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The lagged effects of parent-child relationship on internet addiction: parallel mediation of psychological need frustration and self-esteem

Xin Liu¹, Fang Ran² and Yaoyao Zhang^{1,3*}

Abstract

Background Adolescent Internet addiction has emerged as a major social and public health concern worldwide. Previous studies have indicated that parent–child relationship plays a crucial role in adolescent Internet addiction. However, most of these studies have adopted a cross-sectional design, making it difficult to reveal the lagged effects of the parent-child relationship on adolescent Internet addiction and its underlying developmental mechanisms.

Methods This study conducted a three-wave survey over one year, employing cluster sampling between October 2023 and October 2024. The survey assessed parent-child relationship, Internet addiction, basic psychological need frustration, and self-esteem among 2,483 adolescents ($M_{age} = 13.82$, SD = 1.53; 51.71% girls) from two middle schools in Shaanxi, China. Descriptive statistics and correlation analyses were performed using SPSS 26.0. Additionally, the lagged effect of T1 parent-child relationship on T3 Internet addiction, as well as the parallel mediating roles of T2 basic psychological needs frustration and T2 self-esteem in this lagged effect, were examined using PROCESS macro Model 4.

Results (1) The lagged effect of T1 parent-child relationship on T3 Internet addiction was significant ($\beta = -0.20$, SE = 0.03, p < 0.001). (2) T2 basic psychological need frustration ($\beta = -0.06$, SE = 0.01, 95% CI: -0.08, -0.04) and T2 self-esteem ($\beta = -0.02$, SE = 0.01, 95% CI: -0.04, -0.01) served as parallel mediators in the lagged effect of T1 parent-child relationship on T3 Internet addiction.

Conclusions These findings provide empirical evidence for preventing and intervening in adolescent Internet addiction and hold significant implications for reducing its risk.

Keywords Internet addiction, Parent–child relationship, Basic psychological need frustration, Self-esteem, Adolescents

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Introduction

In the digital age, Internet use has become an integral part of adolescents' daily lives, encompassing a range of activities related to learning and entertainment; however, excessive Internet use may lead to the development of Internet addiction. Internet addiction refers to an inability to control Internet use, which subsequently harms physical and mental health, leads to difficulties in social adaptation, and is classified as a control or behavioral disorder [1]. With the widespread use of the internet, adolescent internet addiction has shown a high prevalence in many countries. For example, the prevalence of internet addiction among adolescents is 10.7% in South Korea [2], 11.3% in Germany [3], and 16.32% in China [4]. Clearly, adolescent internet addiction is gradually becoming a global public health issue that requires urgent attention [5-7].

Internet addiction can have severe consequences for adolescents [8-15], including decreased academic performance, estrangement from interpersonal relationships, and the development of depressive symptoms and suicidal behaviors [16-18]. Given the high prevalence of Internet addiction among adolescents and its detrimental effects on development and health, researchers should identify the influencing factors and developmental mechanisms to inform the prevention and intervention of adolescent Internet addiction.

Relationship between the parent-child relationship and internet addiction

Numerous factors influence adolescent Internet addiction, including external environmental factors, personal characteristics, and the specific features of the Internet itself [7, 19, 20]. The parent–child relationship within the family environment has garnered significant attention as one of the most impactful factors in adolescent growth and development [21].

The parent-child relationship refers to the interpersonal relationship formed between parents and their children through mutual interaction and influence in daily life [22]. As one of the most enduring interpersonal relationships in an individual's lifespan, it plays a crucial role in shaping a person's psychology and behavior [23]. Attachment theory suggests that a positive parent-child relationship can promote the positive development of adolescents' mental health and good behavior, while a negative parent-child relationship increases the risk of psychological and behavioral issues in adolescents [24]. Specifically, a supportive parent-child relationship provides adolescents with warmth and support in the real world, which helps to prevent and reduce excessive Internet use [25]. Conversely, a poor parent-child relationship fails to meet adolescents' emotional needs, leading them to seek emotional compensation in the virtual world [26].

