

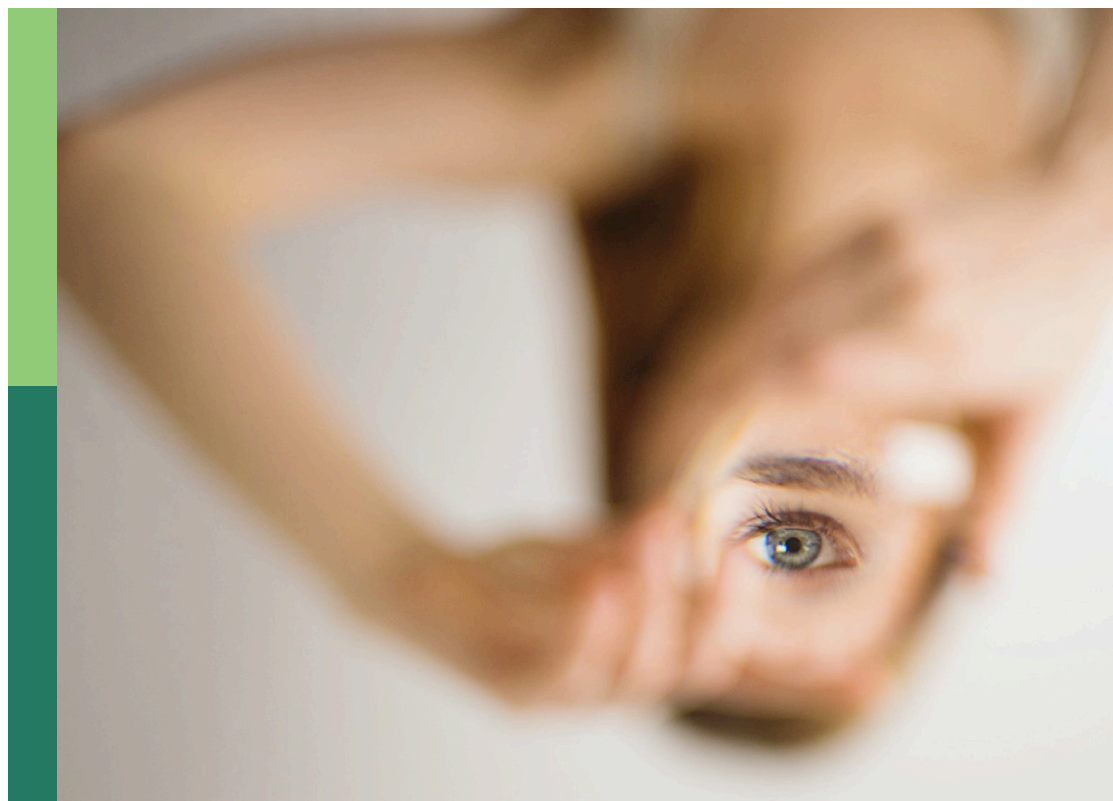
# Significant influencing factors and effective Interventions of mobile phone addiction, volume II

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# Significant influencing factors and effective Interventions of mobile phone addiction, volume II

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# Editorial: Significant influencing factors and effective interventions of mobile phone addiction, volume II

Qingqi Liu<sup>1</sup>, Zongkui Zhou<sup>2\*</sup> and Christiane Eichenberg<sup>3</sup>

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## KEYWORDS

mobile phone addiction, individual factors, environmental factors, interventions, mechanisms

## Editorial on the Research Topic

### Significant influencing factors and effective interventions of mobile phone addiction, volume II

The issue of mobile phone addiction has garnered significant attention among researchers over the past two decades. Expanding on our previous work, we have successfully completed the Research Topic titled “*Significant Influencing Factors and Effective Interventions of Mobile Phone Addiction - Volume II*”. This Research Topic encompasses both empirical research and meta-analysis studies. Empirical studies allow for the discovery of new insights, while meta-analysis enables the formulation of more robust conclusions based on a synthesis of multiple research findings. Meta-analyses in our Research Topic have extensively synthesized previous research findings regarding the impact of self-esteem, self-control, social support (Ding et al.), and academic burnout (Li S. et al.) on and exercise (Zhang et al.) mobile phone addiction. Our Research Topic has made notable advancements in understanding the causes of mobile phone addiction, as well as the practical implications for addressing this issue through effective interventions.

Our Research Topic contributes to a comprehensive understanding of influencing factors from both individual and environmental perspectives. Regarding individual factors, according to the Interaction of Person-Affect-Cognition-Execution model (Brand et al., 2019), addictive behaviors are the result of the interaction between individual personality, cognitive factors, emotional factors, and executive functions. Our Research Topic aligns well with the Person-Affect-Cognition-Execution model. In our Research Topic, personality factors such as self-esteem and self-control (Ding et al.), emotional factors such as anxiety and depression (Ge et al.), loneliness (Li G.-R. et al.), and academic burnout (Li S. et al.), cognitive factors such as automatic thoughts (Lian et al.), as well as executive dysfunction (Ge et al.), have all been confirmed to have significant predictive effects on mobile phone addiction. From an environmental perspective, the family is an important environmental micro-system that influences mobile phone addiction (Liu et al., 2020). In our Research Topic, family functioning (Li G.-R. et al.), family cohesion and adaptability (Lian et al.), and parenting style of encouraging autonomy (Li Z.-k. et al.) have all been found to be closely associated with mobile phone addiction. Moreover, based on comprehensive research findings, environmental factors not only predict mobile phone addiction through the mediation of individual factors, but also the predictive effect of environmental factors on mobile phone addiction varies depending on certain individual factors. In other words,

mobile phone addiction is a complex outcome resulting from the joint influence of external environmental factors and internal individual factors.

