ORIGINAL ARTICLE

Longitudinal Associations of Social Anxiety Trajectories with Internet-Related Addictive Behaviors Among College Students: A Five-Wave Survey Study

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Abstract

The college stage is characterized by increased interpersonal interaction and intense social anxiety. Although the associations between social anxiety and internet-related addictive behaviors have been established, the question of whether the developmental trajectory of social anxiety is linked to subsequent internet-related addictive behaviors remains unexplored. Utilizing a longitudinal design combined with a person-centered approach, the current study examined the developmental trajectory of social anxiety among 3,861 students throughout their university years. Additionally, we explored the impacts of specific change patterns of social anxiety on subsequent internet-related addictive behaviors. The growth mixture modeling identified three distinct profiles of social anxiety: high-stable group (n=515, 13.33%), high-decreasing group (n=243, 6.30%), and low-decreasing group (n=3103, 80.37%). Furthermore, the results of binary logistic regression analysis revealed that students in the high-decreasing and low-decreasing groups were less likely to experience smartphone addiction and Internet game addiction compared to those in the high-stable group. These findings underscore the importance of identifying individuals with a high risk for social anxiety and providing them with personalized and effective mental health services to mitigate their susceptibility of developing internet-related addictive behaviors.

Keywords Social anxiety · Trajectories · Addictive behaviors · Longitudinal cohort · College students

The college years represent a critical period as students navigate the transition from late adolescence to emerging adulthood (Arnett, 2015; Arnett et al., 2014). During this periods, college students are exposed a wide range of social activities and are tasked with

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establishing new social relationships (Collins et al., 2018). However, for some students, the unfamiliarity of these social situations and environmental may trigger feelings of social anxiety. Therefore, it is not uncommon that up to 25% of college students report experiencing feelings of nervousness or anxiety when interacting with others (Melkam et al., 2023). Depending on the diagnostic threshold, the prevalence of social anxiety disorder among college students ranges from 11% to 33% (Baptista et al., 2012; Melkam et al., 2023; Reta et al., 2020), which is much higher than that of the general population (Brook & Willoughby, 2015). In addition, Meng et al. (2021) surveyed 2759 college students from China, and revealed that 33.38% of students have reported experiencing at least one social anxiety symptom. Furthermore, females are more likely to experience social anxiety disorder than males (Asher et al., 2017; Caballo et al., 2014). Individuals with social anxiety often have excessive and impaired fears in social and interpersonal situations and may actively avoid situations where they fear negative evaluation by others (American Psychiatric Association, 2013). Social anxiety among college students can be particularly problematic because it is related to other psychological and interpersonal challenges. Severe social anxiety can even result in substance abuse (Schry & White, 2013), depression (Stein et al., 2001), and suicidal ideation (Buckner et al., 2017).

Developmental Trajectories of Social Anxiety

At the macro level, spanning across different age groups, the highly social environment of college campuses and the pressure to conform may increase the risk of social anxiety among college students. At the micro level, social anxiety may gradually decline as students mature and adapt to new environments. For example, a recent meta-analysis of longitudinal studies have found that a decline in social anxiety during emerging adulthood (B. Chen et al., 2023). However, most previous studies have relied on short-term longitudinal designs, variable-centered approaches and the Western population (Brook & Willoughby, 2015; Gautreau et al., 2015; Schry et al., 2016), paying less attention to the long-term dynamic changes in social anxiety experienced by college students over time. Therefore, a multiple-wave design to examine continuous trajectory of social anxiety across the university years is crucial from a developmental perspective.

Developmental theories of anxiety suggest that individuals can be categorized into subgroups based on their distinctive patterns of anxiety symptoms (Weems, 2008). Research on the taxonomy of social anxiety emphasizes the importance of examining heterogeneity in its development, as there may be significant differences between individuals with symptomatic problems, regardless of whether they meet diagnostic criteria for the disorder (Levinson et al., 2014). Growth mixture models (GMM), a person-centered approach, have been developed to separate a general population of individuals into subgroups characterized by qualitatively distinct patterns of change over time (Jung & Wickrama, 2008; Mo & Bodner, 2007). Existing research using GMM has provided evidence regarding the developmental trajectory of social anxiety (Branje et al., 2013; Broeren et al., 2013; Krygsman & Vaillancourt, 2022; Marmorstein et al., 2010; Miers et al., 2013). For instance, Marmorstein et al. (2010) followed a sample of 2,451 participants from childhood to early adolescence, and identified five trajectories of social anxiety symptoms: stable moderate group, stable high group, increasing symptom group, moderate decreasing symptom group, and high decreasing symptom group. Krygsman and Vaillancourt (2022) examined the heterogeneous development of social anxiety symptoms across childhood and adolescence, and

found three distinct trajectories: high increasing group, moderate group, and low group. Similar results were found in two other studies (Branje et al., 2013; Miers et al., 2013).

