were lower than other parents (4, 21, 22).

Psychological status and adolescents with IGD

Many studies of IGD have suggested that comorbidities play a critical role in the development of IGD (23–26). In a cohort of 755 patients with IGD, Han et al. (24) suggested that age, family support, social factors, and psychological status including attention, anxiety, and mood could impact the initial and sustained responses to treatment for IGD. Ko et al. (25) suggested that psychiatric diseases including ADHD, major depressive disorder (MDD), and social anxiety disorder were significantly associated with the prevalence of IGD. Lee et al. (26) reported that a comorbidity of ADHD in patients with IGD was associated with a poor clinical course in response to treatment. Furthermore, Cudo et al. (23) suggested that depression could mediate the correlation between self-esteem and IGD.

Remondi et al. (27) also suggested that insecure attachment between adolescents and their parents had an indirect effect on the development of problematic use of mobile devices (smartphones and tablets) mediated by psychological risk factors. Similar to the findings of Remondi et al. (27), we speculated that psychological status could mediate the association between parenting style and the severity of IGD.

Hypothesis

We hypothesized that ADHD and parenting style would be associated with IGD in adolescents and that affective parenting styles would have particularly positive effects on IGD. In addition, psychological status could mediate the link between parenting style and the severity of IGD.

Methods

Participants

From August 2016 to July 2020, patients who visited the IT and Human Research Center at Chung Ang University Hospital for the treatment of IGD were asked to participate and recruited in the current study. The inclusion criteria were as follows: (1) diagnosis of IGD based on the Diagnostic and Statistical Manual of Mental Disorders (DSM)-5 (28); (2) adolescents aged from 13–18 years; and (3) adolescents living with their mothers. The exclusion criteria were as follows: (1) history of a psychotic disorder including bipolar disorder, schizophrenia, or severe depressive disorder with psychotic features; (2) history of developmental disorders including autism spectrum disorder (ASD) or intellectual disability (intelligence quotient (IQ) < 70); and (3) history of chronic medical conditions.

Of 374 consecutive patients who were eligible to participate in the current study, 295 patients and their mothers agreed to take part. Of 295 patients, 19 patients were excluded due to low intelligence, 11 patients were excluded due to ASD, five patients were excluded due to bipolar disorder, and four patients were excluded due to schizophrenia. Finally, 256 adolescents with IGD and their mothers participated in the research.

As a comparison group, healthy internet game players were recruited from the same hospital via flyers and banner advertisements. The inclusion criteria were as follows: (1) adolescents who played internet games for at least 2 hours per week [the mean game play time in Korean adolescents has been to be 2.5 h per week (Game Self-Governance Organization of Korea, GSOK, http://www.gsok.or.kr/gsok-news/?mod=document&uid=1914)]; (2) adolescents aged from 13–18 years; and (3) adolescents living with their mothers. The exclusion criteria were follows: (1) diagnosis of IGD based on the DSM-5 (28); (2) history of a psychotic disorder including bipolar disorder, schizophrenia, or severe depressive disorder with psychotic features; (3) history of developmental disorders including ASD or intellectual disability (IQ < 70); and (4) history of chronic medical conditions.

Of 233 individuals who wanted to participate in the current study, 211 healthy participants were recruited. Eleven participants were excluded due to a diagnosis of IGD. Five participants were excluded due to low intelligence. Three participants were excluded due to bipolar disorder. Three participants were excluded due to ASD.

All participants understood the study procedures and agreed to participate voluntarily in the current study. The current research received approval from the Chung Ang University Institutional Review Board (1990-007-386), and the participants completed and signed consent forms. Adolescents also provided written consent for participation from their parents or guardians. The study was conducted in accordance with the Declaration of Helsinki.

Measures

Demographic data were assessed which could affect bias. The severity of IGD was assessed using Young Internet Addiction Scale Korean version (29, 30). This scale consists of 20 items that measure problematic internet use including internet games and has good internal consistency (Cronbach's $\alpha = 0.90$). The cutoff values of the IAT were as follows: <20: below average users; 20–49: average users; 50–79: occasional/frequent problems; and 80–100: significant problems (29, 30).

Depressive mood was assessed using the Beck Depression Inventory II (BDI-II) (31), which consists of 21 self-report items that are rated on a 4-point Likert-type scale ranging from 0 to 3. The total BDI-II score can range from 0 to 63. The anxiety level was assessed using the Beck Anxiety Inventory (BAI) (32), which consists of 21 self-report items that are rated on a 4-point Likert-type scale ranging from 0 to 3. The total BAI score can range from 0 to 63. Both the BDI-II (Cronbach's $\alpha = 0.89$) (33) and BAI (Cronbach's alpha = 0.95) (32) have good internal consistency.

IQ was estimated using the Korean Wechsler Intelligence Scale for Children IV (K-WISC-IV), which was administered by clinical psychologists (34) The K-WISC-IV is modified from WISC-IV and designed for persons aged from 6 years to 16 years 11 months. It consists of four sub-index scores: the Verbal Comprehension Index, Perceptual Reasoning Index, Working Memory Index, and Processing Speed Index. IQ assessment was conducted by clinical psychologists in the same hospital, Chung-Ang University Hospital.

Attention problems were assessed using the Korean version of Dupaul's ADHD Rating Scale (K-ARS) (35, 36), which includes 18 items including 9 items for assessing inattention and 9 items for assessing hyperactivity. The internal consistency of the K-ARS ranges from 0.77 to 0.89 (36). Behavioral control was assessed using the Behavioral Inhibitory System/Behavioral Activation System (BIS/BAS) Scale (37, 38). The BIS/BAS is composed of a four-point Likert scale with responses ranging from "not at all" to "strongly agree." The total scores of the BIS/BAS range from 0 to 80. The internal consistency (Cronbach's α) of the BIS/BAS has been reported to range from 0.78 to 0.79 (38).

The parenting style of each adolescent's mother was assessed using the Maternal Behavior Research Instrument (MBRI-K) (Korean version) (3, 39). The MBRI-K is a 48-item, self-report instrument assessing maternal parenting attitudes. Parenting styles were classified into four types including affective, rejecting, autonomous, and controlling types. Each style has 12 items and is scored by summing the subscale responses (values ranging from 1 to 5). The sum of the subscale scores ranges between 12 and 60. Higher scores on each subscale indicate that the maternal parenting attitude shows a greater degree of that style.

Statistical analysis

The differences in demographic data including age, sex, education level, and smoking and alcohol habits between the IGD and healthy game play groups were analyzed using independent *t*-tests and the chi-square test. The differences in game play style including the genre of game play, mean game play time in a weekday, and mean game play time on the weekend between the IGD and healthy game play groups

were analyzed using the chi-square test and independent *t*-tests. The differences in psychological scale scores including the YIAS, BDI-II, BAI, K-ARS, BISBAS, and KWAIS scores as well as the differences in parenting styles between the IGD and healthy game play groups were analyzed using independent *t*-tests.

The Durbin-Watson test was used to confirm the problem of collinearity of the data. Hierarchical logistic regression was used to assess how much the variables in the questionnaires, psychological scales, and parenting styles explained a statistically significant amount of the variance in the dependent variable of IGD. In a multiple hierarchical regression analysis of all participants, a discrete set of hierarchical variables, with IGD as the dependent variable, was added: demographic factors were included in model 1; model 1 factors + game play patterns were included in model 2; model 2 factors + psychological state were included in model 3; and model 3 factors + parenting style were included in model 4. The dependent variable of "IGD" was coded as "1," and the healthy game players were coded as "0." The definition of "IGD" coincided with the inclusion criteria above.

The mediating role of attention problems on the relationship between parenting style and IGD was assessed using Hayes's PROCESS macro for SPSS (model 4) (40). The mediating effect verification model was divided into two models according to the factors related to the parenting method. The independent variable of Model A was set as a parent effective variable, and the independent variable of Model B was set as a parent autonomous variable. In addition, the dependent variable was set as the YIAS score, and the K-ARS score was set as a parameter to verify the direct and indirect effects of ADHD on the YIAS score through the parenting style. With the bootstrap confidential intervals (CIs) in PROCESS, the indirect effect was considered significant if the 95% CI did not include zero.

Results

Demographic data, game play pattern, psychological status, and parenting style

A total of 467 participants' data were analyzed. There were no significant differences in age, sex distribution, education level, or smoking and alcohol habits between the IGD and healthy game play groups (Table 1).

There was no significant difference in the game genre distribution between the IGD and healthy game play groups. However, those in the IGD group played internet games more times on weekdays and weekends than those in the healthy game play group. The IGD group showed increased YIAS scores compared with the healthy game play group.

The IGD group showed increased scores on the BDI-II, BAI, K-ARS, and BISBAS compared with the healthy game play group (Table 1). There was significant difference in the prevalence of a comorbidity of ADHD between the IGD and healthy game play groups ($\chi^2 = 103.7$, $p < 0.01$). Of 256 individuals with IGD, 165 (64.5%) had a comorbidity of ADHD; in contrast, only 37(17.5%) of 211 healthy game players had a comorbidity of ADHD. However, there was no significant difference in the K-WAIS total scores between the IGD and healthy game play groups.

TABLE 1 Demographic data, psychological characteristics, and parenting style.

	IGD group	Healthy game play group	Statistics
Demographic information			
Age	15.7 ± 2.0	15.5 ± 1.9	$t = 1.10$, $p = 0.27$
Sex (male/female)	239 (93.4%)/17 (6.6%)	194 (91.9%)/17 (8.1%)	$\chi^2 = 0.34$, $p = 0.59$
Education level (years)	8.8 ± 2.0	8.6 ± 1.9	$t = 1.00$, $p = 0.32$
Smoking			
Heavy	10 (3.9%)	13 (6.2%)	$\chi^2 = 1.37$, $p = 0.51$
Occasional	35 (13.7%)	26 (12.3%)	
Non-smoking	211 (82.4%)	172 (81.5%)	
Alcohol			
Heavy	5 (2.0%)	5 (2.4%)	$\chi^2 = 1.56$, $p = 0.46$
Occasional	38 (14.8%)	40 (19.0%)	
Non-drinking	213 (83.2%)	166 (78.7%)	
Game play style			
Game genre			
MMORPG	87 (34.0%)	85 (40.3%)	$\chi^2 = 2.03$, $p = 0.57$
RTS	112 (43.8%)	85 (40.3%)	
FPS	30 (11.7%)	21 (10.0%)	
Others	27 (10.5%)	20 (9.5%)	
Play time each weekday (hours/day)	4.1 ± 3.1	2.6 ± 1.9	$t = 6.42$, $p < 0.001$*
Play time each weekend (hours/day)	4.6 ± 3.3	2.9 ± 1.8	$t = 6.99$, $p < 0.001$*
Psychological scales			
YIAS	57.3 ± 13.7	34.2 ± 12.5	$t = 18.87$, $p < 0.001$*
BDI-II	16.3 ± 10.9	10.9 ± 8.5	$t = 5.86$, $p < 0.001$*
BAI	11.6 ± 9.4	8.6 ± 7.7	$t = 3.71$, $p < 0.001$*
K-ARS	16.8 ± 12.9	12.6 ± 12.0	$t = 3.61$, $p < 0.001$*
BISBAS	55.4 ± 8.1	51.2 ± 8.9	$t = 5.41$, $p < 0.001$*
K-WAIS total	101.7 ± 18.2	103.2 ± 18.5	$t = -0.86$, $p = 0.39$
Parenting style			
Affective attitudes	34.3 ± 7.5	38.5 ± 7.0	$t = -6.23$, $p < 0.001$*
Rejecting attitudes	37.6 ± 7.9	38.4 ± 7.1	$t = -1.09$, $p = 0.28$
Autonomous attitudes	33.5 ± 6.8	35.7 ± 7.3	$t = -3.29$, $p = 0.001$*
Controlling attitudes	36.5 ± 5.6	37.6 ± 6.0	$t = -2.05$, $p = 0.04$

K-ARS, Korean version of Dupaul's ADHD rating scale; BIS/BAS, behavioral inhibitory system/behavioral activation system; K-WAIS-IV, Korean–Wechsler adult intelligence scale-IV; MMORPG, massively multiplayer online role-playing games; FPS, first-person shooter; RTS, real-time strategy; YIAS, young internet addiction scale; BDI-II, beck depression inventory II; BAI, beck anxiety inventory. Hierarchical logistic regression analysis.
*$p < 0.001$.

The scores for maternal affective attitudes and autonomic attitudes in the IGD group were significantly decreased compared with those observed in the healthy game play group (Table 1). The scores for controlling attitudes in the IGD group were decreased compared with those observed in the healthy game play group. There was no significant difference in the scores for controlling attitudes between the two groups.

Considering the results of the Durbin–Watson test, there was no autocorrelation in the current dataset. Of the four models suggested in the current study, models 2, 3, and 4 were significantly associated with IGD. In model 2, the model χ^2 (67.8, $p < 0.01$) and Nagelkerke's R2 (0.181, 18.1% of the variance in the dependent variable of IGD) indicated that the model was adequate to predict IGD. When the practical usefulness of the model was assessed considering the classification accuracy, eight variables in model 2 enhanced the predictive accuracy of the group membership of the dependent variable to 65.7%. With the step χ^2-value (Step $\chi^2 = 64.1$, $p < 0.01$), game play pattern was found to be a predictive factor for IGD.

In model 3, the model χ^2 (109.7, $p < 0.01$) and Nagelkerke's R2 (0.280, 28.0% of the variance in the dependent variable of IGD) indicated that the model was adequate to predict IGD. When the practical usefulness of the model was assessed considering the classification accuracy, 13 variables in model 3 enhanced the predictive accuracy of the group membership of the dependent variable to 70.2%. With the step χ^2-value (Step $\chi^2 = 41.9$, $p < 0.01$), psychological status was a predictive factor for IGD.

In model 4, the model χ^2 (147.8, $p < 0.01$) and Nagelkerke's R2 (0.363, 36.3% of the variance in the dependent variable of IGD) indicated that the model was adequate to predict IGD. When the practical usefulness of the model was assessed considering the classification accuracy, 17 variables in model 4 enhanced the predictive accuracy of the group membership of the dependent variable to 72.8%. With the step χ^2-value (Step $\chi^2 = 38.0$, $p < 0.01$), parenting style was a predictive factor for IGD.

According to the Wald statistics for all independent variables, higher ADHD scores, less affective parenting styles, and less autonomous parenting styles were significant predictors of IGD (Table 2).

Testing for mediation

With the results of the hierarchical logistic regression analysis, attention problems, affective parenting styles, and autonomous parenting styles were determined to be significant predictive factors for IGD. With those factors, we performed tests for meditation.

Controlling for all the covariates, the scores for affective parenting style were negatively associated with the K-ARS scores ($\beta = -0.271$, $p < 0.01$), which in turn affected IGD ($\beta = 0.630$, $p < 0.001$). In addition, a significant residual direct effect was observed ($\beta = -0.321$, $p < 0.01$). This indicates that the K-ARS scores partially mediated the link between an affective parenting style and IGD (indirect effect = −0.171, SE = 0.074, 95%CI = −0.317 to −0.023; Figure 1).

Controlling for all the covariates, the scores for autonomous parenting style were negatively associated with the K-ARS scores ($\beta = -0.244$, $p < 0.01$), which in turn affected IGD ($\beta = 0.645$, $p < 0.001$). Furthermore, a significant residual direct effect was observed ($\beta = -0.218$, $p < 0.05$). This indicates that the K-ARS scores partially mediated the link between an autonomous parenting style and IGD (indirect effect = −0.157, SE = 0.072, 95%CI = −0.301 to −0.019; Figure 1).

Discussion

In the current results, there were significant differences in the game play patterns, psychological status, and parenting styles between the IGD and healthy game play groups. In particular, the K-ARS scores, affective parenting styles, and autonomous parenting styles were significant predictive factors for IGD. In addition, attention problems could mediate the association between parenting style and the severity of IGD.

Comparison of the game play patterns, psychological status, and parenting styles between the IGD and healthy game play groups

In current study, the IGD group showed increased BDI-II, BAI, K-ARS, and BISBAS scores compared with the healthy game play group. Many studies have already suggested that IGD is associated with various comorbidities including MDD, anxiety disorders, ADHD, and impulse control disorders (41–43). These psychiatric comorbidities are associated with the cause of IGD (44) and aggravate the progression of IGD (24). Of several comorbidities, ADHD was the most common comorbidity in the IGD group (26). Lee et al. (26) reported that an IGD group with a comorbidity of ADHD showed a poor clinical course of IGD and that changes in ADHD symptoms were associated with changes in IGD symptoms. In the hierarchical regression analysis in the current study, problematic attention scores were found to predict IGD.

In the current study, the scores for maternal affective attitudes and autonomous attitudes in the IGD group were significantly decreased compared with those observed in the healthy game play group. Several studies have suggested that parenting style influences psychopathology and the severity of IGD in children and adolescents (45, 46). Durkee et al. (45) reported that low parental involvement could predict a high risk of internet addiction in children (46). In addition, a negative parenting style including strict attitudes, heavy punishment, and low affection was found to provoke internet addiction in middle school and college students (27). However, previous studies of the relationships between parenting style and internet addiction (or IGD) have suggested that negative parenting is associated with IGD but that positive parenting has controversial protective effects against IGD in children and adolescents (47).

Mediation effects of attention problems on the interaction between parenting style and IGD

As mentioned above, positive parenting may have protective effects against IGD in children and adolescents, but these remain controversial. However, in the current study, positive parenting

TABLE 2 Hierarchical logistic regression analysis.

Independent variables		Model 1			Model 2			Model 3			Model 4		
		B	Wald	OR	B	Wald	OR	B	Wald	OR	B	Wald	OR
Demographic characteristics	Sex	−0.193	0.289	0.824	−0.196	0.266	0.822	−0.652	2.597	0.521	−0.681	2.319	0.506
	Age	0.376	0.857	1.457	0.620	2.038	1.859	0.655	2.069	1.926	0.665	1.965	1.944
	Education	−0.316	0.603	0.729	−0.568	1.716	0.567	−0.662	2.117	0.516	−0.654	1.901	0.520
	Smoking	−0.254	0.141	0.775	−0.524	0.469	0.592	−0.675	0.680	0.509	−0.538	0.379	0.584
	alcohol	−0.418	2.003	0.658	−0.371	1.344	0.690	−0.257	0.599	0.774	−0.274	0.609	0.760
Game play pattern	Game genre				0.143	1.718	1.153	0.114	1.015	1.121	0.136	1.329	1.145
	Weekday				0.165	9.327	1.179**	0.142	6.389	1.153*	0.100	2.658	1.106
	Weekend				0.175	9.388	1.239**	0.139	5.103	1.125*	0.138	1.401	1.148
Psychological status	BDI-II							0.007	0.572	1.007	0.002	0.018	1.002
	BAI							−0.009	0.322	0.991	0.003	0.021	1.003
	KARS							0.047	10.389	1.049**	0.049	9.805	1.050**
	BISBAS							0.054	15.751	1.055	0.001	0.004	1.001
	K-WAIS							−0.002	0.106	0.998	0.002	0.077	1.002
Parenting style	Affective										−0.217	26.578	0.717**
	Rejecting										0.020	1.375	1.021
	Autonomous										−0.119	25.357	0.888**
	Controlling										0.024	0.906	1.024

Indices	Model 0	Model 1	Model 2	Model 3	Model 4
−2LL	692.345	639.328	575.267	533.313	495.285
Nag R^2	N/A	0.011	0.181	0.280	0.363
Step χ^2/p	N/A	3.728/0.589	64.1/<0.01	41.9/<0.01	38.0/<0.01
Model χ^2/p	N/A	3.728/0.589	67.8/<0.01	109.7/<0.01	147.8/<0.01
Class Accur	54.8	56.7	65.7	70.2	72.8

−2LL, −2 log likelihood; Nag R^2, Nagelkerke's R^2; Class Accur, classification accuracy; Dependent variable, internet gaming disorder; Model 1, demographic factors; Model 2, Model 1 + game play pattern; Model 3, Model 2 + Psychological status; Model 4, Model 3 + parenting style; K-ARS, Korean version of Dupaul's ADHD rating scale; BIS/BAS, behavioral inhibitory system/behavioral activation system; K-WAIS-IV, Korean-Wechsler adult intelligence scale-IV; YIAS, young internet addiction scale; BDI-II, Beck depression inventory II; BAI, Beck anxiety inventory. *$p < 0.05$ and **$p < 0.01$.

styles including affective and autonomous parenting styles directly affected the severity of IGD. Consistent with the findings of previous studies (48–50), a less authoritative parenting style was found to be associated with IGD. On the other hand, there is controversy regarding the autonomous parenting style because both authoritative and autonomous styles share the characteristic of autonomy. Therefore, it is believed that the low level of autonomy characteristic of the autonomous parenting style may affect the severity of IGD. In contrast, in the current study, no association was found between the rejecting parenting style or controlling parenting style and IGD. Previous studies have indicated that the relationship between parenting style and IGD may vary depending on factors such as the age of the children (51). Specifically, whether the rejecting or controlling parenting style is associated with IGD remains disputed across studies. Therefore, the disparities in the findings of the literature may be attributed to differences in sample characteristics or the influence of parents with diverse cultural dynamics (51).

In the current study, attention scores were found to directly and indirectly mediate the relationship between affective attitudes and autonomous parenting styles and the severity of IGD. Several studies have suggested the mediation effects of ADHD symptoms on the risk of IGD in children and adolescents (52, 53). Jung et al. (52) reported that inattentive ADHD symptoms partially mediated the link between immersive tendencies and susceptibility to IGD. Lim et al. (53) showed that psychological status including anxiety, depression, and attention problems had a partial mediating effect on the link between aggression and the risk of IGD in 714 middle school students. It is possible that there is a bidirectional relationship between ADHD and IGD, in which the symptoms of ADHD contribute to an increased attraction to playing computer games and video games, while gaming, in turn, can worsen the symptoms of ADHD by reinforcing them. These symptoms may include inattention, disinhibition, impulsive response, and a strong desire for immediate rewards. In accordance with this, internet games have also been found to be used as a means of self-medication by children with ADHD (54).

Many studies have supported the relationships between affective and autonomous parenting styles and improving ADHD symptoms and mother–child relationships (55–57). Nelson et al. (56) reported

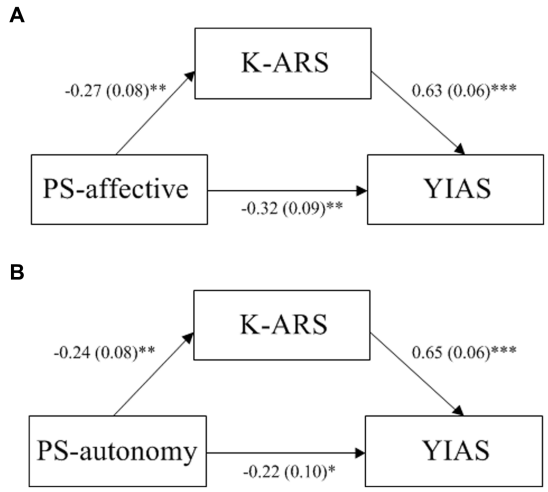

FIGURE 1
Mediation effect of attention problems on the link between parenting style and the severity of internet gaming disorder *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ **(A)** The link between an affective parenting style (PS-affective) and the severity internet gaming disorder (IGD) as assessed with the Young Internet Addiction Scale (YIAS) is mediated by attention as assessed using the Attention Deficit Hyperactivity Disorder Rating Scale (Korean version) (K-ARS). Path values are the path coefficients (standard errors). Direct effect = −0.32, SE = 0.09, 95% CI (−0.435 to −0.039). Indirect effect = −0.17, SE = 0.07, 95% CI (−0.317 to −0.023). **(B)** The link between an autonomous parenting style (PS-autonomous) and the severity internet gaming disorder (IGD) as assessed with the Young Internet Addiction Scale (YIAS) is mediated by attention as assessed using the Attention Deficit Hyperactivity Disorder Rating Scale-Korean version (K-ARS). Path values are the path coefficients (standard errors). Direct effect = −0.22, SE = 0.10, 95% CI (−0.437 to −0.061). Indirect effect = −0.16, SE = 0.07, 95% CI (−0.301 to −0.019).

a mediating effect of hyperactivity symptoms of ADHD on the relationship between mother and children. More severe hyperactivity symptoms of children at 5.5 years old was found to lead to increased maternal hostility to their children at 10 years old; in turn, this caused increased delinquent behaviors and aggression in adolescents (56). Thomassin and Suveg (57) also reported that parental support of autonomy moderated the link between ADHD symptoms and task perseverance in difficult puzzle tasks. Furthermore, Breaux et al. (55) suggested that an affective parenting style could facilitate the development of emotional regulation skills in children with ADHD.

Limitations

There were several limitations in the current study. First, data on parenting style were gathered from the participants' mothers. The father's parenting style is also known to play an important role in children's behavior (58). Second, the cross-sectional design of current study could not show causality or directionality. Finally, with the exception of the K-WISC-IV, most of the scales used in this study relied on self-report measures, which could have introduced bias. Future studies should recruit fathers to assess parenting style as well as apply a longitudinal design to delineate the directionality of the relationships between parenting style and IGD.

Conclusion

The IGD group showed differences in K-ARS scores, affective parenting styles, and autonomous parenting styles compared with the healthy game play group. Moreover, attention problems were found to directly and indirectly mediate the relationship between positive parenting styles including affective and autonomous styles and the severity of IGD. Improved concentration through ADHD treatment could potentially help control the symptoms of IGD, making this treatment plan applicable in a clinical setting. In addition, providing parents with information about parenting styles that include emotional support may help to reduce the symptoms of both IGD and ADHD in children. In the future, our findings have the potential to aid in the development of educational resources regarding parenting styles.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Chung Ang University Institutional Review Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

DH and SB designed the study and wrote the protocol. JL and HH conducted the statistical analysis. SC and HK wrote the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Problematic smartphone use and sleep disturbance: the roles of metacognitions, desire thinking, and emotion regulation

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Background: The association between problematic Smartphone use (PSU) and sleep disturbance is evidenced in the literature, but more research is required to investigate the potential factors that may influence the effect of PSU on sleep disturbance. Given the considerable prevalence of PSU (9.3 to 36.7%) and sleep disturbance (55.2%) in Iran, the current study sought to examine an interactional model to test whether metacognitions about Smartphone use, desire thinking (verbal perseveration and imaginal prefiguration), and emotion regulation (expressive suppression and cognitive reappraisal) could have a moderating effect on the above-mentioned association.

Method: This present study is a cross-sectional, observational study that was conducted between June and September 2022 in a convenience sample of Iranians (n=603, Female=419, Age=24.61$\pm$8).

Results: Despite the significant association between metacognitions about the Smartphone use, PSU, and sleep disturbance, metacognitions failed to predict sleep disturbance above PSU. A slope analysis showed, however, that a high (not low or moderate) levels of imaginal prefiguration strengthen the association between PSU and sleep disturbance, while a high (not low or moderate) level of cognitive reappraisal and expressive suppression dampen the PSU-sleep disturbance association. We also found that verbal perseveration and expressive suppression were unique predictors of sleep disturbance, while imaginal prefiguration and reappraisal only predicted sleep disturbance if they interacted with PSU.

Conclusion: Theoretically, findings suggest that enhancing cognitive reappraisal (by 1 SD) and reducing imaginal prefiguration (by 1 SD), might protect against sleep disturbance by reducing its association with PSU. Limitations and future directions are discussed.

KEYWORDS

desire thinking, emotion regulation, metacognitions about smartphone use, problematic smartphone use, sleep disturbance

1. Introduction

The Smartphone is used widely for many aspects of our daily lives, such as communication, entertainment, and paying bills (1). Despite all benefits of a Smartphone, people have been found to be prone to engaging in 'problematic Smartphone use (PSU)'. This term refers to the excessive, compulsive, and compensatory use of the Smartphone in improper situations (2), and is one of the types of non-chemical behavioral addiction given the incapacity to regulate smartphone use time which could span from mild PSU to a more extreme addictive behavior (3). PSU is related to main components of addiction: tolerance (i.e., increasing Smartphone use to achieve satisfaction), compulsion (overuse), withdrawal (i.e., negative symptoms which occur after Smartphone use discontinuation), mood modification (Smartphone use induces direct alterations in mood), conflict (intrapersonal and interpersonal difficulties stemming from smartphone use), relapse (after a period of abstinence, the return to PSU), and functional impairment (4, 5). PSU can cause adverse consequences in different aspects of a user's life, including psychological and physical health, and poor sleep quality (6).

Given that the prevalence of PSU is between 9.3 and 36.7% (7–9), and the prevalence of sleep disturbance is in the region of 55.2% (10) and 35.7% (11) in Iran and the globe, respectively, this appears to be an important area of research in behavioral addiction. A recent meta-analysis (7) found that among 41,871 children and young adults (female = 55%) found that PSU could double the odds of sleep disturbance, i.e., the incidence of sleep disturbance among people with PSU is two and a half times higher than among people without PSU, nonetheless, several factors may be associated with the persistence of sleep disturbance although few studies have assessed in depth this issue. In general, sleep disturbance refers to symptoms of chronic insomnia, hypersomnia, excessive daytime lethargy, circadian rhythm disturbance, difficulty falling asleep and/or staying asleep, which are associated with daytime function impairment (12).

