

Internet Addiction and Non-Suicidal Self-Injury in Adolescents with Major Depressive Disorder: The Sequential Mediating Roles of Insomnia and Depressive Symptoms

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Abstract

Background

Internet addiction (IA) frequently co-occurs with major depressive disorder (MDD) and was associated with non-suicidal self-injury (NSSI). However, the underlying psychological mechanisms linking IA to NSSI, particularly through the roles of depressive symptoms and insomnia, remain inadequately explored. This study aimed to investigate whether depressive symptoms and insomnia mediate this relationship.

Methods

This cross-sectional study included 166 adolescent MDD patients and 101 matched healthy controls. Participants completed measures assessing IA, depressive symptoms, insomnia severity, NSSI frequency, and NSSI functions (emotion regulation-ERG, attention seeking-ASG, social avoidance-SAE). Mediation analysis was employed to examine direct and indirect pathways between IA, depressive symptoms, insomnia, and NSSI outcomes.

Results

The prevalence of IA was significantly higher in the MDD group than in controls (47.6% vs. 17.8%, $P < 0.001$). MDD patients with IA demonstrated more severe depressive symptoms, insomnia, and NSSI (all $P < 0.05$). Linear regression showed that while IA initially predicted all NSSI outcomes, these associations became non-significant after controlling for depressive symptoms and insomnia. Mediation analysis revealed that IA had direct effects on NSSI functions (ERG: $\beta = 0.200$, $P = 0.005$; ASG: $\beta = 0.176$, $P = 0.025$; SAE: $\beta = 0.181$, $P = 0.027$) but not on NSSI frequency. Crucially, significant sequential mediation was observed, with IA influencing NSSI through insomnia and subsequently through depressive symptoms (DSHI: $\beta = 0.058$, $P = 0.005$; ERG: $\beta = 0.059$, $P = 0.014$; ASG: $\beta = 0.047$, $P = 0.032$; SAE: $\beta = 0.056$, $P = 0.018$).

Conclusion

The association between IA and NSSI in MDD adolescents is primarily explained by a sequential worsening of insomnia and then depressive symptoms, highlighting these as critical intervention targets to reduce self-injury risk.

Trial registration:

Introduction

Non-suicidal self-injury (NSSI), defined as deliberate self-inflicted bodily harm without suicidal intent, represents a significant public health concern[1]. Typical manifestations include cutting, burning, hitting, and scratching, often implemented using sharp objects or through direct physical impact[2]. Epidemiological studies indicate that NSSI affects approximately 4.6% to 32.8% of adolescents and 6.1% to 8.5% of adults in community samples[3–8]. Notably, the prevalence is substantially elevated among adolescents with major depressive disorder (MDD), with reported rates ranging from 48.2% to 76.1%[9–11]. Although NSSI may temporarily alleviate emotional distress or serve interpersonal functions, it often exacerbates psychological burden and social isolation over time[12, 13]. Critically, even in the absence of initial suicidal intent, NSSI is a robust predictor of subsequent suicidal ideation and behaviors. Individuals within the higher NSSI severity demonstrate significantly elevated risks for suicidal ideation and suicide attempts compared to those without NSSI[14, 15]. Therefore, understanding the functional underpinnings of NSSI is essential for elucidating its mechanisms. NSSI behaviors typically serves intrapersonal and interpersonal emotional regulatory purposes. A well-established three-factor model categorizes these functions into emotion regulation, attention seeking, and social avoidance[2, 16]. Previous studies reported that intrapersonal motives were most strongly endorsed for NSSI, such as terminating negative emotions, seeking stimulation, escaping distressing thoughts, or self-punishment[17–19]. Consistent with this, studies involving Chinese adolescents with depressive disorders have identified emotion regulation and social avoidance as mediators between anxiety and NSSI [20]. These findings underscore the importance of investigating both the risk factors and functional dimensions of NSSI, particularly in adolescent MDD populations.

Internet addiction (IA) has garnered increasing attention as another critical behavioral health condition. According to the 55th Statistical Report on China's Internet Development, as of December 2024, the country's internet user base has exceeded 1.1 billion individuals. Notably, adolescents aged 6–19 years account for 16.7% of all users, while urban residents comprise 71.8% of the total online population[21]. Extensive evidence indicates that excessive internet use is positively associated with IA and serves as a significant risk factor for the development of negative emotional states, including depression and anxiety[22, 23]. Cross-cultural epidemiological studies have consistently demonstrated a high comorbidity rate between MDD and IA across diverse populations and geographic regions. In Chinese clinical samples, approximately 50.2%-57.7% of adolescents with MDD meet diagnostic criteria for IA, a prevalence markedly higher than the 3.5% -16.5% observed in the general adolescent population[24–28]. Similar patterns also have been documented in Indian, Turkey and Nigerian contexts [29–31]. Notably, the relationship between IA and MDD is bidirectional: depressive symptoms may drive individuals to seek emotional escape through online immersion, while excessive internet use in turn exacerbates depression via mechanisms such as social displacement, sleep disruption, and exposure to harmful content[32, 33]. In addition, IA has also been associated with multiple psychosocial factors. Such as,