Despite accumulating evidence demonstrating significant heterogeneity in social anxiety, the literature has several limitations. On the one hand, most previous studies have focused more on the developmental trajectory of social anxiety in children and adolescents, with less attention given to the college student. On the other hand, previous studies have predominantly relied on small samples from Western countries, overlooking the potential influence of cultural factors on the development of social anxiety. For example, collectivist countries tend to report higher levels of social anxiety and fear of blushing than individualist countries (Heinrichs et al., 2006).

Social Anxiety and Internet-Related Addictive Behaviors

College students are particularly susceptible to developing excessive reliance on smartphones or online games due to having large amounts of free time outside of class (Aljomaa et al., 2016; Borges et al., 2019). Social anxiety is an important predictor of the development of internet-related addictive behaviors, such as smartphone addiction and Internet game addiction (Gioia et al., 2022; Ran et al., 2022; Stănculescu & Griffiths, 2022). According to the compensatory Internet use theory, individuals with social anxiety may turn to the Internet as a substitute for face-to-face social and emotional connections, potentially leading to a dependence on online interactions (Kardefelt-Winther, 2014). More specifically, Internet-mediated communication can provide alternative virtual environments that allow highly socially anxious individuals to redirect most of their social interactions and alleviate their negative emotions associated with real-life social situations (Marino et al., 2020; Przepiorka et al., 2021). In addition to fulfilling social functions, smartphones and online games can serve as avoidance coping strategies (Elhai et al., 2018). Numerous studies have shown that social anxiety is indicative of distorted perceptions, such as low self-worth and excessive concern for negative feedback from others (Iancu et al., 2015; Morrison & Heimberg, 2013). According to the cognitive-behavioral model of pathological Internet use, individuals with negative emotions (such as social anxiety) are more prone to Internet addiction because they use the Internet as a coping strategy to regulate their negative emotions and escape from real-world troubles (Davis, 2001). Although previous studies have explored the relationship between social anxiety and internet-related addictive behaviors, most of these studies are cross-sectional. Moreover, it is still unclear whether there were differential associations between trajectories of social anxiety and internet-related addictive behaviors.

The Current Study

Using a prospective design and a person-centered approach, we aim to investigate the heterogeneous trajectory of social anxiety and further explore whether distinct patterns of social anxiety are differentially linked to subsequent internet-related addictive behaviors. Based on the literature and theories, we propose the existence of three or four trajectories of social anxiety in Chinese college students. Furthermore, we hypothesize that college students in the low-risk group (e.g., stable low group, decreasing symptom group) have a

lower risk of internet-related addictive behaviors than those in the high-risk group (e.g., stable high group, increasing symptom group).