The compensatory Internet use model posits that individuals use the Internet to compensate for unmet needs in real life, potentially increasing Internet use time and eventually leading to Internet addiction [27]. Empirical studies have also indicated that adolescents with good parent-child relationships tend to exhibit lower levels of internet addiction [28, 29]. In contrast, adolescents with poor parent-child relationships are more likely to have higher levels of internet addiction [26, 30]. A meta-analysis also found a negative association between parent-child relationship and adolescent Internet addiction [21].

Although several studies have enhanced our understanding of the relationship between parent-child relationship and adolescent Internet addiction, they still have some limitations. First, most studies are based on crosssectional data, making it difficult to determine the lagged effect of the parent-child relationship on Internet addiction [31, 32]. Internet addiction is a dynamically evolving process that necessitates studies conducted over time to determine the temporal explanatory power of the parent-child relationship on adolescent Internet addiction [1, 16].

Second, while several studies have explored the mediating roles of individual risk factors or protective factors in the relationship between the parent-child relationship and adolescent Internet addiction [29, 31], they have not simultaneously investigated the parallel mediating roles of both risk and protective factors. The ecological risk/ protection theory suggests that the prevention of problem behaviors should not solely focus on reducing risk factors or enhancing protective factors in isolation but should simultaneously consider both to achieve more effective interventions [33]. Therefore, simultaneously considering both risk and protective factors when examining the lagged effect of the parent-child relationship on Internet addiction would provide more comprehensive and effective guidance for adolescent Internet addiction intervention.

Basic psychological need frustration, as a recurring negative experience in adolescents' daily lives, has been shown to contribute to various psychological and behavioral problems and is recognized as a significant risk factor for adolescent development [34, 35]. In contrast, self-esteem, as an essential psychological resource for adolescents, facilitates self-recognition and self-guidance [36], and is widely regarded as a crucial protective factor against negative behavioral outcomes [37]. Incorporating these two factors as process variables into the investigation of the lagged effect of the parent-child relationship on Internet addiction may not only enhance intervention strategies but also deepen our understanding of the underlying developmental mechanisms. Therefore, research conducted over time is warranted to examine the lagged effect of the parent-child relationship on

adolescent Internet addiction, while simultaneously exploring the mediating roles of risk factor (basic psychological need frustration) and protective factor (selfesteem) in this process.

Mediating role of basic psychological need frustration

Basic psychological need frustration refers to specific negative psychological experiences that arise when an individual's three basic psychological needs—autonomy, relatedness, and competence—are threatened or undermined by the external environment [38]. Autonomy frustration pertains to the sense of losing control over one's own behavior and decisions [39]; relatedness frustration involves feelings of loneliness and rejection owing to others' detachment [40]; and competence frustration refers to feelings of frustration and self-doubt arising from failing to accomplish tasks [41].

Basic psychological needs theory (BPNT) shows that unfavorable proximal environmental factors fail to provide the necessary nourishment for psychological integration and growth, and frustrate an individual's psychological needs [34]. A poor parent-child relationship often implies that parents employ negative parenting practices. When adolescents perceive control, feelings of alienation, and blame from their parents, their basic psychological needs are frustrated [42]. Conversely, a positive parent-child relationship often involves supportive parenting practices. When adolescents experience support, care, and encouragement from their parents, the likelihood of their basic psychological needs being frustrated is low [35]. Empirical studies also show that the more parents exert control, rejection, and criticism toward adolescents, the greater adolescents' psychological need frustration [43, 44]. Conversely, the more autonomy, warmth, and praise parents provide adolescents, the lower their psychological need frustration [44, 45].

BPNT further suggests that the frustration of these needs may lead individuals to seek substitutes to compensate for unmet needs [34]. The Internet offers a "colorful" world that provides adolescents with numerous opportunities to compensate for their frustrated psychological needs such as controlling virtual characters to satisfy autonomy needs, engaging in virtual social interactions to satisfy relatedness needs, and completing game challenges to satisfy competence needs [46]. When adolescents' psychological needs are frustrated, they are more likely to spend excessive time online [47]. Cross-sectional studies have shown a positive correlation between psychological need frustration and Internet gaming and smartphone addiction [47, 48]. A longitudinal study has directly demonstrated that psychological need frustration in early adolescence can positively predict the later occurrence of smartphone addiction [49].

