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The association between autistic traits and excessive smartphone use in Chinese college students: The chain mediating roles of social interaction anxiety and loneliness

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ABSTRACT

This study draws upon a large sample of Chinese college students to examine the chain mediating roles of social interaction anxiety and loneliness in the relation between autistic traits and excessive smartphone use. To test our hypothesis that social interaction anxiety and loneliness mediate the relation between autistic traits and excessive smartphone use, we recruited a sample of 1103 college students and asked them to complete an assessment that measured the degrees of autistic traits, social interaction anxiety, loneliness, and excessive smartphone use. The results showed significant correlations among these variables. More autistic traits, which are correlated with higher levels of social interaction anxiety and higher levels of loneliness, were found to be associated with excessive smartphone use. In conclusion, this study highlights the need for screening for excessive smartphone use among college students who demonstrate autistic traits. Social interaction anxiety and loneliness show great potential in screening for excessive smartphone use among college students with high levels of autistic traits. We discuss the practical implications of the findings and directions for future study.

1. Introduction

In recent years, along with the rapid development of communications and information technologies, smartphone penetration and usage has been increasing in young people, particularly college students (Huang et al., 2020). Smartphones offer extended functions and a wide range of applications including three important types: interpersonal communication, entertainment, and information seeking (Jiang & Zhao, 2016). In China, smartphones play an important role in daily life, but the use and addiction process of smartphones vary according to the users' needs and desires. Some individuals use their smartphones for routine activities, such as making payments, distance learning, or sending and receiving work emails, and these activities might be associated with few negative effects. However, some people are addicted to the entertainment and social features of their smartphones, such as social networking, short videos, and mobile games, even develop a pathological dependence on their smartphones (Olson et al., 2022). Researchers widely agree that excessive smartphone use is defined as extreme cognitive, emotional, and behavioral smartphone involvement

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(Hefner et al., 2019), exhibiting addictive symptoms and signs of deficient self-regulation, such as preoccupation and an inability to control cravings (Bian & Leung, 2015). Researchers have previously found that more excessive smartphone use may negatively influence the mental health and well-being of young people, as it is associated with poorer sleep quality, higher perceived stress, increased anxiety, and increased odds of depression (Liu et al., 2022). In addition to these psychological consequences, excessive smartphone use can potentially impair cognitive functioning, as it is correlated with the impairment of specific attention domains, such as focused attention and divided attention, and changes in social cognition (Wacks & Weinstein, 2021). Thus, to improve college students' mental health and well-being, it is important to improve our understanding of the mechanisms by which excessive smartphone use develops.

1.1. Autistic traits within the context of excessive smartphone use

Autism spectrum disorder (ASD) is a set of neurodevelopmental conditions characterized by challenges in communication and limited social interaction and repetitive patterns of behavior, activity, or interest (American Psychiatric Association, 2013). Autistic traits are assumed to be distributed continuously throughout the general population (Baron-Cohen et al., 2001; De Groot & Van Strien, 2017). Higher levels of autistic traits are associated with increased sensitivity, attention to detail, and intense focus on specific tasks, but also poorer affect recognition, impaired social interactions, decreased fantasy life, and poorer communication skills (Mandy et al., 2018; Zhao et al., 2019). Studies have found that autistic traits are positively correlated with social interaction anxiety and loneliness among adolescents and young adults (Lei & Russell, 2021; Schiltz et al., 2021). Higher levels of autistic traits were associated with more mental health problems (e.g., anxiety and loneliness) in college student samples (Stice & Lavner, 2019; Yang et al., 2021).