Methods

Participants and Procedure

Participants were recruited from a large-scale health-related cohort among Chinese college students. This cohort was a five-wave design from 2019 to 2021 and participants enrolled from three universities in Guangdong Province, China. The waves were conducted at the interval of 6 months, except for the second and the third wave, which had a 12-month interval. This longer interval between the second and the third waves was due to the outbreak of the COVID-19 pandemic, which resulted in students not returning to school during that period. Detailed sampling and data collection have been described in Fig. 1. In brief, at
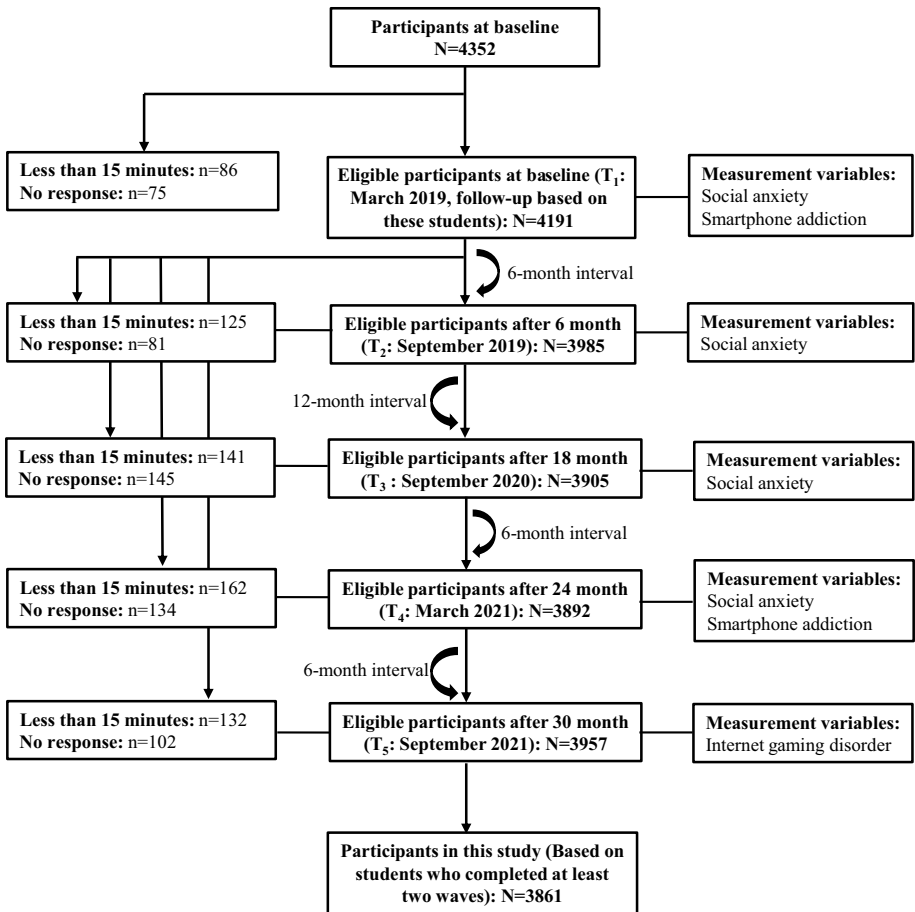

Fig. 1 Sampling procedure for the current study. Notes in this figure: "less than 15 minutes" means that if the time it took to complete the survey was <15 min, the questionnaire was considered to be invalid

the baseline (T_1), a total of 4352 freshmen were invited to complete an online-based mental health survey. After excluding the invalid questionnaires, a final sample of 4191 freshmen was identified for subsequent follow-up investigations. Of the participants at T_1, 3985 (4.9% attrition rate), 3905 (6.8% attrition rate), 3892 (7.1% attrition rate), and 3957 (5.6% attrition rate) provided valid responses from T_2 to T_5, respectively. The main reason for attrition was that students were absent from classes on the day of evaluation. To facilitate subsequent trajectory analysis, only participants who completed data collection for at least two waves were included in the present study ($N = 3861$, $M_{age} = 19.12$, $SD = 0.98$). All sociodemographic and other characteristics of the participants were summarized in Table S1 (Supplemental Materials).

Before collecting data, we obtained permission from the principals of three schools and obtained an electronic version of the informed consent form from students. All participants were informed that their participation in the study was voluntary and that they could withdraw from the study at any time without repercussions. It took approximately 30 minutes to complete the questionnaires. The present study protocol was reviewed and approved by the Research Ethics Committee of the corresponding author's institution.

Measures

Social Anxiety

Social anxiety was measured using the subscale of Screen for Adult Anxiety Related Disorders (SCAARED) (Angulo et al., 2017). The SCAARED is a self-assessment questionnaire with 44 items, which was adapted from the Screen for Children Anxiety Related Emotional Disorders (SCARED) (Birmaher et al., 1999). The SCAARED evaluated four types of anxiety disorders in DSM-5: panic disorder, generalized anxiety disorder, separation anxiety disorder, and social anxiety disorder. The Chinese version of the SCAARED was translated and revised by Wang et al. (2022). The social anxiety subscale consists of 7 items (e.g., "*It is hard for me to talk with people I don't know well*"). Each item was evaluated on a 3-point scale from 0 (not true or hardly ever true) to 2 (very true or often true). Item scores are summed to get a total score ranging from 0 to 14, and a cutoff score of 7 has been used to screen clinically probable social anxiety (Angulo et al., 2017). The SCAARED has shown good reliability and validity among Chinese adults (X. Chen et al., 2020). In this study, the Cronbach's alpha coefficients were 0.86, 0.86, 0.86, and 0.90 at T_1, T_2, T_3, and T_4, respectively.