PSU may predispose people to sleep disturbance due to several factors including, using Smartphones in bed, which shortens nighttime sleep duration, the light from Smartphones disrupting the circadian rhythm (13), using a mobile phone at night affecting brain activity, particularly the pineal gland, and altering the brain's electrical activity and cerebral blood flow, all of which have a negative impact on sleep quality (14), reducing rapid eye movement (REM) sleep, longer sleep latency, slow wave sleep (15), shortened sleep duration (16), and suppressing sleep-promoting hormones like melatonin given the blue light emitted from Smartphones (17, 18). Thus, research suggests that people with sleep disturbance should also be screened for PSU (19). Furthermore, the association between PSU and sleep disturbance, may be affected by factors potentially linked to sleep quality or with PSU such as metacognitions, desire thinking, and emotion regulation, which will be discussed below.

Metacognition is a multifaceted concept that is broadly defined (in the psychopathology arena) as knowledge of mental activities ('metacognitions') and strategies for appraising, monitoring, and regulating cognition, which can include worry, rumination, thought suppression and threat monitoring, for example (20). Two levels of sleep-related arousal involve metacognition and cognition processes. Primary arousal is related to thoughts about the inability to sleep and secondary arousal consists of amplifying the negative emotions' valence and/or creating biases in the attention to sleep-related thoughts (21). Metacognitions (beliefs about cognition and how it should be controlled) play a critical role in the etiology and maintenance of sleep disturbance (22, 23). Cognitive intrusive thoughts about sleep (e.g., "thinking in bed means I will not get to sleep" or "thinking in bed prevents me from getting to sleep") and how to control these unwanted thoughts before sleep will come in (e.g., "Before I fall asleep, I must try to have a restful mind, maybe by using my Smartphone" or "Before I fall asleep, I must try to switch off my thoughts and my Smartphone may help me with it") are the main focus of people's metacognition about sleep (24), particularly in the context of PSU.

Recently, Casale and colleagues (2020), have developed the Metacognitions about Smartphone Use Questionnaire which aimed to assess: (i) positive metacognitions about emotional and cognitive regulation (e.g., "My Smartphone helps me control my negative thoughts") and about socio-cognitive regulation through Smartphone use (e.g., "Using a Smartphone increases my sociability when I am feeling lonely"); and (ii) negative metacognitions about the uncontrollability (e.g., "My Smartphone use is beyond my control") and cognitive harm arising from Smartphone use (e.g., My mind will be damaged by the use of a Smartphone). Recently, Casale et al. (25) published a systematic review on the association between metacognitions and technological addictions, such as PSU. However, they suggested that additional research on metacognitions in the context of PSU is necessary to provide a more thorough picture of the role of metacognitions in PSU.

Given the association between metacognitions and sleep disturbance (22, 23), and the association between PSU and sleep disturbance (6), we were curious to examine whether there is an interaction between PSU and metacognitions about Smartphone use in predicting sleep disturbance.

> *H1*: Metacognitions about Smartphones will interact with PSU in predicting sleep disturbance.

Testing such interaction would be interesting, given the evidence supporting the role of metacognitions in sleep disturbance was assessed by a generic measure of metacognitions (21), and given the role of PSU in sleep disturbance. Furthermore, exploring such interaction using a tailored measure of metacognitions about Smartphone use may provide a deeper understanding of PSU-related sleep disturbance.

Another concept related to PSU is desire thinking. Desire thinking is a transdiagnostic factor in addictive behaviors (26) and can be conceptualized as voluntary cognitive process that is characterized by the conscious elaboration of memories and images about the positive target-related experience (27). Desire thinking is bi-dimensional in nature and encompasses: (i) imaginal prefiguration, which refers to the allocation of attentional resources toward elaborating (through imagery) positive target-related information and (ii) verbal preservation, which refers to prolonged self-talk regarding worthwhile reasons for engaging in positive target-related experience. Recent research by Marino et al. (28) suggests that Smartphone use and social media use are overlapping concepts, given that Smartphones provide access to social media. Consequently, the literature on the association between desire thinking and social media use may establish the groundwork for the potential association between desire thinking and PSU. In addition, research has verified the association

between desire thinking and problematic social media use (29, 30) and identified desire thinking as a distinct predictor of problematic social media use (31), to our knowledge, however, no research has examined the association between desire thinking and sleep disturbance. Desire thinking has been associated with negative affect, impulsivity, and thought suppression in relation to desire thinking and problematic social media use (32). Considering the association of desire thinking with problematic social media use and its overlap with PSU, and also the association between PSU and sleep disturbance, we were curious as to whether there would be an interaction between PSU and desire thinking in predicting sleep disturbance. This might shed light on the underlying factors that explain variance in sleep disturbance by keeping the PSU 'engine' active. According to the above-mentioned studies, it is of interest, to explore whether the association between PSU with sleep disturbance is moderated by desire thinking.

> *H2*: Desire thinking will interact with PSU in predicting sleep disturbance.

The last construct, emotion regulation, has been found to be another predictor of sleep disturbance (33). Emotion regulation is defined as an attempt to modify and control processes involved in the initiation, duration, and maintenance of negative and positive emotions (34). Some emotion regulation strategies such as problem-solving, acceptance and cognitive appraisal, and distraction, appear to be adaptive in some contexts while other strategies such as suppression, rumination, and avoidance appear to exacerbate emotional distress (35). Research has shown that cognitive reappraisal, defined as the re-evaluation of emotional eliciting stimuli to change their emotional relevance, and expression suppression, characterized by an active attempt to inhibit the behavioral expression of an emotional experience, are related to sleep quality (33). Considering the associations between both emotion regulation strategies and PSU on the one hand and sleep disturbance on the other, it would be interesting to explore whether is there an interaction between PSU and emotion regulation strategies (cognitive reappraisal and expressive suppression) in predicting sleep disturbance. It is of interest, as those higher on reappraisal and lower on expression suppression appear to be more prone to psychological distress, experiencing negative emotions and low quality of life (36). Thus, testing the interaction between PSU and emotion regulation strategies may provide insights into the extent to which different levels of emotion regulation might affect the association between PSU and sleep disturbance.

> *H3*: Emotion regulation will interact with PSU in predicting sleep disturbance.

Given that PSU is a predictor of sleep disturbance and that metacognitions about smartphones, desire thinking, and emotion regulation are associated with PSU, it was intriguing to investigate whether these variables interact with PSU in predicting sleep disturbance. Although it is possible to merely use hierarchical regression analysis or a multiple regression model to explore what other variables could predict sleep disturbance above and beyond PSU, such analysis is based on average score and would not tell us how the association between PSU and sleep disturbance would differ according to variations in the variables of interest. Such understanding could be accomplished by developing an interactional model using slope analysis to explore whether the possible differences in the association between PSU and sleep disturbance are moderated by other variables. An interactional model examines "when" or "for whom" a variable strongly influences an outcome variable (37), which may provide us with new theoretical insights (38). Given that the presence of an interaction indicates that the association between each of the interacting variables and a third "dependent variable" depends on the value of the other interacting variable, it may have clinical implications regarding the optimal therapeutic target, which variable should be intervened on at what level, and for whom.

2. Method

This present study is a cross-sectional, observational study that was conducted between June and September 2022 in a convenience sample of Iranians.

2.1. Measures

2.1.1. Pittsburgh sleep quality index scale (PSQI)

The PSQI (39) is a self-report measure of the quality and pattern of sleep over a 1-month interval. It contains 12 items which are scored on a 4-point Likert scale, from 0 (not in the past month) to 3 (three or more times per week). The PSQI has 7 factors: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The Persian version of this measure indicated good internal consistency (40). In the current study, the McDonald's omega (ω) of internal consistency was 0.70. Higher scores on PSQI represent higher sleep disturbance.

2.1.2. Emotion regulation questionnaire (ERQ)

The ERQ (41) is a self-report measure of emotion regulation strategies. It contains 10 items which are scored on a 7-point Likert scale, from 1 (strongly disagree) to 7 (strongly agree). The ERQ has two factors: cognitive reappraisal and expressive suppression. The Persian version of this measure indicated good internal consistency (42). In the current study, the McDonald's omega (ω) of internal consistency for cognitive reappraisal and expressive suppression were 0.82 and 0.75, respectively. Higher scores on cognitive reappraisal and expressive suppression represent higher cognitive reappraisal and higher expressive suppression, respectively.

2.1.3. Metacognitions about smartphone use questionnaire (MSUQ)

The MSUQ (43) is a self-report measure of positive and negative metacognitions about Smartphone use. It contains 24 items which are scored on a 4-point Likert scale, from 1(do not agree) to 4 (agree very much). The MSUQ has three factors: positive metacognitions about emotional and cognitive regulation (MSUQ – PM ECR) through Smartphone use, positive metacognitions about the socio-cognitive regulation (MSUQ – PM SR) through Smartphone use, and negative metacognitions about the uncontrollability and cognitive harm (MSUQ – NM UH) of Smartphone use. The Persian version of this measure indicated good internal consistency (44). In the current study, the McDonald's omega (ω) of internal consistency for MSUQ

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– PM ECR, MSUQ – NM UH, and MSUQ – PM SR were 0.94, 0.93, and 0.77, respectively. Higher scores on MSUQ – PM SR represent higher positive metacognitions about emotional and cognitive regulation. Higher scores on MSUQ – PM SR represent higher positive metacognitions about the socio-cognitive regulation. Higher scores on MSUQ – NM UH represent higher negative metacognitions about uncontrollability and cognitive harm.

2.1.4. Desire thinking questionnaire (DTQ)

The DTQ (45) is a self-report measure of desire thinking. It contains 10 items which are scored on a 4-point Likert scale from 1 (almost never) to 4 (almost always). The DTQ has two factors: verbal perseveration and imaginal prefiguration. The Persian version of this measure indicated good internal consistency [but item 10 from the verbal perseveration factor is removed from the Persian version due to low loading; (46)]. In the current study, the McDonald's omega (ω) of internal consistency for verbal perseveration and imaginal prefiguration were 0.89 and 0.87, respectively. Higher scores on verbal perseveration and imaginal prefiguration represent higher verbal perseveration and imaginal prefiguration.

2.1.5. Smartphone addiction scale-short version (SAS-SV)

The SAS-SV (47) is a self-report measure of Smartphone addiction in adolescents and adults. It contains 10 items which are scored on a 6-point Likert scale, from 1 (completely disagree) to 6 (completely agree). The Persian version of this measure indicated good internal consistency (48). In the current study, the McDonald's omega (ω) of internal consistency was 0.88. Higher scores on SAS-SV represent higher PSU.

2.2. Participants, procedure, and data analysis

The sample of this study included 603 participants (males = 184, females = 419) aged from 18 to 55 years with a mean age of 24.61 (SD = 8) years. 67.5% of the sample had educational attainment at university level, 46% were employed, 85% were passive users, and 83% were using Smartphones for more than 3 h per day (Please see Table 1 for more information). The participants were recruited voluntarily with no inceptions for participation, using an anonymous online survey advertised on popular social media in Iran (i.e., WhatsApp, Telegram, Twitter, and Facebook) describing the aim of the study. Inclusion criteria were: (i) being able to read and write in Persian; (ii) being resident in Iran; (iii) and being 18 years of age or older.

Once participants had been informed about the study and provided informed consent, they completed the study questionnaires. All participants were assured that their data would be kept confidential. Answering all questions was mandatory, therefore, there was no missing data. The study was conducted in alignment with the Declaration of Helsinki (49) for research with human participation.

Before analyzing data for regression analyses, assumptions were tested. The Mahalanobis distance scores identified no multivariate outliers. The multicollinearity statistics were within acceptable limits for the model. The residual analysis (including Loess line fitting and Q-Q plots), scatterplots, and statistic coefficients demonstrated that the normality, linearity, and homoscedasticity assumptions were met.

TABLE 1 Demographic features of the participants (N=603).

	N (%)
Gender	
Male	184 (31%)
Female	419 (69%)
Educational attainment	
Less than Diploma	42 (7.0%)
Diploma	154 (26%)
Associate degree	48 (8.0%)
Bachelor degree	220 (36%)
Master Degree	106 (18%)
Ph.D.	33 (5.5%)
Occupational status	
Unemployed	325 (54%)
Part-time	122 (20%)
Full-time	156 (26%)
Type of smartphone use	
Active	93 (15%)
Passive	510 (85%)
Smartphone use time spent	
1 h\day	7 (1.2%)
2 h\day	97 (16%)
3 h\day	200 (33%)
4 h\day	299 (50%)

We inquired as to whether the participants are active on social media if they post frequently, manage online groups or channels in addition to their regular activities. In addition, we inquired as to whether they are passive on social media if they only engage in routine activities such as viewing others' posts, clips, conversations, etc.

Data were analyzed using IBM SPSS (version 26) and Jamovi (version 2.3.18).

3. Results

As seen in Table 2, all variables are normally distributed as measured by skewness and kurtosis indices. According to a Pearson Product–moment set of correlation analyses, sleep disturbance was significantly and positively associated with PSU, desire thinking, metacognitions about Smartphone use, and emotion regulation (except the cognitive reappraisal factor). Moreover, PSU was significantly and positively associated with desire thinking, metacognitions about Smartphone use, and emotion regulation (except the expressive suppression factor).

Table 3 presents the results for predicting sleep disturbance scores from PSU (step 1), metacognitions about Smartphone use factors (step 2), desire thinking factors (step 3), and emotion regulation factors (step 4). The results indicated that PSU significantly predicted sleep disturbance, $F\,(1, 601) = 31.65$, $p < 0.01$, explaining a 5% variance. The addition of metacognitions about Smartphone use factors (step 2) resulted in a significant regression equation, $F\,(4, 598) = 8.297$, $p < 0.001$, explaining an extra 0.03% of

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TABLE 2 The means, standard deviation, kurtosis, skewness, and method of moment correlations of the variables.

Variable	*M*	SD	Range	Skewness	Kurtosis	1	2	3	4	5	6	7	8	9
Sleep disturbance (1)	10.6	5.7	0–36	0.56	−0.09	–	0.22**	0.12**	0.18**	0.08*	0.28**	0.22**	0.10**	−0.06
PSU (2)	35.7	12.1	10–60	−0.13	−0.67		–	0.38**	0.77**	0.34**	0.59**	0.68**	0.06	−0.08*
MSUQ – PM ECR (3)	25.5	9.1	11–44	0.33	−0.83			–	0.30**	0.69**	0.35**	0.43**	0.12**	0.09*
MSUQ – NM UH (4)	21.7	9.0	10–40	0.48	−0.99				-	0.27**	0.57**	0.65**	0.03	−0.10**
MSUQ – PM SR (5)	6.7	2.6	3–12	0.35	−0.80					-	0.32**	0.39**	0.03	0.08*
Verbal Perseveration (6)	6.4	3.1	4–16	1.57	1.84						–	0.84**	0.08*	−0.04
Imaginal Prefiguration (7)	9.1	3.8	5–20	1.18	0.78							–	0.08	−0.04
Expressive Suppression (8)	16.4	4.0	4–28	−0.10	−0.15								–	0.37**
Cognitive Reappraisal (9)	25.9	6.7	6–42	−0.35	−0.05									–

PSU, Problematic Smartphone Use; MSUQ – PM ECR, Positive Metacognitions about Emotional and Cognitive Regulation; MSUQ – NM UH, Negative Metacognitions about Uncontrollability and Cognitive Harm; MSUQ – PM SR, Positive Metacognitions about Socio-cognitive Regulation. ** $p < 0.01$; * $p < 0.05$.

the variation in sleep disturbance scores, ΔF (3, 598) = 0.535, $p = 0.659$, which was non-significant (Cohen's $f = 0.003$). The inclusion of desire thinking factors (step 3) produced a significant equation, F (6, 596) = 10.242, $p < 0.001$, accounting for an additional 4.1% of the variation explained in sleep disturbance scores, ΔF (2, 596) = 13.441, $p < 0.001$ (Cohen's $f = 0.044$). Finally, the addition of the emotion regulation factor (step 4) resulted in a significant equation, F (8, 594) = 8.936, p < 0.001, accounting for an additional 4.1% of the variation in sleep disturbance scores, ΔF (2, 594) = 4.642, p < 0.001 (Cohen's $f = 0.015$). The final model revealed that predicted variability in sleep disturbance scores was 14.0%, and it was small in term of Cohen's f (< 0.20). In this model, the verbal perseveration factor of desire thinking predicted sleep disturbance scores above and beyond PSU, metacognitions about Smartphone use, and emotion regulation. Additionally, it is imperative to remark that PSU was no longer a significant predictor of sleep disturbance after adding desire thinking and emotion regulation.

3.1. Moderator analysis

In addition to the above analysis, we examined whether the significant predictors (desire thinking and emotion regulation) of sleep disturbance would be predicted by their different levels, i.e., average (mean), one standard deviation above the mean, and one standard deviation below the mean. However, given the non-significant equation for metacognitions about Smartphone use predicting sleep disturbance scores, the moderating effect for this variable was not investigated.

3.1.1. Expressive suppression as a moderator

As seen in Table 4, expressive suppression positively and significantly predicted sleep disturbance. Also, it significantly moderated the association between PSU and sleep disturbance. The slope at the low level of expressive suppression was (0.15), at a high level, it was (0.06), and at the average level, it was (0.10). Figure 1 depicts the moderating role of expressive suppression at different levels. This suggests expressive suppression's strongest influence is at its low and average level.

3.1.2. Cognitive reappraisal as a moderator

Interestingly, cognitive reappraisal did not significantly predict sleep disturbance (see Table 4). However, its moderation role was significant. The association between PSU and sleep disturbance was found to be different at different levels of cognitive reappraisal; the slope shows that it was (0.15) at the low level, it was (0.05) at the high level, and it was (0.10) at the average. Figure 2 depicts the moderating role of cognitive reappraisal at different levels. As with expressive suppression, the strongest influence of cognitive reappraisal was at its low and average level.

3.1.3. Verbal perseveration as a moderator

As seen in Table 4, verbal perseveration significantly and positively predicted sleep disturbance; however, it was not a significant moderator of the association between PSU and sleep disturbance. Consequently, the moderating role of verbal perseveration at different levels was not investigated.

3.1.4. Imaginal prefiguration as a moderator

Interestingly, imaginal prefiguration did not significantly predict sleep disturbance; however, it significantly moderated the association between PSU and sleep disturbance. The slope for the low level was not significant. However, it was significant at a high level (0.12) and average (0.08) level. The slope indicates that most influence of

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TABLE 3 Hierarchical regression model for predicting sleep disturbance.

Predictor	*B 95%CI*[Ul, Ll]	*β*	*T*	Sr^2	*R*	R^2	Adjusted R^2	ΔR^2
Step 1					0.224	0.050	0.048	0.050*
PSU	0.10 [0.06, 0.14]	0.22*	5.63	0.22				
Step 2					0.229	0.053	0.046	0.003
PSU	0.08 [0.02, 0.14]	0.19*	2.88	0.11				
MSUQ – PM ECR	0.04 [−0.02, 0.11]	0.06	1.14	0.04				
MSUQ – NM UH	0.01 [−0.05, 0.09]	0.03	0.48	0.01				
MSUQ – PM SR	−0.06 [−0.30, 0.17]	−0.03	−0.57	−0.02				
Step 3					0.306	0.093	0.084	0.041*
PSU	0.06 [0.003, 0.12]	0.14*	2.07	0.08				
MSUQ – PM ECR	0.03 [−0.03, 0.10]	0.05	0.91	0.03				
MSUQ – NM UH	−0.01 [−0.09, 0.06]	−0.03	−0.42	−0.01				
MSUQ – PM SR	−0.09 [−0.32, 0.14]	−0.04	−0.76	−0.03				
Verbal Perseveration	0.61 [0.35, 0.88]	0.34*	4.63	0.18				
Imaginal Prefiguration	−0.12 [−0.45, 0.03]	−0.14	−1.71	−0.07				
Step 4					0.328	0.107	0.095	0.014*
PSU	0.06 [−0.002, 0.12]	0.13	1.92	0.07				
MSUQ – PM ECR	0.02 [−0.04, 0.09]	0.04	0.72	0.02				
MSUQ – NM UH	−0.01, [−0.09, 0.06]	−0.03	−0.48	−0.02				
MSUQ – PM SR	−0.05 [−0.28, 0.18]	−0.02	−0.42	−0.01				
Verbal perseveration	0.60 [0.34, 0.86]	0.33*	4.56	0.18				
Imaginal Prefiguration	−0.12 [−0.45, 0.02]	−0.14	−1.73	−0.07				
Suppression	0.16 [0.04, 0.28]	0.12*	2.73	0.11				
Reappraisal	-0.08 [-0.15, -0.01]	−10*	−2.29	−09				

PSU, Problematic Smartphone Use; MSUQ – PM ECR, Positive Metacognitions about Emotional and Cognitive Regulation; MSUQ – NM UH, Negative Metacognitions about Uncontrollability and Cognitive Harm; MSUQ – PM SR, Positive Metacognitions about Socio-cognitive Regulation. * $p < 0.05$.

imaginal prefiguration is at its high level and then its average level. Figure 3 depicts the moderating role of imaginal prefiguration at different levels (see Table 5).

4. Discussion

Given that PSU is a predictor of sleep disturbance and that metacognitions about smartphones, desire thinking, and emotion regulation are associated with PSU, the current study sought to investigate whether these variables interact with PSU in predicting sleep disturbance.

All factors of the MSUQ were positively and significantly associated with PSU and sleep disturbance. However, when the PSU level was accounted for, the MSUQ factors were no longer predictors of sleep disturbance which led to their omission in the interaction analysis. This finding is interesting given that in a pairwise association, it was observed that higher scores on the MSUQ factors were associated with higher scores on PSU and sleep disturbance, but additional variance in sleep disturbance could not be explained when PSU was controlled for. It might be argued that the non-significant role of the MSUQ factors is due to their non-linear effects on sleep disturbance, for example, they may be non-linear (e.g., curvilinear) moderators of the association between PSU and sleep disturbance which could not be examined using linear regression analysis [for more information on curvilinear moderators, please see (50)], and requires further investigation. Another potential explanation for this null effect might be explained by the notion of prediction interval -in some populations, an effect might be (a) null, (b) in the expected direction, or (c) even reverse (51), as some well-known associations might not be observed in all samples, for example, fear of missing out is not associated with Facebook use in some populations (52). That said, the MSUQ might explain additional variance in PSU in predicting sleep disturbance in other samples.

The findings show that desire thinking (verbal perseveration) predicted sleep disturbance above and beyond PSU, suggesting that self-talk regarding reasons for engaging in Smartphone use is a stronger predictor of sleep disturbance and it is above and beyond merely the excessive use of a Smartphone, i.e., the higher the desire (motivated by personal reasons) to use a Smartphone the higher the sleep disturbance. However, the effect of the imaginal prefiguration factor of desire thinking in predicting sleep

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TABLE 4 The moderation analysis, sleep disturbance as the dependent variable.

Variable	*B 95%CI* [Ul, Ll]	SE	*Z*	*p*
Model 1 – Suppression as a moderator				
PSU	0.10 [0.06, 0.14]	0.0202	5.15	<0.001
Suppression	0.11 [0.01, 0.22]	0.0556	2.09	0.037
PSU * Suppression	−0.01 [−0.02, −0.002]	0.0049	−2.29	0.022
Model 2 – Reappraisal as a moderator				
PSU	0.10 [0.06, 0.14]	0.0204	5.14	<0.001
Reappraisal	−0.04 [−0.10, 0.02]	0.0344	−1.28	0.200
PSU * Reappraisal	−0.007 [−0.01, −0.001]	0.0028	−2.50	0.013
Model 3 – Verbal Perseveration as a moderator				
PSU	0.043 [0.006, 0.07]	0.0243	1.77	0.076
Verbal perseveration	0.39 [0.25, 0.54]	0.1173	3.40	<0.001
PSU * Verbal perseveration	0.003 [−0.006, 0.01]	0.0079	0.41	0.677
Model 4 – Imaginal Prefiguration as a moderator				
PSU	0.082 [0.04, 0.11]	0.0262	3.15	0.002
Imaginal prefiguration	0.068 [−0.04, 0.18]	0.0983	0.69	0.486
PSU * Imaginal prefiguration	0.012 [0.003, 0.02]	0.0059	2.06	0.039

PSU, Problematic Smartphone Use.

disturbance was not significant, suggesting that constructing mental images on what Smartphones can afford is not a significant predictor of sleep disturbance when PSU, metacognitions about Smartphone use and verbal perseveration are controlled for. Interestingly, the moderation analysis revealed that verbal perseveration has no interaction with PSU in predicting sleep disturbance, while imaginal prefiguration when PSU was not controlled for, was found to be a significant predictor of sleep disturbance at the average score and high score (+1SD) and not low score (-1SD). These findings suggest that verbal perseveration uniquely contributes to sleep disturbance, while imaginal prefiguration only at the average and high scores could contribute to sleep disturbance exclusively by interaction with PSU.

Emotion regulation (expressive suppression and cognitive reappraisal) was also a significant predictor of sleep disturbance when it was added to the hierarchical regression analysis. This said, verbal perseveration remained the strongest predictor of sleep disturbance, but the effect of PSU become non-significant which might suggest the importance of emotion regulation in explaining sleep disturbance. However, when it comes to the moderator analysis when PSU was controlled for, expressive suppression was still a predictor of sleep disturbance, but this was not the case for cognitive reappraisal, suggesting that expressive suppression is a unique predictor of sleep disturbance. Nonetheless, the interactions between emotion regulation factors with PSU were significant, suggesting that cognitive reappraisal only by interacting with PSU could predict sleep disturbance, but expressive suppression by itself and by interacting with PSU could do the same. The slope analysis revealed that the association between PSU and sleep disturbance is at its highest, moderate, and lowest value when the suppression score is low (-1SD), average, and high (+1SD). This could be explained by the fact that expressive suppression is an emotional regulation strategy that has a sympathetic activation effect by increasing emotional arousal which substitutes appropriate emotion regulation (53). When it is at its lowest and average value, the association between PSU and sleep disturbance is substantial, i.e., PSU still maintains its effect, but when it is at the high level, the association between PSU and sleep disturbance would be negligible which might be a sign of the unique effect of expressive suppression on continuing sleep disturbance by increasing emotional arousal. This explanation is supported by the hierarchical regression analysis which shows that when adding emotion regulation factors in the model the effect of PSU in predicting sleep disturbance becomes non-significant.

Concerning cognitive reappraisal, although the slope analysis revealed the same result compared with expressive suppression, the association between PSU and sleep disturbance is at its highest, moderate, and lowest value when the cognitive reappraisal score is low (-1SD), average, and high (+1SD). This suggests that the association between PSU and sleep disturbance among people with low and average scores on cognitive reappraisal is higher, but it is negligible when the cognitive reappraisal score is high. Accordingly, expressive suppression and cognitive reappraisal both could reduce the association between PSU and sleep disturbance, however, theoretically, only cognitive reappraisal could protect against sleep disturbance in people with high scores on cognitive reappraisal. This said, it appears that expressive suppression, by decreasing the strength of association between PSU and sleep disturbance, by itself may maintain sleep disturbance given that the effect of PSU on sleep disturbance becomes non-significant when emotion regulation factors are added to the hierarchical regression model.

4.1. Limitations and future directions

All findings should be interpreted in light of the study's limitations. Self-report measures can be influenced by recall bias and data gathering during the COVID-19 pandemic may have inflated the strengths of the estimation provided, given that Iranians experienced considerable psychological distress and pandemic related anxiety (54, 55). Moreover, the findings might be limited in generalization only to Iran and countries with similar demographics such as lower-middle income level countries and not to individuals from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) nations (56). Also, given the cross-sectional nature of the findings, it is not possible to conclude a causal association between the variables, thus, bi-directionality between variables also needs to be considered. However, our work lays ground for further research. Researchers might want to replicate the moderating effects of metacognitions about Smartphone use in the association between PSU and sleep disturbance to see whether the observed null-effect might be better explained by prediction intervals as discussed previously. In addition, it would be useful if participants could be interviewed for sleep disorders and to see whether a different result could be found in

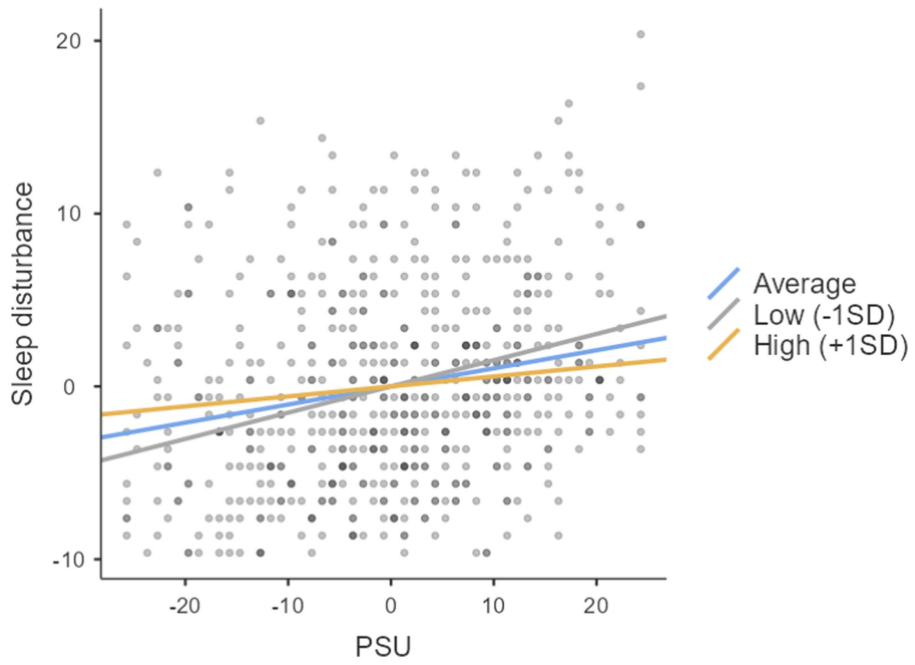

FIGURE 1
The moderating role of expressive suppression at different levels.