impaired peer relationships and experiences of bullying were identified as significant contributors[34, 35]. Furthermore, familial instability and academic difficulties may also play a role by diminishing self-esteem and promoting avoidance behaviors, thereby enhancing the appeal of digital environments [26, 36]. Collectively, these risk factors contribute to the progression toward more severe maladaptive behaviors in individuals with IA, particularly manifesting as elevated NSSI frequency[24, 37]. Recent studies found a moderate positive association between IA and NSSI[27, 38], and network analysis revealed that the key bridge symptoms included "interpersonal and health-related problems," and "social anxiety" [24]. Both behaviors represent dysfunctional coping strategies employed in response to adverse circumstances. Nevertheless, previous studies have not established a direct association between IA and NSSI after controlling for confounding factors such as depressive symptoms, implying the existence of underlying mediating mechanisms[39, 40].

Insomnia affects 46.0% to 78.6% of individuals with MDD and transcends a core symptom, potentially serving as a critical mediator in the progression toward severe psychopathology [41–44]. The bidirectional relationship between insomnia and depressive symptoms is well-established. Furthermore, extensive research confirms that excessive internet use, particularly at night, disrupts circadian rhythms via daytime dysfunction, psychological arousal, and delayed sleep timing [45, 46]. Notably, recent network analysis identified difficulty initiating sleep as a central node connecting IA with depressive symptoms [47]. Moreover, some studies reported that insomnia was positively associated with NSSI, suggesting its broader role in the psychopathology of self-harm behaviors[48, 49]. For instance, a two-year follow-up study observed that the frequency of NSSI increased correspondingly with the worsening of insomnia symptoms within the participant cohort[48]. While insomnia was known to partially mediate the IA-suicidality link, its involvement in the pathway from IA to NSSI (behavior and functions) requires further investigation[50, 51].

Therefore, the primary aim of this study is to explore the relationship between IA and NSSI in adolescents with MDD, and to test the hypothesis that depressive symptoms, insomnia, serve as significant mediators in this relationship.

Methods

Participants

This cross-sectional study was conducted between January and August 2021 in Anhui Province, China. Eligible participants were Han Chinese adolescents aged 12–18 years. The MDD group (n = 166) included individuals whose diagnosis was confirmed via a structured clinical interview per DSM-5 guidelines, and who were excluded for comorbid psychiatric/neurological conditions or intellectual disability. Healthy controls (n = 101), group-matched for age and sex, were recruited from local schools and had no history of psychiatric or neurological disorders. All participants possessed adequate comprehension of the study instruments. The collective sample (N = 267) had a mean age of 15.19 ± 1.74 years, with 151 females (56.5%).

Sociodemographic Information

Demographic and clinical characteristics were collected for all participants, including sex, age, and educational level (coded 1 to 6, corresponding to grades 7 through 12). Academic performance and peer relationships was evaluated on a 5-point Likert scale and dichotomized into 'good' or 'poor'; Parental marital status was defined as stable (harmonious) or unstable (divorce, separation, etc.). Additional data encompassed living area (urban or rural), school bullying (yes or no), age of onset, illness duration (months), and antidepressant dosage (expressed as fluoxetine equivalents)[52].

Measurement tools

The Internet Addiction Test (IAT)

The IAT is a 20-item self-report instrument rated on a 5-point Likert scale (1 = almost never to 5 = always), yielding total scores from 20 to 100, where higher scores reflect greater severity of internet addiction. Following established criteria, a total score of 50 or higher was used to define internet addiction in this study[27, 51]. The Chinese version of the IAT has demonstrated satisfactory psychometric properties, and in the current sample, it showed excellent internal consistency with a Cronbach's α of 0.942.

The Insomnia Severity Index (ISI)

ISI is a widely used self-report measure for assessing alexithymia. The scale consists of 7 items, rated on a 5-point Likert scale, ranging from 0 (no problem) to 4 (extremely severe problem). Higher scores on the ISI indicate greater levels of insomnia. Previous studies have demonstrated that the questionnaire exhibits good reliability in Chinese populations (Cronbach's α = 0.931)[47]. The Cronbach's α for this study was 0.876.

The Deliberate Self-Harm Inventory (DSHI)

DSHI, a 17-item self-report instrument, was employed to assess the frequency of NSSI[53]. It quantifies 16 specific behaviors (e.g., cutting, burning) and one open-ended item for other acts, each rated on a 4-point Likert scale from 0 (never) to 4 (very often). A higher total score indicates greater NSSI frequency. The Chinese version of the DSHI has established psychometric validity, with a previously reported Cronbach's α of 0.908[54]; in the present study, its internal consistency was excellent, with a Cronbach's α of 0.911.