Smartphone Addiction

The Smartphone Addiction Scale-Short Version (SAS-SV) was used to measure smartphone addiction at T_1 and T_4 (Kwon et al., 2013). This scale comprises 10 items (e.g., "*Feeling impatient and fretful when I am not holding my smartphone*") and each item is answered on a six-point scale ranging from 1 (strongly disagree) to 6 (strongly agree). Summing the scores on the ten items creates a total score ranging from 10 to 60, with a higher total score indicating a higher level of smartphone addiction. The scale developers proposed SAS-SV cut-off scores of ≥ 31 for males and ≥ 33 for females to identify individuals with potential smartphone addiction. The SAS-SV has demonstrated good psychometric properties in the Chinese population

(Luk et al., 2018; Peng & Liang, 2023). In this study, the Cronbach's alpha coefficients were 0.88 and 0.93 at T_1 and T_4.

Internet Game Addiction

Internet game addiction was measured using the Internet Gaming Disorder Scale-Short-Form (IGDS9-SF) (Leung et al., 2020; Pontes & Griffiths, 2015). IGDS9-SF was developed according to the diagnostic criteria of IGD described in the DSM-5. This scale comprises 9 items (e.g., "*Do you feel more irritability, anxiety or even sadness when you try to either reduce or stop your gaming activity*"). All items were evaluated on a 5-point Likert scale ranging from 1 (never) to 5 (very often). Scores were summed, with higher scores indicating higher levels of Internet game addiction. A cutoff score of 21 has been recommended for identifying probable addictive behaviors (Monacis et al., 2016). The Chinese version of the IGDS9-SF has demonstrated good psychometric properties (Leung et al., 2020; Poon et al., 2021). In this study, the Cronbach's alpha coefficient was 0.92 at T_5.

Other Covariates

Other covariates were assessed at baseline, including gender (0 = female, 1 = male), age, the only child (0 = no, 1 = yes) and parental education levels (0 = less than nine years; 1= nine years or more).

Statistical Analyses

The primary analyses in this study included four steps. First, descriptive analyses and Pearson correlation analyses were conducted to examine main variables. Second, latent growth curve models (LGCM) were conducted to examine overall developmental trajectory of social anxiety. Third, growth mixture modeling (GMM) was used to identify distinct social anxiety trajectories across the four time points. Unconditional models with one- to five-class were tested for social anxiety. Intercepts, linear slope, and quadratic slope were estimated for each latent class. Full information maximum likelihood (FIML) estimation was applied to handle missing values (Giletta et al., 2015). Multiple criteria were applied to determine the optimal number of classes (Nylund et al., 2007), including lower information criteria fit indices (AIC, BIC, SSBIC), higher entropy values, likelihood ratio tests (LRTs; $p < 0.05$ implies c classes fit better than c-1), and a minimum of 5% of participants in each class. Furthermore, prior empirical evidence and theoretical considerations were taken into account to determine the final model (Nagin & Odgers, 2010). Fourth, binary logistic regression analysis was performed to examine whether social anxiety trajectories could prospectively predict internet-related addictive behaviors (i.e., smartphone addiction and Internet gaming disorder). Both crude and adjusted models were tested. All analyses in this study were performed using SPSS 21.0 and Mplus 8.3.

Results

Attrition Analyses

The missing completely at random (MCAR) test was conducted on all variables across the five waves of the study. The results indicated that the data were not missing completely at random ($\chi^2 = 223.05$, $df = 186$, $p < 0.05$), which is common in longitudinal studies (Engels & Diehr, 2003). To further understand the missing data mechanism, the chi-square test and t test were conducted to compare demographic characteristics at baseline between participants who dropped out and those who participated in all waves. The results revealed that males ($\chi^2 = 70.85$, $df = 1$, $p < 0.001$) were more likely to drop out. No significant differences were found in other variables.

Sample Characteristics and Prevalence of Social Anxiety

Among the 3861 participants, 46.9% were females and 21.0% were only child. The average age at baseline was 19.12 years (ranging from 17 to 28, SD = 0.98). Regarding the prevalence of social anxiety, 23.0%, 20.3%, 14.8%, and 13.4% of college students reported probable social anxiety at four time points, respectively. Female college students reported higher prevalence rates of social anxiety than males at all time points (see Fig. 2). Table 1 provided zero-order correlations among the main variables. The results found that participants' social anxiety at four time points were positively correlated with smartphone addiction and internet gaming disorder.