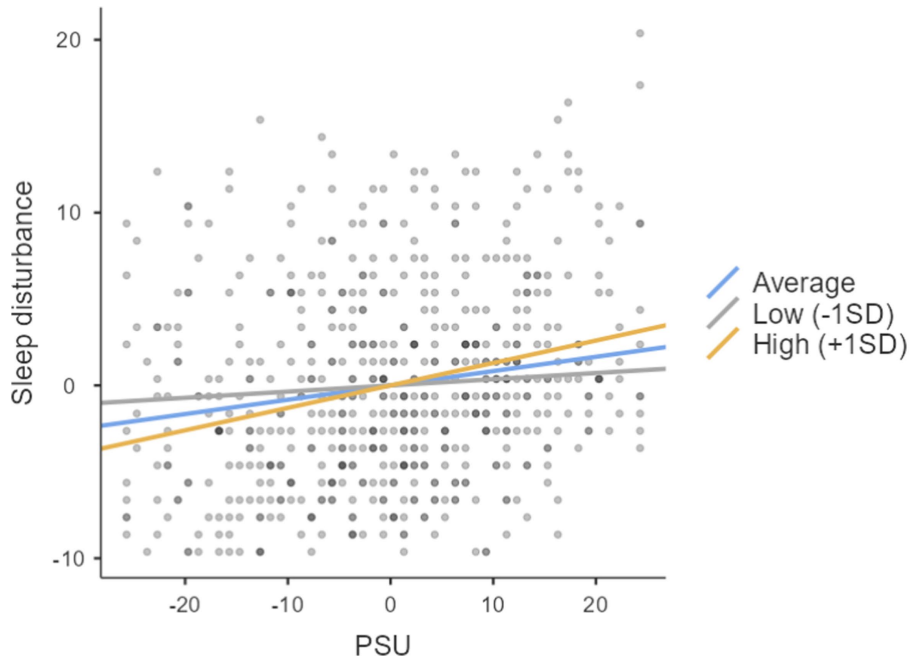

FIGURE 2
The moderating role of cognitive reappraisal at different levels.

confirmed cases of sleep disorder and not only sleep disturbance. Moreover, because we did not ask the participants about their state of emotion regulation, desire thinking, or metacognition about Smartphones, particularly when attempting to fall asleep, it is recommended that future studies use ecological momentary assessment to investigate the role of the aforementioned variables in this context and with greater specificity. Due to the cross-sectional nature of the findings, it is not feasible to infer a causal association between the variables; therefore, bidirectionality between variables must also be considered. Further, future studies may want to employ longitudinal designs to ensure the temporality of the observed moderation effects. Finally, given that cognitive reappraisal and

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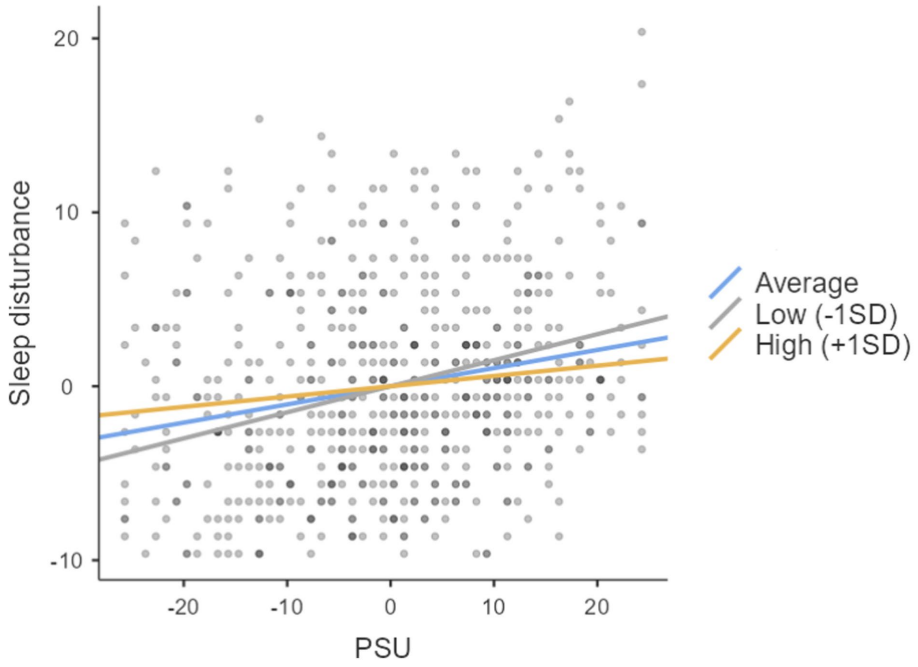

FIGURE 3
The moderating role of imaginal prefiguration at different levels.

TABLE 5 Slope analysis based on a different level of moderators, with sleep disturbance as the dependent variable.

Variable	*B 95%CI* [Ul, Ll]	SE	*Z*	*p*
Model 1 – Suppression as a moderator				
Average	0.10 [0.06, 0.14]	0.0204	5.13	<0.001
Low (-1SD)	0.15 [0.09, 0.20]	0.0302	4.95	<0.001
High (+1SD)	0.06 [0.009, 0.10]	0.0261	2.27	0.023
Model 2 – Reappraisal as a moderator				
Average	0.10 [0.06, 0.14]	0.0205	5.12	<0.001
Low (-1SD)	0.15 [0.10, 0.20]	0.0287	5.29	<0.001
High (+1SD)	0.05 [0.007, 0.10]	0.0272	2.12	0.034
Model 3 – Imaginal Prefiguration as a moderator				
Average	0.08 [0.04, 0.11]	0.0262	3.16	0.002
Low (-1SD)	0.03 [−0.01, 0.08]	0.0276	1.30	0.194
High (+1SD)	0.12 [0.08, 0.17]	0.0407	3.19	0.001

expressive suppression both at high levels dampened the association between PSU and sleep disturbance it is worthy of more investigation to examine whether this finding could be replicated.

4.2. Conclusion

Overall, PSU was a predictor of sleep disturbance and while metacognitions about Smartphone use was linearly associated with sleep disturbance but they were not significant predictors of sleep disturbance when the PSU was controlled for. In addition, verbal perseveration and expressive suppression were unique predictors of sleep disturbance when the PSU was controlled, while imaginal prefiguration and cognitive reappraisal only could predict sleep disturbance if they interact with PSU. Given the significant interaction between desire thinking and emotion regulation with PSU in predicting sleep disturbance, it is recommended that clinicians assess for imaginal prefiguration and cognitive reappraisal because, theoretically, findings suggest that enhancing cognitive reappraisal (by 1 SD) and reducing imaginal prefiguration (by 1 SD), might protect against sleep disturbance by reducing its association with PSU.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Kharazmi university. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MA, MoS, SS, and MaS: conception and drafting of the work. SS, MA, and MoS: data acquisition. MoS and MA: data analysis. MA, MoS, SS, and MaS: data interpretation. MA, MaS, and MoS: revising

the manuscript critically for important intellectual content. All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved and they approved the final version to be published.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer GM declared a past collaboration with the authors to the handling Editor.

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Investigating links between Internet literacy, Internet use, and Internet addiction among Chinese youth and adolescents in the digital age

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Introduction: In current digital era, adolescents' Internet use has increased exponentially, with the Internet playing a more and more important role in their education and entertainment. However, due to the ongoing cognitive, emotion, and social development processes, youth and adolescents are more vulnerable to Internet addiction. Attention has been paid to the increased use of Internet during the COVID-19 pandemic and the influence of Internet literacy in prevention and intervention of Internet addiction.

Methods: The present study proposes a conceptual model to investigate the links between Internet literacy, Internet use of different purpose and duration, and Internet addiction among Chinese youth and adolescents. In this study, *N* = 2,276 adolescents studying in primary and secondary schools in East China were recruited, and they completed self-reports on sociodemographic characteristics, Internet literacy scale, Internet use, and Internet addiction scale.

Results: The results showed a significant relationship between Internet use and Internet addiction. To be specific, the duration of Internet use significantly and positively affected Internet addiction. With different dimensions of Internet literacy required, entertainment-oriented Internet use had positive impact on Internet addiction, while education-oriented Internet use exerted negative effects on Internet addiction. As for Internet literacy, knowledge and skills for Internet (positively) and Internet self-management (negatively) significantly influenced the likelihood of Internet addiction.

Discussion: The findings suggest that Internet overuse increases the risk of Internet addiction in youth and adolescents, while entertainment-oriented rather than education-oriented Internet use is addictive. The role of Internet literacy is complicated, with critical Internet literacy preventing the development of Internet addiction among youth and adolescents, while functional Internet literacy increasing the risk.

KEYWORDS

Internet addiction, Internet literacy, Internet use, youth and adolescents, China

1. Introduction

In recent years, the world has witnessed rapid development and diffusion of digital technologies, especially for the Internet. International Telecommunication Union (ITU) estimated that there were 5.3 billion Internet users in the world, accounting for approximately

66% of the global population in 2022 (1). By the end of 2022, there were 1.07 billion Internet users in China, with the penetration rate of 75.6%, of which 18.7% were Chinese netizens aged 19 and younger (2). According to the latest official statistics on adolescent Internet users, Internet users under the age of 18 in China reached 191 million in 2021, with Internet penetration as high as 96.8% of the Chinese population of youth and adolescents (3).

Nowadays, the Internet exerts a powerful influence on daily life, and it is bringing about a digital life that can be seen, touched and felt. For youth and adolescents as digital native, the Internet is so indispensable for entertainment, relaxation, interpersonal communication, information acquisition, as well as learning and education. However, as the younger generation engage in various online activities and spend a considerable amount of time online, the potential risks associated with Internet use (IU) or its adverse impacts on adolescents have attracted wide attention, including Internet addiction (IA) (4). A meta-analysis of 31 countries estimated IA prevalence rate worldwide at 6.0% (5), which was even higher in China (6).

Due to those serious social and psychological consequences of Internet addiction, increasing academic studies keep a watchful eye on the intervention of adolescent Internet addiction, which has identified many effective intervention strategies, such as cognitive behavioral therapy, family therapy, and school-based prevention programs (7–9). Although many efforts have been made to promoting media literacy among the young, studies being conducted to test the effectiveness of Internet literacy in preventing Internet addiction are far from enough. Therefore, this study attempted to explore the possible relationships between Internet literacy, Internet use, and Internet addiction among Chinese youth and adolescents, so as to provide empirical findings and practical implications for effective prevention of Internet addiction among the kids in the digital age.

2. Literature review

2.1. Internet addiction: a pressing issue among youth and adolescents in the digital age

With the development and increasing importance of Internet, the side effects have also aroused growing public concern, such as Internet addiction. In 1995, Internet addiction was initially coined by American psychiatrist Ivan Goldberg, and then empirically studied by pioneer scholars, such as Kimberly Young and Mark Griffiths. Internet addiction is defined as the incapacity to control one's online behaviors, mainly manifested as excessive use of the Internet, leading to adverse outcomes (10).

Based on existing empirical research, there are two primary theoretical traditions of Internet addiction have been established. The first, exemplified by Kimberly Young, identifies Internet addiction as an impulse control disorder, separate from substance addiction but sharing similar features (11). The second, represented by Mark Griffiths, views Internet addiction as a form of technology addiction, belonging to behavioral addiction and encompassing all core components of behavioral addiction. Griffiths specifically emphasizes that Internet addiction results from excessive human-computer interaction prompted by the inducement and reinforcement characteristics of the medium and specific activities (12). Despite variations in theoretical conceptualization of Internet addiction, most of current studies recognize compulsivity and impairment as the two essential elements of Internet addiction (13). To be specific, compulsivity refers to the difficulty in regulating the impulse to go online and experiencing intense cravings when unable to access the Internet, while impairment relates to negative effects such as neck and back pain, insomnia, anxiety, depression, loneliness, social isolation, and poor academic performance resulting from excessive Internet use.

As for youth and adolescents, current studies on IA prevalence present high variability worldwide. The prevalence of Internet addiction in European young and adolescent community samples was approximately 4–10% (14), while it ranged from 0 to 26.3% among American undergraduate students (15). According to those studies with the focus on Asia, the overall prevalence of Internet addiction in Southeast Asian general populations was 20.0% (16), and it was estimated to be 3–26.8% in Hong Kong adolescents (17). Although these prevalence rates varies depending on the heterogeneity of measurement instruments and research samples, Internet addiction has been found to show profound negative influence on youth and adolescents. Those adolescents who suffer from Internet addiction have demanded considerable investment of time and effort online that they may have a series of physical health diseases or problems, such as obesity, eye strain, headaches, eating disorders, and lowered sleep quality (18). Apart from its adverse effects on physical health, Internet addiction also threatens the mental health of teenagers. A wealth of evidences have suggested that Internet addiction can increase the risk of psychological distress, negative emotions, body dissatisfaction, alexithymia, and less subjective well-being (19, 20).

In China, the rising prevalence of the Internet, especially mobile Internet usage has brought about a significant concern for Internet addiction in the young generation (4). A meta-analysis indicates that the prevalence of Internet addiction is growing in China, which now reaches 11.3% among Chinese younger generation (6). In order to address this pressing issue, the latest amended version of *the Law on the Protection of Minors* has added a special chapter named *Internet Protection*, which further highlights the potential risks youth and adolescents may face in cyberspace and prompts strong social attention. Correspondingly, regulation, prevention, intervention, and various strategies have been carried out to prevent excessive Internet use among Chinese minors and cope with adverse impact of Internet addiction.

2.2. Entertainment vs. education: two types of Internet use among youth and adolescents

According to an authoritative report, 97% of the American teenagers use the Internet daily, with video apps like YouTube and TikTok being the primary source of media consumption (21). Similarly, Chinese youth also spend quite a lot of time online. The national Internet use report among youth and adolescents indicates that 88.9 and 62.3% of teenage netizens frequently use educational and gaming applications, respectively, (3), revealing two critical motives for the young to use the Internet, i.e., education and entertainment.

Entertainment-oriented IU is characterized as a type of pleasure-seeking self-moderation *via* the Internet (22), encompassing activities such as gaming, video streaming, social media browsing, etc. Existing research has predominantly concentrated on the impact of

entertainment-based IU on emotional regulation, such as reducing stress (23) and satisfying intrinsic human needs (22). During the COVID-19 pandemic, consumption of entertainment content online continued to rise, serving as coping strategies for emotional disturbance caused by the external environment (24).

Meanwhile, there is a lot of education-oriented IU among youth and adolescents, which involves utilizing applications like Zoom or Tencent Meeting for e-learning or online coursework. In recent years, the enforcement and promotion of education-oriented IU among the youth have substantially increased as a result of home quarantine policies implemented in response to the global health crisis (25). Some scholars find that urgent remote education has significantly enhanced students' academic performance during the early stages of the COVID-19 pandemic (26).

As for the inter-relationship between Internet use and Internet addiction, past literatures have shown that prolonged Internet use is linked to higher risks of addiction, with long-term usage being identified as one of the most significant factors contributing to teenager Internet addiction (27). Nevertheless, as Young stated, the Internet itself is not addictive, while various types of Internet use, such as gaming, online chatting, social networking sites, short-form videos, and smartphone apps, are possible predictive factors for Internet addiction (11, 28). Hence, different forms of Internet use may exert dissimilar influences on Internet addiction. Although both entertainment-oriented and educational-oriented IU have played vital roles during young people's daily life, these two types of Internet use may differ in their impact on Internet addiction among youth and adolescents. Specifically, entertainment-oriented IU, such as gaming, has been found to be closely related with adolescents' dependence and addiction to the Internet (28). Moreover, studies have identified a surge in problematic Internet use resulting from increasing exposure to entertainment media in the COVID-19 outbreak (29). In contrast, existing studies have not reached a consensus on whether education-oriented IU will lead to Internet addiction. Some scholars contend that the proliferation of online education has increased the duration of students' Internet use, which may further lead to Internet addiction (30), while others believe that education-oriented IU is more likely to result in cyberloafing than direct Internet addiction (31). Different from previous research, the current research aims to take both the duration and forms of Internet use into consideration, and examine their relationship between Internet use and Internet addiction among Chinese youth and adolescents. Thus, the following research question was raised.

RQ1: How does Internet use, including both duration and two types, i.e., entertainment-oriented and education-oriented IU, affect Internet addiction among Chinese youth and adolescents?

2.3. Internet literacy: a multidimensional concept

Internet literacy was coined by McClure about 30 years ago, who believe that this emerging concept encompasses the capacity to comprehend the value of online resources, utilize search tools to retrieve specific information and assist individuals in problem-solving (32). However, over the past few decades, a consensus has not yet been reached on the definition of Internet literacy within academia. According to Dupuis, Internet literacy should encompass knowledge and comprehension of the informational background in contemporary society, the composition and arrangement of information, as well as its utilization in lifelong learning (33). After Shapiro and Hughes proposed a seven-dimensional structure for Internet literacy (34), subsequent scholars have defined Internet literacy as the capability to access, understand or analyze, and generate digital content, in response to the advancement of various media technologies (35).

Internet literacy is understood and deconstructed by some scholars from two main aspects, both skill literacy and information literacy. The former pertains to the abilities related to using and incorporating the Internet, while the latter focuses on people's ability to access, collect, and filter information (36). Given the intricate dimensions and structures of Internet literacy, it is likely that proficiency levels among youth and adolescents may vary across different aspects of Internet literacy. Particularly in the era of digital and even intelligent media technologies, there is a growing need for expertise in media consumption, while adolescents, who are often known as digital natives, tend to exhibit a superior level of Internet skill literacy (27, 37). Facing a vast amount of complex information, particularly in the post-COVID-19 era, where misinformation and disinformation still abound, it is crucial to be able to perceive information critically. With regard to teenagers, although they tend to have higher level of skill literacy, their critical thinking abilities concerning online information still need enhancement, resulting in an uneven distribution of different aspects of their Internet literacy (38).

Previous studies have investigated the link between Internet literacy and various aspects of Internet use, including IU duration and different types of IU. A study involving 2,303 students found no significant correlation between media literacy and the number of days or hours spent consuming media (39). Regarding different types of IU, a survey of 1,018 individuals by van Deursen and his colleagues showed that higher proficiency in Internet skills were associated with more Internet use for information-seeking and career-related purposes (40). Additionally, Internet literacy has been found to be a significant predictor to explain online political engagement among adolescents and enhance the capacity of individuals to participate in different types of online user interactions (41). Overall, prior studies failed to reach a consensus regarding the impact of Internet literacy on Internet use, and did not take both IU duration and types of online activity into consideration simultaneously. In light of this, this study seeks to fill the gap through investigating the impact of Internet literacy on Internet use with consideration of both use duration and types.

RQ2: How do different dimensions of Internet literacy influence Internet use among Chinese youth and adolescents?

2.4. Internet literacy and Internet addiction

Whether Internet literacy can have significant influence on prevention and intervention of Internet addiction, pertinent literatures have demonstrated a complex relationship between Internet literacy and Internet addiction, with both positive and negative effects of different aspects of Internet literacy linked to Internet addiction. For instance, a survey carried out in Germany revealed that higher levels of technical literacy may be positively associated with Internet addiction, whereas higher levels of reflective and self-regulatory skills

are linked to a smaller likelihood of Internet addiction (42). In a study involving structured questionnaire interviews with 718 Hong Kong adolescents, two researchers found that certain types of Internet literacy, such as publishing and technology skills, could increase the risk of Internet addiction (27, 37). Similarly, a positive link between information and communication technology (ICT) literacy and problematic Internet use in adolescents was reported (43). On one hand, scholars from different social contexts find positive relationship between certain dimensions of Internet literacy and Internet addiction. On the other hand, some research found no significant correlation between Internet literacy and Internet addiction among teenagers (44). Therefore, it seems that the multi-dimensional structure of Internet literacy can have varied and even quite different impacts on Internet addiction, which calls for more empirical studies to reveal specific mechanism of different dimensions of Internet literacy on Internet addiction. Additionally, despite the growing number of youth netizens in contemporary China, studies on Internet literacy and Internet addiction of this group are still far from enough. Previous studies have also emphasized the cultural uniqueness of Internet addiction in China (45). Thus, the following research question was proposed to investigate the association between Internet addiction and Internet literacy in the Chinese context.

RQ3: As a multidimensional concept, how do different dimensions of Internet literacy influence Internet addiction among Chinese youth and adolescents?

Based on the aforementioned literature review on Internet addiction, Internet use and Internet literacy, the following conceptual framework (see Figure 1) was proposed to answer the three research questions, so as to investigate the links between Internet literacy, Internet use, and Internet addiction among Chinese youth and adolescents in current digital age.

3. Methods

3.1. Data collection

The survey data was collected in East China. Primary and middle students from a county-level city in Suzhou, Jiangsu Province participated in this research. With the assistance of the local education bureau, a paper-based survey was conducted in October 2022, by using random sampling and quota sampling. Firstly, according to the basic conditions of schools within the region in Suzhou Statistical Yearbook (46), specific percentages and planned sample size of students from local primary school, middle school, and high school were calculated based on student enrollment. Secondly, various situations of different types of local schools were also fully considered, and 5 primary schools, 3 middle schools, 3 high schools, 1 vocational high school, 1 nine-year school and 1 twelve-year school, therefore in total 14 schools were randomly selected for this study. Thirdly, classes of each school were numbered and the corresponding classes (30–50 students in each class) were selected by using random number table. Finally, 40 primary school classes, 20 middle school classes and 14 high school classes were selected. Given that students of first grade in primary school had just entered the nine-year compulsory education system and might not fully understand the measurement items in the questionnaire, they were excluded from the survey. Table 1 shows the sampling details.

Based on the aforementioned sampling procedures, participants were recruited with consent from the students, their parents and teachers. In total, 3,187 paper-based questionnaires were distributed and collected, and 2,276 were confirmed as valid. As for the sample profile, the participants were aged 7–18 (Mean = 12.28, SD = 2.85), 52.9% (1204) were male, and 47.1% (1072) were female. In terms of age, 434 students (52.9%) were aged 7–9, 779 (34.2%) were aged 10–12, 627 (27.5%) were aged 13–15, and 436 (19.2%) were aged 16–18. Regarding their grade levels, 1,069 (47.0%) were primary school students, 677 (29.7%) were middle school students, and 530 (23.3%) were high school students.

3.2. Measurement

3.2.1. Internet use

Given the limitations of time-based or frequency-based measurement, Internet use was measured by both IU duration and Internet activities in this study. The two items ("How much time do you spend online everyday, from Monday to Friday?" and "How much time do you spend online everyday, on weekends or holidays?") were measured on a five-point Likert scale (from 1 = not at all to 5 = more than 3 h) to assess IU duration among the participants (see Supplementary Appendix 1 for the results of IU duration). The

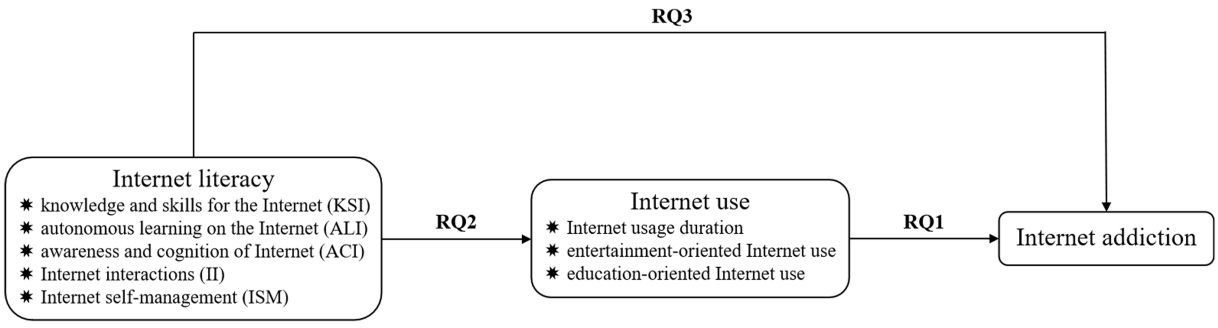

FIGURE 1
Conceptual framework of the links between Internet literacy, Internet use and Internet addiction.

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TABLE 1 Details of the student enrollment, planned sample size and actual sample size.

School type	Student enrollment	The planned sample size	The actual sample size
Primary school	94,834 (64.1%)	1,923	1,607 (50.4%)
Middle school	37,155 (25.1%)	753	870 (27.3%)
High school	15,875 (10.8%)	324	644 (20.2%)
Total	147,864	3,000	3,187 (with 66 user-missing values)

reliability Cronbach's α was 0.689. As for Internet activities, a five-point Likert scale (1 = not at all to 5 = always) was adopted to measure the frequency of online entertainment, information acquisition, online learning, and social interaction *via* the Internet (i.e., How often do you engage in entertainment/learning/information acquisition/social interaction through the Internet every day?). The reliability Cronbach's α was 0.647, which was not optimal but also surpassed the acceptable level (47).

3.2.2. Internet literacy

The Internet Literacy Scale (ILS) developed by Huang et al. (48), which was verified among Chinese junior students, was adopted to investigate multiple dimensions of Internet literacy in the present study. The 18-item scale (see Supplementary Appendix 2) defines the structure of Internet literacy with five main dimensions, including knowledge and skills for the Internet (KSI, e.g., I can make good use of Internet tools, such as office software and search engines), autonomous learning on the Internet (ALI, e.g., I can access and analyze useful information on the website to complete learning tasks), awareness and cognition of the Internet (ACI, e.g., I think the Internet is a double-edged sword), Internet interactions (II, e.g., I am able to make new friends through the Internet), and Internet self-management (ISM, e.g., I can control how much time I spend online). Participants were asked to respond to these items by using a five-point Likert scale (from 1 = strongly disagree to 5 = strongly agree). The reliability Cronbach's α was remarkably high at 0.917.

3.2.3. Internet addiction

The proposed diagnostic criteria for Internet addiction by Tao et al. (49) was adopted in this survey. Participants needed to answer eight items by using a five-point Likert scale (from 1 = strongly disagree to 5 = strongly agree). The reliability Cronbach's α was 0.885.

3.2.4. Demographics

The investigators collected demographic characteristics on the gender, grade and age of participants.

3.3. Statistical analysis

The statistical analyses were performed by using SPSS and AMOS. Firstly, exploratory factor analysis (EFA) was run to explore the multi-type Internet activities among Chinese adolescents. Secondly, the construct validity of Internet literacy in this research sample was examined through confirmatory factor analysis (CFA). Finally, this study adopted structural equation model (SEM) to examine the inter-relationships between Internet literacy, Internet use and Internet addiction.

Additionally, *a priori* power analysis by G*Power was used to estimate the sample size of SEM by assuming a small effect size of 0.02 and α of 0.05. The research model encompassed a total of 11 predictors, consisting of five independent variables (five subdimensions of Internet literacy), three mediators, and three control variables. The outcome of the G*Power analysis indicated that a minimum sample size of 1,267 participants would be necessary to achieve a desired statistical power of 95%. Actually, the current study went beyond the requirements by involving a sample of 2,276 adolescents as research participants. This sample size significantly exceeded the threshold suggested by G*Power, which further enhanced the statistical robustness of the study.

4. Results

4.1. Exploratory factor analysis of Internet use

In order to examine the multi-structure of Internet use among Chinese adolescents, an EFA was conducted. Principal component analysis was used as the method for factor extraction. The results demonstrated that the original 4 items were formed into two types of Internet use, i.e., entertainment-oriented and education-oriented IU. Based on eigenvalues greater than 1.0, EFA generated two factors that together explained 75.742% of the total variance. To be specific, the first factor, entertainment-oriented IU (eigenvalue = 1.991, 45.078% of variance, Cronbach's α = 0.658), consisting of 2 items, revealed the respondents' frequency of online entertainment and social interaction through the Internet. Education-oriented IU (eigenvalue = 1.039, 30.664% of variance, Cronbach's α = 0.709) as the second factor showed the respondents' frequency of information acquisition *via* the Internet and online learning. In addition, parallel analysis was conducted for factor extraction, and the results (see Supplementary Appendix 3) indicated that the number of factors was two according to both the mean and percentile of parallel analysis, which further supported the factor extraction based on EFA. Table 2 presents the results of EFA.