The 20-item Center for Epidemiologic Studies Depression scale (CESD-20)

CESD was utilized to evaluate depressive symptomatology over the preceding week[55]. Responses are recorded on a 4-point scale (0 = rarely to 3 = most of the time), yielding total scores from 0 to 60 where higher values signify greater severity. The Chinese version of the scale has demonstrated good reliability (Cronbach's $\alpha = 0.724$)[56], a finding supported by the higher internal consistency observed in this study ($\alpha = 0.848$).

The Functional Assessment of Self-Mutilation-Chinese version (C-FASM)

C-FASM comprises 33 items, with 11 addressing forms of self-harm and 22 evaluating its functional dimensions[57]. While the DSHI offers broader behavioral coverage, the C-FASM specifically examines psychological functions, which are categorized into three domains: Emotion Regulation (ERG; items 2,4,10,14,22) referring to the modulation of affective states; Attention Seeking (ASG; items 3,7,8,15,17,20) aimed at obtaining social attention; and Social Avoidance (SAE; items 1,5,9,13) used to evade interpersonal demands[2]. The Chinese version has established reliability (Cronbach's $\alpha = 0.84$) [57], a result consistent with the high internal consistency observed in the present sample ($\alpha = 0.970$).

Statistical analysis

Descriptive statistics are presented as mean $\pm$ standard deviation for continuous variables and as frequency (%) for categorical variables. Group comparisons were performed using independent samples t-tests, Mann-Whitney U tests, or chi-square tests, as appropriate, based on data distribution. Variables showing significant intergroup differences were subsequently included as independent variables in separate linear regression models, with the DSHI total score and the ERG, ASG, and SAE subscales of the C-FASM serving as dependent variables to identify independent risk factors for NSSI. Furthermore, mediation analyses were performed using the lavaan package with maximum likelihood (ML) estimation to examine whether depressive symptoms and insomnia mediated the association between IA and NSSI. To ensure the robustness of indirect effects, bootstrap resampling with 5,000 iterations was applied [51]. All analyses were conducted in RStudio (version 4.5.2), and statistical significance was defined as a two-sided P-value < 0.05 . The hypothesized mediation model is illustrated in Fig. 1.

Results

Demographic and Clinical Characteristics of Participants

The prevalence of IA was significantly higher in MDD patients (47.6%) than in healthy controls (17.8%, $P < 0.001$). Additionally, the MDD group demonstrated a significantly higher proportion of poor peer relationships (83.1% vs. 27.7%) and school bullying (47.0% vs. 7.9%) (all $P < 0.05$). MDD patients also reported more severe insomnia, increased frequency of self-injury behaviors, and stronger self-injury functions (ERG, ASG, and SAE) (all $P < 0.001$). In contrast, no significant differences were observed in

gender, age, educational level, academic performance, or parental marital status between the two groups (all $P > 0.05$, Table 1). Furthermore, among MDD patients, those with IA exhibited more severe depressive and insomnia symptoms, poorer peer relationships, stronger self-injury functions, and more frequent NSSI behaviors compared to those without IA (all $P < 0.05$), while no significant differences were found in other variables (Table 2).

Table 1
Social-demographic and clinical characteristics of Participants.

Variables	Total (n = 267)	Health (n = 101)	MDD (n = 166)	$\chi^2/T/Z$	P
Female	151(56.6)	51(50.5)	100(60.2)	2.427	0.119
Age(years)	15.19 ± 1.77	15.10 ± 1.78	15.25 ± 1.76	-0.663	0.508
Education	3.85 ± 1.78	4.02 ± 1.63	3.74 ± 1.86	-1.533†	0.125
Academic performance				1.857	0.173
Good	118(44.2)	50(49.5)	68(41.0)		
Poor	149(55.8)	51(50.5)	98(59.0)		
Peer relationships				81.975	< 0.001*
Good	101(37.8)	73(72.3)	28(16.9)		
Poor	166(62.2)	28(27.7)	138(83.1)		
Marital status				3.281	0.070
Stable	212(79.4)	86(85.1)	126(75.9)		
Unstable	55(20.6)	15(14.9)	40(24.1)		
School bullying	86(32.2)	8(7.9)	78(47.0)	43.892	< 0.001*
Living in rural area	109(40.8)	43(42.6)	66(39.8)	0.206	0.650
CESD	45.79 ± 17.40	29.12 ± 8.17	55.94 ± 13.19	-18.401	< 0.001*
ISI	9.72 ± 6.48	4.90 ± 3.36	12.64 ± 6.17	-9.782	< 0.001*
FASM					
ERG	5.12 ± 5.33	1.31 ± 3.24	7.43 ± 5.02	-9.317†	< 0.001*
ASG	4.33 ± 5.39	1.52 ± 3.8	6.04 ± 5.5	-7.771†	< 0.001*
SAE	3.82 ± 4.35	1.02 ± 2.65	5.52 ± 4.31	-8.483†	< 0.001*
DSHI	7.96 ± 10.7	1.31 ± 4.3	12.01 ± 11.4	-9.716†	< 0.001*

Values are presented as mean ± standard deviation or number (%); *P < 0.05; †Mann-Whitney U-test; IA, Internet Addiction; CESD, Center for Epidemiologic Studies Depression Scale; ISI, Insomnia Severity Index; FASM, Functional Assessment of Self-Mutilation; ERG, emotion regulation; ASG, attention seeking; SAE, social avoidance; DSHI, Deliberate Self-Harm Behavior Inventory.