Mediating role of self-esteem

Self-esteem refers to an individual's overall evaluation, attitude, and beliefs about their self-worth and abilities [50]. As a crucial dimension of personality development, self-esteem undergoes significant changes and restructuring during adolescence [51]. Its development is influenced not only by cognitive abilities and social comparison but also by the quality of the parent-child relationship [52].

Attachment theory posits that children use their experiences with their parents to form their self-concept [24]. Secure attachment fosters a self-concept where children believe they are valuable and capable, whereas insecure attachment leads to a self-concept where children perceive themselves as worthless and incompetent [53]. Consequently, a positive parent-child relationship helps children to develop high self-esteem, while a negative parent-child relationship may result in low self-esteem [54]. Empirical studies have shown that adolescents with warm, positive parent-child relationships tend to have higher self-esteem [52, 55], whereas those with negative and distant parent-child relationships tend to have lower self-esteem [56, 57].

Self-esteem, an individual's perception of their worth and abilities, is also closely linked to psychological and behavioral outcomes [50]. Self-esteem has been identified as a significant influencing factor in Internet addiction [58]. Adolescents with low self-esteem often experience more failures and insecurities in the real world; consequently, they tend to create a more satisfying self-image in the online world. As a result, they spend more time on the Internet, increasing the likelihood of developing Internet addiction [59, 60]. In contrast, adolescents with high self-esteem typically have a stronger sense of selfawareness and self-worth, which reduces their need to seek validation or enhance their value in the online world. Consequently, they are less likely to spend excessive time online and have a lower risk of developing Internet addiction [61, 62].

Current study

In summary, this study employs a design conducted over time to examine the lagged effect of the parent-child relationship on adolescent Internet addiction and explores the parallel mediating roles of basic psychological need frustration and self-esteem in this relationship. Through this investigation, we aim to enhance the understanding of the association between the parent-child relationship and adolescent Internet addiction, along with its underlying mechanisms. Furthermore, the findings are expected to provide valuable insights for the prevention and intervention of adolescent Internet addiction. Based on the above review of the relevant literature, this study proposes the following hypotheses and a conceptual model (see Fig. 1).

Hypothesis 1 T1 parent-child relationship has a negative lagged effect on T3 adolescent Internet addiction.

Hypothesis 2 T2 basic psychological need frustration mediates the lagged effect of T1 parent-child relationship on T3 Internet addiction.

Hypothesis 3 T2 self-esteem mediates the lagged effect of T1 parent-child relationship on T3 Internet addiction.

Methods

Participants and procedure

T1

We used a cluster sampling method to conduct a threewave survey of students from two secondary schools in Shanxi Province, China. The survey, conducted from October 2023 to October 2024, included three waves of data collection at 6-month intervals. During the first survey, 2,951 adolescents ($M_{age} = 13.86$, SD = 1.52; 50.80% girls) participated. Due to reasons such as illness and school transfers, the second and third surveys included 2,652 and 2,663 adolescents, respectively. After excluding 23 participants who provided invalid responses (e.g., failing to follow instructed response items, such as "Please select 'strongly disagree' for this question"), a total of 2,483 adolescents (M age = 13.82, SD = 1.53; 51.71% girls) successfully completed all three waves of the survey. Regarding participant attrition, no significant differences were found between adolescents who completed all three waves and those who participated in only one or two waves regarding parent-child relationship (t = 1.65, p = 0.10), psychological need frustration (t = -0.10, p = 0.92), self-esteem (t = 0.75, p = 0.45), and Internet addiction (t = 0.18, p = 0.86) at T1. However, there were significant differences in age (t = -3.50, p < 0.001) and gender $(\chi^2(1) = 5.25, p < 0.05)$, with older and male adolescents more likely to drop out. Overall, we observed no severe structured attrition. The initial survey's demographic information indicated that 64.20% of the adolescents lived in urban areas; 51.41% of the adolescents' fathers and 48.77% of the adolescents' mothers reported having completed junior high school education; 32.33% of the families had a monthly income ranging from 3,001 to 5,000 RMB, and 33.67% of the families had a monthly income ranging from 5,001 to 10,000 RMB.