Identification of Overall Social Anxiety Trajectories

The results of latent growth curve models indicated that a quadratic model fit the data better (CFI = 0.998; TLI = 0.989; RMSEA = 0.062). The mean of the intercept (b = 5.41, SE = 0.05, $p < 0.001$), linear slope (b = -0.44, SE = 0.04, $p < 0.001$) and quadratic slope (b = 0.03, SE = 0.01, $p = 0.007$) were statistically significant, indicating a significant downward trend in social anxiety levels among college students. Moreover, the variance of the
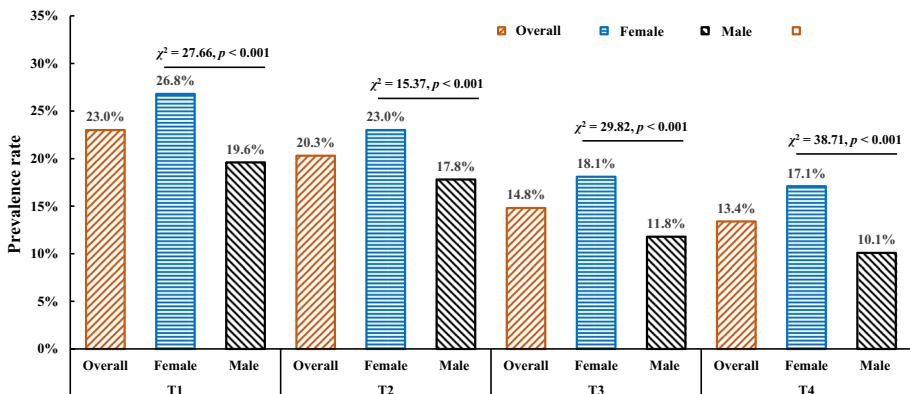

Fig. 2 The prevalence of social anxiety in male and female college students across four timepoints

Table 1 Zero-order correlations among main variables

Variables	1	2	3	4	5	6	7
1. Social anxiety (T_1)	1						
2. Social anxiety (T_2)	0.68***	1					
3. Social anxiety (T_3)	0.58***	0.65***	1				
4. Social anxiety (T_4)	0.55***	0.61***	0.75***	1			
5. Smartphone addiction (T_1)	0.38***	0.31***	0.29***	0.28***	1		
6. Smartphone addiction (T_4)	0.31***	0.32***	0.41***	0.48***	0.49***	1	
7. Internet game addiction (T_5)	0.20***	0.23***	0.27***	0.28***	0.20***	0.30***	1
Mean	5.37	5.08	4.27	4.12	34.54	30.17	11.42
SD	3.33	3.28	3.35	3.38	9.53	11.33	4.21

***$p < 0.001$. T = Time

intercept ($b = 8.28$, SE $= 0.36$, $p < 0.001$), linear slope ($b = 1.17$, SE $= 0.28$, $p < 0.001$) and quadratic slope ($b = 0.05$, SE $= 0.01$, $p < 0.001$) were also significant, suggesting significant inter-individual differences in both the initial level and the change trend of social anxiety.

Identification of Distinct Social Anxiety Trajectories

As shown in Table 2, model selection criteria were used to identify the optimal social anxiety trajectories. The four- and five-class models were not considered as the percentage of the smallest group was below 5% in both models (Nylund et al., 2007). The AIC, BIC and SSBIC all decrease from one- to four- class solution, which indicated improved model fit compared with base model. The significant LRT statistics produced by the three-class model supported accepting the hypothesis of a third trajectory. Additionally, the three-class model showed a higher entropy value than the two-class model. Based on these criteria mentioned above and the theoretical meaningfulness of group membership, the three-class model was finally chosen.

The final model included three trajectory groups (see Table 3 and Fig. 3). Specifically, the first trajectory group (n=3103, 80.37%), labeled as the "*low-decreasing group*", consisted of participants who reported low levels of social anxiety across four waves. The second trajectory group (n=515, 13.33%), named the "*high-stable group*", was characterized

Table 2 Model fit statistics for growth mixture models

Classes	AIC	BIC	SSBIC	Entropy	LRT p value	BLRT p value	Smallest Group
1-class	70427.49	70508.84	70467.54	NA	NA	NA	NA
2-class	70222.84	70329.24	70275.22	0.70	< 0.001	< 0.001	14.2%
3-class	**70064.31**	**70195.74**	**70129.01**	**0.77**	**0.003**	**0.004**	**6.3%**
4-class	69394.58	69551.05	69471.61	0.80	0.02	0.02	2.0%
5-class	69402.58	69584.08	69491.94	0.82	< 0.001	< 0.001	0.02%