Variables	Total (n = 267)	Health (n = 101)	MDD (n = 166)	$\chi^2/T/Z$	P
IAT	116(43.4)	45.83 ± 14.26	50.99 ± 17.88	-6.999 [†]	< 0.001 [*]
IA	97(36.3)	18(17.8)	79(47.6)	24.057	< 0.001 [*]
Values are presented as mean ± standard deviation or number (%); *P < 0.05; †Mann-Whitney U-test; IA, Internet Addiction; CESD, Center for Epidemiologic Studies Depression Scale; ISI, Insomnia Severity Index; FASM, Functional Assessment of Self-Mutilation; ERG, emotion regulation; ASG, attention seeking; SAE, social avoidance; DSHI, Deliberate Self-Harm Behavior Inventory.					

Table 2
Comparison of Characteristics between MDD Patients with and without IA.

Variables	Total (n = 166)	IA (n = 79)	Non-IA (n = 87)	$\chi^2/T/Z$	P
Female	151(56.6)	51(50.5)	100(60.2)	2.427	0.119
Age(years)	15.19 ± 1.77	15.27 ± 1.63	15.23 ± 1.88	-1.131	0.896
Education	3.85 ± 1.78	3.65 ± 1.82	3.83 ± 1.91	-0.620 [†]	0.536
Academic performance				5.412	0.020*
Good	68(41.0)	25(31.6)	43(49.4)		
Poor	98(59.0)	54(68.4)	44(50.6)		
Peer relationships				0.303	0.582
Good	28(62.2)	12(15.2)	16(18.4)		
Poor	138(62.2)	67(84.8)	71(81.6)		
Marital status				0.726	0.123
Stable	126(75.9)	59(74.7)	67(77.0)		
Unstable	40(24.1)	20(25.3)	20(23.0)		
Living in rural area	66(39.8)	36(45.6)	30(34.5)	2.125	0.145
School bullying	78(47.0)	37(46.8)	41(47.1)	0.001	0.970*
Age at onset	13.55 ± 2.11	13.78 ± 2.09	13.34 ± 2.13	-1.088	0.277
Duration of illness	21.30 ± 19.33	20.53 ± 18.68	21.99 ± 19.97	-0.007 [†]	0.995
CESD	45.79 ± 17.40	58.22 ± 12.16	53.87 ± 13.79	-2.142	0.034*
Antidepressants	16.91 ± 19.15	16.02 ± 18.65	17.70 ± 19.67	0.568 [†]	0.570
ISI	12.64 ± 6.17	14.10 ± 6.28	11.32 ± 5.78	-2.966	0.003*
FASM					
ERG	5.12 ± 5.33	8.46 ± 4.63	6.51 ± 5.20	-9.317 [†]	0.018*

Values are presented as mean ± standard deviation or number (%); *P < 0.05; †Mann-Whitney U-test; IA, Internet Addiction; CESD, Center for Epidemiologic Studies Depression Scale; ISI, Insomnia Severity Index; FASM, Functional Assessment of Self-Mutilation; ERG, emotion regulation; ASG, attention seeking; SAE, social avoidance; DSHI, Deliberate Self-Harm Behavior Inventory.

Variables	Total (n = 166)	IA (n = 79)	Non-IA (n = 87)	$\chi^2/T/Z$	P
ASG	4.33 ± 5.39	7.15 ± 5.42	5.03 ± 5.41	-7.771 [†]	0.010 [*]
SAE	3.82 ± 4.35	6.53 ± 4.13	4.60 ± 4.29	-8.483 [†]	0.004 [*]
DSHI	7.96 ± 10.7	14.23 ± 12.34	9.99 ± 10.13	-2.421 [†]	0.015 [*]
Values are presented as mean ± standard deviation or number (%); *P < 0.05; †Mann-Whitney U-test; IA, Internet Addiction; CESD, Center for Epidemiologic Studies Depression Scale; ISI, Insomnia Severity Index; FASM, Functional Assessment of Self-Mutilation; ERG, emotion regulation; ASG, attention seeking; SAE, social avoidance; DSHI, Deliberate Self-Harm Behavior Inventory.					

Linear Regression

In Model 1, which adjusted for academic performance, IA emerged as a significant independent predictor for all four NSSI outcomes ($P < 0.05$). When depressive symptoms and insomnia severity were added in Model 2, the association between IA and all NSSI measures was attenuated and became non-significant ($P > 0.05$). In this fully adjusted model, depressive symptoms sustained a significant positive association with the DSHI total score and all three functional subscales (All $P < 0.001$). Insomnia severity was independently associated with the DSHI total score ($\beta = 0.181$, $P = 0.048$). These results suggest that the influence of IA on NSSI may be largely explained by the comorbid severity of depressive symptoms and insomnia (Table 3).