Previous studies have demonstrated that individuals with more autistic traits may be more likely to use smartphone excessively due to their deficits in social communication and difficulties in building and maintaining real-life relationships (Concerto et al., 2021). In fact, smartphone and online communication may represent a more accessible way for individuals with high levels of autistic traits to communicate with other people because the internet diminishes the constraints that they experience in offline interactions (Finkenauer et al., 2012). Furthermore, according to the compensatory internet use theory, individuals with low psychological well-being might rely on their smartphones to reduce the complexity of their social environment and create the opportunity for more protected interactions (Kardefelt-Winther, 2014). Although smartphones may be attractive and helpful mediums for individuals with high levels of autistic traits, it is important to closely monitor excessive smartphone use and its potentially addictive properties to ensure that smartphone use does not have many negative effects on the individual's offline social relationships (Kerkhof et al., 2011).

There may be an association between autistic traits and excessive smartphone use. Furthermore, higher levels of autistic traits may create the conditions that develop more excessive smartphone use by affecting psychological well-being (McCarthy et al., 2020). Although several studies have tested the link between autistic traits and internet addiction using adult and adolescent samples (Chen et al., 2015; Concerto et al., 2021), few studies have investigated the relation between autistic traits and excessive smartphone use. This study thus examined whether social interaction anxiety and loneliness serially mediate the association between autistic traits and excessive smartphone use among Chinese college students.

1.2. The mediating role of social interaction anxiety in the relation between autistic traits and excessive smartphone use

Social interaction anxiety refers to the persistent fear of situations involving social interaction, social performance, or social situations in which there is the potential for negative evaluation by others (American Psychiatric Association, 2013). Socially anxious individuals may have a social interaction deficit and use inefficient coping mechanisms (e.g., excessive smartphone use) (Konan & Celik, 2019). Studies have shown that higher levels of autistic traits are associated with heightened social interaction anxiety (Dickter et al., 2018; Lei & Russell, 2021). Individuals with higher degrees of autistic traits seem likely lack not only social skills and social knowledge, but lack the initiative to engage in interpersonal interaction (Baiano et al., 2021), which may be associated with psychological distress and higher levels of social interaction anxiety (Rosbrook & Whittingham, 2010). This suggests that the presence of multiple autistic traits may be associated with increased social interaction anxiety (Yang et al., 2021).

Furthermore, previous studies have found that individuals with increased social interaction anxiety often have more excessive smartphone use (Turgeman et al., 2020). Compared to interacting in real life, individuals with higher levels of social interaction anxiety may tend to have a perceived need for smartphone use, which fulfills the need to interact in a less direct way (Lee et al., 2014). Individuals who are socially self-conscious may seek pseudo-social connections through their devices. This behavior may be correlated with heavy smartphone use and technological dependency (Wang, 2017), which is likely to decrease the individual's anxiety during interactions with others because it provides opportunities to think more about every reply in a conversation (Konan & Celik, 2019). Thus, this study hypothesized that social interaction anxiety plays a mediating role in the relation between autistic traits and excessive smartphone use. In addition to social interaction anxiety, loneliness may play an important mediating role in the relation between autistic traits and excessive smartphone use. This is further discussed below.

1.3. The mediating role of loneliness in the relation between autistic traits and excessive smartphone use

Loneliness is defined as a subjective discrepancy between the social connections one desires and those that are available (Ernst et al., 2021). It has been observed that higher levels of autistic traits are related to higher levels of loneliness (Schiltz et al., 2021). This can probably be explained by the fact that individuals with more autistic traits may have poorer social cognition, information processing, and social interaction abilities (Mandy et al., 2018), which makes it difficult for them to form relationships and positions them

on the social perimeter. One study found that individuals with more autistic traits had fewer friends and shorter friendships and were more likely to feel lonely (Stice & Lavner, 2019). Individuals with autistic traits may also be reluctant to reveal their true feelings, and they may pay more attention to themselves while interacting with others (Lee & Ko, 2018). This supports the idea of a close relation between autistic traits and loneliness.

