



OPEN The chain mediating effect of anxiety and inhibitory control between bullying victimization and internet addiction in adolescents

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Although some studies have revealed the association between bullying victimization and internet addiction in adolescents, the mediating and moderating factors between the two need to be further discussed. This study aimed to discuss the chain mediating role of anxiety and inhibitory control between bullying victimization and internet addiction among Chinese adolescents. A cross-sectional study was conducted in seven schools in five provinces of China by convenience sampling from February to March 2024. A total of 1673 participants (695 boys and 978 girls) with an average age of 15.86 ± 0.74 years were included in this study. Subjective data on bullying victimization, internet addiction, anxiety, inhibitory control were collected and analyzed, and a mediation model test was carried out. After controlling for age and gender, bullying victimization was found to be a significant predictor of internet addiction ($\beta = 0.098$, $p < 0.001$). However, when anxiety and inhibitory control were added, the predictive effect was no longer significant ($\beta = 0.006$, $p > 0.05$). Bullying victimization can predict internet addiction through anxiety and inhibitory control. It is suggested that guardians should provide adequate support to adolescent bullying victims in order to reduce the negative impact of bullying victimization on adolescents and prevent the occurrence of internet addiction.

Keywords Bullying victimization, Internet addiction, Anxiety, Inhibitory control

Bullying victimization is an important public health issue that has received worldwide attention¹. It refers to individuals being repeatedly exposed to negative behaviors from others over time, and find it difficult to defend themselves². Studies conducted in about 80 countries and regions have shown that approximately 30% of adolescents have experienced bullying victimization^{3,4}, with an alarming prevalence rate of 20% in China⁵. Experiencing bullying victimization is associated with a series of severe negative psychological and behavioral consequences in adolescents, such as anxiety^{6–9}, depression^{6,7,9}, suicidal ideation^{7,9–11}, sleep problems^{9,12–14}, and substance use disorders^{7,15}. As studies continue to reveal the extensive reach and profound impact of bullying, as well as its enduring effects^{1,3,4,7,16,17}, and with the emergence of theories linking victimization to mental and behavioral addictions^{18,19}, the relationship between bullying and adolescent internet addiction has increasingly become a focus of scholarly interest^{20–22}. This study, therefore, aims to explore the intricate relationship between bullying victimization and adolescent internet addiction, considering the psychological mechanisms that may underlie this association.

Bullying victimization, which encompasses physical, verbal, relational, and cyber forms, is a negative interpersonal experience that affects individual development^{23–25}. The convenience²⁶, anonymity²⁷, and social support provided by the internet^{26,28,29} make adolescents prone to engage with social networking platforms to enhance emotional and interpersonal support and communication^{30,31}, which can lead to problematic and compulsive social behavior, ultimately resulting in internet addiction^{32,33}. Research has found that adolescents who have experienced bullying victimization are more than three times more likely to have experienced internet addiction³⁴, and there is a significant positive correlation between bullying victimization and adolescent internet addiction^{20–22,35}. Bullying victimization increases the risk of internet addiction in rural Chinese adolescents³⁶. Similarly, bullying victimization significantly predicts adolescent internet addiction^{35,37}. According to the Life History Strategy Theory³⁸, individuals adjust their behavior and decision-making based on their surrounding

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environment and personal experiences, and tend to lean towards either a slow life history strategy or a fast life history strategy. When the environment is safe and predictable, individuals tend to choose the slow life history strategy, which focuses on survival tasks, maintaining physical health, learning knowledge and skills, and raising offspring, showing less impulsive behavior and better self-control. When the environment is harsh and unpredictable, individuals tend to choose the fast life history strategy, which focuses on reproductive tasks, seeking immediate pleasure or temporary satisfaction, and showing greater impulsivity and lower self-control. Combined with the characteristics of bullying victimization, the internet may become an important carrier for individuals to obtain instant satisfaction under impulsive and low self-control conditions^{39,40}.