This study was approved by the Ethics Committee of Psychology, Southwest University, China (IRB protocol number: H23130) and was conducted in accordance with the Declaration of Helsinki. Before each survey, the participants were informed about the study's purpose, their anonymity, and the right to withdraw at any time. Each survey was conducted after obtaining the written consent of the school administrators, teachers, parents, and students. Surveys were administered in the students' classrooms, with guidance provided by psychology graduate students. At the end of each survey, Participants were given study supplies as a way of expressing appreciation.

T3



Т2

Measurement

Parent-child relationship at T1

Adolescents' parent-child relationship at T1 was assessed using the Chinese version of the Parent-Child Cohesion Questionnaire, originally developed by Olson et al. (1985) and revised by Zhang et al. (2006) [63, 64]. This scale consists of 20 items measuring two dimensions: father-child relationship (10 items, e.g., "I feel very close to my father") and mother-child relationship (10 items, e.g., "I feel very close to my mother"), with identical content for both dimensions. Items 3, 4, 8, 9, 13, 14, 18, and 19 are reverse-scored. All items are rated on a 5-point Likert scale (1 = never, 5 = always), with higher average scores indicating a stronger parent-child relationship. Previous research has demonstrated good reliability of this scale among Chinese adolescents [65]. In the present study, the scale exhibited good internal consistency at T1 (Cronbach's $\alpha = 0.83$).

Basic psychological need frustration at T1 and T2

Adolescents' basic psychological need frustration at T1 and T2 were assessed using the Chinese version of the Basic Psychological Need Frustration Scale, developed by Chen et al. (2015) [40]. This scale consists of 12 items measuring three dimensions: autonomy frustration (four items, e.g., "I feel pressured to do too many things"), relatedness frustration (four items, e.g., "I feel excluded from the group I want to belong to"), and competence frustration (four items, e.g., "I have serious doubts about whether I can do things well"). Responses are rated on a 5-point scale (1 = Completely not true; 5 = Completely true), with higher average scores indicating higher levels of need frustration. Previous research has demonstrated the effectiveness and reliability of this scale in Chinese adolescent populations [66]. The scale demonstrated good internal consistency at both T1 and T2 (Cronbach's $\alpha = 0.88$ and 0.92, respectively).

Self-esteem at T1 and T2

Adolescents' self-esteem at T1 and T2 was measured using the Chinese version of the Rosenberg Self-Esteem Scale, originally developed by Rosenberg (1965) and revised by Ji and Yu (1993) [50]. The scale comprises 10 items (e.g., "Generally speaking, I am satisfied with myself"), with items 3, 8, 9, and 10 being reverse-scored. Each item is rated on a 4-point Likert scale (1 = completely disagree, 4 = completely agree), with higher average scores indicating greater self-esteem. This scale has shown good measurement effectiveness in Chinese adolescent populations [67]. The scale demonstrated good internal consistency at both T1 and T2 (Cronbach's $\alpha = 0.82$ and 0.84, respectively).

Internet addiction at T1 and T3

Adolescent Internet addiction at T1 and T3 was assessed using the Chinese version of the Short Problematic Internet Use Questionnaire, originally developed by Demetrovics et al. (2008) and revised by Koronczai et al. (2017) [68, 69]. This questionnaire consists of nine items covering three dimensions: obsessive involvement (3 items, e.g., "How often do you feel tense, irritated, or stressed if you cannot use the Internet for as long as you want to?"), neglect of reality (3 items, e.g., "How often do you neglect household chores due to Internet use?"), loss of control (3 items, e.g., "How often do you try to reduce your Internet use but fail?"). Responses are rated on a 5-point scale (1 = Never; 5 = Always), with higher average scores indicating more severe Internet addiction. This scale has demonstrated good measurement properties in Chinese adolescent populations [69]. The scale demonstrated good internal consistency at both T1 and T3 (Cronbach's $\alpha = 0.88$ and 0.89, respectively).

Statistical analysis

Little's test was used to examine the missing data pattern, and the result was not significant $(\chi^2 (31) = 41.57)$, p = 0.10), indicating that the data were missing completely at random [70]. Therefore, missing values were replaced with the mean values [71]. SPSS 26.0 was used to conduct descriptive statistics and correlation analyses of the main study variables, with the mean, standard deviation, skewness, kurtosis, and correlation coefficients presented in tables. The PROCESS macro Model 4 in SPSS [72] was used to examine the lagged effect (with $\alpha < 0.05$ indicating significance) of T1 parent-child relationships on adolescents' T3 Internet addiction and to explore the parallel mediating roles of T2 basic psychological need frustration and T2 self-esteem in this relationship. The significance of the mediation effects was tested using the bootstrap method with 1,000 iterations, with mediation considered significant if the 95% confidence interval (CI) did not include zero [73]. Results were presented through regression analysis tables and path diagrams.