In addition, there may be an association between loneliness and excessive smartphone use. It has been reported that aversive feelings associated with loneliness motivate individuals to reconnect with other people (Cacioppo et al., 2015). In other words, lonely individuals are aware of their unmet social needs, difficulties in interacting, and less satisfying relationships (Kornienko et al., 2020), and they use various approaches to cope with this situation. Given the risk of offline social withdrawal, lonely individuals frequently use non-face-to-face social media (e.g., Twitter, Facebook, and WeChat) and entertainment apps (e.g., TikTok and YouTube) on their smartphones to relieve stress and renew their social connections (Li et al., 2021). Substantial research has documented that the higher the level of loneliness in an individual, the more likely the individual is to indulge in entertaining smartphone use (Cheng et al., 2021; Kayis et al., 2021). Therefore, loneliness may be another mediator in the relation between autistic traits and excessive smartphone use.

1.4. Mediating effects of social interaction anxiety and loneliness in the relation between autistic traits and excessive smartphone use

It has been shown that higher social interaction anxiety is associated with increased levels of loneliness (Kealy et al., 2021). The cognitive behavioral model of social interaction anxiety proposes that individuals' attention to evaluation from others is one of the main causes of social interaction anxiety. Accordingly, individuals with higher levels of social interaction anxiety are more likely to fear negative evaluation from those with whom they interact (Fungi et al., 2017). Such a negative expectancy bias interferes with individuals' attempts to interact with others, which may detrimentally affect their ability to engage in appropriate social interaction, which may in turn elevate their experience of loneliness (Liu et al., 2020). A recent study empirically demonstrated that social interaction anxiety plays a unique role in the onset and maintenance of loneliness (Lim et al., 2016).

Therefore, individuals with higher autistic traits may have more social interaction anxiety, which could be associated to greater loneliness, in turn relating to the tendency to engage in excessive smartphone use. In other words, together, social interaction anxiety and loneliness serially mediate the association between college students' autistic traits and excessive smartphone use.

1.5. Theoretical framework

This study explored the mechanism underlying the relation between autistic traits and excessive smartphone use according to compensatory internet use theory (Kardefelt-Winther, 2014). This theory posits that negative life situations may motivate individuals to go online to mitigate their negative emotions, and frames internet use as a coping strategy to compensate for the things that individuals might lack in real life. Individuals with higher levels of autistic traits, who are more likely to lack social stimulation and social skills, may feel uncomfortable communicating face-to-face with others, which may make them feel anxious in social situations (Baiano et al., 2021). This may be associated with feelings of loneliness and isolation (Stice & Lavner, 2019). Accordingly, to cope with negative emotions and stress, individuals experiencing social interaction anxiety and loneliness may resort to increased smartphone use as a coping mechanism, either for increased comfort when socializing or for entertainment. Social interaction anxiety and loneliness have already been shown to positively associate with the extent to which individuals report using their smartphones to regulate and compensate for their social fears (Jin & Park, 2013; Shepherd & Edelmann, 2005). Based on compensatory internet use theory, we proposed that the relation between autistic traits and excessive smartphone use would be serially mediated by social interaction anxiety and loneliness. The hypothesized model is shown in Fig. 1.

2. Methods

2.1. Participants

We conducted a cross-sectional survey in Guangdong province in southern China from November 2020 to January 2021. The researchers contacted local college students who did not have formal diagnoses of ASD or other medical conditions. Eligible participants were given a description of the study and asked whether they would be willing to participate. After providing their informed consent, the participants were asked to complete an anonymous self-report questionnaire to provide demographic information and data on their autistic traits, social interaction anxiety, loneliness, and excessive smartphone use. The recruitment and data collection

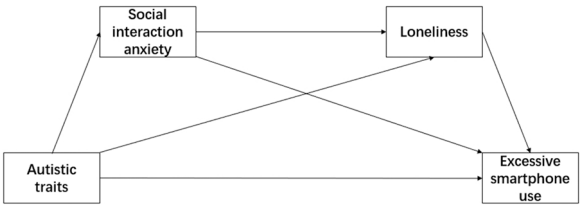

Fig. 1. Research model.

procedures were approved by the Ethics Committee of the authors' university.