In general, the relationship between bullying victimization and internet addiction is often mediated by negative emotions. The study found that bullying victimization brings a series of negative emotional experiences to adolescents^{41–43}, as they may worry about experiencing bullying victimization again^{44,45} and often become anxious^{34,46}. As defined by anxiety^{47,48}, victims experience unpredictability and worry about future occurrences. The chronic stress model posits that such negative interpersonal experiences accumulate psychological distress, with anxiety being a notable outcome^{49,50}. Bullying, encompassing physical, verbal, and relational forms^{1,51–53}, severely disrupts individuals coping mechanisms⁵⁴, leading to increased fear, helplessness, and anxiety⁵⁵. Research shows that adolescents who have experienced bullying victimization being over four times more likely to experience anxiety than those who have not, while those who have experienced severe bullying victimization are over 18 times more likely to experience anxiety³⁴. Anxiety plays a mediating role between bullying victimization and internet addiction⁵⁶. Furthermore, longitudinal studies have also found that bullying victimization can significantly predict adolescent anxiety⁵⁷. Similarly, when experiencing negative emotions, individuals may choose to use the internet to regulate and escape^{18,58}. Studies have found a significant positive correlation between anxiety and adolescent internet addiction^{59,60}, with anxiety significantly predicting adolescent internet addiction^{60–62}. This prediction has also been found in longitudinal studies^{63,64}. According to strain theories, bullying victimization is a type of stress for adolescents⁶⁵. When faced with this stress, adolescents often experience insecurity⁶⁶, avoidance behavior, more inactive behavior⁶⁷, and anxiety^{68,69}. Therefore, the use of the internet often becomes a coping mechanism for adolescents in such negative situations⁷⁰, which may lead to the formation of internet addiction.

In addition, the influence of bullying victimization on individuals also extends to the field of cognitive psychology, one of which is inhibitory control. Inhibitory control refers to an individual's conscious regulation of behavior, especially suppressing behaviors that are detrimental to development^{71,72}, and is an important component of cognitive function. Bullying victimization also has a negative impact on inhibitory control in adolescents. Research has found a significant negative correlation between the degree of bullying victimization and the volume of the left caudate and putamen in adolescents, with individuals with higher bullying victimization scores showing greater reductions in putamen volume over time⁷³. The caudate plays a crucial role in the selection tendency of inhibitory control⁷⁴, while the putamen regulates the relationship between inhibitory control and addictive behaviors^{75,76}. In addition, the default mode network (DMN) of bullying victimization individuals is disrupted in connection with other multi-brain networks⁷⁷. These network connectivity efficiencies are usually related to inhibitory control^{6,78}. Studies have found that the executive functions of bullying victimization children (inhibitory control, cognitive flexibility, working memory) are impaired to varying degrees⁷⁹. Therefore, bullying victimization can affect the inhibitory control function of adolescents. Inhibitory control can inhibit individuals' risky behavior^{78,80,81}, including internet addiction⁶⁰. Studies have found that adolescents with internet addiction have lower levels of inhibitory control task completion^{82,83}, and DMN connectivity is disrupted⁸⁴. Therefore, high levels of inhibitory control can prevent the occurrence of adolescent internet addiction.

Among these negative effects of bullying victimization on individuals, there are often links between each other. Study found that negative emotions can affect individual cognitive processing^{85,86}. Similarly, anxiety can also impair inhibitory control^{87,88}. Studies have found that laboratory-induced anxiety impairs early and late event-related potential components of both emotional and cognitive inhibitory control⁸⁹, and may call for higher-level cognitive resources to maintain and complete inhibitory control tasks⁹⁰. This phenomenon has also been found in retrospective studies⁹¹. Moreover, research has found that anxiety significantly predicts adolescent inhibitory control⁶⁰.

In summary, this study constructs a chain mediation model to delve into the psychological mechanisms linking bullying victimization with adolescent internet addiction. The study posits bullying victimization as the independent variable and internet addiction as the dependent variable, with anxiety and inhibitory control serving as mediators. The hypotheses are as follows:

H1 Bullying victimization can significantly predict adolescent internet addiction.

H2 Bullying victimization can significantly predict adolescent anxiety, which in turn can significantly predict adolescent internet addiction.

H3 Bullying victimization can significantly predict adolescent inhibitory control, which can significantly predict adolescent internet addiction.

H4 Anxiety and inhibitory control had a chain mediating effect between bullying victimization and internet addiction in adolescents.