4.2. Confirmatory factor analysis of Internet literacy

A CFA was carried out to examine the construct validity of ILS. The fit indices indicated that $\chi^2/df = 6.411$, CFI = 0.977, GFI = 0.971, NFI = 0.973, TLI = 0.963, and RMSEA = 0.049. The Cronbach's α was 0.917, and the composite reliability (CR) of each dimension was greater than 0.8, indicating that ILS had good internal consistency. Moreover, all the standardized factor loadings were highly significant at the 99% confidence level, and all the average variance extracted (AVE) values exceeded the acceptable threshold of 0.5, which confirmed the convergence validity of ILS. By comparing the square roots of AVE of

TABLE 2 Exploratory factor analysis of Internet use (IU).

Items	Mean	SD	Factors	
			1	2
1, Entertainment-oriented IU				
Entertainment	3.218	1.365	0.868	−0.023
Social interaction	2.778	1.521	0.845	0.115
2, Education-oriented IU				
Information acquisition	3.432	1.328	0.213	0.773
Online learning	3.393	1.285	−0.031	0.941
Eigenvalue			1.991	1.039
Percent of variance explained			45.078	30.664
Cronbach's α			0.658	0.709

TABLE 3 Confirmatory factor analysis of Internet literacy.

Paths			Estimate	AVE	CR
Knowledge and skills for the Internet (KSI)					
KSI	--->	ILS-01	0.680	0.530	0.849
KSI	--->	ILS-02	0.686		
KSI	--->	ILS-03	0.767		
KSI	--->	ILS-04	0.744		
KSI	--->	ILS-05	0.758		
Autonomous learning on the Internet (ALI)					
ALI	--->	ILS-06	0.849	0.670	0.802
ALI	--->	ILS-07	0.787		
Awareness and cognition of Internet (ACI)					
ACI	--->	ILS-08	0.693	0.594	0.854
ACI	--->	ILS-09	0.774		
ACI	--->	ILS-10	0.842		
ACI	--->	ILS-11	0.767		
Internet interactions (II)					
II	--->	ILS-12	0.687	0.546	0.827
II	--->	ILS-13	0.661		
II	--->	ILS-14	0.801		
II	--->	ILS-15	0.797		
Internet self-management (ISM)					
ISM	--->	ILS-16	0.919	0.682	0.865
ISM	--->	ILS-17	0.806		
ISM	--->	ILS-18	0.743		

AVE is the abbreviation for average variance extracted values. CR is the abbreviation for composite reliability.

all variables and their correlation coefficient with other variables, the results showed that the former was greater than the latter, which indicated that ILS had good discriminant validity and the five dimensions of Internet literacy were not difficult to distinguish. Specifically, the results of CFA demonstrated that KSI, ALI, ACI, II, ISM as five dimensions constitute the Internet literacy of Chinese youth and adolescents, with the details being presented in Table 3.

4.3. Estimation of the conceptual model

Regarding the conceptual model developed founded on the literature review and proposed research questions, the SEM was adopted to explore the inter-relationships between Internet literacy, Internet use and Internet addiction among Chinese youth and adolescents. Figure 2 showed that all the fit indexes were completely in accord with acceptable standards, which fully indicated that the model had a good fitting effect.

As for RQ1, the results clearly illustrated that Internet usage duration ($\beta = 0.185$, $p < 0.001$) significantly and positively affected Internet addiction, while two types of IU influenced Internet addiction differently. To be specific, entertainment-oriented IU ($\beta = 0.292$, $p < 0.001$) affected Internet addiction significantly and positively, but education-oriented IU ($\beta = -0.100$, $p < 0.01$) affected Internet addiction negatively among Chinese youth and adolescents.

To answer RQ2, the analytical results suggested that KSI exerted a significant and positive effect on Internet usage duration ($\beta = 0.257$, $p < 0.001$), entertainment-oriented IU ($\beta = 0.403$, $p < 0.001$), and education-oriented IU ($\beta = 0.372$, $p < 0.001$), and the same applied to the impact of ACI on Internet usage duration ($\beta = 0.201$, $p < 0.001$), entertainment-oriented IU ($\beta = 0.130$, $p < 0.01$), and education-oriented IU ($\beta = 0.110$, $p < 0.01$). Besides, ALI had a significant and negative impact on Internet usage duration ($\beta = -0.133$, $p < 0.01$) and entertainment-oriented IU ($\beta = -0.160$, $p < 0.01$), while its impact on education-oriented IU ($\beta = 0.076$, $p > 0.05$) was not significant. Moreover, II affected Internet usage duration ($\beta = 0.290$, $p < 0.001$) and entertainment-oriented IU ($\beta = 0.481$, $p < 0.001$) positively, but did not have a significant impact on education-oriented IU ($\beta = -0.033$, $p > 0.05$). Finally, ISM had a significant and negative impact on Internet usage duration ($\beta = -0.428$, $p < 0.001$), entertainment-oriented IU ($\beta = -0.444$, $p < 0.001$), and education-oriented IU ($\beta = -0.120$, $p < 0.001$).

Regarding RQ3, the results indicated that KSI ($\beta = 0.156$, $p < 0.01$) influenced Internet addiction significantly and positively, while ISM ($\beta = -0.179$, $p < 0.001$) affected Internet addiction significantly and negatively. However, the effects of ALI ($\beta = -0.008$, $p > 0.05$), ACI ($\beta = -0.054$, $p > 0.05$), and II ($\beta = 0.046$, $p > 0.05$) on Internet addiction were not significant. The results of SEM were shown in Figure 2 in details.

5. Discussion and implications

In current digital age, Internet addiction has become a pressing issue among youth and adolescents in China. As digital native, today's young generation rely on the Internet use for both entertainment and education, which was especially prominent during the COVID-19 pandemic. To examine the mechanism of Internet use on Internet addiction, and explore the role of multi-dimensional Internet literacy, this study investigated links between Internet literacy, Internet use and Internet addiction among Chinese youth and adolescents. Based on a systematic sampling survey conducted in a county-level city in East China and comprehensively measured Internet literacy and Internet use, this study captured more fine-grained aspects of Chinese adolescents' digital life.

Consistent with previous studies, longer Internet usage duration can lead to Internet addiction among the young. Not surprisingly,

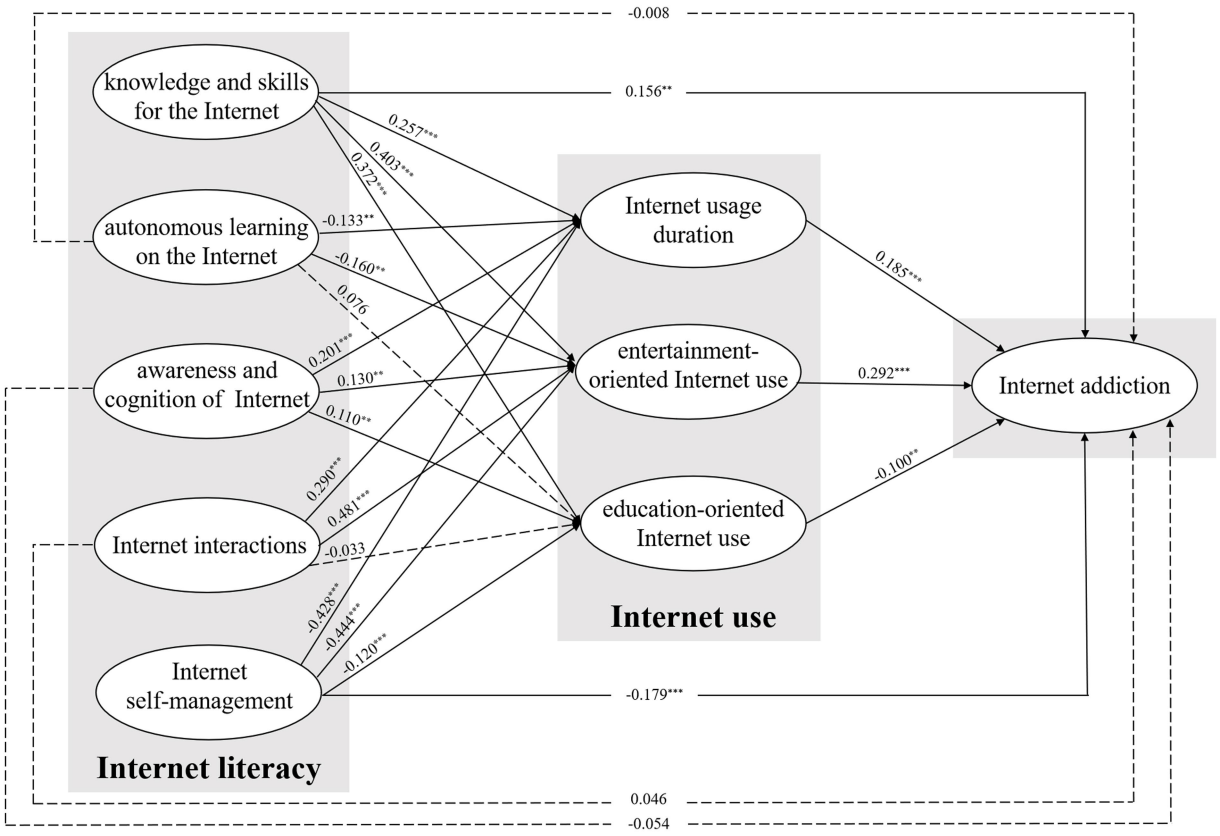

FIGURE 2
Path analysis of the structural model of the inter-relationships between Internet literacy, Internet use, and Internet addiction. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, N=2276. The solid line represents the path is significant, while the dotted line represents the path is not significant. Model fit statistics: χ^2/df=6.916, GFI=0.929, NFI=0.929, IFI=0.939, TLI=0.923, CFI=0.939, RMSEA=0.051.

Internet usage duration was closely linked to addictive Internet use, since the principal manifestation of Internet addiction is involuntary and long-term compulsive use of the Internet. However, based on the above findings, more attention should be paid to distinguish different patterns of Internet use, which may have varied impacts on Internet addiction. Specifically, the results demonstrated that more entertainment-oriented IU caused higher degree of Internet addiction, while more education-oriented IU was significantly correlated to lower degree of Internet addiction. As Young emphasized, the Internet itself is not addictive, it is vital to compare different types of Internet use and find out their influences on Internet addiction (9). As found in this study, youth and adolescents who used the Internet for entertainment or social interaction tended to show higher degree of Internet addiction, while those who engaged in education-oriented Internet activities such as information acquisition and online learning were more likely to have a lower degree of Internet addiction. Therefore, as shown in previous studies, prevention and intervention of Internet addiction should target those high risk groups who often unable to control their online time and related behaviors, and spent countless hours chatting, socializing or playing games on the Internet (28, 50).

As a multi-dimensional concept, the structure of Internet literacy was again confirmed in this research. As for Chinese youth and adolescents, Internet literacy can be divided into five sub-dimensions, i.e., KSI, ALI, ACI, II and ISM. Although there are some differences in conceptualization of Internet literacy, current concrete connotations are relatively consistent in a heuristic theoretical framework (51) that not only pays attention to knowledge learning and skill development, but also lays emphasis on the cultivation of social–emotional and critical literacy. In the present study, KSI is more focus on technical dimension, while ACI is close to cognitive dimension. As the social–emotional perspective of Internet literacy, II mainly evaluates the degree of interaction with others on the Internet, which is related to the sociability to communicate, collaborate, and handle daily routines online. ALI assesses the level of adolescents' spontaneous learning through the Internet, and ISM measures self-control ability of youth and adolescents and whether they can manage their online time reasonably, both of which belong to critical literacy. It is worthy to note that Internet literacy as a comprehensive concept is not immutable and frozen, but needs to advance with the times and add new content or elements. For example, it is not uncommon for youth and adolescents to suffer from psychological illness caused by online risks such as cyberbullying and privacy disclosure, so Internet security and privacy literacy may become an important component of adolescents' Internet literacy in the future.

Investigating Internet literacy as a comprehensive and exhaustive concept with five dimensions, this study further captured more precisely inter-relationships between Internet literacy and Internet use among Chinese youth and adolescents. This study found that higher levels of KSI and ACI positively correlated with a higher level

of Internet use, including Internet usage duration, as well as both entertainment-oriented and education-oriented IU, and II associated with Internet usage duration and entertainment-oriented IU positively. However, adolescents with a higher degree of ISM were found to show less Internet use, and those with a higher degree of ALI showed lower levels of Internet usage duration and entertainment-oriented IU. In general, those youth and adolescents who had higher degree of KSI, ACI, and II tended to show more Internet use, while those who had higher degree of ISM and ALI turned out to show less Internet use, especially for Internet usage duration and entertainment-oriented IU. Thus, Internet literacy as a multi-dimensional concept plays a complicated role in affecting Internet use, with different dimensions showing even conflicting impacts.

Similarly, findings about the direct effects of Internet literacy on adolescent Internet addiction also suggest that not all types of Internet literacy will play a positive part in IA prevention and intervention. This study finds out that only ISM can effectively reduce adolescent Internet addiction, while KSI may actually increases Internet addiction. Consistent with previous research (27, 37, 42, 43), adolescents with higher self-management ability can be helpful to reduce Internet addiction, while the cultivation of KSI may require adolescents to devote a lot of time to study and practice on the Internet. Whereas, the more time youth and adolescents spend online, the higher possibility that they may develop Internet addiction. These findings mean that critical Internet literacy (especially ISM) can help prevent the development of Internet addiction among youth and adolescents, while functional Internet literacy (especially KSI) may increases the risk of Internet addiction.

Based on these findings, practical implications are provided. The first implication is embodied in the diagnosis of Internet addiction among youth and adolescents. In real life, many people relied on the amount of time took on the Internet or the frequency of Internet use to reflect adolescents' excessive Internet use. However, due to its simplicity, time- and frequency-based measurements cannot take into account why adolescents use the Internet or what they do online (52). This study highlighted that it is necessary to combine Internet usage duration with specific types of Internet use into the diagnosis of Internet addiction among youth and adolescents, rather than relying solely on time or frequency as the single indicator. According to the findings of this study, if adolescents use the Internet for online learning for longer time, the probability of Internet addiction can even be greatly reduced. On the contrary, if adolescents cost plenty of time online for leisure and entertainment, it is essential for their family members, school teachers, community and health professionals to provide reasonable guidance for them to avoid them being addicted to the Internet. Those young Internet users with prolonged and more entertainment-oriented IU should be paid more attention for higher risks of Internet addiction. This study also contributes to prevention and intervention of Internet addiction for adolescents themselves, parents, clinicians, public health staff, and policy makers. For young Internet users, critical Internet literacy, especially ISM, should be improved to cope with Internet addiction, while functional Internet literacy, such as KSI, may have a hidden risk for forming Internet addiction. Therefore, more education and strategies should be done to nurture and improve adolescents' critical Internet literacy in order to cope with the negative effects of Internet addiction, instead of simply teaching their Internet operational skills.

6. Limitations

Despite the above-mentioned findings, the current study still carries some limitations. First, due to the cross-sectional nature of the data, path analysis cannot guarantee casual relationships. Future research can examine the directionality of the association between Internet literacy and Internet addiction by using experimental or longitudinal designs. Second, although Internet use was systematically measured in this study to reflect the diversity of online activities and avoid the disadvantages of dichotomy measurement, the combination of self-reported measurement and objective methods would contribute to future studies (53), such as using smartphone applications or social media data to assess users' Internet usage in more details. Third, given that inter-regional differences in the prevalence of Internet addiction in China and many countries around the world (5), there is a need to perform research in more culturally-varied settings to describe the cross-cultural aspects of the relationship between Internet literacy, Internet use, and Internet addiction. Lastly, Internet addiction as measured in general, while in the future, specific types of Internet addiction, such as social media addiction, smartphone addiction, gaming addiction, can be investigated to provide more understanding of the role that Internet literacy plays in specific type of Internet addiction among youth and adolescents.

7. Conclusion

To deal with the pressing issue of Internet addiction among the young in China, this study investigated the links between Internet literacy, Internet use and Internet addiction. Excessive Internet use and entertainment-oriented IU were found to closely correlate with Internet addiction among Chinese youth and adolescents, while education-oriented IU exerted negative effects on Internet addiction. As a multidimensional and comprehensive concept, ALI and ISM dimensions of Internet literacy reduced Internet use among youth and adolescents, while KSI, ACI, and II had exactly the opposite effect on Internet use. Not all sub-types of Internet literacy can reduce the degree of Internet addiction in youth and adolescents. Wherein, critical literacy (especially ISM) is helpful to cope with Internet addiction, while functional literacy (especially KSI) can be associated with higher risk for Internet addiction. Therefore, special emphasis should be placed on critical Internet literacy rather than functional literacy regarding prevention and intervention for Internet addiction targeting youth and adolescents.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Tsinghua University Science and Technology Ethics Committee (Humanities, Social Sciences and Engineering). The studies were conducted in accordance with the local legislation and institutional requirements.

Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

QJ: conceptualization, methodology, supervision, writing – original draft, writing – review and editing, and funding acquisition. ZC: conceptualization, formal analysis, writing – original draft, and writing – review and editing. ZZ: investigation, software, and writing – review and editing. CZ: conceptualization, methodology, data curation, resources, validation, and project administration. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1233303/full#supplementary-material

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Assessment of Hazardous Gaming in children and its dissimilarities and overlaps with Internet Gaming Disorder

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Background and aims: Children have been vastly overlooked in Internet Gaming Disorder (IGD) and Hazardous Gaming research so far. The diagnoses are listed in different ICD-11 chapters (addiction vs. problematic health condition) and are thus considered as distinct constructs. However, screening tools for children do not exist yet. We aimed to investigate the psychometric properties of an existing IGD screening tool modified to also assess Hazardous Gaming in children. Further, we aimed to compare the dissimilarity and overlap between (subclinical) IGD and Hazardous Gaming in children.

Methods: The study analyzed data from a mixed school and clinical sample. Data from $N = 871$ children aged between 8 and 12 years of age ($M = 10.3$, $SD = 0.90$) were analyzed. Data were collected via the Video Game Dependency Scale (CSAS) in its parent report version, which was adapted to assess Hazardous Gaming symptoms in addition to the IGD symptoms. Item analyses and reliability and factor analyses were conducted on the Hazardous Gaming version.

Results: The results show that the adapted CSAS version that assesses Hazardous Gaming symptoms in children mostly shows acceptable psychometric properties. Explorative Factor Analysis (EFA) shows a two-factor structure with one factor of higher order. Additionally, results show that 35.2% of all children meeting the threshold for Hazardous Gaming exclusively meet criteria for Hazardous Gaming but not for (subclinical) IGD. Vice versa, 91.3% of children with IGD also meet the criteria for Hazardous Gaming.

Discussion: Hazardous Gaming and (subclinical) IGD are distinct constructs with some overlaps and might have a temporal relation. We recommend adding four items to assess Hazardous Gaming using the CSAS and further evaluate the validity. The assessment of Hazardous Gaming in children is crucial because it might occur earlier than subclinical or full-syndrome IGD.

KEYWORDS

IGD, diagnostics, psychological assessment, gaming disorder, clinical sample, school sample

1. Introduction

Internet Gaming Disorder (IGD) has received high scientific interest. IGD is characterized amongst other criteria by loss of control over gaming, prioritizing gaming over other activities, and continuous gaming despite the knowledge of negative consequences (1). Together with gambling disorder, Gaming Disorder is considered a behavioral addiction by the ICD-11 (2). Other proposed (online) behavioral addictions include social-network-use disorder, pornography-use disorder, buying-shopping disorder (3), and streaming disorder (4, 5). The sum of these disorders is often referred to as Internet Addiction. Within these different types of (online) behavioral addictions, overlapping underlying mechanisms have been reported and similar theoretical frameworks have been applied [e.g., (6, 7)]. However, more research is needed to investigate the distinctive features of each behavioral disorder (3). This paper focusses - as stated above - on IGD specifically. In IGD research, children are a population that is often overlooked. In Figure 1 you can see the amount of research on IGD in the database PsycInfo between 2013 and 2023. As depicted, research solely focusing on child age is scarce. Yet, practitioners already observe risky gaming behavior in children. In fact, gaming has become part of many children's free time at a young age [e.g., (8–10)]. It has been observed that, especially during childhood, gaming time increases with age (8–10). Therefore, childhood seems to be a phase in which people are vulnerable to forming gaming habits. First steps have been taken to analyze diagnostic questionnaires for IGD during childhood (11, 12), which is the basis for validly recording IGD in children. As negative consequences of excessive gaming might not have manifested in children yet (12), it could be even more important to screen children for signs of risks for developing an IGD rather than for criteria of a full-syndrome IGD. To this end one might think of investigating subclinical IGD in children. Subclinical IGD can be understood as the endorsement of some IGD criteria but not sufficient (i.e., five) criteria for a full-syndrome IGD. This means that for subclinical IGD the same criteria as for a full-syndrome IGD apply. The only difference lies within the number of endorsed criteria. Yet, in addition to subclinical IGD, Hazardous Gaming might also be a precursor to IGD.

Therefore, another approach to address this subject would be to consider the construct of Hazardous Gaming [ICD-11 code QE22; (13)] in addition to the assessment of IGD in children. Hazardous Gaming describes a risky gaming pattern instead of a manifested IGD and the diagnosis is characterized by different symptoms to IGD. The threshold for Hazardous Gaming diagnosis is lower than the one for IGD and can be categorized as a "problem associated with health behavior" before a full behavioral addiction has manifested (13). Therefore, it can draw attention to problematic gaming behavior at an earlier stage than IGD can. Being aware of Hazardous Gaming in children might be especially relevant since children are beginning to spend increasingly more time gaming (8–10). If existent in childhood, we would expect that IGD in children is yet in its early stages and therefore assessing lower threshold Hazardous Gaming seems more beneficial in identifying children in need of prevention or (early) intervention. This might prevent children from developing a full IGD during their adolescence or from interferences between Hazardous Gaming with other mental conditions such as depression, anxiety, or peer relationship problems, which are commonly known to occur with problematic gaming [e.g., (14, 15)]. Consequently, Hazardous Gaming can be understood as a complementary perspective to the diagnosis of IGD.

In the ICD-11 Hazardous Gaming describes "a pattern of gaming, either online or offline, that appreciably increases the risk of harmful physical or mental health consequences to the individual or to others around this individual" (13). The risk can result "from [1a] the frequency of gaming, [1b] from the amount of time spent on these activities, [2] from the neglect of other activities and priorities, [3] from risky behaviors associated with gaming or its context, [4] from the adverse consequences of gaming, or from the combination of these" (13). Additionally, the gaming might continue despite the individual being aware of the heightened risk associated with it (13).

To the knowledge of the authors, there are so far no instruments to assess Hazardous Gaming in children and adolescents. To date, only

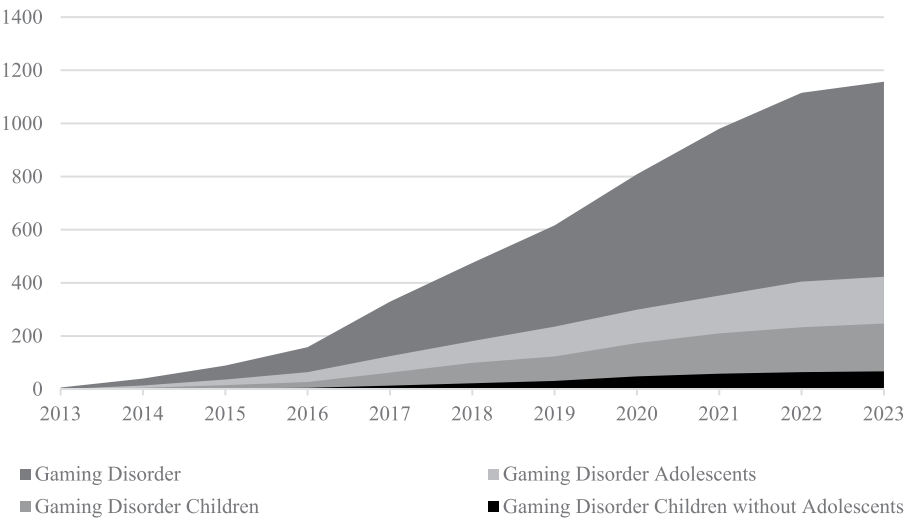

FIGURE 1
Cumulative published research on Gaming Disorder between 2013 and 2023. Cumulative published papers on PsycInfo between 2013 and 2023 including the terms "'Gaming Disorder'", "'Gaming Disorder' AND Adolescent*" "'Gaming Disorder' AND Child*" or "'Gaming Disorder' AND Child* NOT Adolescent*". The term "Gaming Disorder" was used as it also includes Internet Gaming Disorder. Retrieved May, 9th, 2023 (16).

nine search results were identified within the database PsycInfo (16) to investigate Hazardous Gaming at all. The only questionnaire investigating Hazardous Gaming is the Gaming Disorder and Hazardous Gaming Scale (GDHGS) by Balhara et al. (17). This scale shows good psychometric properties for college students, but the wording does not seem applicable to children. The Video Game Dependency Scale [*Computerspielabhängigkeitsskala*; CSAS; (18)] is a scale that validly assesses IGD in adolescents and adults. This scale is repeatedly used in scientific research [e.g., (19–21)] as well as in clinical practice, especially in Germany, because it provides norm values (stanines) which are essential for clinical diagnostics. Furthermore, the self-report version of the CSAS has been evaluated in one of the biggest non-convenience adolescent samples (22, 23). The wording for the questionnaire seems more applicable for children. Additionally, a parental report version for the CSAS exists (18). Since in children parental report is often used as a valid source of information (24), this is a helpful addition in assessing risky gaming behavior in children.

Therefore, we aimed to investigate (a) whether an established questionnaire, measuring IGD in adolescents and adults, is also suitable to measure Hazardous Gaming in German children and/ or (b) whether there are adjustments needed to this questionnaire in order to capture criteria of Hazardous Gaming. On top of that, we aimed to investigate (c) how many children in our study population show symptoms of Hazardous Gaming. Finally, (d) we analyzed the overlap and dissimilarities between (subclinical) IGD and Hazardous Gaming in children.

2. Methods

2.1. Participants

Our study examined a mixed school and clinical sample of children aged 8 to 12 years. Initially, $N = 877$ children were assessed, $n = 6$ were excluded from analyses due to missing data, resulting in a final sample of $N = 871$ children. The children were on average 10.3 ($SD = 0.90$) years old. Of the sample, 43.5% ($n = 379$) were female, 51.4% ($n = 448$) were male, and 5.1% ($n = 44$) did not specify their gender. The sample consisted of children attending primary or high school, with an overrepresentation of children attending the highest level of German high school (*Gymnasium*), which accounted for 65.8% ($n = 557$) of the sample. Other school types included primary school ($n = 121$) and medium-level high schools (*Realschule*; $n = 116$). The school subsample was composed of $n = 703$ primary school students and fifth graders from the Rhine-Neckar metropolitan region in Germany. Data were retrieved from 39 classes across seven schools as part of the PROTECTdissonance study (25). Data was collected in all schools or classes that were willing to host the prevention program. Therefore, the sample is a convenience sample. Within each participating class, data from all students were collected and analyzed. The data were collected prior to participation in the prevention program PROTECTdissonance. Additionally, $n = 168$ patients from an outpatient clinic in Heidelberg, Germany were included in the study. These data were collected as part of a complete survey conducted by Kewitz et al. (26) in a clinic that treats a variety of psychological disorders without specialization on IGD. All patients with valid data on the CSAS were included in the study. At the time of data collection, $N = 235$ individuals between 8 and 12 years of age were patients at the clinic. Thus, we retained data from 71.5% of all patients at the outpatient clinic between 8 and 12 years of age. The clinical sample included children primarily diagnosed with depressive episodes (3.6%, $n = 6$), neurotic, stress-related, and somatoform disorders (14.9%, $n = 25$), eating disorder, unspecified (0.6%, $n = 1$), habit and impulse disorder, unspecified (0.6%, $n = 1$), disorders of psychological development (4.8%, $n = 8$), as well as behavioral and emotional disorders with onset usually occurring in childhood and adolescence (75.6%, $n = 127$), including hyperkinetic disorders (37.5%, $n = 63$), conduct disorders (10.7%, $n = 18$), and emotional disorders with onset specific to childhood (12.5%, $n = 21$).

We applied no exclusion criteria, and the participants did not receive any form of recompense.

2.2. Measures

(Subclinical) Internet Gaming Disorder was assessed through the German version of the CSAS (18) by administering the parent report version (CSAS-PR). The questionnaire was completed by the children's primary caregivers, who were predominantly their biological parents (97.2%). The CSAS was also completed by the children's stepparents ($n = 1$), grandparents ($n = 2$), foster parents ($n = 3$), and other individuals ($n = 18$, e.g., siblings or educators). A majority of the caregivers who completed the survey were female (75.7%, 18.4% were male, and 6.0% did not disclose their gender). The questionnaire takes approximately 5 to 10 min to complete and evaluates both online and offline gaming behavior using 18 items, with two items per criterion of the DSM-5 diagnosis for IGD. Respondents rate each item on a 4-point Likert scale from 0 "strongly disagree" to 3 "strongly agree," with only the highest rating counting as endorsement, and only one item needed to fulfil a corresponding criterion. A tentative diagnosis of IGD can be made if at least five out of nine criteria are met, while the presence of two to four criteria indicates a subclinical IGD. The internal consistency for the CSAS in self-report ranges between $\alpha = 0.92$ and $\alpha = 0.95$ (18). The CSAS also assesses the average *gaming time* per day by requesting the parents to estimate their child's weekday and weekend gaming times. The average gaming time per day was then calculated by combining the two estimates, using the following formula: (5 * average weekday time + 2 * average weekend time)/7.