Results

Harman's single-factor test

Harman's single-factor method was used to test for common method bias. The results showed that when all the variables were constrained to a single factor, this factor explained only 22.07% of the total variance, which is below the 40% threshold [74], indicating no serious common method bias.

Descriptive statistics

Table 1 presents the descriptive statistics and correlation analyses. Skewness and kurtosis analyses indicated that the skewness of all the variables ranged from -0.38

 Table 1
 Descriptive statistics and correlations among variables

M(SD)	S	К	1	2	3	4	5	6	7	8	9
13.82(1.53)	-0.05	-1.60	1								
-	-	-	_	1							
3.16(0.59)	0.08	0.96	-0.04	0.02	1						
2.81(0.77)	0.10	-0.16	0.13***	0.01	-0.29***	1					
2.68(0.47)	-0.38	0.25	-0.03	-0.06**	0.28***	-0.69***	1				
2.39(0.86)	0.28	-0.32	0.27***	-0.06**	-0.19***	0.37***	-0.26***	1			
2.78(0.84)	0.05	-0.1	0.09***	0.05*	-0.34***	0.59***	-0.50***	0.30***	1		
2.68(0.48)	-0.36	0.47	0.02	-0.08***	0.33***	-0.54***	0.64***	-0.21***	-0.70***	1	
2.43(0.88)	0.18	-0.45	0.18***	-0.02	-0.25***	0.32***	-0.25***	0.52***	0.41***	-0.32***	1
	M(SD) 13.82(1.53) - 3.16(0.59) 2.81(0.77) 2.68(0.47) 2.39(0.86) 2.78(0.84) 2.68(0.48) 2.43(0.88)	M(SD) S 13.82(1.53) -0.05 - - 3.16(0.59) 0.08 2.81(0.77) 0.10 2.68(0.47) -0.38 2.39(0.86) 0.28 2.78(0.84) 0.05 2.68(0.48) -0.36 2.43(0.88) 0.18	M(SD) S K 13.82(1.53) -0.05 -1.60 - - - 3.16(0.59) 0.08 0.96 2.81(0.77) 0.10 -0.16 2.68(0.47) -0.38 0.25 2.39(0.86) 0.28 -0.32 2.78(0.84) 0.05 -0.1 2.68(0.47) -0.36 0.47 2.43(0.88) 0.18 -0.45	M(SD) S K 1 13.82(1.53) -0.05 -1.60 1 - - - - 3.16(0.59) 0.08 0.96 -0.04 2.81(0.77) 0.10 -0.16 0.13*** 2.68(0.47) -0.38 0.25 -0.03 2.39(0.86) 0.28 -0.32 0.27*** 2.78(0.84) 0.05 -0.1 0.09*** 2.68(0.47) -0.36 0.47 0.02 2.78(0.84) 0.18 -0.45 0.18**	M(SD) S K 1 2 13.82(1.53) -0.05 -1.60 1 - - - - 1 3.16(0.59) 0.08 0.96 -0.04 0.02 2.81(0.77) 0.10 -0.16 0.13*** 0.01 2.68(0.47) -0.38 0.25 -0.03 -0.06** 2.39(0.86) 0.28 -0.32 0.27*** -0.06** 2.78(0.84) 0.05 -0.1 0.09*** 0.05* 2.68(0.47) -0.36 0.47 0.02 -0.08*** 2.43(0.88) 0.18 -0.45 0.18*** -0.02	M(SD) S K 1 2 3 13.82(1.53) -0.05 -1.60 1 - - - - - 1 - 3.16(0.59) 0.08 0.96 -0.04 0.02 1 2.81(0.77) 0.10 -0.16 0.13*** 0.01 -0.29*** 2.68(0.47) -0.38 0.25 -0.03 -0.06** 0.28*** 2.39(0.86) 0.28 -0.32 0.27*** -0.06** -0.19**** 2.78(0.84) 0.05 -0.1 0.09** 0.05* -0.34*** 2.68(0.48) -0.36 0.47 0.02 -0.08** 0.33*** 2.43(0.88) 0.18 -0.45 0.18*** -0.02 -0.25***	M(SD) S K 1 2 3 4 13.82(1.53) -0.05 -1.60 1	M(SD) S K 1 2 3 4 5 13.82(1.53) -0.05 -1.60 1 - - - - - 1 - - - - 1 - - - 1 - - - - 1 - - - - - - - - 1 -	M(SD) S K 1 2 3 4 5 6 13.82(1.53) -0.05 -1.60 1	M(SD) S K 1 2 3 4 5 6 7 13.82(1.53) -0.05 -1.60 1 - - - - - - - 1 -	M(SD) S K 1 2 3 4 5 6 7 8 13.82(1.53) -0.05 -1.60 1 - - - - - - 1 - - - - 1 -