The initial sample included 1377 participants. We excluded all questionnaires with missing construct-level data. Questionnaires that take less than 300 s to answer are exclusive. The final sample included 1075 valid questionnaires. Of the respondents, 303 were males and 772 were females. Their average age was 39.71 years, and the age range was 18–26 years (please note that 15 participants did not report their age). The breakdown by area of study was as follows: 493 were humanities students, 162 were social sciences students, and 420 were science and engineering students. All participants were intellectually able adults with a long-term residence in China. Detailed information on the sample is shown in Table 1.

2.2. Measures

2.2.1. Brief demographic questionnaire

The respondents were asked about their age, gender and area of study. They were also asked about the grade level and whether or not they were only children.

2.2.2. Autism-Spectrum Quotient

The Autism-Spectrum Quotient is a self-administered questionnaire developed by Baron-Cohen et al. (2001). The scale has five dimensions: social skill, attention switching, attention to detail, communication, and imagination. The items are scored 0 or 1, with the total score ranging from 0 to 50. Every response that is characteristic of autism scored 1 if the respondent responds "definitely agree" or "slightly agree" and 0 if the respondent chooses "definitely disagree" or "slightly disagree". Higher scores indicate higher levels of autistic traits (Baron-Cohen et al., 2001). An example item is "I find social situations easy." This scale has demonstrated good reliability and validity in Chinese student samples (Zhang et al., 2016). For the current study, the Cronbach's alpha coefficient was .661.

2.2.3. Social Interaction Anxiety Scale: short form

The short form of the Social Interaction Anxiety Scale (SIAS-6) is a self-report measure of the severity of underlying social interaction anxiety (Peters et al., 2012) consisting of six statements. Respondents rate how characteristic of themselves the statements are using a five-point scale, which ranges from 0 (i.e., not at all characteristic or true of me) to 4 (i.e., extremely characteristic or true of me). Higher scores indicate greater social interaction anxiety. An example item is "I have difficulty talking with other people." It has a similar structure to the original form, and has good aggregation validity and reliability validity (Peters et al., 2012). This scale demonstrated good reliability and validity in Chinese student samples (Wang et al., 2018). For the current study, the Cronbach's alpha coefficient was 0.789.

2.2.4. UCLA Loneliness Scale

The ULS-8 Loneliness Scale was developed by Hays & DiMatteo (1987). It includes eight items, with six positive sequence entries and two reverse-scored items. Each item is rated on a four-point scale, ranging from "never" to "always", with higher total scores indicating greater loneliness. An example item is "I feel isolation from others." This scale has demonstrated good reliability and validity in Chinese student samples (Xu et al., 2018). For the current study, the Cronbach's alpha coefficient was .722.

2.2.5. Smartphone Addiction Scale-Short Version

The SAS-SV was developed by Kwon et al. (2013). It consists of 10 symptoms of excessive smartphone use. Each item is rated on a six-point Likert-type self-report scale, where 1 represents "strongly disagree" and 6 represents "strongly agree". Higher scores indicate greater levels of excessive smartphone use. An example item is "Missing planned work due to smartphone use." And we changed item 8 of the original SAS-SV, "Constantly check your smartphone so as not to miss other people's conversations on Twitter or Facebook" by replacing "Twitter or Facebook" with "WeChat, Weibo or QQ", as these are more relevant to the study population. The Chinese version of SAS-SV demonstrated good reliability and validity (Cheung et al., 2019). For the current study, the Cronbach's alpha coefficient was .889.

Table 1
Demographic information.