To measure *Hazardous Gaming*, selected items from the CSAS were re-analyzed in a different manner. The criterion [1a] "excessive gaming frequency" and [1b] "excessive gaming time" were combined into one criterion. Gaming daily was considered excessive gaming frequency. It was assessed by asking how often the child had played video games within the last year on (1) computers, macs, or tablets, (2) game consoles, (3) portable game consoles, and/or (4) mobile phones or smartphones. If the child had played daily on any of these devices, gaming frequency was considered excessive. The frequency was assessed by a 7-point Likert scale ranging from 0 "never" to 6 "daily." Leaning on the study by Rehbein et al. (27), any amount of average gaming time per day lying in the 90th percentile or above was considered to be excessive. In the current study, 115 min gaming time per day was considered excessive. Thus, the criterion [1] excessive gaming frequency and excessive gaming time was endorsed if a child played on a daily basis at least 115 min per day. The criterion [2] "neglect of other activities and priorities" was endorsed if the IGD criterion "give up other activities" (Item 11 and Item 15) was met. As

in the regular analysis of the CSAS, the highest category ("strongly agree") had to be met on at least one of the two items assessing "give up other activities" for the criterion to be endorsed. The criterion [4] "adverse consequences of gaming" was assessed via the IGD criteria "continue despite problems" (Item 6 and Item 14) and "risk/lose" (Item 16 and Item 18). If at least one of these two criteria was met (i.e., one out of four items), the criterion "adverse consequences of gaming" was considered endorsed. The criterion [3] "risky behaviors associated with gaming or its context" could not be assessed through the CSAS. A recommendation for its future assessment is included in the discussion.

Sociodemographic variables that were assessed include age, gender, and school type. Primary diagnoses were solely collected in the clinical sample.

2.3. Procedure

The data collection took place via paper-pencil questionnaires that were assigned a pseudonym code. For the school sample, the parents completed the CSAS at home before their children participated in the prevention program. The children brought the questionnaires to school and handed them over to study psychologists. Data for this non-clinical sample were collected from March 2017 to December 2019. For the clinical sample, parents completed the CSAS between April 2018 and November 2019, either at home or on-site at the outpatient clinic. The completed questionnaires were handed over to the responsible psychotherapists, coded with a pseudonym, and passed on to the study coordinator.

2.4. Statistical analysis

Psychometric properties of the modified CSAS assessing the Hazardous Gaming criteria "excessive gaming frequency and excessive gaming time," "neglect of other activities and priorities," and "adverse consequences of gaming" were analyzed using the mixed school and clinical sample. Descriptive data were analyzed, considering item mean, item standard deviation, item difficulty (p_i = item mean/ maximum of scale), and item discrimination. On top of that, the homogeneity and internal consistency were considered. Due to different scaling of the items, standardized Cronbach's alpha is reported. The analyses were conducted in SPSS, version 29.0.0.0.

Afterwards, an explorative factor analysis (EFA) was conducted using Maximum Likelihood with oblimin rotation. First, the premises for an EFA were analyzed via the Bartlett-Test, the Kaiser-Meyer-Olkin (KMO) coefficient and Measure-of-Sample-Adequacy (MSA) coefficients for each item. A variety of criteria for factor extraction were considered: Parallel analysis, Empirical Kaiser Criterion (EKC), Comparison Data (CD), Maximum-Likelihood (ML) testing, scree plot, BIC, and RMSEA. For interpretation of the factor loadings, confidence intervals were computed to estimate the significance of factor loadings. Additionally, it was tested if a factor of higher order could be retrieved. The EFA was conducted in R, version 4.3.0. The packages psych (28), GPArotation (29, 30), and EFAtools (31) were applied.

Finally, the overlap and dissimilarities between Hazardous Gaming, subclinical IGD, and IGD were examined. Therefore, the percentage of children meeting the threshold for Hazardous Gaming, subclinical IGD, and IGD were considered. Shares of valid data were computed, excluding missing data. For each percentage a 95% confidence interval is given. Finally, Cohen's Kappa was applied to estimate the overlap in assessment through the different versions of the CSAS. Missing data were not replaced.

2.5. Ethics

The Ethics Committee of the Heidelberg University of Education granted approval for the PROTECTdissonance study (EV2019/01). The clinical sample data were assessed as part of a routine care setting, with permission from Heidelberg University's ethical guidelines. Informed written consent from legal guardians, mainly parents, was obtained, and the study adhered to the principles outlined in the Declaration of Helsinki.

3. Results

3.1. Item analyses of the modified CSAS assessing Hazardous Gaming

To analyze Hazardous Gaming in children, item analyses of the modified CSAS version were considered first.

3.1.1. Excessive gaming time and frequency

Children played on average $M = 52$ ($SD = 52$, $Min = 0$, $Max = 463$) minutes per day. The most frequent used gaming devices were mobile phones/ smartphones which were being used by 49.2% ($n = 423$) of the children at least multiple times a week, followed by computers which were being used by 32.9% ($n = 277$) of the children at least multiple times a week. The usage frequency per device is given in Table 1.

Excessive gaming time was considered endorsed when a child met at least the 90th percentile of gaming time. This equivalated to 115 min per day ($n = 82$). Excessive gaming frequency was considered as daily usage of any gaming device. This criterion was met by 20.5% ($n = 168$) of the children. Daily gaming on any device of at least 115 min per day (i.e., excessive gaming time and excessive gaming frequency) was shown by 6.3% ($n = 53$) of all children.

3.1.2. Neglect of other activities and priorities

Item responses were right skewed and base rates of individuals meeting item cut-offs were low. For item 11 "Because of his/her gaming, my child enjoys other activities less than he/she used to do," item difficulty was $p_i = 0.13$ and for item 15 "My child gave up other hobbies or cut down on them because gaming is more important to him/her," item difficulty was $p_i = 0.07$. Both items were strongly intercorrelated and moderately correlated with gaming time (see Tables 2, 3).

3.1.3. Adverse consequences of gaming

Least difficult was item 14, "My child often gets into serious fights or arguments at home because he/she spends so much time playing games" ($p_i = 0.17$), followed by item 6, "Due to his/her frequent gaming, my child sometimes gets in trouble at school or work" ($p_i = 0.07$), item 16, "My child has already lost or risked an important relationship or friendship because of gaming" ($p_i = 0.03$), and item 18, "Due to gaming, my child has risked his/her opportunities at school

or work" ($p_i = 0.03$). Item 14 was also most strongly correlated with gaming time (see Table 3). All other descriptive item characteristics can be found in Table 2. For all items, the entire scale was exhausted (for items on usage frequency: $Min = 0$, $Max = 6$, for all other items (excluding gaming time): $Min = 0$, $Max = 3$).

3.2. Homogeneity and internal consistency of the modified CSAS assessing Hazardous Gaming

Standardized Cronbach's alpha was considered to analyze the scale's reliability. We found evidence for a high reliability ($\alpha = 0.81$, $n = 693$). The mean inter-item correlation laid at $r_{ij} = 0.28$ with inter-item correlations ranging from $r = 0.08$ to $r = 0.65$. All inter-item correlations can be found in Table 3.

3.3. Factor analyses of the modified CSAS assessing Hazardous Gaming

The factor structure of the modified CSAS to assess Hazardous Gaming was analyzed using EFA. Before conducting the EFA, the premises of an EFA were tested. Since the Bartlett-test reached significance ($\chi^2 = 2239.53$, $df = 55$, $p > 0.001$) and KMO coefficient (KMO = 0.85) as well as MSA coefficients (0.79–0.87) were above 0.50, an EFA could be conducted (32). To determine the number of extracted factors, multiple criteria were considered: EKC and CD suggested the extraction of two factors. The BIC reached a minimum at three factors (BIC = −84.4). Parallel analysis and ML-testing suggested the extraction of four factors (at five factors the χ^2 test did not reach significance anymore, $\chi^2(10) = 13$, $p = 0.20$), whereas the RMSEA reached its minimum at five factors (RMSEA = 0.02). The scree plot can be found in Figure 2. If different extraction methods do not converge, Auerswald and Moshagen (33) suggest that results of parallel analysis, CD, or EKC can be chosen. Due to facility of interpretation and the convergence of CD and EKC, the two-factor solution was chosen. The first factor's eigenvalue laid at 2.48, explaining 23% of variance. The second factor's eigenvalue laid at 1.76, explaining 16% of variance. The factors were correlated ($r = 0.55$). Afterwards, an extraction of a higher order factor was conducted. The extraction of one factor of higher order is suggested by parallel analysis. This factor had an eigen-value of 1.35, explaining 67% of variance. The significant factor loadings of the complete EFA are illustrated in Figure 3. The double loading of Item 14 hinders clear interpretation. Yet, it seems

TABLE 1 Frequency of gaming per device as assessed through the CSAS-PR (23).

Frequency	Computer (*N*)	Game console (*N*)	Portable game console (*N*)	Mobile phone (*N*)
Never	21.6% (182)	40.0% (337)	64.8% (541)	16.2% (139)
1 or 2 times	9.4% (79)	11.9% (100)	9.1% (76)	5.9% (51)
3 to 12 times	12.5% (105)	16.7% (141)	9.7% (81)	12.2% (105)
Multiple times per month	13.7% (115)	11.0% (93)	6.7% (56)	9.5% (82)
Once a week	10.0% (84)	7.5% (63)	3.2% (27)	7.0% (60)
Multiple times a week	26.7% (225)	10.9% (92)	5.3% (44)	33.4% (287)
daily	6.2% (52)	2.0% (17)	1.2% (10)	15.8% (136)

Frequency of gaming was assessed for the past year.

TABLE 2 Item characteristics.

	N	Mean	SD	Difficulty p_i	Discrimination for *z*-standardized items
Computer	842	2.9	2.0	0.48	0.21
Game console	843	1.8	1.8	0.30	0.31
Portable game console	835	1.0	1.6	0.17	0.24
Mobile phone	860	3.5	2.1	0.58	0.27
Daily gaming time (in minutes)	764	52	52	0.45[1]	0.52
Item 11	839	0.4	0.8	0.13	0.61
Item 15	840	0.2	0.5	0.07	0.63
Item 6	838	0.2	0.5	0.07	0.62
Item 14	839	0.5	0.8	0.17	0.65
Item 16	837	0.1	0.4	0.03	0.60
Item 18	838	0.1	0.3	0.03	0.44

Computer: frequency of gaming on the computer. Game console: frequency of gaming on game consoles. Portable game console: frequency of gaming on portable game consoles. Mobile phone: frequency of gaming on mobile phones.
[1]Computed with 115 min as maximum (since that is the threshold for excessive gaming time).

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TABLE 3 Inter-item correlations.

	Computer	Game console	Portable console	Mobile phone	Gaming time	Item 11	Item 15	Item 6	Item 14	Item 16	Item 18
Computer	–	0.20***	0.10**	0.12***	0.24***	0.20***	0.14***	0.15***	0.18***	0.11**	0.12***
N	842	828	819	836	743	812	813	811	812	810	811
Game console	–	–	0.26***	0.25***	0.29***	0.20***	0.15***	0.17***	0.28***	0.16***	0.13***
N		843	822	834	746	813	814	812	813	811	812
Portable game console	–	–	–	0.08*	0.17***	0.14***	0.15***	0.16***	0.22***	0.11**	0.09**
N			835	830	741	804	805	803	804	802	804
Mobile phone	–	–	–	–	0.39***	0.21***	0.16***	0.19***	0.27***	0.15***	0.11**
N				860	758	828	829	827	828	826	827
Gaming time	–	–	–	–	-	0.34***	0.38***	0.33***	0.45***	0.28***	0.13***
N					764	740	740	740	739	737	738
Item 11	–	–	–	–	–	–	0.62***	0.42***	0.57***	0.43***	0.40***
N						839	839	838	838	836	837
Item 15	-	–	–	–	–	–	–	0.49***	0.54***	0.52***	0.43***
N							840	838	839	837	838
Item 6	–	–	–	–	–	–	–	–	0.53***	0.65***	0.36***
N								838	837	835	836
Item 14	–	–	–	–	–	–	–	–	–	0.45***	0.28***
N									839	837	837
Item 16	–	–	–	–	–	–	–	–	–	–	0.48***
N										837	835
Item 18	–	–	–	–	–	–	–	–	–	–	–
N											838

*$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$. Computer: frequency of gaming on the computer. Game console: frequency of gaming on game consoles. Portable game console: frequency of gaming on portable game consoles. Mobile phone: frequency of gaming on mobile phones.

that factor 1 represents risky gaming behavior and factor 2 excessive gaming.

3.4. Prevalence, dissimilarities, and overlap of Hazardous Gaming and (subclinical) IGD

To analyze the overlap between Hazardous Gaming and (subclinical) IGD, we calculated the shares of children fulfilling the threshold for each diagnosis. The threshold for Hazardous Gaming was met by 10.4% (95% CI = 8.3–12.4; $n = 90$) of all children, the threshold for subclinical IGD was met by 10.0% (95% CI = 8.0–12.0; $n = 84$), and the threshold for IGD by 2.7% (95% CI = 1.6–3.8, $n = 23$). Descriptively more boys reached the threshold than girls: Within the male subgroup 15.8% (95% CI = 12.5–19.2, $n = 71$) met the threshold for Hazardous Gaming, 16.3% (95% CI = 12.8–19.8, $n = 71$) for subclinical IGD, and 4.1% (95% CI = 2.3–6.0, $n = 18$) for IGD. In comparison 5.1% (95% CI = 2.8–7.3, $n = 19$) of the girls met the threshold for Hazardous Gaming, 3.3% (95% CI = 1.5–5.1, $n = 12$) for subclinical IGD, and 1.4% (95% CI = 0.2–2.6, $n = 5$) for IGD. The overlap between the different constructs can be seen in Figure 4. In total, 91.3% of the children reaching the threshold for IGD also met the threshold for Hazardous Gaming. Yet only 42.9% of the children that met the threshold for subclinical IGD also met the threshold for Hazardous Gaming. On top of that, 35.2% of all children fulfilling the threshold for Hazardous Gaming neither fulfilled the threshold for IGD nor subclinical IGD, therefore, representing a subgroup of its own.

To quantify the overlap, Cohen's Kappa was computed to analyze the share of the different constructs. Cohen's Kappa laid at $\kappa = 0.35$ ($p < 0.001$) for Hazardous Gaming and subclinical IGD, indicating a fair overlap (34) of the constructs. Also, the similarity between Hazardous Gaming and IGD laid at $\kappa = 0.35$, ($p < 0.001$). The overlap between any IGD (subclinical or full-syndrome) with Hazardous Gaming laid at $\kappa = 0.53$ ($p < 0.001$) which corresponds to a moderate similarity (34).

4. Discussion

This paper analyzed Hazardous Gaming in children as a relevant health condition which by definition is associated with future psychopathology such as IGD or other mental disorders (13). It is one of the first papers investigating Hazardous Gaming in any age group. To date, only nine search results on "Hazardous Gaming" were identified within the database PsycInfo (16), This approach might

be especially promising in a young age group, since based on substance addiction research it is known that earlier onset of harmful use predicts addiction patterns later in life (35). Since prevalence rates of IGD among adolescents are already substantial (36) and children spend a lot of their leisure time gaming (8), it is crucial to address much younger age groups with screenings for Hazardous Gaming. However, instruments to screen for Hazardous Gaming in children do not exist yet. Therefore, this study aimed to test whether Hazardous Gaming in children can be assessed by using specific items from a validated IGD questionnaire (CSAS) that capture Hazardous Gaming symptoms and to assess the psychometric properties of this modified version. Moreover, this study aimed to investigate whether adjustments or additions are needed to capture criteria of Hazardous Gaming using this tool.

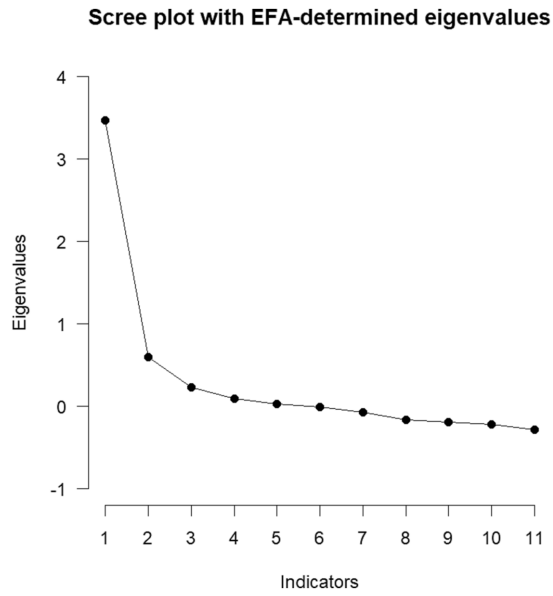

FIGURE 2
Scree plot of the EFA.

Three out of four ICD-11 criteria could be captured with the modified version of the CSAS. The results suggest a good reliability and adequate item difficulty of the adapted version. EFA displayed that a two-factor structure with one factor of higher order showed satisfying results. Thus, the Hazardous Gaming construct seems to be best described by one factor of higher order (Hazardous Gaming) and two factors representing [1] risky gaming behavior (neglect of other activities and adverse consequences of gaming) and [2] excessive gaming (gaming time and frequency). Taken together, it is possible to reliably screen for Hazardous Gaming using an alternative score of the CSAS.

Since our adapted version of the CSAS did not cover all criteria named in the ICD-11, we suggest assessing the criterion "risky behaviors associated with gaming or its context" by including four more items to the CSAS when assessing Hazardous Gaming, displayed in Supplementary Table 1. The suggested items cover the negative impact of gaming on the child's finances, diet, sleep, and behavior in traffic. The latter focusses on the direct impact of gaming in traffic, e.g., playing a game on a smartphone while walking in the street. This question does not aim to ask for risky behavior in traffic due to Game

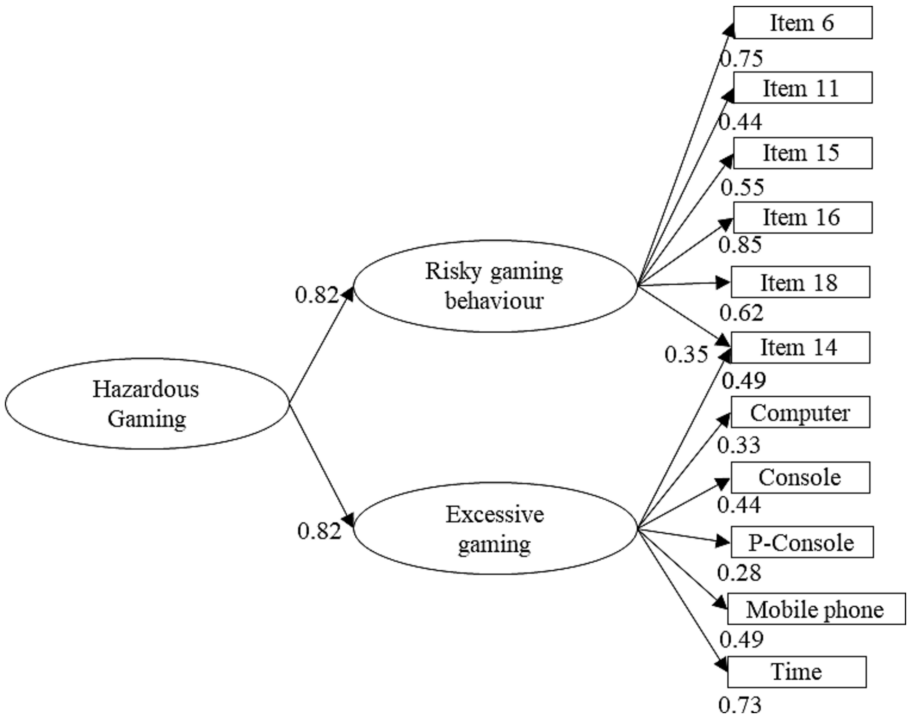

FIGURE 3
Significant factor loadings. Computer: frequency of gaming on the computer. Game console: frequency of gaming on game consoles. Portable game console: frequency of gaming on portable game consoles. Mobile phone: frequency of gaming on mobile phones.

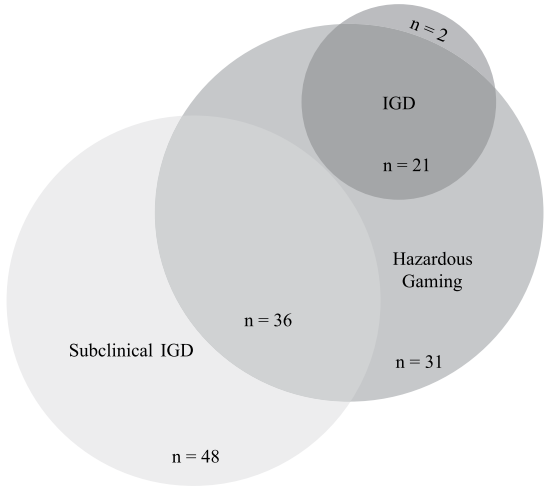

FIGURE 4
Overlap and dissimilarities between Hazardous Gaming, subclinical IGD, and full-syndrome IGD. The threshold for Hazardous Gaming was met by $n = 90$. However, two of those individuals had too many missing data points to analyze their (subclinical) IGD data. Therefore, only 88 individuals reaching the threshold for Hazardous Gaming are depicted in this figure (excluding the two individuals that have missing data on (subclinical) IGD).

Transfer Phenomena (37), as this is another complex construct. The set of additional items was generated by the authors on a theoretical basis. Future research should address the assessment of its psychometric properties. To facilitate the calculation of the alternative CSAS score for Hazardous Gaming, we designed a supplementary sheet (see Supplementary Table 2).

Beyond the analysis of the psychometric properties of the modified CSAS version, we aimed to investigate how many children of our study population show symptoms of Hazardous Gaming. Further, we aimed to analyze the overlap and dissimilarities between individuals fulfilling the construct of Hazardous Gaming and (subclinical) IGD.

Although we captured only three out of four Hazardous Gaming criteria and thus might probably underestimate the prevalence (because the criteria are linked by an "or" condition in ICD-11), a relevant share of the child sample ($n = 90$; 10.4%) met the criteria for Hazardous Gaming. Another 10.0% ($n = 84$) met the criteria for subclinical IGD. These populations seem to be largely distinct, represented by a share of 35.2% of children meeting the threshold for Hazardous Gaming exclusively and a share of 57.1% meeting the threshold for subclinical IGD exclusively. Vice versa, 91.3% of children with IGD also met the criteria for Hazardous Gaming.

Hazardous Gaming and subclinical IGD seem to represent two different risk factors for the development of a full-syndrome IGD. Thus, a precursor diagnosis for IGD seems to not only be subclinical IGD but also Hazardous Gaming. One crucial difference between the concepts of Hazardous Gaming and subclinical IGD may be explained by excessive gaming (time and frequency), which is part of the definition of Hazardous Gaming, but not of (subclinical) IGD (1, 13). The results underpin that Hazardous Gaming is not just a sub-construct of IGD but a standalone construct of its own that overlaps with IGD. However, more fundamental research is needed to investigate the validity of the proposed criteria for Hazardous Gaming by the ICD-11.

In clinical practice we suggest screening for children's risky gaming behavior to avoid full-syndrome IGD (possibly later in life). If risky behavior becomes apparent at an early stage, prevention or early intervention might hinder the onset of a disorder later in life. At this moment, the scientific data cannot give a clear answer whether to prefer screening for subclinical IGD or Hazardous Gaming. It does, however, give insights into some overlaps and differences between the two constructs. Thus, this study paves the way for future studies enabling clear recommendations for clinical practice in the future.

There are some limitations to the adaptability of the CSAS in assessing Hazardous Gaming during childhood: Some items assessing gaming frequency (i.e., computers, portable game consoles, mobile phones) show an item discrimination below 0.30. This is below a desirable threshold (38). The items measuring gaming frequency also show relatively low correlations with other items and some show relatively low factor loadings. On the one hand, the reason for this relatively low suitability might lie within the assessment of gaming frequency through a questionnaire. Daily gaming on any device is the highest resolution for the assessment of gaming frequency possible through the CSAS. Yet, in the current sample 20.5% of the children were gaming daily. Therefore, an even higher resolution for the assessment of gaming frequency might be necessary to assess "excessive" gaming validly. Excessive frequency might also be represented by playing games on multiple devices at the same time. That higher resolution could possibly be assessed by Ecological Momentary Assessment (EMA) multiple times a day. Alternatively, tracking data of electronic devices might be helpful. Though, data from multiple devices would have to be integrated in order to get a valid measure. On the other hand, the lacking psychometric properties of the items measuring gaming frequency might also question the validity of the criterion of excessive frequency. In the current study, gaming frequency is in fact less relevant to assess excessive gaming, compared to gaming time (as can be derived from the factor loadings). Therefore, gaming time might in fact be a sufficient feature to assess excessive gaming. Future research should further investigate the role of excessive gaming frequency in context of Hazardous Gaming.

Additionally, item 14 ("My child often gets into serious fights or arguments at home because he/she spends so much time playing games") has significant factor loadings on both factors. It is also the least difficult item in assessing risky gaming behavior. It is imaginable that excessive gaming in childhood is often associated with conflicts with parents. These conflicts might arise even if no negative consequences (e.g., trouble in school or sleep problems) have occurred yet. At the same time, conflicts with parents can be regarded as a negative consequence itself and, therefore, this item may be part of both factors.

Finally, the adaptation only used parental report. Even though parental report is often considered crucial in diagnostics for children (24), it does come with some limitations as parents do not monitor their children all day long. Therefore, they might not be able to give valid answers on every item, especially concerning gaming patterns. However, in non-clinical samples, adolescents and their parents gave similar answers on IGD questionnaires (39). At the same time, assessments differed in clinical samples (26, 40). Thus, it would be desirable to test whether the proposed adaptation of the CSAS can also be applied to children in self-report so that both perspectives can

be assessed. Additionally, as stated above, tracking or EMA data might be helpful additional ways to validly assess gaming patterns.

5. Conclusion

The study was able to show that the CSAS can be applied to children to assess three out of four criteria for Hazardous Gaming and, thus, provide a good screening tool. However, future research should include the suggested fourth criterion to assess "risky behaviors associated with gaming or its context" and further investigate the clinical relevance of the different criteria for the construct of Hazardous Gaming. Hazardous Gaming can be a promising way to make children with problematic gaming behavior visible. This approach might help to avoid stigma of an addiction diagnosis at a young age and give a low threshold alternative.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Heidelberg University of Education and by the Ethics Committee of Heidelberg University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

SK was involved in conception and design of the study, collected and analyzed data, and wrote the paper. KLe and FR were involved in conception, design of the study, and writing. KLi conceived and designed the study and was involved in data collection, analysis, writing, and supervision. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1226799/full#supplementary-material

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An app-based training for adolescents with problematic digital-media use and their parents (Res@t digital): protocol for a cluster-randomized clinical trial

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Background: Digital media-use disorders (DMUD) in adolescents are a rising phenomenon associated with psychological distress, comorbid mental disorders, and high burden on affected families. Since the ICD-11 introduced criteria for gaming disorder, these can now be transferred to describe additional DMUD associated with social media platforms and streaming services. Most evidence for effective treatments comes from cognitive-behavioral therapy (CBT). However, interventions based on theoretical models for adolescents and their parents are widely missing, leading to a significant clinical gap.

Methods: Res@t digital (Resource-Strengthening Training for Adolescents with Problematic Digital-Media Use and their Parents) is the app-based translation of the first model-based digital intervention for adolescents with DMUD and their parents based on CBT. It comprises separate but content-related modules for adolescents (Res@t–A) and parents (Res@t–P), applying multimodal techniques. The effectiveness of Res@t will be evaluated within a multicenter cluster-randomized controlled evaluator-blinded pre–post follow-up trial with the waitlist control group (CG). In addition to the Res@t program in the intervention group, both groups will receive treatment as usual within primary child and adolescent psychiatric/psychotherapeutic healthcare. The primary outcome addresses DMUD symptom reduction after 10 weeks. Secondary outcomes are related to a reduction in psychological and family-related problems and an increase in parental self-efficacy. All outcomes will be assessed using standardized self-report measures. A total of 1,334 participating adolescent–parent dyads from a large clinical network throughout Germany are planned to be included in the primary analyses based on an intention-to-treat approach, applying linear mixed models.

Discussion: Assuming superiority of Res@t over the control condition, the intervention has the potential to provide evidence-based treatment for a significant number of help-seeking families, supporting local healthcare structures and resources. It is a promising program for practicable implementation and flexible use in different settings.