Note. N = 2483; Gender (1 = boy, 2 = girl); *p < 0.05, **p < 0.01, ***p < 0.001

Table 2 Summary of the mediation effect an
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Predictor variables	T3 Internet addiction		T2 Psycho frustratio	ological need n	T2 Self-esteem		T3 Internet addiction	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Age	0.03	[0.01, 0.05]	0.01	[-0.01, 0.03]	0.01**	[0.01, 0.02]	0.03**	[0.01, 0.05]
Gender	0.01	[-0.05, 0.07]	0.07**	[0.02, 0.13]	-0.04**	[-0.07, -0.02]	-0.02	[-0.07, 0.04]
T1 Parent–child relationship	-0.20***	[-0.25, -0.15]	-0.24***	[-0.29, -0.20]	0.12***	[0.10, 0.15]	-0.12***	[-0.17, -0.07]
T1 Psychological need frustration			0.45***	[0.40, 0.50]				
T1 Self-esteem					0.49***	[0.45, 0.63]		
T1 Internet addiction	0.45***	[0.42, 0.49]	0.07***	[0.04, 0.10]	-0.01	[-0.02, 0.01]	0.44***	[0.40, 0.47]
T2 Psychological need frustration							0.24***	[0.18, 0.29]
T2 Self-esteem							-0.16***	[-0.25, -0.07]
R ²	0.31		0.40		0.45		0.36	
<u>F</u>	185.84***		276.52***		333.53***		171.80***	

Note. N = 2483; Gender (1 = boy, 2 = girl); ** p < 0.01, *** p < 0.001

to +0.28, which is within the acceptable range of -2 to +2, and the kurtosis ranged from -1.6 to +0.96, which is within the acceptable range of -7 to +7, thus satisfying the assumption of a normal distribution [75]. The correlation analysis revealed that the T1 parent-child relationship was significantly negatively correlated with T3 Internet addiction and with T2 basic psychological need frustration, while it was significantly positively correlated with T2 self-esteem. T2 basic psychological need frustration and T3 Internet addiction were significantly positively correlated, whereas T2 self-esteem was significantly negatively correlated with T3 Internet addiction. Additionally, the study variables were significantly correlated with gender and age. Considering both the correlation with the main study variables and the structured dropout by age and gender, these factors were controlled in subsequent analyses to reduce bias in the results.

Test of the mediation model

After controlling for the baseline levels of the key variables (i.e., T1 basic psychological need frustration, T1 self-esteem, and T1 Internet addiction) and covariates, we examined the impact of T1 parent–child relationship on T3 Internet addiction, as well as the parallel mediating roles of T2 basic psychological need frustration and T2 self-esteem in the relationship between T1 parentchild relationship and T3 Internet addiction. As shown in Table 2, T1 parent-child relationship was significantly negatively associated with T3 Internet addiction (β = -0.20, SE = 0.03, p < 0.001), supporting Hypothesis 1. T1 parent-child relationship was also significantly negatively associated with T2 basic psychological need frustration $(\beta = -0.24, SE = 0.02, p < 0.001)$, while T2 basic psychological need frustration was significantly positively associated with T3 Internet addiction ($\beta = 0.24$, SE = 0.03, p < 0.001). T1 parent-child relationship was also significantly positively associated with T2 self-esteem ($\beta = 0.12$, SE = 0.01, p < 0.001), and T2 self-esteem was significantly negatively associated with T3 Internet addiction (β = -0.16, SE = 0.05, p < 0.001). The overall path coefficients are shown in Fig. 2.