Variables	Prevalence	Variables	Prevalence
Age (M ± SD)	20.08 ± 1.586	Grade	
Gender		freshman	236 (21.89 %)
Male	303 (28.29 %)	sophomore	366 (33.95 %)
Female	772 (71.71 %)	junior	280 (25.97 %)
Subjects		senior	193 (18.18 %)
Humanities	493 (45.92 %)	Regularity of exercise	
Sociology	162 (15.12 %)	never	73 (6.86 %)
Polytechnic	420 (38.96 %)	once a week or less	467 (43.41 %)
Only-child status		two to four times a week	436 (40.54 %)
Yes	305 (28.48 %)	five to seven times a week	99 (9.18 %)
No	770 (71.52 %)		

Note. N = 1075.

2.3. Statistical analyses

Common method bias was assessed using Harman's single factor test and was indicated as a concern if one factor explained more than 50 % of the total variance. Pearson correlations were then calculated to detect the initial bivariate relations between the variables. The bias-corrected percentile bootstrap method was used to test the hypothesized chain mediation model. The chain mediation model (Model 6, the Process Macro; Hayes, 2013) was implemented with 5000 bootstrap samples and 95 % corrected confidence intervals (CIs). Autistic traits was the independent variable (X), excessive smartphone use was the dependent variable (Y), social interaction anxiety was the first order mediator (M_1), and loneliness was the second order mediator (M_2). The demographic variables (gender, age) that were significantly correlated with any key variable served as covariates in the mediation analysis. The paths and their notations were as follows: a_1, effect of X on M_1; a_2, effect of X on M_2; a_3, effect of M_1 on M_2; b_1, effect of M_1 on Y; b_2, effect of M_2 on Y; c, total effect of X on Y; c', direct effect of X on Y while controlling for the effect of M_1 and M_2; ab, total indirect effect; a_1b_1, indirect effect of X on Y through M_1; a_2b_2, indirect effect of X on Y through M_2; $a_1a_3b_2$, indirect effect of X on Y through M_1 and M_2. The effect was considered significant when 95 % of the CIs did not contain zero. All analyzes were performed using SPSS software and the PROCESS macro.

3. Results

3.1. Common method bias

Common variance analysis was applied to the four questionnaires through factor analysis. The chi-square statistic of Bartlett's test of sphericity was significant. The results indicated that 18 factors had an eigenvalue higher than one; the first factor explained only 11.14 % of the total variance, which is less than the 40 % required by the critical standard (Podsakoff et al., 2003). This demonstrated that the questionnaires used in the current study had no significant common method biases.

3.2. Means, standard deviations, and correlations

The means and standard deviations for each variable and the correlations among them are presented in Table 2.

Autistic traits were significantly and positively correlated with social interaction anxiety, loneliness, and excessive smartphone use. Additionally, loneliness was significantly positively correlated with excessive smartphone use. The correlation between gender and smartphone use was also significant.

3.3. Chain mediation analysis

Fig. 3 presents the overall path coefficients of the mediation analysis. In the total effect model, autistic traits had a significant effect on excessive smartphone use ($c = 0.127, p < .001$, see Fig. 2). When social interaction anxiety and loneliness were included, the effect of autistic traits on excessive smartphone use was not significant ($c' = -0.010$, p = .757), while autistic traits had significant effects on social interaction anxiety ($a_1 = .357, p < .001$) and loneliness ($a_2 = .134, p < .001$). The effect of social interaction anxiety on loneliness was also significant ($a_3 = .354, p < .001$). Similarly, social interaction anxiety had a significant effect on excessive smartphone use ($b_1 = .249, p < .001$). Loneliness also had a significant effect on excessive smartphone use ($b_2 = .184, p < .001$). The total indirect effect was significant ($ab = 0.1366$, 95 % CIs [0.1040,0.1700], see Table 3), accounting for 61.42 % of the total effect of autistic traits on excessive smartphone use. The indirect effect of autistic traits through social interaction anxiety and loneliness was also significant ($a_1a_3b_2 = 0.0233$, 95 % CIs [0.0135,0.0341]), accounting for 10.52 % of the total effect of autistic traits on excessive smartphone use. The relation between autistic traits and excessive smartphone use was mediated by social interaction anxiety ($a_1b_1 = 0.0886$, 95 % CIs [0.0588,0.1199]), which accounted for 39.83 % of the total effect of autistic traits on excessive smartphone use. The relation between autistic traits and excessive smartphone use was also mediated by loneliness ($a_2b_2 = 0.0247$, 95 % CIs [0.0120,0.0398]), which accounted for 11.11 % of the total effect of autistic traits on excessive smartphone use.