Table 3
Linear Regression Analysis of IA and NSSI in MDD patients.

Variables	Model1	Model2		
	OR (95%CI)	P	OR (95%CI)	P
ERG				
IA	0.214(0.606, 3.678)	0.007*	0.121(-0.197, 2.617)	0.091
CESD			0.338(-0.006, 0.282)	< 0.001*
ISI			0.170(0.049, 0.273)	0.061
ASG				
IA	0.198(0.477, 3.865)	0.012*	0.126(-0.252, 3.018)	0.097
CESD			0.371(0.066, 0.164)	< 0.001*
ISI			0.125(-0.056, 0.279)	0.189
SAE				
IA	0.224 (0.610, 3.249)	0.004*	0.136(-0.054, 2.398)	0.061
CESD			0.318(0.046, 0.162)	< 0.001*
ISI			0.161(-0.013, 0.239)	0.078
DSHI				
IA	0.184(0.668,7.699)	0.020*	0.091(-1.173, 5.306)	0.210
CESD			0.321(0.124, 0.430)	< 0.001*
ISI			0.181(0.002, 0.667)	0.048*
OR, odds ratio; CI, confidence interval; *P < 0.05; IA, Internet Addiction; CESD, Center for Epidemiologic Studies Depression Scale; ERG, emotion regulation; ASG, attention seeking; SAE, social avoidance; DSHI, Deliberate Self-Harm Behavior Inventory. Model 1 included IA and Academic Performance as predictors; Model 2 added CESD, ISI to Model 1.				

Mediation Analysis

The model pathways are detailed in Table 4. IAT demonstrated significant direct effects on the ERG ($\beta = 0.200$, $P = 0.005$), ASG ($\beta = 0.176$, $P = 0.025$), and SAE ($\beta = 0.181$, $P = 0.027$) functions of NSSI. However, its direct effect on the overall DSHI score was not statistically significant ($\beta = 0.099$, $P = 0.170$). Crucially, significant indirect pathways were identified. Specifically, insomnia mediated the relationship between IAT and the DSHI score ($\beta = 0.054$, $P = 0.048$). Furthermore, a significant sequential mediation pathway was observed, wherein IAT influenced NSSI outcomes through ISI and subsequently through depressive

symptoms. This pathway was significant for the DSHI total score ($\beta = 0.058$, $P = 0.005$) as well as for the ERG ($\beta = 0.059$, $P = 0.014$), ASG ($\beta = 0.047$, $P = 0.032$), and SAE ($\beta = 0.056$, $P = 0.018$) subscales. The ratios of indirect to total effects for the functional subscales ranged from 0.211 to 0.236, underscoring the substantial role of mediation. The overall model is illustrated in Fig. 1.

Table 4
Mediation pathways of IAT, depressive symptoms, insomnia and NSSI.

Depended variables	Model pathways	Standardized coefficient (95%CI)	P
DSHI			
Direct effects	IAT → DSHI	0.099(-0.042, 0.239)	0.170
Indirect effects	IAT → CESD → DSHI	0.021(-0.015, 0.258)	0.257
	IAT → ISI → DSHI	0.054(0.000, 0.108)	0.048*
	IAT → ISI → CESD → DSHI	0.058(0.017, 0.099)	0.005*
Indirect effect/total effect		1	
ERG			
Direct effects	IAT → ERG	0.200(0.060, 0.340)	0.005*
Indirect effects	IAT → CESD → ERG	0.022(-0.016, 0.060)	0.258
	IAT → ISI → ERG	0.046(-0.015, 0.107)	0.139
	IAT → ISI → CESD → ERG	0.059(0.012, 0.107)	0.014*
Indirect effect/total effect		0.228	
ASG			
Direct effects	IAT → ASC	0.176(0.022, 0.329)	0.025*
Indirect effects	IAT → CESD → ASG	0.017 (-0.012, 0.046)	0.240
	IAT → ISI → ASG	0.035(-0.024, 0.093)	0.243
	IAT → ISI → CESD → ASG	0.047(0.004, 0.009)	0.032*
Indirect effect/total effect		0.211	
SAE			
Direct effects	IAT → SAE	0.181(0.021, 0.342)	0.027*
Indirect effects	IAT → CESD → SAE	0.021(-0.016, 0.057)	0.270
	IAT → ISI → SAE	0.046(-0.011, 0.103)	0.115
*P < 0.05; IAT, Internet Addiction Test Scale; CESD, Center for Epidemiologic Studies Depression Scale; ERG, emotion regulation; ASG, attention seeking; SAE, social avoidance; DSHI, Deliberate Self-Harm Behavior Inventory.			