Clinical trial registration: https://drks.de, DRKS00031043.

KEYWORDS

digital media-use disorders, e-health, digital intervention, cognitive-behavioral therapy, adolescents, parents

1 Introduction

The digital entertainment and media market industries belong to the fastest-growing businesses in the world (1). In 2022, revenue from digital games amounted to 184 billion U.S. dollars with mobile games accounting for 50% of the global gaming market (2). During the last decades, improved design mechanisms and broad availability led to increased usage frequency and duration worldwide over all age groups (3). During the COVID-19 pandemic, this development was fostered by contact restrictions, quarantines, and the closure of schools and leisure facilities, especially for children and adolescents (4–6). The majority of German children and adolescents use digital media on a regular basis from several times a week to daily, including social media (SM, more than 90%), video streaming (*VS*) services (more than 80%), and digital games (more than 70%) (7).

For some users, frequent digital media use as a leisure activity can turn into problematic patterns, resulting in severe negative personal, family, social, educational, and work-related sequelae with significant subsequent costs to healthcare and economic systems (8). Recent meta-analyses estimated the worldwide prevalence of problematic gaming between 3.1 and 3.3% (9, 10) and problematic SM use at 5% (11) with a peak during adolescence. Much less research has been conducted on problematic *VS*, although similar addiction-promoting mechanisms are applied to increase user bonding (12). Most associated research has focused on binge-watching, i.e., the consumption of several (television) series episodes in a row (13, 14). However, the series resembles only a small subentity of *VS* services. A representative study on German adolescents estimated the prevalence of pathologic *VS* at 4.7% in frequent (at least weekly) *VS* users (15).

Adolescents are particularly at risk for behavioral addictions including problematic gaming due to neuronal remodeling processes with a mature reward system, on the one hand, and a cognitive-control system that is still in development on the other hand (16, 17).

As the first behavioral addiction purely associated with digital media, problematic (online or offline) gaming has been included in the current (11th) version of the International Classification of Diseases (ICD-11) as *Gaming Disorder* (GD, 6C51) (18). Four criteria have been defined for diagnosing GD which must usually be present for the past 12 months: loss of control over the temporal and situational use of digital games, increased prioritization of digital gaming over alternative activities, continued or increased gaming despite negative consequences, and the occurrence of significant impairments in important areas of functioning. At the current state, other digital-media-related disorders (DMUD), such as *Social Media Use Disorder* (SMUD) or *Video Streaming Disorder* (VSD), can be classified under the umbrella *Other specific disorders due to addictive behaviors* (GC5Y), applying comparable criteria as for GD (19). Affected individuals who do not (yet) fulfill all criteria of addiction can be classified under *Hazardous Gaming* (HG, QE22) or *problems with other specified health-related behaviors* (QE2Y). The latter can include Hazardous Social Media Use (HSMU) and Hazardous Video Streaming (HVS). Disordered or hazardous usage patterns can be summarized as Problematic Gaming (PG), Problematic Social Media Use, or Problematic Video Streaming (PVS).

The etiology of DMUD can, e.g., be described by the *Triad Model of Addiction* by Kielholz & Ladewig (20). This biopsychosocial model describes an interaction of personal, social, and agent-related factors. It employs mechanisms of learning, stress management (21), and information processing and can be comprehensively applied to DRMD in adolescents. For more details, please refer to the study by Paschke et al. (22).

If DMUD remains untreated, there will be a high risk of chronicity with severe psychological consequences, repeated hospitalizations, and failure to fulfill necessary developmental tasks (e.g., no school qualifications, no education) with negative effects on the mental and physical health of the affected person and high costs for society. The best effects on symptom reduction have been shown for cognitive-behavioral therapy (CBT) (23). However, model-based and evidence-based treatment programs, addressing adolescents and their parents, are currently not available (24–26).

1.1 Aim of the study and hypotheses

The present study aims to evaluate the effectiveness of a new model-based standardized online intervention program, the Resource-Strengthening Training for Adolescents with Problematic Digital-Media Use, and their Parents (Res@t digital) in an outpatient setting. The Res@t digital intervention group (IG) will be compared with a waiting control group (CG). The IG will receive the Res@t digital intervention, and both groups will receive treatment as usual (TAU) during the study period. The waitlist CG will be offered access to the intervention after individual data collections are completed. It is hypothesized that Res@t digital + TAU is superior to TAU only and will lead to a decrease in adolescent DMUD (i.e., GD, SMUD, or VSD) symptoms. In the case of an adolescent being affected by more than one DMUD or hazardous use pattern, the clinician will identify the most prominent phenomenon that will be focused on within the

targeted intervention. Moreover, Res@t digital will reduce mental-health-related problems in adolescents and increase parental self-efficacy.

There are three primary hypotheses structured hierarchically which address the one most prominent DMUD or hazardous use pattern in the individual adolescent identified by the clinician (i.e., PG, PSMU, or PVS). This is referred to the term "specific" DMUD:

First primary hypothesis: Res@t + TAU reduces symptoms of specific DMUD in adolescents compared with TAU, measured as change from screening to post-intervention. Second primary hypothesis: Res@t + TAU reduces symptoms of specific DMUD in adolescents assessed by their parents compared with TAU, measured as change from screening to post-intervention. Third primary hypothesis: Res@t + TAU reduces symptoms of specific DMUD in adolescents assessed by their treating clinicians compared with TAU, measured as change from screening to post-intervention.

To the best of our knowledge, although positive effects of online interventions have been repeatedly suggested to fill substantial treatment gaps for mental health issues in adults (27–29) and adolescents (30–32) including addictive behavior (33–35), no comparable intervention for adolescents with DMUD and their parents is available yet. Therefore, Res@t strives to close a significant void.

2 Methods and analysis

2.1 Study design

The current study is a multicenter, prospective, cluster randomized-controlled, observer-blind clinical trial on the effectiveness of Res@t regarding symptom reduction in adolescents with DMUD. A two-arm study design will be applied with an IG and a waitlist CG with pre–post follow-up assessments. All patients will receive surveillance by a child and adolescent psychiatrist and psychotherapist who offers TAU in regular treatment parallel to the study.

2.2 Study sample and setting

Adolescents aged 10 to 19 years (based on the WHO definition of adolescence) and their respective parents, i.e., caregivers, will be recruited for the study by their child and adolescent psychiatrists and/or psychotherapists. Recruitment sites will include 10 outpatient departments of participating clinics (five university hospitals, five large care clinics) and approximately 40 practices throughout Germany (coordinated via the Professional Association for Child and Adolescent Psychiatry, Psychosomatics, and Psychotherapy in Germany e.V., BKJPP).

All eligible recruitment sites will be assigned randomly to IG or CG. Sites randomized to CG will have the opportunity to use Res@t after study recruitment and follow-up are completed.

In addition to introducing the study in regular appointments, advertisements will be carried out via five health insurance companies and the German Society for Child and Adolescent Psychiatry, Psychosomatics, and Psychotherapy (DGKJP) who support the study. Adolescents and parents who are interested in the study will be referred to participating clinics and practices, an appointment for screening and diagnosis will be made, and they will be informed about study details.

Screening for DMUD will take place for all patients within regular child and adolescent psychiatric diagnostics. If a DMUD is confirmed during clinical examination, adolescents and parents will be informed verbally and in writing about the study purpose and procedure including intervention, assessments, and recruitment-site-associated randomized group allocation. Further information concerns confidentiality and data protection procedures including pseudonymization, anonymous data storage at the study center (German Center for Addiction Research in Childhood and Adolescence, DZSKJ, University Clinic Hamburg-Eppendorf, UKE) for 10 years after study completion, possible advantages and disadvantages of participation, and the option to withdraw from the study at any time and without any given reason. Before study enrolment, adolescents and parents give their informed consent and receive all necessary documents on the study.

Since all participants are patients in regular treatment, they will not be financially compensated. However, patients will be offered a voucher for a large selection of online shops as incentive for full questionnaire completion with graded values according to assessment points.

Patient recruitment (first patient in to last patient out) is planned from January 2024 to May 2025. This includes a recruitment period of 12 months and a treatment and follow-up period of 17 months in total.

2.3 Eligibility criteria

Recruitment sites have been selected based on the following criteria:

- They are either approved outpatient departments of clinics for child and adolescent psychiatry and psychotherapy,
- Medical care centers for child and adolescent psychiatry and psychotherapy, or
- Practices for child and adolescent psychiatry and/or psychotherapy listed with the local Association of Statutory Health Insurance Physicians or Chamber of Psychotherapists.
- Local healthcare providing professionals need to be experienced with child and adolescent psychiatry and/or psychotherapy. They will comprise specialists for child and adolescent psychiatry, registrars in training as child and adolescent psychiatrists, psychologists, certified psychotherapists for children and adolescents, or psychotherapists for children and adolescents in training.
- All sites will be supervised by a certified experienced child and adolescent psychiatrist and/or psychotherapists.
- The sites are located in Germany.

Participants will be included in the study if they:

- Are between 10 and 19 years old (WHO definition of adolescence);
- Reach the cutoff values for hazardous or pathological use on the Gaming Disorder, Social Media Use Disorder or Streaming

Disorder Scale for Adolescents or Parents (GADIS-A/-P, SOMEDIS-A/-P, STREDIS-A/P);
- Fulfill the ICD-11 criteria of disordered or hazardous gaming, social media use, or streaming based on clinical examination;
- Have sufficient German language skills;
- Give written informed consent (for adolescents <16 years with additional informed consent of legal guardians).

OR
- Are a parent, i.e., caregiver, of a patient fulfilling the criteria above.

Participants will be excluded from the study if they:

- Show symptoms of an acute psychosis;
- Are acute suicidal;
- Are substance intoxicated or fulfill criteria of substance use disorder (alcohol, illegal substances, and non-prescribed medication);
- Show a severe reduction in literacy and/or intelligence;
- Have no access to the Internet or are not able to operate on a smartphone, tablet, or computer.

2.4 Sample size calculation

The sample size was computed with the procedure tests for Two Means in a Cluster-Randomized Design in PASS 16.0.4 (NCSS, LLC. Kaysville, Utah, United States). A small standardized mean difference (Cohen's $d = 0.2$) between IG and CG in symptom reduction measured as change from baseline to post-intervention is assumed. The number of study centers is assumed to be 50, each recruiting 27 patients on average. This leads to a feasible sample size of 667 per group. The coefficient of variation of the cluster sizes is set to 0.4 because recruitment is assumed to be heterogeneous due to the different sizes of the study sites. The intra-cluster correlation (ICC) is set to 0.005. With the achievable sample size of 667 patients with respective parents in each of the two groups ($N_{dyads} = 667$) and a two-sided type I error of 5%, the power will be 77%. A dropout rate of 40% before post-intervention assessment (10 weeks) and 20% before follow-up (20 weeks) is assumed. The sample size calculation refers to the three primary hypotheses, taking into account the hierarchical structure. A drop-out rate of 40% before post-intervention assessment (week 10) is considered. With an estimated proportion of adolescents in the outpatient setting with hazardous or disordered digital media use of 20% and a participation rate of 50%, $N = 13{,}340$ patients must be initially screened. Due to the novelty of the study, conservative estimates were chosen for the assumed effect size and drop-out and participation rates. Digital CBT-based intervention studies with comparable adolescent age groups reported small to medium effect sizes regarding the reduction in depression and anxiety symptoms (36, 37).

Three nuisance parameters (drop-out rate, coefficient of variation, and intraclass correlation coefficient) enter the sample size planning, the assumptions of which are not known with certainty. Therefore, a blinded interim analysis will be performed after the collection of post-intervention data from half of the planned patients (200 per group, 400 total) to estimate the nuisance parameters and possibly adjust the sample size.

2.5 Randomization

A stratified cluster randomization will be employed, resulting in each recruitment site (outpatient department or practice) being randomly allocated to the intervention or waitlist control. Stratification is performed according to recruitment site size (annual patient number ≤ 600, > 600 and $\leq 1{,}600$, and $> 1{,}600$) and location (urban or rural). An independent statistician at the Institute of Medical Biometry and Epidemiology (IMBE) at the University Medicine Hamburg-Eppendorf will randomly allocate recruitment sites using computerized random number generations within each stratum to IG or CG based on internal standard operating procedures, without knowledge of the identity of recruitment sites (with variable block length). Cluster randomization will be applied to avoid contamination between IG and CG conditions regarding TAU. Based on the resulting allocation, the intervention will be made available immediately (IG) or after the recruitment phase and follow-up data collection is completed (CG).

2.6 Assessment and data collection

Clinical assessments with the adolescents and respective parents will be realized at screening, baseline, week 10 (post-intervention), and week 20 (follow-up). By the latter, the durability of the treatment effect should be estimated. Screening and baseline visits should not be apart by more than 4 weeks, otherwise a clinical reevaluation will become necessary. In addition to clinical diagnosis and post-treatment evaluation, all assessments are performed digitally via standardized questionnaires, which are provided on an online platform without the involvement of the clinician. They will be automatically presented to the participants at the time points according to the study protocol. Participants will receive e-mail reminders just before and during the scheduled time frame. All data will be initially stored in a patient dossier on the ISO-certified e-mental health platform run by Embloom[1] before pseudonymization and secure transfer to the central study center. Regular visits with the clinician will take place within TAU. These should support compliance and adherence to keep the drop-out rate as low as possible. Figure 1 shows all study phases including assessment time points. Table 1 shows all questionnaires and items used in the current study. Table 2 shows the schedule of the questionnaire application.

2.7 Blinding

Practitioners will be informed whether their recruitment site has been assigned to IG or CG at the beginning of the study. Once a patient has been identified to be eligible for study participation and the family gave informed consent to participate, the practitioner will individually inform about the assignment to IG or CG. Evaluating data analysists at IMBE will be blinded and will receive blinded datasets only.

1 https://www.embloom.com

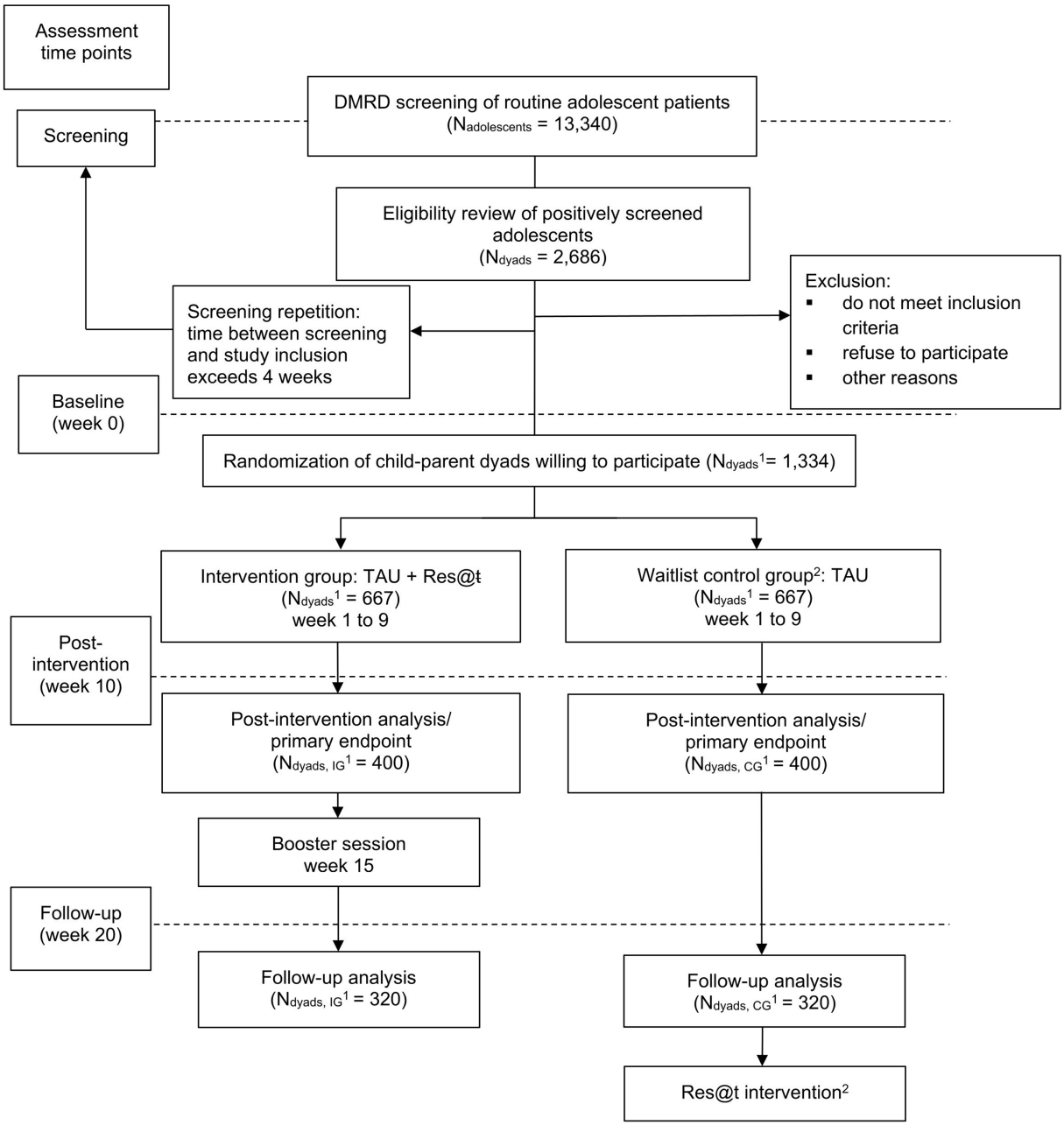

FIGURE 1
Flow chart of the study. [1]Total number of adolescent–parent dyads; [2]Participants of the waitlist control group will be offered the Res@t intervention after data collection is completed. DMUD, digital-media use disorders; TAU, treatment as usual; IG, intervention group; CG, control group.

2.8 Compliance

Compliance and adherence will be fostered by the treating clinician who observes the participants regularly within the context of normal treatment. Moreover, automatic reminders will be presented via the online app to the participating adolescents and parents. To all participants in the CG, the Res@t intervention will be offered after the completion of study recruitment. Incentives are planned for participants and clinicians to compensate for additional effort. These measures should increase study motivation and reduce drop-out rates.

2.9 Res@t digital intervention

Res@t digital is the app-based translation of a manualized CBT-based treatment package comprising offline programs for adolescents with GD (Res@t–A *offline*) and their parents (Res@t–P *offline* (64)). A detailed description of the original program package and its further development can be found in a recent publication by Paschke et al. (22). For better readability, a short summary is given by:

Res@t was created within the theoretical framework of the Trias model of addiction (20) based on clinical experiences and up-to-date research findings on the etiology of DMUD and potentially

TABLE 1 Overview of study questionnaires for adolescents and their parents.

	Instrument	Construct	Number of items	References
Adolescents				
	Sociodemographics	Sociodemographic data including age, sex, and educational status	18 Items	Standard, adapted to setting
	Media use	Media use (duration and frequency)	13 Items	(38)
	Gaming Disorder Scale for Adolescents (GADIS-A)	Gaming disorder according to ICD-11 criteria	10 Items	(39)
	Social Media Disorder Scale for Adolescents (SOMEDIS-A)	Social media disorder according to ICD-11 criteria	10 Items	(40)
	Streaming Disorder Scale for Adolescents (STREDIS-A)	Streaming disorder according to ICD-11 criteria	10 Items	(15)
	Strength and Difficulties Questionnaire (SDQ)	Emotional and behavioral problems in children and adolescents (self-report)	25 Items	(39, 41, 42)
	Pittsburgh Sleep Quality Index (PSQI)	Sleep quality	24 Items	(43)
	Epworth Sleepiness Scale - Children and Adolescents (ESS-CHAD)	Day-time sleepiness	8 Items	(44–46)
	Perceived Stress Scale (PSS-10)	Psychological stress perception	10 Items	(47, 48)
	Family APGAR	Family functioning	5 Items	(49, 50)
	Family Communication Scale (FCS)	Family communication	10 Items	(51, 52)
	Mindfulness Attention Awareness Scale (MAAS-5)	Mindfulness	5 Items	(53, 54)
Parents				
	Sociodemographics	Sociodemographic data including age, sex and gender, parental, educational/ socioeconomic status	18 Items	Standard, adapted to setting
	Parental media use	Parental media use (duration and frequency)	6 Items	(38)
	Gaming Disorder Scale for Parents (GADIS-P)	Gaming disorder according to ICD-11 criteria	10 Items	(43)
	Social Media Disorder Scale for Parents (SOMEDIS-P)	Social media disorder according to ICD-11 criteria	10 items	(55)
	Streaming Disorder Scale for Parents (STREDIS-P)	Streaming disorder according to ICD-11 criteria	10 Items	(12)
	Strength and Difficulties Questionnaire, External Assessment (SDQ-f)	Emotional and behavioral problems in children and adolescents (parental report)	25 Items	(39, 41, 42)
	Media Rules	Media rules	6 Items	(38)
	Family APGAR	Family functioning	5 Items	(49, 50)
	Family Communication Scale (FCS)	Family communication	10 Items	(51, 56)
	Patient Health Questionnaire-9 (PHQ-9)	Parental depression	9 Items	(57–59)
	Generalized Anxiety Disorder-7 (GAD-7)	General anxiety of parents	7 Items	(58, 60)
	Parenting Inventory – Revised (EEI-R)	Parenting style (without subscale about religion)	44 Items	(61)
	Questionnaire on Self-Efficacy in Parenting (FSW)	Parental self-efficacy	9 Items	(62)
	Perceived Stress Scale (PSS-10)	Psychological stress perception	10 Items	(47, 48)
	Ulm Quality of Life Inventory for Parents of Chronically Ill Children (ULQIE)	Quality of life of parents	29 Items	(63)
	Mindfulness Attention Awareness Scale (MAAS-5)	Parental mindfulness	5 Items	(53, 54)

TABLE 2 Diagram of trial activities and measurement time points.

	Study period								
	Enrollment			Intervention		Post-intervention and follow-up		Post-data collection	
Timepoint/ Content	Screening (<4 weeks before baseline)	Baseline assessment (week 0)	Allocation	Res@t intervention (week 1–9 and week 15 [booster])	TAU	Post-intervention (week 10)	Follow-up (week 20)	Res@t intervention	TAU
Enrollment									
Eligibility screening	X								
Clinical assessment	X								
Informed consent	X								
Randomization IG/ CG			X						
Interventions									
Intervention group (adolescent-parent dyads)				X	X				X
Waitlist control group (adolescent-parent dyads)					X			X	X
Assessments									
Adolescents						IG/CG	IG/CG		
Sociodemographics	X	X							
Media use	X								
GADIS-A	X					X	X		
SOMEDIS-A	X					X	X		
STREDIS-A	X					X	X		
SDQ	X					X	X		
PSQI		X				X	X		
ESS-CHAD		X				X	X		
PSS-10		X				X	X		
Family APGAR		X				X	X		
FCS		X				X	X		
MAAS-5		X				X	X		
Parents						IG/CG	IG/CG		
Sociodemographics		X							
Parental media use		X							
GADIS-P	X					X	X		
SOMEDIS-P	X					X	X		
STREDIS-P	X					X	X		
SDQ-f	X								
Media Rules		X				X	X		
Family APGAR		X				X	X		
FCS		X				X	X		
PHQ-9		X							
GAD-7		X							
EEI-R		X							
FSW		X				X	X		
PSS-10		X				X	X		
ULQIE		X				X	X		
MAAS-5		X				X	X		

GADIS-A, Gaming Disorder Scale for Adolescents; SOMEDIS-A, Social Media Disorder Scale for Adolescents; STREDIS-A, Streaming Disorder Scale for Adolescents; SDQ, Strength and Difficulties Questionnaire; PSQI, Pittsburgh Sleep Quality Index; ESS-CHAD, Epworth Sleepiness Scale - Children and Adolescents; PSS-10, Perceived Stress Scale; Family APRGAR, Family Functionality; FCS, Family Communication Scale; MAAS-5, Mindfulness Attention Awareness Scale; GADIS-P, Gaming Disorder Scale for Parents; SOMEDIS-P, Social Media Disorder Scale for Parents; STREDIS-P, Streaming Disorder Scale for Parents; SDQ-f, Strength and Difficulties Questionnaire – External Assessment; PHQ-9, Patient Health Questionnaire; GAD-7, Generalized Anxiety Disorder Questionnaire; EEI-R, Parenting Inventory - Revised; FSW, Parental Self-Efficacy; ULQIE, Ulm Quality of Life Inventory for Parents of Chronically Ill Children.

effective treatment components. During the developmental process, qualitative interviews and focus groups had been conducted with clinical experts, affected adolescents, and their parents on needs and program requirements (26, 64). The findings were considered for the final Res@t version. Original content was adapted to fit digital demands, and specific elements for the treatment of SMUD and VSD have been added. Res@t digital is comprised of nine weekly sessions and one booster session in week 15 of approximately 20 min processing time each. Additionally, participants are encouraged to complete a daily calendar on usage times, non-digital activities, mood, and sleep.

Table 3 gives an overview of the Res@t session contents as offered to adolescents and parents. Modules with adaption to address the type of DMUD are indicated.

The digital application in the adolescent and the parental versions will be made available via app stores. It is hosted in the secure Embloom platform environment. Based on the study arm allocation, the app, i.e., the intervention content, will be made available directly (for IG) or after individual data collection is completed (for CG). Figure 2 shows examples of the Res@t digital interface (in German language).

2.10 Outcome measures

2.10.1 Primary outcome

The primary outcome is the reduction of specific DMUD (GD, PSMU, or VSD) symptoms assessed by the DMUD test battery for adolescents and parents based on differential scores in pre–post comparison.

It includes the Gaming Disorder Scale for Adolescents/Parents (GADIS-A/-P), the Social Media Disorder Scale for Adolescents/Parents (SOMEDIS-A/-P), and the Streaming Disorder Scale for Adolescents/Parents (STREDIS-A/-P). All 10-item scales are identical except for the initial explanation and continuous naming of the specific digital medium of interest (digital games, social media platforms, and video-streaming services) and address either the potentially affected adolescent (self-rating version) or the respective parent (external-rating version). The whole test battery is based on the ICD-11 criteria of GD and has been adapted for SMUD and VSD accordingly. It has been validated in large nationally representative adolescent–parent samples and showed profound psychometrical properties with good to excellent internal consistency, criterion validity, and discriminatory power (12, 15, 40, 55, 65, 66). Accordance between self-rating and parental rating was moderate. Moreover, GADIS-A has been evaluated with Persian and Russian adolescents with good to very good internal consistency and adequate to very good retest reliability (67, 68). Adolescents and parents indicate their agreement with nine statements on a five-point Likert scale (strongly disagree [0]–strongly agree [4]) under consideration of the past 12 months with higher total scale scores resembling more problems. The 10th item reflects the frequency of problems, conflicts, or difficulties due to the digital medium and is answered by choosing one out of four response options (not at all [0]–nearly daily [3]). The questionnaires can be used for a categorical assessment of the DMUD. Accordingly, a score of ≥ 2 is considered significant regarding the ICD-11 criteria. Moreover, factor analyses confirmed two underlying scale factors, one for *cognitive-behavioral symptoms* (CBS) of problematic media usage and one for *negative consequences* (NC) of the media usage pattern. Cutoffs between scales are comparable, although slightly differing. For GADIS-A and GADIS-P, these are >9 (CBS) and >5 (NC), for SOMEDIS-A and SOMEDIS-p >8 (CBS) and >6 (NC), and for STREDIS-A and SOMEDIS-p >6 (CBS) and >11 (NC).

Children and adolescents will be classified as disordered if the cutoffs for both factors are reached and the time criterion is met. Reaching the cutoff of CBS only suggests hazardous media use. In the clinical context, the DMUD test battery has been regularly used and could prove to be helpful in assessing potential symptom changes during therapy.

Additionally, each treating clinician will assess symptom expression, rate fulfillment of the ICD-11 criteria (based on criteria of GD), and diagnosis of a potential specific DMUD. They will be provided with a digital criterion checklist including examples to enhance interpretation based on ICD-11 suggestions, the clinical interview guideline of the Gaming Disorder and Hazardous Gaming Scale (GDHGS) (69), and clinical expert experience.

In the case of the diagnosis of more than one DMUD, the clinically most prominent one (i.e., by total rating scores and clinical evaluation) will be defined as the main DMUD. This will be addressed during intervention and used as a primary outcome, which was assessed during enrollment, at post-intervention, and follow-up. The differences between screening and post-intervention total scale scores will be investigated primarily.

2.10.2 Secondary outcomes

Secondary outcomes can be divided into psychological, media-associated, parental, and family-associated factors and are assessed with the participating adolescents and parents separately (Table 1). For adolescents, these include adolescent emotional and behavioral problems (based on self-rating and parental rating), sleep-associated aspects, mindfulness, and psychological stress perception, media usage times, and family communication/functioning. For the parents, these comprise mindfulness, quality of life, parental media usage, media rules, parental self-efficacy, and family communication/functioning.

2.10.3 Additional variables

Additional variables that will be included as covariates cover sociodemographic information (age, sex/gender, region of living, and parental status), parental mental distress, and parenting style (Table 1). Moreover, data on media usage and app usage patterns, i.e., media usage time as well as number of app usage sessions, days, weeks, quests started, quests completed, mindfulness exercises observed, and calendar entries, as well as the relative completion of modules and complete training will be collected.