4. Discussion

This study found that the scores for autistic traits in college students were significantly and positively correlated with their levels of

Table 2
Descriptive statistics and correlation matrix of all variables.

Variables	*M*	*SD*	1	2	3	4
1. Autistic traits	22.290	5.685	1			
2. Social interaction anxiety	10.316	3.700	0.348**	1		
3. Loneliness	18.800	3.996	0.258**	0.393**	1	
4. Excessive smartphone use	36.073	9.952	0.130**	0.319**	0.294**	1

Note. N = 1075.
** $p < .01$.

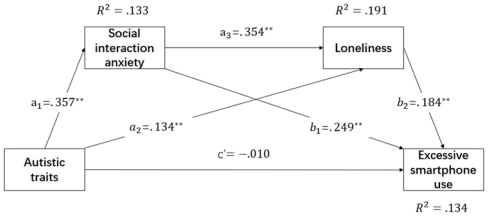

Fig. 3. Chain mediation model. *Note.* ** $p < .01$.

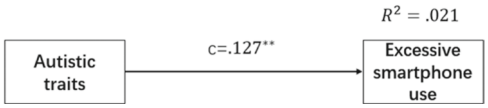

Fig. 2. Total effect model. *Note.* ** $p < .01$.

Table 3
Chain mediation analysis results.

		Effect	BootSE	95 % CI	
				Lower	Upper
c	Autistic traits → excessive smartphone use (total effect)	0.2224	0.0530	0.1184	0.3263
c'	Autistic traits → excessive smartphone use (direct effect)	-0.0167	0.0539	-0.1225	0.0891
ab	Total indirect effect	0.1366	0.0168	0.1040	0.1700
a_1b_1	Autistic traits → social interaction anxiety → excessive smartphone use	0.0886	0.0154	0.0588	0.1199
a_2b_2	Autistic traits → loneliness → excessive smartphone use	0.0247	0.0072	0.0120	0.0398
$a_1a_3b_2$	Autistic traits → social interaction anxiety → loneliness → excessive smartphone use	0.0233	0.0052	0.0135	0.0344

social interaction anxiety, loneliness, and excessive smartphone use. In addition, the results of the model showed that social interaction anxiety and loneliness played a chain-mediating role in the relation between autistic traits and excessive smartphone use in college students. Therefore, this study investigated the overuse of smartphones by individuals with high levels of autistic traits by focusing on social interaction anxiety and loneliness.

4.1. Descriptive statistics and correlations among the variables of interest

The overall mean score for autistic traits in our study was 22.29. This is slightly higher than the scores reported in previous studies of other Asian countries: 21.65 for Malaysia and 21.22 for India (Carruthers et al., 2018; Freeth et al., 2013). The data were collected through self-report scales during the COVID-19 pandemic, which may have influenced the students' subjective experience (Wu et al., 2021). We collected the data during the 2020 autumn semester, when all of the Chinese students had gone back to college for in-person classes after the long pandemic lockdown, and during online classes of the spring semester. These behaviors were associated with higher scores for unfamiliarity with social skills and communication. In line with previous studies, there was no significant gender difference in the overall mean autistic traits score (Yu et al., 2020). The correlation analyses support the significant relations between the main study variables. The results show that autistic traits indirectly encourage excessive smartphone use via three pathways: social interaction anxiety, loneliness, and the chain mediating effect of social interaction anxiety and loneliness.