Depended variables	Model pathways	Standardized coefficient (95%CI)	P
	IAT → ISI→CESD→SAE	0.056(0.010, 0.102)	0.018*
Indirect effect/total effect		0.236	
*P < 0.05; IAT, Internet Addiction Test Scale; CESD, Center for Epidemiologic Studies Depression Scale; ERG, emotion regulation; ASG, attention seeking; SAE, social avoidance; DSHI, Deliberate Self-Harm Behavior Inventory.			

Discussion

This study provides robust empirical evidence illuminating the complex relationships between IA, depressive symptoms, insomnia, and NSSI in a clinical sample of adolescents with MDD. Our findings consistently demonstrate that IA is not merely a comorbid condition but plays a significant and multifaceted role in exacerbating the risk and functional profile of NSSI, primarily through its aggravating effects on core depressive and sleep-related symptoms.

First, consistent with prior reports, our study showed that 47.6% of MDD patients suffered from IA, which was significantly higher than that of the healthy control [28]. For example, findings from an epidemiological study in Korea indicate a strong link between experiencing a depressive episode (whether current or past) and a heightened susceptibility to IA[58]. Another separate three-year cohort study found that individuals with psychiatric disorders had an approximately 2.33-fold increased risk of developing IA[59]. An underlying motivation to escape from distressing real-life circumstances and lack social skills and family support may explain this observed phenomenon[60]. Meanwhile, neurophysiological impairments in sleep continuity and rapid eye movement sleep may underlie the high rate of sleep disturbances comorbid with depression. The wide spectrum of these disturbances, including insomnia, sleep complaints, fatigue, and daytime sleepiness, is consistently reported and matches our observations [41, 52, 61]. Analogously, due to emotion dysregulation, individuals with depression often resort to deliberate self-harm as a means of managing intense affective states[2, 62, 63]. Studies have shown that the risk of engaging in self-injurious behaviors was significantly higher among depressed patients and correlated with loneliness, rumination, and psychological resilience[10, 64]. Mirroring this, our study found that patients with MDD had more severe NSSI functions and a greater tendency to engage in NSSI behaviors. In parallel, our study found that among adolescents with MDD, those with comorbid IA exhibited further exacerbated NSSI frequency, functional severity, depressive symptoms, and insomnia symptoms relative to their non-IA counterparts. This pattern suggests that IA may play a contributory role in aggravating these adverse clinical outcomes. Supporting this notion, meta-analysis found that youth with digital addiction were more likely to have higher odds of symptoms of depression (OR: 1.76) and sleep problems, such as insomnia (OR: 1.46), and poor sleep quality (OR: 1.50) [65]. A longitudinal study also reported that problematic social media use significantly predicted subsequent depressive and insomnia symptoms[66]. Additionally, recent large-scale study demonstrated

that adolescents with higher level of IA was associated with increased risks of NSSI behaviors [38, 67, 68]. Notable, the absence of prior research on self-injury functions and IA contrasts with our key finding: MDD patients with IA have significantly stronger self-injury functions. This provides novel evidence supporting IA's role in promoting NSSI behaviors through these core motivations.

Furthermore, we found that adolescents with MDD were more likely to report poorer peer relationships and experiences of being bullied at school. This result aligns with a robust body of literature indicating that social rejection, peer victimization, and a lack of supportive social networks are not merely correlates but potent risk factors and maintaining elements of depressive psychopathology in youth [69, 70]. Poor peer relationships can severely limit opportunities for positive social reinforcement and emotional co-regulation, while bullying constitutes a chronic, intense psychosocial stressor [71]. Although previous studies have reported higher rates of depression among older adults or adolescents in rural areas compared to their urban counterparts, this characteristic was not observed in our present study [72, 73]. This discrepancy likely stems from the inherent characteristics of our clinical sample. Participants were recruited from psychiatric outpatient or inpatient settings. Significant inequalities in mental health service accessibility and utilization between urban and rural areas may have resulted in fewer depressed adolescents from rural communities entering the clinical research pipeline [74, 75]. However, the present study did not identify a significant association between IA and the variables of peer relationship quality, experience of school bullying, or place of residence. While prior research suggests that adverse peer experiences may drive online social compensation, whereas gaining peer trust encourages offline engagement and reduces reliance on the internet, recent studies had further nuanced this perspective [34, 35, 76]. Individuals, whether socially rejected or popular, are at risk for problematic social media use, albeit through divergent motives: the former primarily to avoid negative affect and compensate for deficits, and the latter to maintain positive affect and seek social rewards. Paradoxically, both motivational patterns are positively associated with IA [77]. In addition, our study also confirmed that poorer academic performance was associated with a significantly higher rate of IA among adolescents with depression. This link is exemplified in broader educational contexts; for instance, research among university students demonstrates a significant positive correlation between academic burnout and IA—a dynamic that can precipitate a cascade of negative outcomes, including class absenteeism and even dropout [36, 78, 79]. This highlights the necessity for early intervention targeting adolescents with IA.