Bold indicates final class solution; *AIC* Akaike information criterion, *BIC* Bayesian information criterion, *SSBIC* Sample size adjusted Bayesian information criterion, *LRT* Likelihood ratio test, *BLRT* Bootstrap likelihood ratio test. NA = Not available

Table 3 Growth factor parameter estimates of three-class model for PDMU

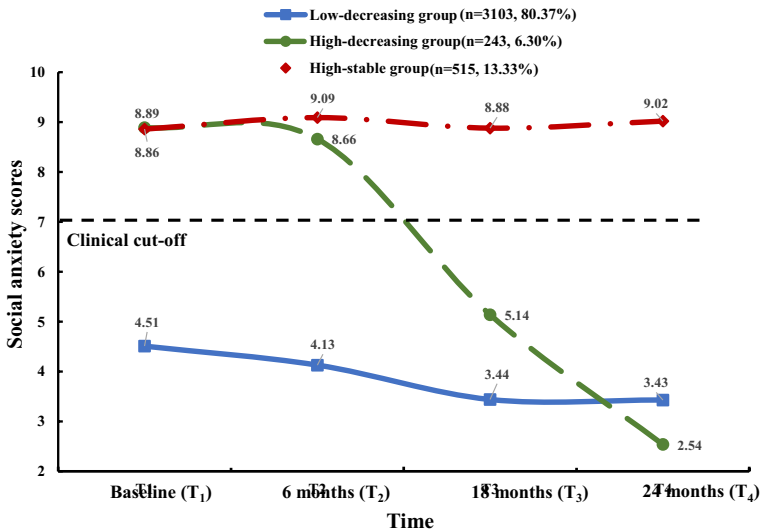| Change patterns	Intercept Mean (S.E.)	Slope mean (S.E.)	Quadratic mean (S.E.)
Moderate-decreasing pattern	8.11 (0.12)***	-0.89 (0.11)***	0.11 (0.03)***
High-decreasing pattern	11.83 (0.42)***	-0.22 (0.94)	-0.51 (0.23)*
High-increasing pattern	9.84 (0.19)***	-0.56 (0.20)**	0.27 (0.05)***

$*p < 0.05$, $**p < 0.01$, $***p < 0.001$; S.E. = Standard Error

Fig. 3 Trajectories of social anxiety in college students across four timepoints

by participants' social anxiety being above the clinical cutoff across all time points. The third trajectory group (n=243, 6.30%) named the "*high-decreasing group*", presented with an initial high level of social anxiety and gradually decreased over time.

Associations Between Social Anxiety Trajectories and Internet-Related Addictive Behaviors

Binary logistic regression analysis was conducted to examine whether social anxiety trajectories could prospectively predict internet-related addictive behaviors. As presented in Table 4, after adjusting demographic information and smartphone addiction at T_1, the results showed that, compared with high-stable group, individuals in low-decreasing group (OR = 0.26, 95%CI = 0.20-0.35) and high-decreasing group (OR = 0.15, 95%CI = 0.10-0.22) were less likely to experience smartphone addiction at T_4. Furthermore, after adjusting for demographic information, we found that compared with high-stable group, individuals in low-decreasing group (OR = 0.15, 95%CI = 0.11-0.22) and high-decreasing group (OR = 0.20, 95%CI = 0.09-0.44) were also less likely to experience Internet game addiction at T_5.

Table 4 Binary logistic regression of social anxiety trajectories on smartphone addiction and Internet game addiction

	Change patterns	Smartphone addiction at T_4 [a]			Internet game addiction at T_5 [b]		
		OR	95%CI	p	OR	95%CI	p
Crude model	High-stable group		Ref			Ref	
	Low-decreasing group	0.22	0.17 to 0.29	< 0.001	0.17	0.12 to 0.24	< 0.001
	High-decreasing group	0.16	0.11 to 0.24	< 0.001	0.22	0.10 to 0.49	< 0.001
Adjusted model	High-stable group		Ref			Ref	
	Low-decreasing group	0.26	0.20 to 0.35	< 0.001	0.15	0.11 to 0.22	< 0.001
	High-decreasing group	0.15	0.10 to 0.22	< 0.001	0.20	0.09 to 0.44	< 0.001

[a] included covariates in the adjusted model: gender, age, the only child, parental education levels, and smartphone addiction at T_1

[b] included covariates in the adjusted model: gender, age, the only child, parental education levels at T_1

Discussion

Utilizing a longitudinal design combined with a person-centered approach, this study conducted the first examination of the developmental trajectory of social anxiety and explored the impacts of specific change patterns of social anxiety on subsequent internet-related addictive behaviors. Three distinct trajectories of social anxiety were identified: low-decreasing group, high-decreasing group, and high-stable group. Compared with the high-stable group, individuals in low-decreasing group and high-decreasing group were less likely to develop subsequent smartphone addiction and Internet game addiction even after adjusting for other covariates.