The mediation model is outlined in Fig. 1, illustrating the proposed relationships and the interplay between the variables under investigation.

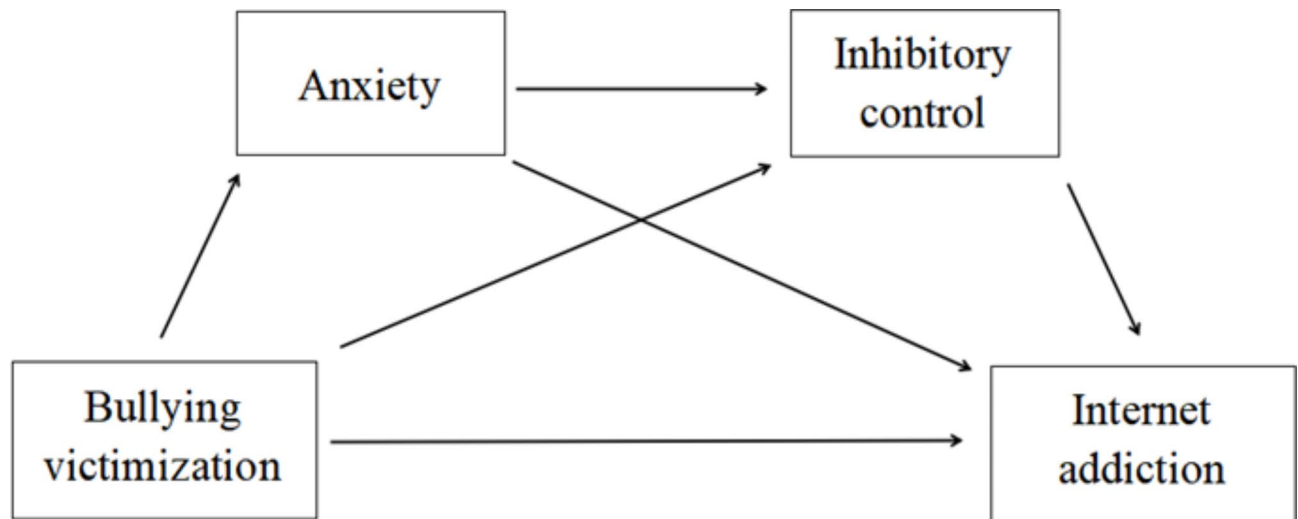


Fig. 1. Mediation hypothesis model.

Methods

Participants

Convenience sampling was used to select 1915 middle school students from 7 schools in Shandong, Shanxi, Hebei, Sichuan, and Hunan provinces from February to March 2024. Prior to this, the study had obtained approval from the Biomedical Ethics Committee of Jishou University. The survey was distributed in electronic form through class group chats with the presentation of the research content, data anonymity, confidentiality, and use. Participants could complete the electronic questionnaire in approximately 20 min. Online informed consent was obtained from all participants and their guardians. The study was conducted in accordance with the provisions of the Declaration of Helsinki. After excluding invalid data (including responses characterized by patterned answers, unusually short completion times, and instances of disregarding reverse-scored or irrelevant items), the final analysis sample of the study consisted of 1673 participants (695 males, 978 females) with an average age of 15.86 years ($SD=0.74$).

The choice of these specific provinces was intentional to ensure a geographically diverse sample, thereby enhancing the generalizability of our findings across different regional contexts. Partner schools in these provinces were selected based on their willingness to participate and their extensive experience in facilitating research initiatives. The schools included in our study span across different regions, encompassing a wide array of socio-economic backgrounds and educational settings, and providing a rich tapestry for our investigation into the impact of bullying victimization on adolescent mental health.

Measurement tools

Bullying victimization

Bullying victimization was assessed using a single question, which detailed the definition of bullying victimization as “repeatedly and frequently being subjected to negative behaviors such as hitting, kicking, pushing, threatening, teasing, insulting, exclusion, spreading rumors, sending hurtful emails or messages by others in situations of power or status imbalance”⁹². Participants were asked to recall their experiences over the past 30 days and respond using a five-level rating (0 = never, 1 = once a month, 2 = two to three times a month, 3 = once a week, 4 = several times a week, 5 = almost every day). This tool had been previously used in other studies⁹³.