More important, this study found that after adjusting for depressive and insomnia symptoms in linear regression models, the associations of IA with NSSI behaviors and functions were no longer statistically significant. This pivotal finding indicates that the apparent effect of IA on NSSI may not be direct but is largely mediated by co-occurring depressive and sleep symptoms, which is consistent with evidence reported in other populations. For instance, a study of 1,060 junior high school students in Taiwan demonstrated that while problematic internet use was associated with significantly more frequent NSSI, this association was substantially attenuated after controlling for depressive symptoms [39]. Similarly, a large-scale network analysis among adolescents found no significant correlation between IA and NSSI after adjusting for symptoms of depression and anxiety [40]. However, longitudinal evidence introduces

nuance. A 14-month cohort study demonstrated that high baseline IA predicted subsequent NSSI, with depression mediating this relationship only partially[80]. This indicates that while depressive symptoms are a major shared pathway, IA may also confer an independent risk for NSSI over time. Moreover, the present findings revealed no direct association between insomnia and self-injury functions, but indicated that insomnia was related to a higher risk of engaging in NSSI behaviors. In contrast to the extensively supported insomnia-suicide connection, some evidence points to a parallel role for insomnia in facilitating NSSI. For example, recent study found that greater initial insomnia severity predicted the frequency of subsequent NSSI episodes, and symptom improvement corresponded to decreased self-injury[48]. Notably, relevant research had found that rumination fully mediated the association between insomnia and NSSI behaviors, suggesting the potential role of emotional processes[49, 81]. Concurrently, results from an online survey verified that depressive and anxious states partially mediate the link between insomnia and NSSI[82, 83]. Collectively, these findings suggest that insomnia and depressive symptoms form a chained, rather than parallel, process connecting IA to NSSI behaviors and functions.

To examine the potential mediating pathways among these variables, a mediation model was employed. Our study confirmed that the IA total score demonstrated a significant direct influence on the functional preparedness for NSSI, as shown by its direct paths to ERG, ASG, and SAE. The link between IA and NSSI may be explained by their shared motivational roots, namely emotion regulation and social compensation. Research indicates that a primary driver for problematic internet use is to alleviate negative affect and avoid social stress through virtual immersion—a motivation directly paralleling two core function of NSSI[84]. However, in the long term, their emotional regulation capacity was significantly impaired, and these pent-up negative emotions may in turn intensify[45, 84]. In addition, interpersonal deficits common in IA may lead to heightened attention-seeking, for which NSSI can become a maladaptive behavioral strategy[85, 86]. In line with our hypothesis, the most robust pathway was a sequential mediation: IA led to increased insomnia, which in turn exacerbated depressive symptoms, ultimately resulting in heightened NSSI behaviors and functions. The finding that the ratio of indirect to total effects for the functional subscales was substantial (21.1%-23.6%) underscores that this cascade is a primary driver of the specific motivations behind self-injury. Furthermore, insomnia itself was identified as a partial mediator in the direct link between IA and NSSI behaviors. Notably, and in contrast to some prior research, depressive symptoms did not demonstrate a significant mediating effect on the direct association between IA and either NSSI behaviors or their functional dimensions[39, 40]. The overall finding underscores insomnia's central and likely more proximal role in the psychopathological pathway from problematic internet use to self-injury.

This study needs to be interpreted in the light of several limitations. First, the cross-sectional design precludes definitive causal inferences. While our model is based on strong theoretical grounds, longitudinal studies are needed to confirm the temporal sequence of these relationships, such as whether IA truly precedes the worsening of insomnia and depression. Second, our sample was composed of Han Chinese adolescents recruited from a clinical setting, which may limit the generalizability of the findings to other cultural contexts, community populations, or age groups. Third, we relied on self-report measures, which are susceptible to biases such as social desirability and recall

inaccuracy. Future research would benefit from incorporating objective measures (e.g., actigraphy for sleep) and multi-informant reports. Finally, while we controlled for several key covariates, other unmeasured variables, such as childhood trauma, personality traits, or specific online activities (e.g., social media vs. gaming), may also influence these complex relationships.

Conclusion

This study demonstrates that in adolescents with MDD, Internet addiction is a critical clinical marker that signifies a heightened risk for more severe depressive symptoms, insomnia, and a more complex profile of non-suicidal self-injury. The path from online addiction to offline self-harm is not direct but is powerfully mediated through the deterioration of sleep and mood. Recognizing and addressing this toxic triad of IA, insomnia, and depression is therefore paramount in breaking the cycle that leads to self-injury and in promoting healthier developmental trajectories for vulnerable youth.

Abbreviations

IA

Internet Addiction

CESD

Center for Epidemiologic Studies Depression Scale

ISI

Insomnia Severity Index

FASM

Functional Assessment of Self-Mutilation

ERG

emotion regulation

ASG

attention seeking

SAE

social avoidance

DSHI

Deliberate Self-Harm Behavior Inventory. OR,odds ratio

CI

confidence interval

IAT

Internet Addiction Test Scale.

Declarations

Ethics approval and consent to participate

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the the Medical Ethics Committee of Chaohu Hospital, Anhui Medical University (approval number: 202009-kyxm-04). All participants and their guardians provided written informed consent after a detailed briefing.