2.11 Data collection and management

All data will be collected on an ongoing basis via the Res@t application and stored within the ISO-certified Embloom platform on secure servers with regular backups. Data will be pseudonymized before transferring it in an encrypted form to the secure UKE server. Sensitive participant data will be accessible only to the treating practitioner within individual digital patient folders (within the recruitment center) and authorized admins of Embloom (across the

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TABLE 3 Intervention modules[1] in Res@t app training for adolescents and their parents.

Session (week)	Adolescents	Parents
1 (1)	Training start The first session presents the purposes and contents of the training and introduces the recurring exercises of self-monitoring and practicing mindfulness. At last, participants are asked to set up training goals, as well as a reward plan together with their parents.	Training start The first session presents the purposes and contents of the training and introduces the recurring exercises of self-monitoring and practicing mindfulness. At last, parents are asked to set up training goals, as well as a reward plan together with their child.
2 (2)[2]	Psychoeducation I* Participants receive a normative comparison during a quiz on digital media usage patterns. They distinguish problematic from unproblematic behaviors in a swiping task and explore the (dis-) advantages of media use, using a four-field-table. Thus, motivation of change should be fostered.	Psychoeducation I* Parents also receive a normative comparison on digital media usage patterns and distinguish problematic from unproblematic behaviors. Then, they get introduced to the assessment of disordered media use and are guided to take their child's perspective on media use.
3 (3)	Psychoeducation II* The vicious circle of addicted media use is presented and the participants create their personal explanatory model. Furthermore, they learn about the concept of self-control and assign self-control strategies to brief descriptions of distressed adolescents.	Psychoeducation II* The vicious circle of addicted media use is presented to the parents and they learn about different influencing factors, before creating an individual explanatory model. Lastly, they also practice assigning self-control strategies.
4 (4)	Health and sleep hygiene Participants are quizzed about general health knowledge. They analyze their sleep quality, and receive psychoeducation on healthy sleep hygiene. Lastly, participants reflect on sleep hygiene strategies.	Communication Parents are introduced to the concepts of validation and I-messages and test their newly learned knowledge in playful exercises. Lastly, they are asked to practice in their day-to-day lives.
5 (5)	Self-care* Participants are presented with (dys-) functional beliefs about media use and practice cognitive restructuring using so-called "firewall questions." They explore their talents during a self-interview, and find alternative activities with the help of a decision tree.	Developmental tasks & parenting styles Parents get familiarized to the concepts of developmental tasks and are guided to distinguish the (dis-)advantages of different parenting styles. Lastly, they reflect on their personal situation.
6 (6)	Dealing with Emotions Participants are introduced to the ABC-model of Albert Ellis and practice building "emotional circuits" in an exercise. Furthermore, participants learn more about dealing with emotional distress using skills. Lastly, participants create their individual skills list.	Implementing rules Parents learn about the importance of rules and the differences of rules and requests. The implementation of rules is linked to the use of positive reinforcements, and parents reflect on their individual family rules.
7 (7):	Social relationships* Participants are asked to differentiate the (dis-)advantages of real-life-compared to virtual (para-social) relationships. They are guided to build their individual social network and learn more about techniques to improve their real-life-relationships in a video.	Applying rules Parents explore the (dis-)advantages of rules and reflect on possible changes in their parenting. Furthermore, they are asked to conduct a "family council meeting" with their family.
8 (8)	Communication Participants are introduced to the concepts of validation and I-messages, before assembling the TOP-5 rules against bullying.	Family health Parents learn about stress perception and the influence of parental stress on family health. Also, they reflect on the different roles they exert in their lives and collect ideas on how to deal with stress.
9 (9)	Relapse Prevention* Participants explore individual risk situations as well as warning signs of a possible relapse. Then, they are guided to create their personal list of self-control strategies.	Relapse Prevention* Parents are guided to establish daily routines and alternative activities with their child. Then, they explore risk situations and build plans in case of a relapse. Lastly, parents explore their children's talents to strengthen their positive mindset.
10 (15)	Booster Participants reflect on their progress and receive a recap-quiz on the contents of the training. Furthermore, they are re-introduced to the different exits of vicious circle of addicted media use. Lastly, participants evaluate their goal attainment.	Booster Parents reflect on their progress and receive a recap-quiz on the contents of the training. Furthermore, they are re-introduced to the different exits of vicious circle of addicted media use. Lastly, parents evaluate their goal attainment.

[1]Content is presented within four tasks per session (i.e., quizzes, psychoeducative videos, fill-in sections for personalized editing). After the first (introductory) session, each session follows the same structure. [2]Starting with session two, participants are presented with a weekly summary of their calendar entries, self-reflect on their progress during the training, and practice mindfulness with the help of a video instruction at the beginning of each session. *Content is targeted according to the focus on digital games/social media/streaming services.

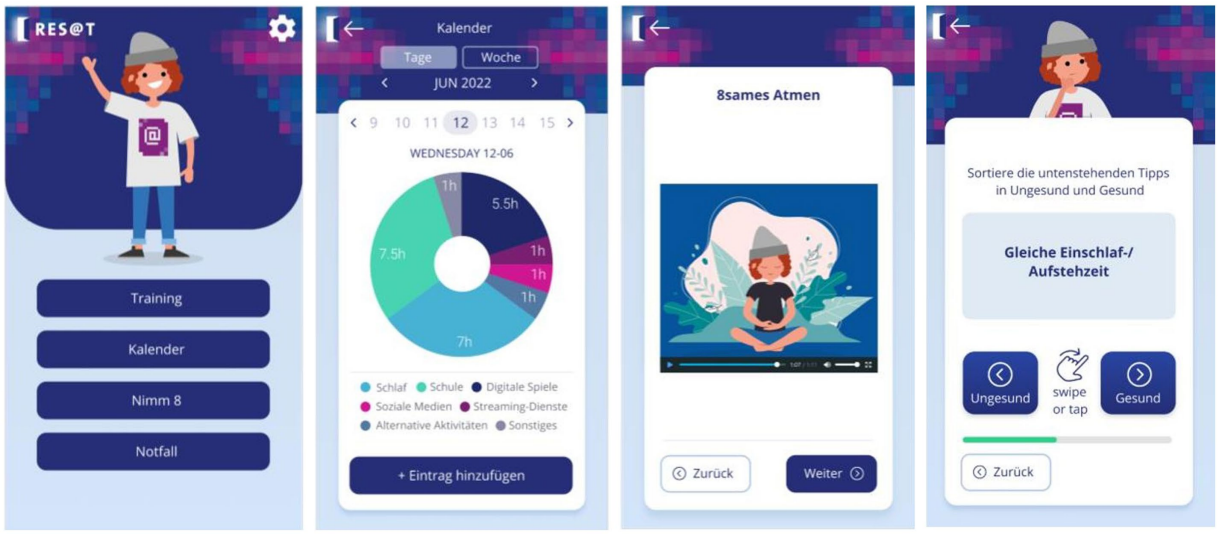

FIGURE 2
Res@t digital dashboard. The dashboard of the German Res@t application includes an overview of weekly sessions and their completion. It organizes access to the diary, individual sessions, mindfulness exercises, and an emergency button with skills for acute stress reduction and contact numbers of the treating child and adolescent psychiatrist and psychotherapist as well as local emergency departments (left frame). The middle-left frame represents the graphical feedback of diary entries on the duration of digital media use, sleep, and other activities. A mindfulness exercise is shown in the middle right frame. The right frame depicts an example of a swiping task within a quest.

recruitment centers). The latter will have the primary responsibility for verifying the integrity of the database and securing pseudonymized data transfer. A statistician at the UKE who is independent of the evaluation team will monitor trial conduct and data collection manually in addition to automatic monitoring of data completeness by the software. Moreover, pseudonymized data will be reprocessed to fit all structural requirements for the analyses. The principal study center at the DZSKJ will be responsible for managing and archiving the transferred database after analysis. All participant data will be always handled confidentially and in accordance with the General Data Protection Regulation (GDPR).

2.12 Data analysis

Data will be analyzed by the independent statisticians at the IMBE with sophisticated experience in multicenter therapy studies. Descriptive statistics will be presented with respect to both the entire sample and group-wise. The primary analysis is based on the intention-to-treat (ITT) approach with all randomized patients. The significance level will be set at 5% (two-sided). All three primary hypotheses are structured hierarchically. The second primary hypothesis will only be evaluated in a confirmatory way if the first primary hypothesis leads to a significant test result. The third primary hypothesis will only be evaluated in a confirmatory way if the second primary hypothesis leads to a significant test result. For the analysis of each primary hypothesis, a linear mixed model with implicit maximum likelihood correction of missing values under the missing-at-random assumption will be calculated, respectively. The change in DMUD symptoms from baseline to post-treatment will be used as an outcome variable, randomization group, type of DMUD (social media, gaming, streaming), recruitment site size and location as fixed effects, individual recruitment site and patient nested within site as random effects, and the baseline DMUD score as a covariate. The interaction between the randomization group and media usage pattern (hazardous vs. pathological) as well as effects of incomplete dyads will be tested within secondary analyses.

To examine the impact of missing values on the outcome of the primary analysis, sensitivity analyses will be performed using multiple imputation methods to replace missing values. The primary endpoint at follow-up and the secondary endpoints will be investigated exploratorily using analogous methods, which are adequate for the scale type. The following subgroup analyses are planned: severity of DMUD, sex, education, and socioeconomic status. Qualitative assessments of treatment provider satisfaction will be supplemented. Details of the analysis will be specified in a statistical analysis plan. The analysis will be performed with the latest version of the software package R (70).

2.13 Quality assurance and monitoring

All recruitment sites will be supervised by and stay in close contact with the principal study center at UKE during the complete course of the study.

At the beginning of the recruitment, a Data Safety Monitoring Board (DSMB) will be implemented with meetings during initiation, regular monitoring visits, and after study closeout. The DSMB will be comprised of experienced scientists not otherwise involved in the study. Members will be independent of the investigarors and the trial sponsor and will have no conflicts of interests. The DSMB will frequently oversee trial processes and data collection based on the requirements of Good Clinical Practice. These include monitoring of study and recruitment progress, considering adherence to the inclusion criteria, study procedure, recruitment rate, completeness of study documents, protocol deviations, loss-to-follow-up data, serious

adverse events (SAEs), adverse events (AEs), and/or newly emerged evidence of potential harmful effects of the intervention, and all potential study problems. Meetings will be held in closed and open manner. The latter includes the discussion of management issues with the coordinating investigator at the principal study center. Recommendations on study continuation, necessary design changes, or the end of the trial will be given by the DSMB without the involvement of the coordinating investigator.

2.14 Safety

Data safety is secured via confirmation with the Information Security Management System Standard (ISO/IEC 27001:2013y) in accordance with the Declaration of Applicability v 2.0 d.d. 22/10/2019. This certificate is valid within the scope of information security related to the development and management of e-health applications for healthcare providers and the purpose of measuring, monitoring, and treating psychological and physical symptoms. Data collection, transfer, and storage are described within a data protection concept, which has been approved by the data protection officer at the UKE.

Participant safety, especially the safety of minor-aged patients, is secured primarily by the clinicians during regular treatment. They will continuously monitor adverse events (AEs) and serious adverse events (SAEs) and report these as an (S)AE comment within the case report form of Embloom software. (S)AEs will be rated based on the NCI Common Terminology Criteria for Adverse Events (71). They will be carefully monitored, documented, and reported to the coordinating investigator and the Data Safety Monitoring Board (DSMB) members within 1 week of the initial observation. DSMB experts will comment on potential causal study relations to identify serious study-related events (SSREs), to determine benefit–risk of trial continuation and adequate participant support. SSREs might include suicidal ideation and behavior, self-harming behavior, worsening of general wellbeing, mental distress, or psychiatric comorbidities with an indication for hospitalization. SAEs and SSREs will be reported to the local ethics committees.

2.15 Clinical trial registry

The trial is registered on the German Clinical Trials Register (DRKS00031043, https://drks.de).

3 Discussion

Given the rising prevalence of DMUD, especially during the vulnerable period of adolescence, and a severe lack of evidence-based treatment options, especially for this age group and their parents, Res@t digital aims to close a significant gap. Res@t is the first model-based manualized training program to reduce DMUD symptoms that specifically includes adolescents and parents. It has been applied and pilot-tested in different settings and translated into a digitalized version. Within a large clinical consortium, the effectiveness of Res@t digital will be independently evaluated in a multicenter cluster RCT study in the clinical context. This setting was chosen to investigate a novel intervention for those in urgent need and secure safety of mostly minor patients. In the case of a positive evaluation, Res@t digital can be applied quickly and support potentially limited local medical care structures by providing evidence-based treatment content. The reliable screening for and treatment of DMUD can prevent aggravation and chronification of symptoms. Res@t digital might be used to bridge waiting time and support patients who initially avoid face-to-face interventions due to factors such as lack of motivation, logistic, time, or financial problems. Accordingly, a recent systematic review and meta-analysis could not find differences between the treatment effectiveness of face-to-face intervention and digital intervention in the context of anxiety disorders (72).

In addition, applying the Res@t app with its up-to-date treatment material within a blended therapy context might enrich and facilitate face-to-face interventions and allow multiple self-guided repetitions to consolidate content. Reviews suggest positive effects of such an approach across age groups including adolescent patients (73, 74) with evidence of beneficial effects of guided (versus unguided) digital interventions (75). Moreover, the beneficial effects of additional face-to-face interventions are assumed to vary according to the reachability of adolescents with DMUD. Therefore, within a subproject of the Res@t digital consortium, it will be investigated how much face-to-face contact is required to guide affected adolescents through the Res@t digital intervention. These adolescents will be supported by the youth welfare system but will not yet be involved in outpatient care.

The Res@t application ensures highest quality standards and has the potential to reduce health care costs. As with other e-health interventions, it might help reaching a broader patient group (76), not only for affected German adolescents but potentially worldwide. By involving primary healthcare providers in the evaluation process, this study is settled within direct healthcare research, mirroring immediate realities of life and high practical relevance.

Based on our current knowledge, Res@t digital has the potential of an effective, safe, and cost-efficient treatment option for a significant number of adolescent patients and their parents. In the future, new modules could be added or current modules could be altered and tested to fit the demands of different settings, such as schools, youth, and counseling services, or expand to additional age groups such as young adults or younger children.

4 Limitations

A cluster-randomized design was chosen to exclude contamination effects on TAU within IG and CG. However, by involving practitioners actively in the study and providing structured diagnostic tools for the assessment of DMUD, it cannot be ruled out that TAU is altered by an increased awareness of the clinicians. This effect might be stronger in recruitment sites that are allocated to CG as child, and adolescent psychiatrists and psychotherapists strive to address detected problems, where no immediate additional support is available. More attention to the CG compared with the IG would result in a potential reduction in the overall outcome effect. Measures taken against this will include proper instruction of recruiting practitioners. Moreover, the cluster-randomized design does not allow initial sample stratification, e.g., regarding the type of DMUD, sex, age, and single versus dyad study participation. However, the number of recruitment sites is aimed to be so high that these variables should be distributed randomly. Another potential drawback of cluster

randomization is that the waiting CG will get access to the intervention after their individual data collection but not after full data collection. Based on the feedback from recruiting clinicians, waiting times of several months up to a year in that case would not have been acceptable. Clinicians will be instructed to not to alter TAU based on their experiences with Res@t digital. However, contamination effects on TAU cannot be ruled out.

A potential risk for project realization could be that recruiting a significant number of parent–child dyads are more challenging than expected. Therefore, a large clinical consortium has been established. The heterogeneity of the consortium might induce additional variance (TAU, support of study). However, measures are being taken to control this effect. These include clear recruitment instructions, attractive remuneration for successful recruiting, including recruitment site size into the stratification process of randomization and recruitment site itself as a nested factor into the multilevel model analyses. Participant dropout has been estimated conservatively but is especially challenging since parent–child dyads are addressed. Hence, dropout could be higher than expected. Rates should be kept as low as possible by personal contacts and motivation via practitioner, reminders, app visualization of progress, fostering parent–child interaction during the intervention process, and family incentives in the case of full assessment completion. Moreover, separate analyses will be performed on incomplete dyads.

The evaluation of the primary outcome includes self-rating, parental rating, and expert rating in a hierarchical order. The use of different ratings for diagnosis and monitoring is highly common in clinical practice. On the one hand, it can be observed that affected adolescents might show a tendency to understate present symptoms due to feelings of shame and social desirability (77), lowered introspective abilities (78), self-regulatory and executive control functions (79), or denial and concealment typical for addictive disorders (80). On the other hand, parents' worries often lead to a focus on (potentially) negative consequences of problematic behavioral patterns of their children. This could result in a more critical symptom evaluation or even exaggeration (81–83). The clinician tries to integrate all available information and applies diagnostic criteria for evaluation. Consequently, diverging symptom estimates might occur which need to be considered when interpreting the evaluation results.

Moreover, since the aim is a large sample, no objective measures can be applied to evaluate intervention effectiveness for the complete sample, even though these would be highly appreciated. Hence, a second subproject within the Res@t consortium focusing on DMUD-associated sleep–wake alterations will apply neuropsychological and physiological measures including actigraphy in a subsample.

5 Conclusion

Res@t digital is the first model-based and app-based intervention that addresses the vulnerable group of adolescents with DMUD or hazardous use patterns and a respective parent in order to reduce symptoms and negative sequelae, prevent chronification, and foster the mastering of developmental tasks. After standardized diagnosis, treatment effectiveness will be evaluated by applying a multicenter cluster-randomized pre–post follow-up waitlist control group design with evaluator blinding within the primary clinical care setting. It will be tested if Res@t digital is feasible for and effective in outpatients who receive the intervention in addition to TAU compared with the control group with TAU only. By selecting a study setting within primary clinical care, optimal patient security can be assured, blended-therapy approaches are made possible, and important implementation factors can be accounted for to increase acceptance and accessibility from the very beginning. If effectiveness is shown, Res@t will be made available for long-term perpetuation, considering practicability and potential independence of local care structures and cost-effectiveness.

Ethics statement

The study was approved by the Ethics Committee of the Medical Board Hamburg. The study will be conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study will be provided by the participants and their legal guardians/next of kin.

Author contributions

KP and RT acquired the funding for the trial. KP contributed to the conceptualization, intervention content, study design and methodology, and prepared the original draft. AZ provided guidance on the study design and statistical issues. KB contributed to manuscript preparation including editing and visualization. SD and TK contributed to project implementation. SD, NA, AP-K, and OR served as scientific advisors. J-OC and A-LS contributed to the intervention content. RT contributed to the resources and supervision. All authors contributed to the article and approved the submitted version.

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Conflict of interest

AP-K received funding and HB consulting fees by mementor by ResMed.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Lonely and scrolling during the COVID-19 pandemic: understanding the problematic social media use and mental health link among university students

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Introduction: Undergraduate university students experienced many academic and non-academic stressors during the first year of the coronavirus (COVID-19) pandemic, putting them at a greater risk of negative mental health outcomes. Reports worldwide have shown high incidences of depressive, anxiety, and stress scores among university students at the beginning of the pandemic. Emerging evidence also suggests that to cope with the stress and loneliness of the pandemic, many youth and young adults increased the amount of time they spent on social media platforms.

Methods: Undergraduate students participated in an online study aimed to understand the link between time spent on social media, coping through the use of social media and problematic social media use (PSMU) with mental health symptoms, such as stress, depression, anxiety, and loneliness, during the COVID-19 pandemic.

Results: While time spent on social media was only weakly associated with stress, depression, anxiety and loneliness scores, PSMU more strongly mapped onto these outcomes. Additionally, students who were coping highly using social media displayed elevated stress, depression, anxiety and loneliness levels in comparison to those reporting low levels of coping with social media. Finally, students who reported high levels of coping using social media displayed higher PSMU scores, with this relationship appearing more pronounced in students who had higher levels of loneliness.

Conclusion: These data support evidence that it is not necessarily time spent on social media but rather PSMU that is relevant for mental health

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symptoms, and that PSMU is exacerbated by loneliness. Moreover, the current results highlight the effects of maladaptive coping on mental health symptoms and PSMU among university students during the COVID-19 pandemic.

KEYWORDS

coping, problematic social media use, COVID-19, university students, stress, loneliness

1 Introduction

University students face a variety of new challenges, which can include leaving their families and support systems, financial stressors, and adapting to a faster pace of learning and academic pressures (1, 2). This transition period marks a critical period of increased vulnerability to mental disorders, with data from university student populations suggesting that 1 in 3 students struggle with a mental health or substance use disorder (3). In 2022, 32.0% and 24.6% of Canadian post-secondary students reported having been either diagnosed with anxiety or depressive disorders, respectively (4). Further, more than half of those students screened positive for loneliness, with rates appearing similar across males and females (4). Positive associations between loneliness, stress, anxiety and depressive symptom scores are frequently reported in the general population (5–7). Specifically, loneliness is strongly related to depression and anxiety symptoms in young adults and mediates the relationship between social skills, including social sensitivity, expressivity and control, and both anxiety and depression disorders (8, 9). Although the association between loneliness and both depression and anxiety symptoms are strong, these associations may differentially relate to mental health symptoms. For example, loneliness mediated the relationship between social components and depressive symptoms, but not anxiety symptoms (10). Similarly, the relationship between loneliness and depression symptoms, but not anxiety, was significantly stronger in females (8). Nevertheless, the relationships between loneliness and mental health symptoms appear strong and bidirectional (11).

In an effort to deal with reduced social networks and loneliness owing to moving away from families and friends in this transitional period, many university students use social media as a coping method (12). However, social media is viewed as a maladaptive coping method to relieve negative emotions, such as rumination and worry (13–15). In fact, high emotional and social stress are predictive of social media use behavior in adolescents and young adults (16). Moreover, social media use can predict mental health symptoms, such as anxiety and depression, and using social media significantly increases stress (17). Smartphone use is also associated with higher depression and anxiety symptoms and lower quality of sleep (18).

Increasingly, scholars are recognizing a pattern of use associated with social media that resembles a substance use disorder (19). In this regard, problematic social media use is characterized by preoccupation, excessive use that affects mood states, and withdrawal symptoms (20). Delineating between screen time, frequency of use or PSMU is important in terms of the contributions to mental health (21). For example, associations between depression and anxiety and use of multiple social media platforms remain strong even after controlling for time spent on social media (22). Using multiple social media platforms is a possible indicator of intensity of use as it has been frequently associated with negative mental health outcomes (23, 24). In addition, time spent on social media only weakly correlates with mental health symptoms, whereas problematic use may represent a more detrimental pattern of social media use (25, 26). To further support this claim, recent meta-analyses suggest that PSMU has a moderate association with depression, anxiety, stress and loneliness symptoms, whereas time spent on social media only weakly relates to depression, loneliness and psychological well-being (21, 27, 28).

In a social media-driven era, it is important to understand the effects that these platforms have on mental health outcomes, particularly during stressful experiences and among populations at risk, such as young adults. The link between loneliness and social media use is evident (29, 30), whereby perceived loneliness predicted excessive social media use and anxiety, with excessive social media use further increasing anxiety levels (28). Further, loneliness is not only associated with both social media use and psychological distress but also mediated the relationship between passive social media use and distress (31). Emerging evidence also suggests that as a means to cope with the stress and loneliness of the COVID-19 pandemic, many youth and young adults increased the amount of time they spent on social media platforms (8, 32, 33). In addition, loneliness during the pandemic was associated with increasing mental health symptoms, where students reporting anxiety or depressive symptoms were six to eight times more likely to report loneliness (34, 35). Consequently, many youth and young adults increased the amount of time they spent on social media platforms as a means to cope with the stress and loneliness of the COVID-19 pandemic (28, 36, 37). Exposure to social media during previous epidemics, such as the Ebola outbreak, and terrorist attacks, such as the Boston Marathon bombings in 2013,

are strongly tied to increased anxiety and psychological distress (38, 39). More recent reports during the COVID-19 pandemic revealed associations between perceived stress and PSMU (40). Furthermore, data exploring mental health and loneliness during the pandemic among young adults show high levels of loneliness and stress, particularly among individuals aged 18-29 years old (8, 36), which was also associated with the use of social media as a method of coping (34, 36). Additionally, individuals who reported higher PSMU during the pandemic also reported higher psychological distress (41).

The current literature suggests a relationship between the experiences of the pandemic and increased mental health symptoms among university students and particularly young women (8, 42). Further, social media exposure during the pandemic among students has, in fact, coincided with higher anxiety and depressive scores (43). However, very few studies to this date explore the relation between coping strategies used by university students and mental health symptoms during the pandemic. Current evidence also suggests an impact of coping and stressors, including loneliness, on different substance disorders, such as alcohol use, gambling disorder and problematic video game use (44–46). Moreover, evidence in the literature reveals an impact of coping with social media and stress symptoms on PSMU (40). However, there remains a lack of evidence explaining the impact of coping with social media and loneliness on PSMU. Since recent reports have indicated that students have increased their time spent using social media (36), the current study focuses on exploring the relationships between using social media as a coping strategy during the pandemic and mental health symptoms. Due to the clear relationship between stress, loneliness, and social media use, it was of interest to explore whether high levels of these mental health symptoms during the pandemic would exacerbate the relationship between using social media as a coping method and PSMU. We predicted that students who report using social media as a coping method would report greater stress, mental health symptoms, and loneliness scores. In addition, we predicted that stress and loneliness symptoms would moderate the relationship between coping by using social media and PSMU.

2 Methods

2.1 Participants and procedure

Students enrolled at Carleton University, Ottawa, Ontario participated in an online study via Carleton University's Psychology study system (SONA). Inclusion criteria comprised any undergraduate student aged 18-29, who had not participated in any previous wave of this study. Participants completed informed consent online followed by a series of online questionnaires which included questions pertaining to PSMU, loneliness, stress, and mental health, as well as questions developed to assess the negative impacts of the COVID-19 pandemic across a number of domains (for more information see Prowse et al., 2021). This study took place from September 2020 to December 2020 during the COVID-19 pandemic. For context, this time period coincides with increased restrictions following a surge in COVID-19 cases in Canada and around the world. In Ontario, where the majority of participants resided (90.6%, n = 730), increased restrictions were implemented between October 2020 and November 2020, which included tighter restrictions on social gatherings between different households (47). Carleton University students were learning almost exclusively online. Students participating and completing this study received a 0.5% credit in their courses. This study was approved by the Carleton University Research Ethics Board (REB #111775).

2.2 Measures

2.2.1 Demographics

Participants completed basic demographic questions related to sex/gender identity, age, ethnicity, year of study, and living arrangements. They were also asked questions pertaining to their general mental and physical health.

2.2.2 Depressive, anxiety and stress symptoms

The Depression, Anxiety and Stress Scale, version 21 (DASS-21) (48) was used to measure states of depression, anxiety and stress using three sub-scales. The responses ranged from "low" (0) to "high" (3) to assess depressive, anxiety and stress symptoms. The stress subscale assesses chronic arousal symptoms, such as difficulty relaxing, nervous arousal, impatience, irritability, and agitation (α_{Stress} = .88). The depression subscale assesses depression symptoms, such as dysphoria, hopelessness, devaluation of life, self-deprecation, lack of interest/involvement, and anhedonia ($\alpha_{Depression}$ = .93). Finally, the anxiety subscale assesses anxiety symptoms, such as autonomic arousal, skeletal muscle effects, situational anxiety, and the subjective experience of anxious affect ($\alpha_{Anxiety}$ = .86).

2.2.3 Loneliness

The 20-item UCLA Loneliness Scale (UCLAL) (49) was used to measure loneliness. Answers were recorded on a range of "Never" (1) to "Always" (4). Higher scores correspond to a higher incidence of loneliness (α = .91).

2.2.4 Problematic social media use

The Bergen Facebook Addiction Scale (BFAS) (50) was used to assess PSMU. The 18-item scale was modified by replacing "Facebook" with "social media." The answers were recorded on a scale ranging from "Very rarely" (1) to "Very often" (5). The total scores for the 18-item scale were calculated and reported in the results section. However, based on the authors' recommendation, 6 items were used to calculate problematic use: items 1, 5, 7, 11, 13 and 16. These items reflect each of the 6 core elements of addiction: salience, mood, modification, tolerance, withdrawal, conflict, and relapse. Students who had a score of 3 or more on at least 4 out of 6

questions were considered to meet the criteria of PSMU (50). Higher scores indicated a higher incidence of PSMU (α = .79).

2.2.5 Social media use

To assess social media use patterns, participants were asked: "How many hours a day do you currently spend on social media altogether (Facebook, Instagram, Snapchat, Twitter, etc.)?" "What social media platform do you spend the most time using?" and "What is currently the main reason you use social media?" In addition, to understand how social media use patterns changed since the pandemic, participants were asked: "Has this [hours spent on social media] increased since the COVID-19 pandemic?" and "If yes, how many extra hours has this increased by?"