The results of the mediation analysis using the bootstrap method indicated that the effect of the T1 parent-child relationship \rightarrow T2 basic psychological need frustration \rightarrow T3 Internet addiction pathway was significant (β = -0.06, *SE*=0.01, 95% CI: -0.08, -0.04),



Fig. 2 A parallel mediation model. Note. The path coefficients are standardized coefficients. To simplify the model, age and gender are not displayed in the figure. **p* < 0.05, ***p* < 0.01

accounting for 28.95% of the total effect. This finding supports Hypothesis 2, confirming that T2 basic psychological need frustration mediates the association between T1 parent-child relationship and T3 Internet addiction. The effect of the T1 parent-child relationship \rightarrow T2 self-esteem \rightarrow T3 Internet addiction pathway was also significant ($\beta = -0.02$, SE = 0.01, 95% CI: -0.04, -0.01), accounting for 9.97% of the total effect. This supports Hypothesis 3 by confirming that T2 self-esteem mediates the association between the T1 parent-child relationship and T3 Internet addiction. Furthermore, the direct effect of T1 parent-child relationship on T3 Internet addiction remained significant ($\beta = -0.12$, SE = 0.03, 95% CI: -0.17, -0.07), accounting for 61.08% of the total effect. This indicates that T2 basic psychological need frustration and T2 self-esteem partially mediate the association between T1 parent-child relationship and T3 Internet addiction.

Discussion

As the primary interpersonal relationship during adolescence, the parent-child relationship profoundly influences the development of adolescent behaviors. Although previous cross-sectional studies have revealed a strong association between parent-child relationships and adolescent Internet addiction, the lagged effects over time and the parallel roles of individual risk factors and protective factors in this relationship remain unclear. By adopting a three-wave survey design, the present study explores the lagged effect of parent-child relationships on adolescent Internet addiction and simultaneously examines the parallel roles of individual risk factors—basic psychological need frustration—and protective factors self-esteem—in this relationship. The results of the oneyear study show that the initial parent-child relationship has a lagged effect on adolescent Internet addiction one year later, with basic psychological need frustration and self-esteem playing parallel mediating roles in this effect.

T1 parent-child relationship was significantly negatively associated with T3 internet addiction, thus supporting Hypothesis 1. This finding suggests that a positive parent-child relationship may reduce the risk of adolescent Internet addiction later, whereas a poor parent-child relationship may increase the likelihood of Internet addiction in the future. This result aligns with previous studies on the relationship between parent-child relationship and Internet addiction [76-78]. It also supports the perspective of attachment theory, which posits that the quality of the parent-child relationship influences individuals' behavioral development [24]. Specifically, when adolescents perceive their relationship with their parents as positive and secure, they are more likely to spend meaningful and supportive moments with their parents in the real world, rather than spending excessive time in a virtual world, thus reducing the risk of Internet addiction [29, 31]. Conversely, when adolescents view their relationship with their parents as negative and distant, they may be less willing to communicate and interact with their parents and turn to the Internet to compensate for emotional support and warmth, ultimately leading to Internet addiction [30, 79].

T2 basic psychological need frustration mediates the lagged effect of T1 parent-child relationship on T3 Internet addiction, supporting Hypothesis 2. According to the BPNT, adverse external environmental factors can frustrate an individual's basic psychological needs, leading them to engage in alternative behaviors (such as Internet use) to compensate for this frustration [34]. Poor parent–child relationships may cause adolescents to experience more constraints, alienation, and rejection from their

parents, frustrating their need for autonomy, relatedness, and competence [43, 44]. To satisfy these basic psychological needs, adolescents may turn to the Internet to seek an alternative fulfillment of their self-competence, social connections, and autonomy, which can significantly increase the likelihood of Internet addiction [47, 49].