Internet addiction

The level of internet addiction among adolescents was measured using the revised and validated Internet Addiction Scale by Wei Qi⁹⁴. The scale consisted of 8 items, rated on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The total score of the items represented the level of internet addiction, ranging from 8 to 40, with higher scores indicating higher levels of internet addiction. The Cronbach's α for the sample in this study was 0.889.

Anxiety

The anxiety level of adolescents was measured using the anxiety subscale of the Depression-Anxiety-Stress Self-Rating Scale, revised and validated by Gong Xu et al.⁹⁵. The subscale comprised 7 items, rated on a 4-point Likert scale from 1 (not at all) to 4 (completely). The total score of the items represented the level of anxiety, ranging from 7 to 28, with higher scores indicating higher levels of anxiety. The Cronbach's α for the sample in this study was 0.878.

Inhibitory control

The inhibitory control subscale from the Executive Function Scale developed by Huang Chunhui et al.⁹⁶ was employed to measure the inhibitory control level of adolescents. The subscale included 6 items, each rated from 1 (often) to 3 (never). The total score of the items represented the level of inhibitory control, ranging from 6 to 18, with higher scores indicating higher levels of inhibitory control. The Cronbach's α for the sample in this study was 0.859.

Statistical analysis

Statistical analysis was performed using SPSS 26.0 software. Firstly, a method bias test was conducted, and if the threshold was less than 40%, it was considered that there was no obvious common method bias in the study⁹⁷. Subsequently, descriptive statistics and correlation analysis were conducted for the demographic characteristics and main variables of the study participants. Before further analysis, the data for the main variables were standardized. Finally, to test our hypotheses, the relationship between bullying victimization and adolescent internet addiction was examined using the PROCESS plugin (Model 6) in SPSS, investigating the chain mediating effect of anxiety and inhibitory control⁹⁸. In this process, 5,000 bootstrap resampling iterations were used to assess model fit and estimate the 95% confidence interval (95% CI), ensuring robustness in the data analysis⁹⁹. Gender and age were controlled as covariates in the analysis. The significance level was set at $\alpha=0.05$.

Results

Common method bias test

The results of the common method bias test in this study revealed two factors with eigenvalues greater than 1. The first factor accounted for 32.63% of the total variance, which was below the threshold of 40%. This suggests that there is no significant risk of common method bias in this study.

Correlation analysis

Table 1 shows the results indicating significant positive correlations between bullying victimization and anxiety ($r=0.170, p<0.001$), as well as between bullying victimization and internet addiction ($r=0.094, p<0.001$). There was also a significant negative correlation between bullying victimization and inhibitory control ($r=-0.151, p<0.001$). Anxiety was significantly positively correlated with internet addiction ($r=0.435, p<0.001$) and negative correlation with inhibitory control ($r=-0.473, p<0.001$). Inhibitory control showed a significant negative correlation with internet addiction ($r=-0.394, p<0.001$).

Mediation analysis

The results from Table 2 and Fig. 2 indicate that bullying victimization significantly and directly predicts adolescent internet addiction ($\beta=0.098, SE=0.024, p<0.001$). However, when adding the mediator variables, the direct prediction of bullying victimization on adolescent internet addiction is no longer significant ($\beta=0.006, SE=0.022, p>0.05$). Furthermore, the mediation model revealed that bullying victimization significantly predicts adolescent anxiety ($\beta=0.175, SE=0.024, p<0.001$), and anxiety significantly predicts adolescent internet addiction ($\beta=0.317, SE=0.024, p<0.001$). Bullying victimization also significantly predicts inhibitory control ($\beta=-0.076, SE=0.022, p<0.001$), and inhibitory control significantly predicts adolescent internet addiction ($\beta=-0.237, SE=0.024, p<0.001$). Finally, anxiety significantly negatively predicts inhibitory control ($\beta=-0.455, SE=0.022, p<0.001$). The proportion of mediation paths can be found in Table 3.