2.2.6 COVID-19 pandemic questionnaire

Questions assessing the impacts of the COVID-19 pandemic were used to examine how the pandemic had impacted different aspects of participants' daily lives across a number of domains. The answers to the questions include five options ranging from "not at all" (0) to "an extreme amount" (4). Furthermore, questions assessing coping with the COVID-19 pandemic were also included. This scale was used previously in a study assessing gender differences in student mental health and coping during a different wave of the pandemic (36). For the purpose of this study, only questions related to coping by using social media were included in the analyses. Responses were collapsed into three categories for analyses: "not at all/a little" (0), "a moderate amount" (1), and "very much/an extreme amount" (2). However, responses were collapsed into two categories for moderation analyses specifically: "not at all/a little/a moderate amount" (1) and "very much/an extreme amount" (2).

2.3 Statistical analysis

All statistical analyses were performed using SPSS for Mac OS 27.0 (SPSS Science, Chicago, IL, USA). For data cleaning, all items were checked for out-of-range scores. Moreover, all outliers (± 3.29) were brought into range. To assess relations between measures, correlational analyses were performed using Pearson correlation coefficients. Analyses examining whether differences in coping by social media use related to stress, depression, anxiety and loneliness scores were conducted using univariate Analysis of Variance (ANOVA). Significant main effects were followed up using Bonferroni *post-hoc* tests. While we recognize that gender identity occurs on a spectrum, due to a small number of participants that did not gender identify as male or female, (n = 13), they were not included in statistical analyses that specifically examined gender differences as a grouping factor, however, were included in all other analyses. Moderation analyses were conducted using model one in PROCESS (51) to examine the moderating role of loneliness and stress symptoms in the relation between coping by using social media and PSMU. Statistical significance was determined at p <.05 (two-tailed).

3 Results

3.1 Participant demographics

Table 1 describes the characteristics of participants in this study. Participants (N = 806) in the current study were undergraduate students aged 17-29 (M = 19.14, SD = 2.18). Of participants, 72.2% identified as female (n = 582), 26.2% as male (n = 211), 0.6% as non-binary (n = 5), 0.4% as gender-fluid (n = 3), 0.2% as transgender

TABLE 1 Demographic characteristics of university students in this study.

Characteristics	Mean	SD
Age, years	19.14	2.18
	Frequency (n)	Percentage (%)
Gender		
Female	582	72.2
Male	211	26.2
Non-binary	5	0.6
Gender-fluid	3	0.4
Transgender	2	0.3
Gender non-conforming	1	0.1
Other	2	0.2
Ethnicity		
White	494	61.3
Asian	59	7.3
Arab	58	7.2
Black	53	6.6
South Asian	47	5.8
South East Asian	22	2.7
Latin American	17	2.1
Indigenous	16	2.0
Other	40	5.0
Living Condition		
With parents	562	69.7
With roommates off-campus	106	13.2
Alone in residence	47	5.8
With roommates in residence	28	3.5
With spouse/significant other	24	3.0
Alone off-campus	23	2.9
With child alone	1	0.1
With child and significant other	1	0.1

(*n*= 2), 0.1% as gender-nonconforming (*n* =1), and 0.2% identified their gender as other (*n* = 2). Participants came from diverse ethnic backgrounds with 61.3% identifying as White (*n* = 494), 7.3% as Asian (*n* = 59), 7.2% as Arab (*n* = 58), 6.6% as Black (*n* = 53), 5.8% as South Asian (*n* = 47), 2.7% as South East Asian (*n* = 22), 2.1% as Latin American (*n* = 17), 2.0% as Indigenous (*n* = 16) and 5.0% of participants reported their ethnicity as other, which largely comprised mixed ethnicity (*n* = 40). The majority of participants in this study lived with their parents (69.7%, *n* = 562), whereas others reported living with roommates off-campus (13.2%, *n* = 106), alone in residence (5.8%, *n* = 47), with roommates in residence (3.5%, *n* = 28), with a spouse/significant other (3.0%, *n* = 24), alone off-campus (2.9%, *n* = 23), and with children either alone or with a spouse/significant other (0.1%, *n* = 1/each).

3.2 Social media use among university students

As shown in Table 2, participants reported varying levels of social media use per day, with the most common response being three or four hours a day, (range = 0 to more than 8 hours/day). Of participants who reported using social media, 77.5% reported that their use had increased since the beginning of the pandemic (*n* = 625), with the most common response being that their use increased by one to two hours/day. When asked about the social media platform students spent the most time using, the top reported social media application was Instagram followed by Snapchat, TikTok, Facebook, YouTube, and Twitter. Finally, when asked about listing the main reasons for using social media, the most common responses included keeping in touch with friends and family (37.5%, *n* = 302), fun/entertainment (26.0%, *n* = 210), and boredom/distraction (23.1%, *n* = 186).

The average problematic social media raw score in this sample was 14.72 ± 5.75. Males and females significantly differed, t (777) = -7.54, p <.001, with females (M = 15.60, SE = .23) scoring significantly higher than their male counterparts (M = 12.21, SE = .37). Of all participants, 37.75% of students (*n* = 299) had a score of 3 or higher on 4 out of the 6 questions (50).

3.3 Mean scores on depression, anxiety, stress and loneliness outcomes

Table 3 shows the mean stress, anxiety, depression and loneliness scores in this sample, with symptoms ranging from mild to moderate. Particularly, the mean loneliness score in the sample was considered moderate. It was of interest to further explore gender differences in the mean stress, anxiety, depression and loneliness scores as shown in Table 3. Upon examining stress, anxiety and depression scores, females had significantly higher stress (t (515.92) = -10.88, p <.001), anxiety, (t (546.11) = -9.04, p <.001), depression (t (445.16) = -6.90, p <.001) and loneliness (t (791) = -3.58, p <.001) scores in comparison to their male counterparts.

TABLE 2 Characteristics of social media use patterns among university students, including time spent on social media and most commonly used social media applications.

Social Media Use	Frequency (*n*)	Percentage (%)
Hours a day spent on social media altogether (Facebook, Instagram, Snapchat, Twitter, etc.)?		
No social media use	19	2.4
One	50	6.2
Two	130	16.1
Three	165	20.5
Four	151	18.7
Five	118	14.6
Six	84	10.4
Seven	31	3.8
Eight or more	58	7.2
If your time spent on social media per day increased since the pandemic, how many extra hours has this increased by?		
One to two hours	389	48.2
Two to three	130	16.1
Three to four	49	6.0
More than four hours	34	4.2
Which social media platform do you spend the most time using?		
Instagram	300	37.2
Snapchat	242	30.0
TikTok	241	29.9
Facebook	45	5.5
YouTube	43	5.3
Twitter	34	4.2
What is currently the main reason you use social media?		
Keep in touch with friends and family	302	37.5
Fun/Entertainment	210	26.0
Boredom/Distraction	186	23.1
Other	108	13.40

3.4 Relationship between time spent using social media, problematic social media use and mental health

Correlational analyses examining the relationship between stress, depression, loneliness, time spent on social media and PSMU scores are shown in Table 4. Importantly, it is apparent that PSMU related more strongly with mental health and loneliness scores than did simply assessing the time spent on social media. Specifically, PSMU

TABLE 3 Mean gender differences for stress, anxiety and depression symptoms and loneliness.

Variables	*Mean*	*SE*	Female		Male		*t-test*	*p*
			Mean	*SE*	*Mean*	*SE*		
Stress (DASS-Stress)	11.97	.36	13.74	.43	6.43	.51	-10.88	<.001
Anxiety (DASS-Anxiety)	8.01	.32	9.28	.38	3.99	.44	-9.04	<.001
Depression (DASS-Depression)	12.35	.41	13.63	.48	9.60	.66	-6.90	<.001
Loneliness (UCLAL)	45.75	.42	46.49	.48	43.09	.85	-3.58	<.001

TABLE 4 Pearson correlation coefficients between stress, depression, loneliness, and PSMU.

	1	2	3	4	5	6
1.Stress (DASS)	–					
2. Depression (DASS)	.77**	–				
3. Anxiety (DASS)	.80**	.70**	–			
4. Loneliness (UCLAL)	.47**	.61**	.43*	–		
5. Time spent using social media	.11*	.11**	.07**	.09**	–	
6. Problematic Social Media Use (BFAS)	.31**	.31**	.27**	.26**	.28**	–

**p <.001, *p <.01.

mainly had moderate associations, whereas time spent using social media had very weak correlations with outcome measures.

Hierarchical regressions were also conducted to explore time spent using social media and PSMU as unique predictors of mental health outcomes and loneliness symptoms, as shown in Table 5. The overall model was significant for stress, R^2_{change} = .08, F (2, 786) = 42.75, p <.001, anxiety, R^2_{change} = .07, F_{change}(2, 786) = 31.57, p <.001, depression, R^2_{change} = .08, F_{change} (2, 785) = 42.22, p <.001 and loneliness, R^2_{change} = .06, F_{change} (2, 787) = 28.91, p <.001. Specifically, time spent using social media independently predicted the mental health symptoms and

TABLE 5 Linear regression models of predictors of stress, anxiety, depression and loneliness symptoms.

	b	*SE B*	*β*	*95% CI*	*p-value*
Stress					
Step 1					
Constant	9.41	.85		[7.75, 11.07]	<.001
Time spent using social media	.63	.18	.12	[.27,.99]	<.001
Step 2					
Constant	6.88	.86		[5.18, 8.57]	<.001
Time spent using social media	.19	.18	.04	[-.16,.55]	.29
Problematic Social Media Use	1.57	.18	.30	[1.21, 1.93]	<.001
Anxiety					
Step 1					
Constant	6.61	.74		[5.15, 8.07]	<.001
Time spent using social media	.35	.16	.08	[.03,.66]	.03
Step 2					
Constant	4.61	.76		[3.11, 6.11]	<.001
Time spent using social media	.001	.16	.00	[-.32,.32]	.99

(Continued)

TABLE 5 Continued

	b	SE B	β	95% CI	p-value
Problematic Social Media Use	1.24	.16	.27	[.92, 1.56]	<.001
Depression					
Step 1					
Constant	9.43	.94		[7.58, 11.29]	<.001
Time spent using social media	.71	.20	.12	[.31, 1.11]	<.001
Step 2					
Constant	6.68	.96		[4.78, 8.57]	<.001
Time spent using social media	.24	.20	.04	[-.16,.64]	.24
Problematic Social Media Use	1.71	.20	.29	[1.30, 2.11]	<.001
Loneliness					
Step 1					
Constant	43.26	.98		[41.33, 45.18]	<.001
Time spent using social media	.59	.21	.09	[.17, 1.00]	.006
Step 2					
Constant	40.81	1.01		[38.83, 42.80]	<.001
Time spent using social media	.16	.21	.03	[-.26,.58]	.45
Problematic Social Media Use	1.52	.22	.25	[1.09, 1.95]	<.001

loneliness, as shown in step 1 in Table 5; however, once PSMU was added to the model in step 2, only PSMU significantly predicted stress, anxiety, depression and loneliness symptoms, while time spent using social media no longer significantly predicted outcome variables.

3.5 Coping with the COVID-19 pandemic

When participants were asked about using social media to deal with the stress of the pandemic, 59.7% reported using it "very much" or "an extreme amount" (n = 481), 24.4% reported "a moderate amount" (n = 197), and 15.9% reported "a little" or "not at all" (n = 128). These results differed significantly by gender, $\chi^2_{(2,\ N\ =\ 793)} = 38.85 = p < .001$. As expected, females were significantly more likely to report using social media as a coping method "very much" or "an extreme amount" (65.1%, n = 379), compared to males (45.5%, n = 96).

Univariate ANOVA analysis was used to examine whether the extent of coping via social media use related to stress, anxiety, depression, and loneliness symptoms. Self-reported stress, F (2,802) = 20.17, p <.001 $_{partial}\eta^2$ = .05, anxiety, F(2,802) = 10.78, p <.001, $_{partial}\eta^2$ = .03 and depression symptoms, F(2,801) = 19.66, p <.001, $_{partial}\eta^2$ = .05, differed significantly depending on the extent of coping. As shown in Figure 1, *post-hoc* analyses revealed that students who reported using social media to cope with the pandemic "very much" or "an extreme amount" had significantly higher stress, anxiety and depression scores compared to students who reported using social media "not at all" or "a little", all p's <.001. However, stress, anxiety and depressive symptoms in students who reported using social media to cope with the pandemic "a moderate amount" did not differ significantly from those who reported using social media "not at all" or "a little", p = .41, p = .60 and p = .76. respectively. As shown in Figure 2, loneliness scores also differed according to the extent of coping by social media use, F (2,803) = 7.14, p <.001, $_{partial}\eta^2$ = .02. Specifically, students who reported coping via social media "very much" or "an extreme amount" had significantly higher loneliness scores (M = 47.03, SE = .54) compared to those who reported coping via social media "not at all" or "a little" (M = 43.38, SE_s = 1.05), p = .006, or "a moderate amount" (M = 44.17, SE= .844), p = .01.

3.6 Coping via social media and problematic social media use

The level of coping via social media during the pandemic differed significantly on PSMU scores, t (788) = -14.07, p <.001. As expected, students reporting high levels of coping with social media (M = 3.50 SE = .08) had significantly higher problematic social media scores compared to students who reported low social media coping levels (M = 1.68, SE = .10). Given that very few studies examine the role of stress and loneliness symptoms in the relationship between coping with social media and PSMU, it was of interest to examine whether these symptoms would exacerbate this relation. When examining whether stress levels moderated the relation between coping via social media and PSMU, it was determined that stress did not differentially influence this relationship, R^2_{change} = .001, F (3, 786) = 1.39, p = .24. However, loneliness did moderate the relationship

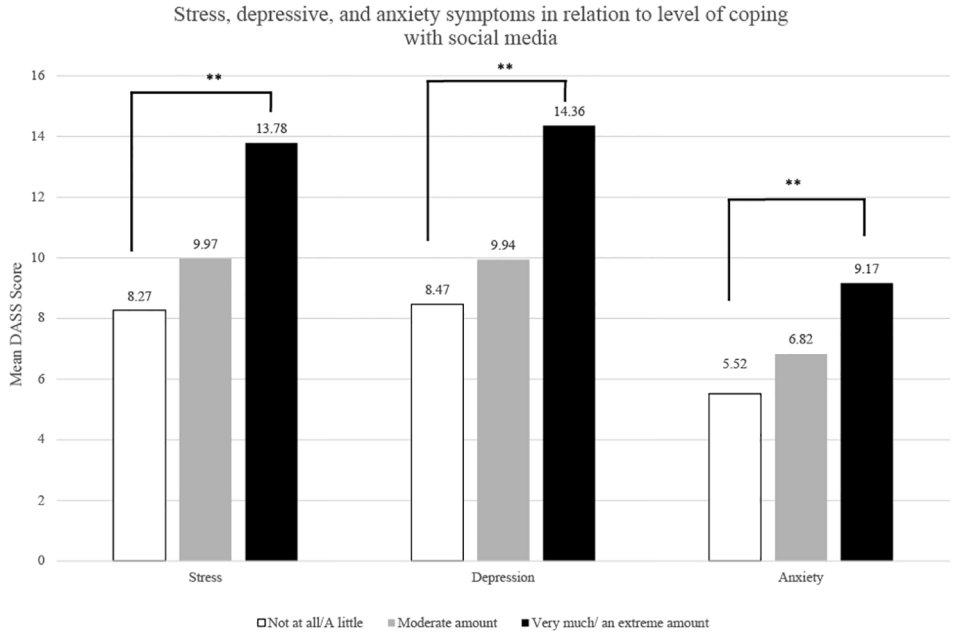

FIGURE 1
Mean stress, depression, and anxiety scores in relation to different levels of coping via social media use. **p <.001 relative to students who reported "not at all" or "a little" to coping via social media use.

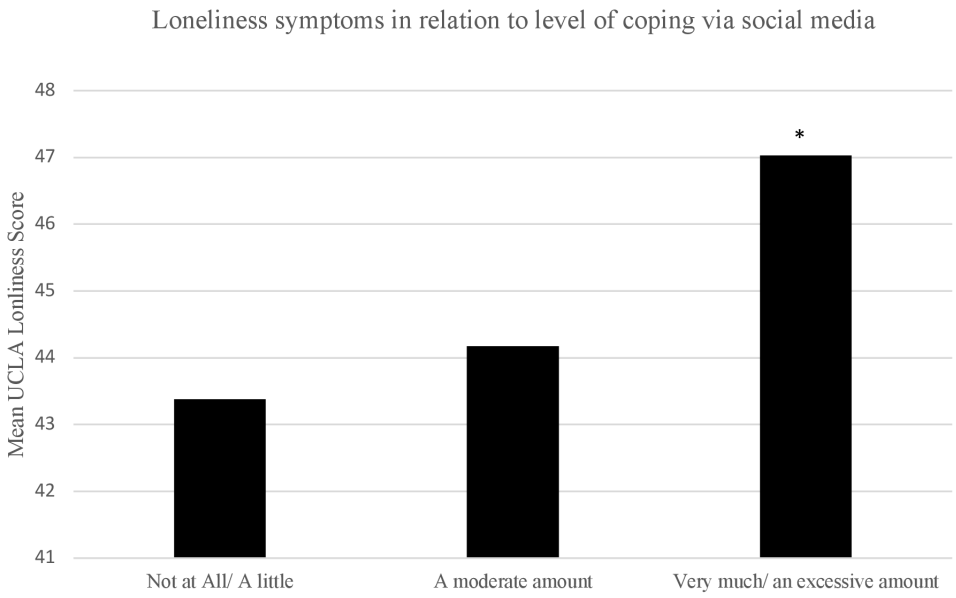

FIGURE 2
Mean loneliness scores in relation to different levels of coping via social media use. *p <.01 relative to students who reported "not at all" or "a little" to coping via social media use.

between coping via social media and PSMU. The overall model was significant, R^2 = .24, F (3, 786) = 84.96, p <.001, as was the interaction, R^2_{change} = .004, F (1, 786) = 4.28, p = .04. Specifically, and as shown in Figure 3, while the relationship between coping via social media and PSMU was significant at low levels of loneliness, B = 1.44, [95% CI (1.09, 1.79)], p <.001, this relationship was stronger at high levels of loneliness, B = 1.98, [95% CI (1.62, 2.35)], p <.001.

4 Discussion

The current study aimed to explore the relationship between using social media as a coping strategy during the COVID-19 pandemic, problematic social media use, and mental health. In our study, the majority of students indicated their use of social media had increased since the pandemic, with 48.2% indicating their use of social media

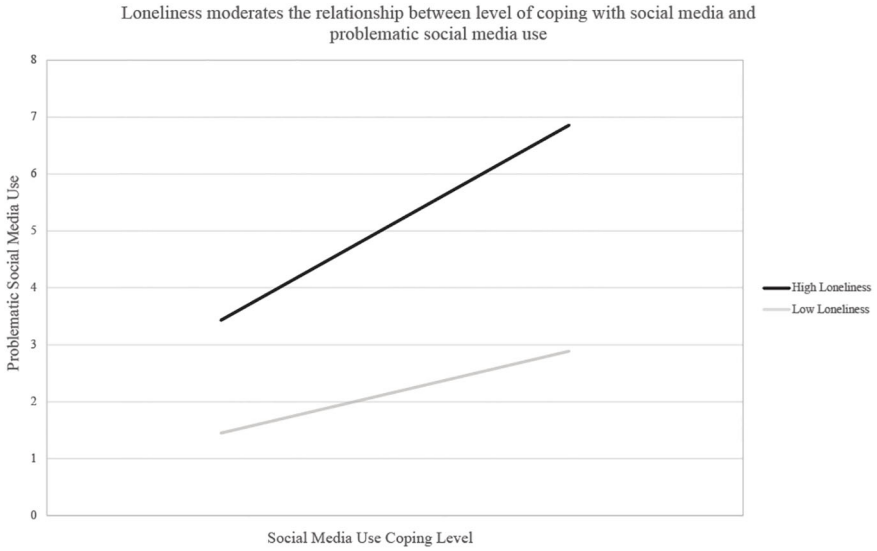

FIGURE 3
Loneliness as a moderator between coping via social media and PSMU.

had increased by one to two hours per day since the pandemic. In addition, 39% of students had reported using social media for three to four hours per day. The most common reasons reported for using social media were "entertainment/fun", "connecting with friends and family," and "boredom." In the current study, more than half of all students (59.7%) reported high rates of coping with social media, and this was more commonly reported among women. This is in line with other reports during the pandemic that show women were more likely to use social media to cope with social isolation during the pandemic in comparison to their male counterparts (36, 52). This could be explained by the fact that women are more sensitive to negative mental health outcomes due to unmet or poor social connections, despite having larger social support systems in comparison to men (53).

When we explored how and whether social media related to mental health symptoms among a population of university students, we found a moderate relation between PSMU and higher depressive and stress scores and a weak relation between PSMU and both anxiety and loneliness scores. In contrast, time spent on social media was very weakly correlated with all mental health symptoms. Further examination of the relationship between time spent using social media, PSMU and mental health symptoms revealed that time spent no longer significantly predicts these symptoms when assessed with PSMU. These results further support evidence in the literature that it is not time spent on social media but rather the pattern of use of social media that is associated more strongly to mental health symptoms (21). As PSMU describes a more clinically relevant behavior, based on the core elements of addiction, it encompasses not only time spent using social media but also other behaviors such as withdrawal and tolerance. Further, evidence from the literature around substance use disorders suggests that coping motivations associated with substance use relate more strongly to problematic use (54, 55). Increasingly, literature exploring social media use seems to suggest that coping motivations (i.e., using to cope with symptoms of ill mental health) may also relate to problematic use (40). Restrictions associated with the COVID-19 pandemic created an environment wherein many endorsed social media as a form of coping (37). The lack of social and peer connections among university students in particular was associated with increased mental health challenges (36, 56). In our study, students who reported using social media more to cope with the pandemic had significantly higher depressive, anxiety, stress and loneliness symptoms, although effect sizes were small, accounting for only 2-5% in the outcomes assessed. Notably, the severity of the mental health outcomes in students differed according to their coping levels. While students reporting low to moderate coping with social media showed normal levels of stress, anxiety, and depressive symptoms, students who reported high levels of coping showed mild to moderate symptom severity. These results support that excessive usage of social media to cope is a form of maladaptive coping as it relates to an increase in mental health symptoms.

Additionally, students who indicated that they used social media to cope with the stress of the pandemic also had significantly higher PSMU scores compared to students who reported low usage of social media to cope. Since the pandemic, there has been a global rise in PSMU rates, in tandem with an increase in stress, anxiety and depressive symptoms as a result of lockdown measures (57, 58). Evidence suggests the relationship between using social media and mental health outcomes may be bidirectional, where some individuals use social media to cope with negative mental health outcomes, such as stress or depressive symptoms, while others experience increasing negative mental health symptoms as a result of excessive social media use. Using social media as a coping method to relieve negative mental health outcomes may also worsen these symptoms, further increasing social media use (40). These behaviors mirror the positive and negative reinforcement processes described in the formation of substance use disorders (59). During the pandemic, individuals who were highly stressed and used social media for entertainment or social motives (i.e., positive reinforcement) or to cope with feelings of

isolation or perceived stress (i.e., negative reinforcement) showed significantly higher PSMU scores (40). These and our data support and extend previous research demonstrating that coping motives associated with substance use (e.g., alcohol), social media and gaming are associated with more problematic use (40, 60, 61).

One other possibility is that individuals may use social media as a means to cope with feelings of loneliness, which may in turn, relate to PSMU. Loneliness is consistently linked with poorer mental health and long-term implications on mental well-being (62). In fact, higher loneliness is significantly associated with higher depressive and anxiety symptoms, as well as video gaming disorder and sleep problems in children and adolescents (62). Evidence also suggests loneliness experienced by university students may mediate the relationship between social skills, including social sensitivity, expressivity, and control, and both anxiety and depressive disorders (9). Longitudinal studies have shown an increase in loneliness levels since the pandemic (62). In addition, experiences of social isolation coincided with an increase in feelings of loneliness and stress, which impacted and/or worsened the mental health of young adults (63, 64). Despite the majority of students in this sample reporting living with their parents/family, the average loneliness score remained moderate. This is indicative of the importance of social connectedness among university students. Social relationships often mitigate the effects of stressors on psychological, emotional and behavioral health (65). In fact, reduced social connectedness is predictive of perceived social isolation (66). As a result of the pandemic restrictions, first-year students, in particular, were deprived of forming social connections with their peers. Indeed, emerging reports suggest first-year students were at a higher risk for mental health symptoms (67).

When further exploring loneliness in the context of coping with social media, we found the relationship between coping via social media and PSMU was especially strong for those with high levels of loneliness. Associations between loneliness and social media use during the pandemic have been widely reported, with some studies even showing a dose-response relationship between the two variables (68). These data support findings from an earlier study showing that younger individuals between the ages of 18-34 also experienced higher levels of loneliness and were more likely to use social media to cope with reduced social contact during the pandemic (69). Thus, our data provide compelling evidence that loneliness and coping with the stress of the pandemic is associated with increased PSMU among university students. In addition, these findings support evidence that individuals experiencing higher levels of loneliness are more likely to use social media more persistently and problematically (70). Together, these and our data point to a role for loneliness as a potential moderating factor influencing social media use, which may explain some of the variability around the development of problematic social media use. Given the increasing reliance of social media among youth and young adults, research exploring what predicts and moderates the development of problematic use is of significant public health concern, particularly as the prevalence and incidence of mental health disorders rise globally (71).

There are some limitations that are important to consider when interpreting results from this study. This is a cross-sectional study obtained during the COVID-19 pandemic; therefore, little is known about how the trends observed in this study compare to individual mental health symptoms before the pandemic. Longitudinal data are needed in order to assess changes in mood and social media use over time, as well as to establish the directionality of the relationship between social media use and mental health symptoms. For example, longitudinal studies have found evidence of a bidirectional relationship between social media use and loneliness, anxiety and depression (72, 73). Furthermore, 72.2% of the participants in the current study identified as women, thus, data from male participants must be interpreted with caution given lower sampling availability. It is also important to note that although a moderating effect of loneliness was found, the effect size was quite small, thus caution should be used when interpreting the importance of this moderated relation. Lastly, this study did not examine specific behaviors associated with social media: different patterns of social media use have been found to have varying effects on mental health symptoms, in which passive use such as scrolling and looking at other people's content, is associated with higher anxiety and depressive symptoms (74). In contrast, active use such as chatting, sharing posts and interacting with others is associated with lower anxiety and depression symptoms, even after controlling for time spent on social media. Thus, it is important to understand how these patterns of use help disentangle the relationships between coping with social media, PSMU and mental health symptoms.

5 Conclusion

The current study provides further evidence into the existing relationship between maladaptive coping with social media and mental health symptoms among university students. Findings from this study also highlight the role of loneliness in exacerbating problematic social media use in individuals heavily coping with social media. Using these results, this study helps clarify some of the complex relationships among coping with social media, mental health symptoms and PSMU. The findings from this study can be used to raise awareness about the growing negative mental health outcomes associated with the high level of coping using social media. Future studies should further examine these relationships in longitudinal studies to help delineate the causal relationships among maladaptive coping, mental health symptoms and PSMU and investigate how different patterns of use of social media can serve as factors of risk or resilience to developing PSMU.

Data availability statement

The datasets presented in this article are not readily available because these data were not approved to be shared outside of the research team. Requests to access the datasets should be directed to Kim G.C. Hellemans, kimhellemans@cunet.carleton.ca.

Ethics statement

The studies involving humans were approved by Carleton University Research Ethics Board-B (CUREB-B). The studies were

conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

KH, LK, RM and LG contributed to the conception and design of the study. LG performed the statistical analyses. LG, LK, and HS wrote first draft of the manuscript. LG, HS, LK, KH and RM each wrote sections of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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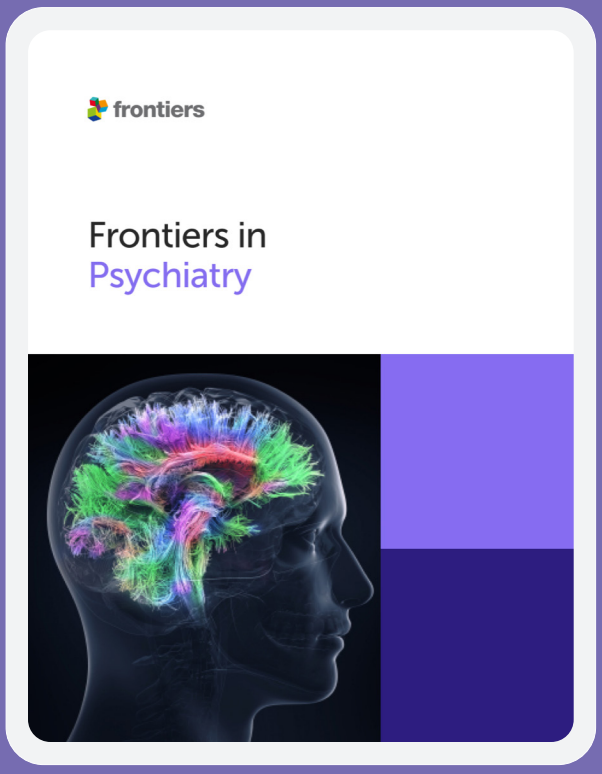

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