T2 self-esteem mediates the lagged effect of T1 parentchild relationship on T3 Internet addiction, supporting Hypothesis 3. Attachment theory suggests that a positive parent-child relationship fosters the development of a positive self-concept, effectively protecting against problematic behaviors. Conversely, poor parent-child relationships can lead to negative self-evaluation, thereby increasing the likelihood of problematic behaviors [24]. Harmonious and supportive interactions with parents provide adolescents with a secure attachment, helping them develop a strong sense of self-worth and competence, which builds high self-esteem [57, 80]. Adolescents with high self-esteem typically hold themselves to high standards, which can limit the time they spend online and protect them from Internet addiction [61, 81]. Frequent conflicts and arguments with parents may foster insecure attachment in adolescents, leading to feelings of inferiority and worthlessness, resulting in low self-esteem [82, 83]. Adolescents with low self-esteem may spend excessive time online in an attempt to alleviate feelings of frustration and inadequacy by seeking positive feedback on their worth and competence, which can ultimately contribute to Internet addiction [60, 84].

This study offers several theoretical and practical implications. Theoretically, it confirms the cross-time association between parent-child relationships and adolescent internet addiction, providing empirical support for attachment theory and emphasizing the importance of the quality of parent-child relationships in adolescent behavioral development [24]. Furthermore, the findings support the idea that basic psychological need frustration and self-esteem are significant factors in adolescent internet addiction, offering a new perspective on understanding the psychological motivations behind this addiction and enriching the application of self-esteemrelated theories in this field [34]. Practically, this study provides valuable insights for the prevention and intervention of Internet addiction. First, improving the relationship between adolescents and their parents could be an effective approach for treating Internet addiction. For instance, family group therapy that enhances parentchild communication could be used to strengthen these relationships and address adolescent Internet addiction [85]. Second, increasing the fulfillment of adolescents' basic psychological needs could reduce the likelihood of Internet addiction. Parents can help by offering adolescents more autonomy, spending more time with them and providing greater encouragement and affirmation. These actions can meet adolescents' basic psychological needs and potentially prevent internet addiction [47, 49]. Third, enhancing adolescents' self-esteem can serve as a preventive measure against Internet addiction. Parents can encourage their children to participate in group counseling sessions that focus on boosting self-esteem and provide positive feedback in daily life. This joint effort can help adolescents develop a positive self-concept, empower them to face the real world with confidence, and reduce the risk and severity of Internet addiction [31, 81].

This study has some limitations that future research should address. First, the sample was drawn exclusively from adolescents in northwestern China, raising questions about the generalizability of the findings to other regions of China or international contexts. Future research should expand the sample size to include participants from various regions and countries to validate and enhance the ecological validity of the findings. Second, the data were based on adolescents' self-reports and may have been influenced by social desirability bias, potentially reducing the accuracy of the results. Future studies could consider collecting data from multiple sources (e.g., parents, peers, and teachers) to overcome the limitations of self-reports and improve the reliability of the findings. Third, while this study simultaneously explored the mediating roles of basic psychological need frustration and self-esteem, other potential mediators, such as social anxiety and psychological resilience, might also play a role in the relationship between parent-child relationship and adolescent Internet addiction. Future studies should investigate additional mediating factors to enrich our understanding of this relationship. Finally, this study did not collect all the research variables in each wave, which limited the consideration of the longitudinal relationships among the main variables. Therefore, future research, when conditions allow, could collect all the research variables in each wave to further explore the causal relationships and interactions between the variables over time.

Conclusions

Although the association between parent-child relationship and adolescent Internet addiction has been widely studied, the cross-temporal association and underlying developmental mechanisms of this association remain unclear. This study used a large sample to examine the cross-time association between parent-child relationship and adolescent Internet addiction and simultaneously explore the mediating roles basic psychological need frustration and self-esteem. The results indicate that the lagged effect of parent-child relationship on adolescent Internet addiction is significant, and the parallel mediating effects of basic psychological need frustration and self-esteem in this lagged effect are also significant. Based on these findings, prevention and intervention efforts for adolescent Internet addiction should focus on improving the quality of parent-child relationships by reducing adolescents' basic psychological need frustration and enhancing self-esteem.

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Author contributions

X.L. wrote the main manuscript and performed the statistical analysis. F.R also contributed to writing the manuscript. Y.Z. conceived and designed the study.

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Data availability

The data presented in this article are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Psychology, Southwest University, China (IRB protocol number: H23130) and was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants as well as their legal guardians.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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