Discussion

This study uncovers the intricate interplay between bullying victimization and adolescent internet addiction, elucidating the chain mediation effects of anxiety and inhibitory control. The research framework encompasses both negative emotional responses (anxiety) and positive cognitive functions (inhibitory control). Our findings demonstrate that bullying victimization is a significant predictor of adolescent anxiety and inversely impacts inhibitory control. Anxiety is shown to negatively influence inhibitory control while concurrently acting as a positive predictor of adolescent internet addiction. Conversely, inhibitory control is identified as a negative predictor of internet addiction. These interconnections shed light on the internal psychological dynamics linking bullying victimization with the propensity for adolescent internet addiction.

Our research indicates that bullying victimization exerts a substantial direct influence on the likelihood of adolescent internet addiction. However, this influence becomes insignificant when accounting for the mediating roles of anxiety and inhibitory control. Previous research found that bullying victimization increases the risk of adolescent internet use³⁶ and the incidence of internet addiction is 3 to 5 times higher in adolescents who have experienced bullying than those who have not³⁴. At the same time, bullying victimization significantly predicted adolescent Internet addiction^{20,37}. Nevertheless, the inclusion of mediating variables in our study attenuates the

Variables	1	2	3	4
1 Bullying victimization	–			
2 Internet addiction	0.094***	–		
3 Anxiety	0.170***	0.435***	–	
4 Inhibitory control	–0.151***	–0.394***	–0.473***	–

Table 1. Correlation analysis. *** $p<0.001$.

Outcome variables	Predictive variables	β	SE	t	R ²	F
Internet addiction	Gender	0.163	0.049	3.312***	0.024	13.366***
	Age	0.122	0.033	3.701***		
	Bullying victimization	0.098	0.024	4.034***		
Anxiety	Gender	0.197	0.049	4.053***	0.040	23.199***
	Age	0.052	0.033	1.589		
	Bullying victimization	0.175	0.024	7.278***		
Inhibitory control	Gender	-0.086	0.044	-1.962*	0.232	125.861***
	Age	-0.050	0.029	-1.707		
	Bullying victimization	-0.076	0.022	-3.465***		
	Anxiety	-0.455	0.022	-20.759***		
Internet addiction	Gender	0.058	0.044	1.339	0.240	105.311***
	Age	0.088	0.029	3.023**		
	Bullying victimization	0.006	0.022	0.252		
	Anxiety	0.317	0.024	12.977***		
	Inhibitory control	-0.237	0.024	-9.731***		

Table 2. Chain mediation model test. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

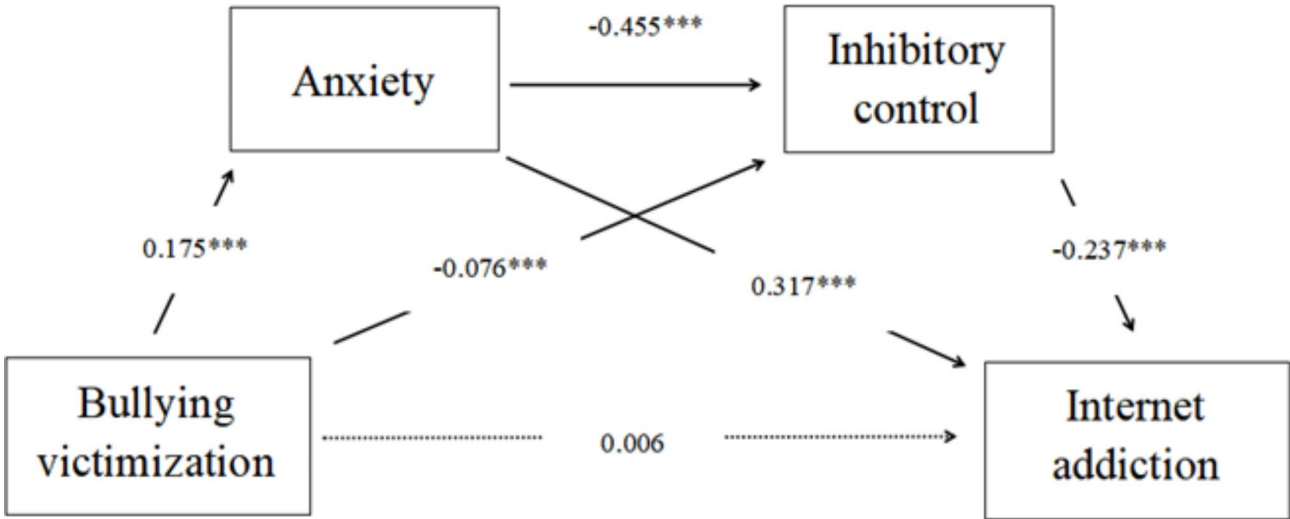


Fig. 2. Chain mediation model test (** $p < 0.001$).