The Prevalence of Social Anxiety

The present study has found a varying prevalence of probable social anxiety among college students, ranging from 13.4% to 23.0% at different time points. The high prevalence of social anxiety indicates the necessity to providing appropriate support for high-risk individuals. Additionally, our results found a significant downward trend in the prevalence of social anxiety, suggesting that the psychological adjustment of college students improves gradually throughout their university stage. In a previous meta-analysis, B. Chen et al. (2023) summarized the developmental trajectory of social anxiety from toddlerhood to young adulthood, highlighting a gradual decline in the average level of social anxiety during emerging adulthood (ages 18-25). With regard to gender differences, female students reported higher prevalence rates than males, which was in line with previous empirical studies (Asher et al., 2017; Caballo et al., 2014; MacKenzie & Fowler, 2013). The reasons for the higher prevalence rate in females are multifactorial. On the one hand, physiological differences such as genetic vulnerability, hormone and cortisol levels, may manifest in emotional and behavioral variations between females and males (McHenry et al., 2014; McLean & Anderson, 2009). These physiological differences can result in varying sensitivities towards stressors, making females more vulnerable to psychosocial stressors like interpersonal conflicts and increasing their likelihood of experiencing social anxiety than males. On the other hand, self-construal theory posits that females have stronger

interpersonal orientations than males (Cross & Madson, 1997). Females are more likely to self-blame in relationship problems and exhibit greater concern about negative evaluations from peers (Rudolph, 2002). This emphasis on interpersonal relationships may contribute to females' heightened susceptibility to social anxiety.

Distinct Developmental Trajectories of Social Anxiety

The present study highlights substantial individual variations in the trajectories of social anxiety among college students. Three distinct trajectories of social anxiety were found, namely, *low-decreasing group*, *high-decreasing group*, and *high-stable group*. First, the predominant pattern observed was low-decreasing group, indicating that the majority of college students possess effective social skills to engage in positive social interactions. Second, about 6.3% of students belonged to the high-decreasing group, showing a recovery pattern characterized by initially high levels of social anxiety that decreased significantly over time. This finding is consistent with a three-wave longitudinal study by Gao et al. (2021), which also identified a recovery group comprising 7.1% of participants experiencing a decline in anxiety symptoms from freshman to junior year. One possible explanation for this recovery pattern is that transition to college can often be a stressful experience for students, requiring them to navigate a new social environment and rebuild their social networks (Arnett, 2015; Zhao et al., 2023). These challenges and changes may exacerbate social anxiety. Although these students may initially struggle with adjustment difficulties upon entering university, they may develop increased adaptability, expand their social networks, and undergo psychological growth over time (Gale & Parker, 2014). This process can lead to improvements in the quality of interpersonal relationship quality and the acquisition of social support, ultimately resulting in a significant reduction in social anxiety. However, it is noteworthy that about 13.33% of participants displayed chronic social anxiety. Compared to other peers, these students may have higher levels of trait social anxiety. Trait anxiety is a personality trait that demonstrates consistency across different situations (Karasewich & Kuhlmeier, 2020). Individuals with trait social anxiety tend to engage in inhibitory and avoidant behaviors during social interactions. Early identification and targeted intervention programs are necessary for supporting these students.

Social Anxiety Trajectories and Subsequent Internet-Related Addictive Behaviors

Although a growing number of studies have explored the relationship between social anxiety and internet-related addictive behaviors (Gioia et al., 2022; Ran et al., 2022), limited investigations have examined whether distinct profiles or classes of social anxiety are differentially linked to subsequent internet-related addictive behaviors. The current study addressed this gap and revealed that the probability of internet-related addictive behaviors was significantly lower in the low-decreasing group and high-decreasing group compared to those in high-stable group. This suggests that the likelihood of engaging in addictive behaviors also decreases as social anxiety decreases. This result was consistent with our research hypothesis and extended the findings of the literature (Gao et al., 2021; Kim et al., 2022). For example, Gao et al. (2021) conducted a three-wave longitudinal survey and found that individuals in the low-stable anxiety group had a significantly lower probability of internet addiction compared to the recovery group and the escalating group.