4.2. Mediating roles of social interaction anxiety and loneliness

First, social interaction anxiety was shown to be an important mediator in the relation between autistic traits and college students' propensity for excessive smartphone use. This result is consistent with previous studies (Dickter et al., 2018; Turgeman et al., 2020). Although individuals with high levels of autistic traits may try hard to create a positive impression on others during social interactions, they often lack confidence in their presentation skills and familiarity with social situations, which can make them prone to getting stuck on negative self-referential cognitions, in turn increasing the possibility of developing social interaction anxiety (Baiano et al., 2021). Increased social interaction anxiety may bring a sense of shame related to their functional and emotional problems in social situations (Kanne et al., 2009), and such negative feelings may be associated with an avoidance of real-time relationships (Wood & Gadow, 2010) and a preference for participating in social life in a non-face-to-face way via smartphones (Lee et al., 2014). Hence, it is reasonable to conclude that college students with higher levels of autistic traits are more likely to overuse smartphones because of increased social interaction anxiety.

Second, the results showed that loneliness mediated the association between autistic traits and excessive smartphone use in college students. More autistic traits are related to higher levels of loneliness, which is consistent with the results of previous research (Schiltz

et al., 2021). The finding can be explained by the poorer social skills and attention switching ability in students with higher levels of autistic traits, which may negatively influence the quality of social interaction and subsequently develop a heightened sense of social discomfort (Bolis et al., 2021). This can be correlated with decreased opportunities for social connections and increase the perception of loneliness (Kall et al., 2020). Additionally, the mediating effect was consistent with previous studies that have suggested a positive relation between loneliness and excessive smartphone use (Cheng et al., 2021; Kayis et al., 2021). Many individuals choose to use their smartphones to satisfy their interpersonal communication and social interaction needs (Stice & Lavner, 2019). Due to the versatility and accessibility of smartphones (Salehan & Negahban, 2013), individuals with heightened loneliness may not be able to disengage from their smartphones in the long run and may therefore be more likely to use their smartphones excessively (Khang et al., 2013). In addition, the relation between loneliness and excessive smartphone use identified in this study may have been affected by the COVID-19 pandemic, and the results may thus have been overestimated. COVID-19 isolation restrictions have led to individuals involuntarily spending more time alone, and they may have experienced other maladjusted behaviors (e.g., excessive smartphone use) related to their efforts to decrease their loneliness. Students use their smartphones frequently not only for distance learning but also to make up for the loss of interpersonal intimacy and to cope with loneliness (Kayis et al., 2021).

Third, this study found that social interaction anxiety and loneliness play a chain-mediating role in the association between autistic traits and excessive smartphone use in college students. Previous research has found that socially anxious individuals are at increased risk of loneliness (Kealy et al., 2021; Lim et al., 2016). Individuals with heightened social interaction anxiety may have more difficulties with interpersonal relationships, as it is difficult for them to interact directly with people face to face (Sigurvinsdottir et al., 2021). Individuals with higher autistic traits describe themselves as being perceived as impolite by others and as having difficulties with long face-to-face conversations (Zhang et al., 2021), which might be related to more social interaction anxiety. Harboring negative beliefs about themselves and finding social environments difficult, they may experience greater avoidance and loneliness (Baytemir & Yildz, 2017). Individuals with greater social interaction anxiety and loneliness may therefore be more likely to view smartphones as enabling communication without interacting directly with others. This practice might have some initial positive effects (as a first solution to enable communication; Kardefelt-Winther, 2014), but later, if they live their lives via their smartphones, they may experience the pronounced negative effects of excessive smartphone use (Liu et al., 2022; Zhang et al., 2022). Thus, the path from social interaction anxiety to loneliness is an important catalyst for the effects of autistic traits on excessive smartphone use among college students.