mediation model paths	Effect	SE	Bootstarp 95% CI	Proportion of mediating effect
Total effect	0.098	0.024	0.050, 0.145	
Direct effect	0.006	0.022	-0.037, 0.048	
Total indirect effect	0.092	0.016	0.062, 0.126	93.878%
Bullying victimization → Anxiety → Internet addiction	0.056	0.011	0.036, 0.079	57.143%
Bullying victimization → Inhibitory control → Internet addiction	0.018	0.006	0.007, 0.031	18.367%
Bullying victimization → Anxiety → Inhibitory control → Internet addiction	0.019	0.004	0.012, 0.028	19.388%

Table 3. Path analysis of chain mediation model.

direct predictive impact of bullying on internet addiction. Bullying victimization is recognized as a source of profound emotional distress for individuals^{100,101}, impairing social interaction skills^{102,103}, and damaging brain structures integral to behavior and emotion regulation¹⁰⁴. Additionally, factors such as personality traits, fear of retaliation, and low social support may prevent victims from employing more effective strategies to protect themselves from further bullying or to mitigate the cascade of negative effects stemming from their victimization. The repercussions of bullying are multifaceted, extending beyond these functions, and potentially propelling affected individuals to seek emotional modulation and refuge in the digital realm. As our study illustrates, the

predictive power of bullying on adolescent internet addiction diminishes with the consideration of mediating factors.

Anxiety, a critical mediating factor in our study, is significantly predicted by bullying victimization and, in turn, predicts adolescent internet addiction. Therefore, anxiety is one of the important mediating variables in the prediction of bullying victimization on adolescent internet addiction. Previous research has found that bullying victimization increases the risk of adolescent anxiety^{43,46}, with adolescents experiencing bullying having 3 to 18 times higher risk of anxiety than those who have not experienced bullying^{34,105}. At the same time, the longitudinal study found that bullying victimization and anxiety have a two-way predictive effect⁵⁷. Additionally, both cross-sectional and longitudinal studies have found that anxiety significantly predicts adolescent internet addiction^{61,63,64}, and which is conforming to general strain theories⁶⁵. Adolescents who have experienced bullying victimization are often anxious about being bullied again. Inhibited by anxiety, adolescents who have experienced bullying may adopt a range of emotional regulation strategies. Those with lower regulatory capabilities might turn to the internet as a medium for emotional support, alleviating negative emotions, and diverting attention, potentially leading to internet addiction when over-reliance and misuse occur.

Our findings also highlight that bullying victimization significantly predicts adolescent inhibitory control, a cognitive function closely associated with the regulation of daily behaviors¹⁰⁶. Therefore, this study found that inhibition control significantly predicted adolescent Internet addiction, which is also consistent with the characteristics of inhibition control. Previous research has found that bullying victimization is related to structural abnormalities in the bilateral paracentral, posterior cingulate cortex, and hippocampus of adolescents^{77,107}. These areas are usually related to individual inhibitory control^{108–110}. Therefore, bullying victimization may impair adolescent inhibitory control. Lower inhibitory control and higher impulsivity are core structures of addictive behavior¹¹¹. Studies have found that addictive behavior is associated with lower inhibitory control and higher impulsivity^{112,113}. A large-scale meta-analysis also found that internet addiction is associated with deficits in inhibitory control¹¹⁴. These evidences show that bullying victimization can not only affect individual psychosocial functioning, but even affect cognitive psychology. The influence on these functions in turn affects the level of Internet addiction among adolescents.