These results support both the compensatory Internet use model (Kardefelt-Winther, 2014) and the cognitive-behavioral model of pathological Internet use (Davis, 2001). The

Internet can provide comfort and reinforcement for individuals, positively reinforcing peer connections and negative reinforcing the avoidance of negative emotional states (Lavoie et al., 2023). On the one hand, college students with social anxiety may perceive the internet as a compensatory mechanism for the lack of social and emotional connections in their offline world. For them, smartphones or online games can serve as essential tools for maintaining current friendships (Valkenburg & Peter, 2007) and establishing new connections and social relationships (Marino et al., 2020). Research has shown that individuals with higher levels of social anxiety can perceive themselves as more successful through online communication, compared to face-to-face interactions (Shalom et al., 2015), all of which make them more susceptible to internet-related addictive behaviors (Sioni et al., 2017). On the other hand, internet-related addictive activities may represent coping mechanisms to alleviate symptoms of psychopathology and/or negative emotions (Blasi et al., 2019). Social networks and video games can help individuals escape from real-life stressors, problems, and feelings of isolation through online social interactions (Billieux et al., 2013). In contrast, individuals with low social anxiety are more inclined to engage in real-life socialization with peers and employ positive coping styles, thus maintaining a low probability of engaging in addictive behavior.

Clinical Implication

Given the heterogeneity of social anxiety, mental health practitioners in school settings should recognize the importance of long-term and continuous monitoring of social anxiety among college students. Early intervention for social anxiety, a modifiable risk factor, shows promise in improving internet-related addictive behaviors of college students. Numerous intervention studies have confirmed that cognitive behavioral therapy (CBT) can be a feasible approach for treating social anxiety (Goldin et al., 2016; Heimberg, 2002; Rodebaugh et al., 2004). CBT involves addressing unhelpful behaviors that contribute to maintaining social anxiety, such as avoidance, safety behaviors, and self-focus. In addition to traditional multi-stage psychotherapy, brief interventions can also serve as valuable alternatives or supplements, particularly in addressing the stigma associated with of mental health interventions and the limited resources available in higher education settings. For instance, a week-long imaginal exposure exercise conducted through a smartphone application has been confirmed effective in managing social anxiety (Schwob & Newman, 2023).

Strengths, Limitations, and Further Research

This study has several strengths, including the large sample size, longitudinal design, and utilization of a person-centered approach to investigate the relationship between social anxiety trajectories and internet-related addictive behaviors. However, several limitations should be acknowledged. First, all variables were assessed using self-reported questionnaires rather than clinical diagnosis to facilitate data collection from a large sample size. However, this reliance on self-report measures introduces the potential for response inaccuracies and social desirability bias. To enhance the reliability of future research, it would be advantageous to incorporate multiple assessment methods, such as clinical interviews and behavioral measures. Second, the measurement of IGD was only assessed at T_5, which means that, IGD at baseline was not controlled for when examining the relationship between social anxiety trajectories and IGD. Cross-lagged panel model (CLPM) or random intercept cross-lagged panel model (RI-CLPM) can be used in future studies to explore the

dynamic relationship between social anxiety and online-related addictive behaviors. Third, although the sample was large, the participants were limited to university students, which limited the generalizability of the current findings to other populations. Future research should aim to include more diverse and representative samples to replicate these findings. Finally, our data were collected during the COVID-19 pandemic. The participants were likely to experiencing reduced offline social interactions due to lockdown measures, which could have influenced their levels of social anxiety (Morrissette, 2021; Thompson et al., 2021).

Conclusion

Three distinct trajectories of social anxiety were found among Chinese college students, including a low-decreasing group (80.37%), a high-decreasing group (13.33%), and a high-stable group (6.30%). Additionally, compared to those in high-stable group, college students in low-decreasing group and high-decreasing group were less likely to develop internet-related addiction. These findings advance our understanding of the relationship between the developmental trajectory of social anxiety and internet-related addictive behaviors.

Data Availability The dataset used and/or analyzed during the current study is available from the corresponding author on reasonable request.

Declarations

Ethics Approval The present study protocol was reviewed and approved by the Research Ethics Committee of the corresponding author's institution. All participants provided informed consents before completing the questionnaires, and were paid after completing the whole questionnaires.

Conflict of Interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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