4.3. Implications and future directions

The present study is an important step in understanding the link between autistic traits and excessive smartphone use among college students, as well as the underlying chain mediating mechanisms of this association. Previous researchers have attached importance to establishing tools and protocols that can accurately identify autistic traits (Daniels et al., 2014). To achieve this, an assessment mechanism for autistic traits in schools should be introduced in a timely manner along with corresponding services from professional psychologists. In conjunction, higher education institutions should provide effective support, such as promoting an inclusive culture in the classroom and increasing specific or individualized academic support for students with high levels of autistic traits (Davis et al., 2021). This study demonstrates that it is necessary to pay attention to and reduce excessive smartphone use among individuals with high levels of autistic traits to enhance meaningful and healthy behaviors that promote the development of social relationships and well-being (Bae, 2019). Focus should be placed on five domains of intervention: involuntary restriction, self-awareness and self-control, school factors, peer support, and professional services (Chun, 2018). Such strategies constitute an important step toward conceptualizing effective interventions.

This study also underscores the importance of social interaction anxiety and loneliness. Cognitive behavioral therapy is recommended for social interaction anxiety in the context of autism (Spain et al., 2018), as it shows efficacy in improving core social deficits such as a lack of sociability and the expression and interaction of autistic traits. More naturalistic forms of behavioral interventions that aim to increase social communication skills have been found to be effective at indirectly reducing symptoms of social interaction anxiety in autistic individuals (Lei et al., 2017). In addition, loneliness can be ameliorated by social interaction (Perese & Wolf, 2005). It is suggested that periodic collective counseling and collective activities (e.g., workshops, support groups) be provided, especially for college freshmen who are suffering a decline in family communication and support. These activities can facilitate positive interactions among students and help them remain in positive interpersonal relationships (Tian et al., 2019).

4.4. Limitations

Several limitations should be considered when interpreting the results of this study. First, this study only recruited college students in China. Second, the data used in this study were cross-sectional and could only reveal a correlation between autistic traits and excessive smartphone use in students, not a causal relation. Further research and experiments are needed to verify causality using longitudinal or experimental studies. Finally, the effect of autistic traits on excessive smartphone use may also be accounted for by other factors, such as emotion regulation and school connectedness. Future research should consider examining the chain mediating effect of factors other than social interaction anxiety and loneliness in the relation between autistic traits and excessive smartphone use.

5. Conclusions

This study investigated the overuse of smartphones by individuals with high levels of autistic traits focusing on social interaction anxiety and loneliness. The findings of the study indicate that social interaction anxiety and loneliness have a chain-mediating effect in the relation between autistic traits and excessive smartphone use. This research provides a new potential perspective to screen for excessive smartphone use in individuals with high levels of autistic traits.

CRediT authorship contribution statement

ML and TP conceived of the study, participated in its design and coordination and drafted the manuscript; FP and RW participated in interpretation of the data, performed the statistical analysis, and provided critical revisions; YL participated in data collection and provided critical revisions All authors read and approved the final manuscript.

Role of funding

The funders had no role in study design, data collection, analysis and interpretation of data, decision to publish, or preparation of the manuscript.

Compliance with Ethical Standards

All the authors of this article have no conflict of interest. All procedures performed in studies involving human participants were in accordance with the ethical standards of Guangzhou University and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors. Informed consent was obtained from all individual participants included in the study.

Declaration of Competing Interest

None.

Data Availability

The data that has been used is confidential.

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What this paper adds

Individuals with more autistic traits may be more likely to use smartphone excessively. However, few studies have explored the effects of psychosocial factors on excessive smartphone use in individuals with high levels of autistic traits. This study explored the mechanism underlying the relations between autistic traits, social interaction anxiety, loneliness, and excessive smartphone use. Social interaction anxiety and loneliness were found to play a chain-mediating role in the association between autistic traits and excessive smartphone use. The research provides a new potential perspective to screen for excessive smartphone use in individuals with high levels of autistic traits.

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