There is a relationship between the influence of bullying victimization on individual emotion and cognition. In this study, it was found that anxiety significantly predicted inhibitory control in adolescents. Previous research has found that anxiety can impair an individual's level of inhibitory control^{87,88}, and significantly negatively predicts adolescent inhibitory control⁶⁰. At the same time, individuals may recruit higher-level attention resources to maintain the negative impact of anxiety on inhibitory control^{90,115}. According to the self-depletion theory¹¹⁶, when individuals regulate emotions, they need to consume cognitive resources. When an individual's cognitive resources are continuously depleted, there is a deficit in inhibitory control when engaging in control behaviors, leading to increased risky behavior¹¹⁷, such as internet addiction¹¹⁸. Therefore, bullying victimization can cause adolescents negative emotions, and this negative emotion is an important risk factor for adolescent internalization and externalization.

This study fills a critical gap in current research by exploring the underlying mechanisms linking bullying victimization to internet addiction. However, when considering the mediating roles of anxiety and inhibitory control, the direct predictive effect diminishes, highlighting the intricate psychological pathways at play. Practically, these findings underscore the urgent need for multifaceted interventions. Educators and policymakers should prioritize initiatives that not only address bullying prevention but also enhance adolescents' emotional well-being and self-regulation skills. By fostering supportive environments and promoting healthy coping strategies, such interventions can effectively mitigate the risk of internet addiction among vulnerable youth^{119,120}. In conclusion, this study not only deepens our theoretical understanding of the dynamics between bullying victimization, anxiety, inhibitory control, and internet addiction but also offers actionable insights for stakeholders invested in adolescent welfare. By addressing these complex interrelations, we can better equip young people to navigate the challenges of the digital age with resilience and well-being.

This study reveals the underlying psychological mechanisms between bullying victimization and adolescent internet addiction by considering both emotional and cognitive factors. However, this study still has some limitations. Firstly, this study is based on a cross-sectional design, which may have limitations in explaining causal relationships. Secondly, the data collection method was based on personal subjective responses, which may have limitations in data objectivity. Thirdly, the assessment of bullying victimization was condensed to a single-item measure, a decision driven by the need to minimize the temporal and cognitive burden on participants. While this approach enhances survey efficiency, it sacrifices the granularity required to differentiate among various forms of bullying victimization, thereby limiting the study's ability to explore the nuances of different bullying experiences. Finally, the study only involved some provinces in China, which may have limitations in sample representativeness. To address these limitations and to enrich future research, we recommend the adoption of longitudinal designs that can capture the evolution of bullying victimization and internet addiction over time. Employing multidimensional data collection methods, such as a combination of quantitative surveys and qualitative interviews, could provide a more comprehensive understanding of the underlying mechanisms. Additionally, expanding the study to include a broader and more diverse range of participants across different regions would enhance the representativeness of the sample. Furthermore, future research should consider incorporating advanced psychometric scales that can more accurately measure the various dimensions of bullying victimization and assess the impact of different bullying modalities on mental health outcomes. The integration of biomarkers, where feasible, may offer additional insights into the physiological correlates of bullying and internet addiction. By adopting these methodological enhancements, subsequent studies will be better positioned to unravel the complex interplay between bullying victimization, internet addiction, and adolescent mental health, leading to more targeted and effective interventions.

Conclusion

This study further reveals the relationship between bullying victimization and adolescent internet addiction by considering the chain mediation effect of anxiety and inhibitory control. The results suggest that anxiety and inhibitory control have a fully chain-mediated effect between bullying victimization and adolescent internet addiction. This study suggests that caregivers should identify adolescent bullying victimization in a timely manner and provide timely support to prevent internet addiction.

Data availability

The datasets generated and/or analysed during the current study are not publicly available due [our experimental team's policy] but are available from the corresponding author on reasonable request.

Received: 18 June 2024; Accepted: 24 September 2024

Published online: 07 October 2024

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Acknowledgements

Ting Xiao, Zirui Zhou, Shiju Zhu, Liangfan Duan, Dan Tan, Bowen Li, Dongbo Cai, Guang Liu, Hao Li, Ning

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Declarations

Ethics approval and consent to participate

The study was approved by the Biomedicine Ethics Committee of Jishou University before the initiation of the project (Grant Number: JSDX-2024-0086). And informed consent was obtained from the participants before starting the program.

Competing interests

The authors declare no competing interests.

Additional information

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