Consent for publication

Not applicable.

Competing interests

The authors have no conflicts of interest to declare.

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Author Contribution

Study design: Huanzhong Liu. Collection, analyses and interpretation of data: Yudong Shi, Qing Zhang, Zhiwei Liu, Jiawei Wang, Xiangwang Wen. Drafting of the manuscript: Yudong Shi, Qing Zhang. Critical revision of the manuscript: Huanzhong Liu. Approval of the final version for publication: All the authors.

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Not applicable.

Data Availability

The datasets used and analyzed during the current study are publicly not available due to limitations of ethical approval involving the patient data and anonymity but are available from the corresponding author on reasonable request.

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Figures

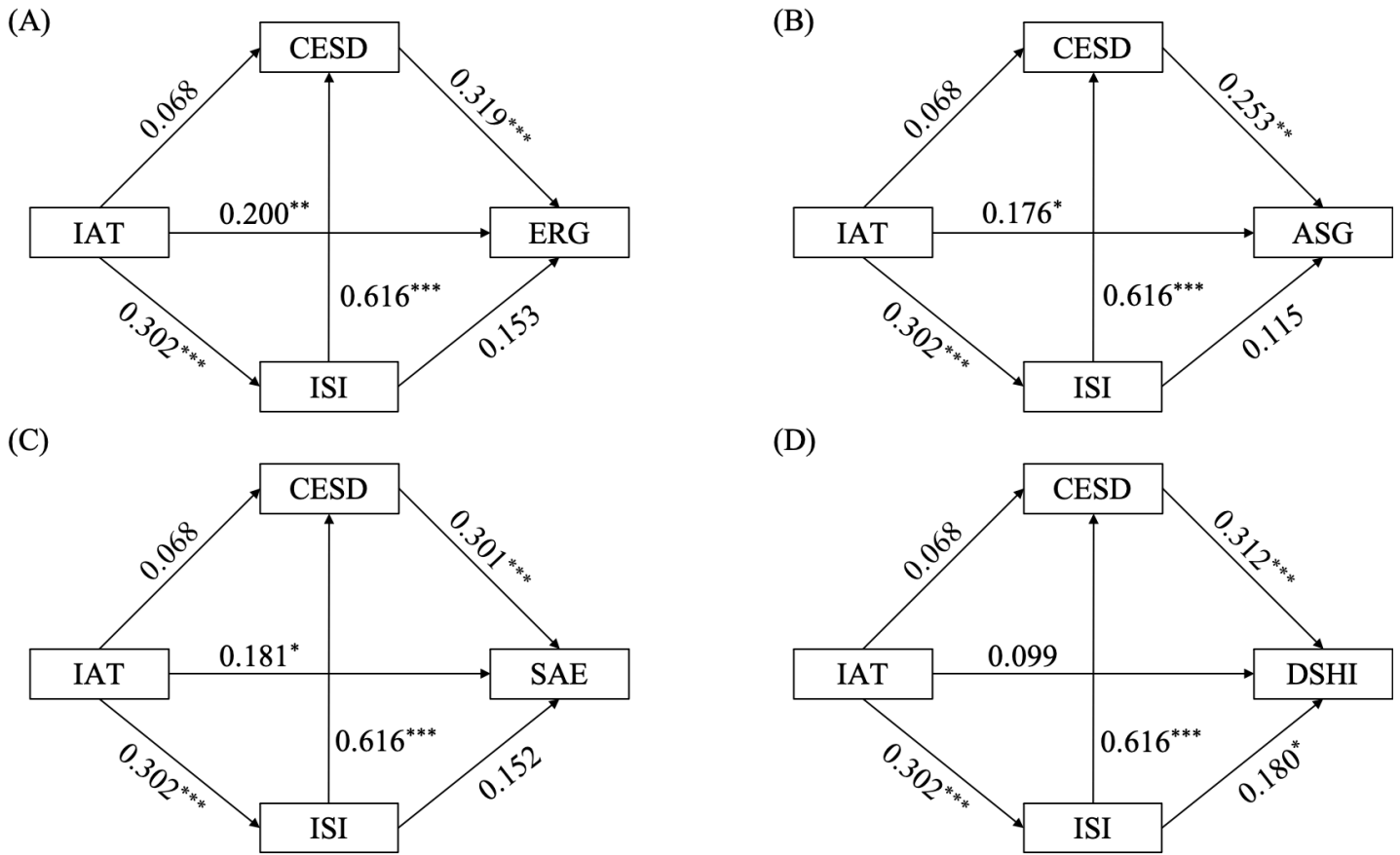


Figure 1

The mediating analysis of depressive symptoms, insomnia on the relationship between IAT and NSSI

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.00$; IAT, Internet Addiction Test Scale; CESD, Center for Epidemiologic Studies Depression Scale; ERG, emotion regulation; ASG, attention seeking; SAE, social avoidance; DSHI, Deliberate Self-Harm Behavior Inventory.