Our Research Topic delves deeper into intervention methods and their effectiveness. One study examines the direct and indirect effects of physical exercise on Internet addiction (Cheng et al.). Another meta-analysis systematically summarizes and compares the intervention effects of different types of exercise on Internet addiction (Zhang et al.). These studies not only inspire further research on internet addiction/mobile phone addiction but also offer empirical support and practical recommendations for future educational practices. Indeed, there are numerous other efficacious intervention approaches to address internet addiction and mobile phone addiction, including cognitive-behavioral therapy (Kim et al., 2018), mindfulness intervention training (Li et al., 2018), and family therapy (Liu et al., 2015), among others. Integrating physical exercise with these interventions has the potential to augment their practical efficacy in everyday life.

In summarizing our two Research Topics, it is evident that they hold significant theoretical and practical implications. However, they also present several areas that merit further investigation by future researchers. Firstly, our Research Topics did not comprehensively explore the complex interactions between multiple environmental systems and various individual factors. To achieve research results of greater ecological validity, it is crucial to consider the combined effects of these factors. Secondly, our Research Topics lacked studies simultaneously analyze and compare the effects of certain influencing factors on different types of internet addiction/mobile phone addiction. Different types of internet addiction/mobile phone addiction exhibit distinct behavioral characteristics (Liu et al., 2022). Revealing the influencing patterns of different types of internet addiction/mobile

phone addiction would contribute to more targeted interventions in practice. Lastly, our Research Topics did not extensively examine the intervention effects of various methods on mobile phone addiction, including cognitive-behavioral therapy, mindfulness intervention, family therapy, and compound psychotherapy. Attachment-based therapy may also be an effective intervention for mobile phone addiction, as insecure attachment has been identified as a risk factor (Eichenberg et al., 2019). In future research, it would be beneficial to focus on analyzing the effects, mechanisms and conditions of multiple intervention methods.

## Author contributions

QL: Writing—original draft, Writing—review and editing. ZZ: Writing—review and editing. CE: Writing—review and editing.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# The associations between smartphone addiction and self-esteem, self-control, and social support among Chinese adolescents: A meta-analysis

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**Background:** Smartphone addiction has become a social problem that affects the healthy growth of adolescents, and it is frequently reported to be correlated with self-esteem, self-control, and social support among adolescents.

**Methods:** A meta-analysis was conducted by searching the PubMed, Web of Science, Embase, PsycINFO, PsycArticles, China National Knowledge Infrastructure (CNKI), WANFANG DATA, and Chongqing VIP Information Co., Ltd. (VIP) databases. Stata 16.0 was used to analyse the overall effect and test the moderating effect.

**Results:** Fifty-six studies were included, involving a total of 42,300 participants. Adolescents' smartphone addiction had a moderately negative correlation with self-esteem ( $r = -0.25$ , 95% CI =  $-0.29$  to  $-0.22$ ,  $p < 0.001$ ), a strong negative correlation with self-control ( $r = -0.48$ , 95% CI =  $-0.53$  to  $-0.42$ ,  $p < 0.001$ ), and a weak negative correlation with social support ( $r = -0.16$ , 95% CI =  $-0.23$  to  $-0.09$ ,  $p < 0.001$ ). Moderation analysis revealed that the correlation between adolescents' smartphone addiction and self-esteem was strongest when smartphone addiction was measured with the Mobile Phone Addiction Tendency Scale for College Students (MPATS;  $r = -0.38$ ). The correlation between adolescents' smartphone addiction and self-control was strongest when self-control was measured with the Middle school students' Self-control Ability Questionnaire (MSAQ;  $r = -0.62$ ). The effect of dissertations on smartphone addiction, self-control, and social support among adolescents was significantly larger than that of journal articles. The correlation between adolescents' smartphone addiction and social support was strongest when smartphone addiction was measured with the Mobile Phone Addiction Index (MPAI;  $r = -0.24$ ). However, the correlations between adolescents' smartphone addiction and self-esteem, self-control, and social support were not affected by age or gender.

**Conclusion:** There was a strong relationship between smartphone addiction and self-esteem, self-control, and social support among adolescents. In the future, longitudinal research should be carried out to better investigate the dynamic changes in the relationship between smartphone addiction and self-esteem, self-control, and social support.

**Systematic review registration:** <https://www.crd.york.ac.uk/PROSPERO/>, identifier: CRD42022300061.

#### KEYWORDS

smartphone addiction, self-esteem, self-control, social support, adolescent, meta-analysis

## Introduction

In the current, rapidly developing information age, smartphones have gradually become an indispensable tool in people's lives due to their characteristics of instant satisfaction, accessibility and function integration (Kuss et al., 2018; Noë et al., 2019; Recio-Rodriguez et al., 2019). The multiple functions of smartphones have brought various conveniences and benefits to adolescents' daily lives, but if individuals use smartphones excessively and uncontrollably for a long time, they may develop smartphone addiction (Cebi et al., 2019; Huang et al., 2022). Smartphone addiction (also known as "smartphone dependence," "smartphone overuse," or "problematic smartphone use") is defined as a compulsive state in which an individual's physiological, psychological, and/or social functions are impaired due to the uncontrolled use of smartphones (Chóliz, 2010). It was categorized as a behavioral addiction (Takao et al., 2009; Yen et al., 2009), which manifests in symptoms including tolerance development and withdrawal, subjective loss of control, and functional impairment (Lee et al., 2014; Lin et al., 2016). At present, smartphone addiction has become a social problem that affects the healthy growth of adolescents. A large number of studies have found that smartphone addiction not only confers psychological and physiological effects on adolescents (e.g., anxiety, depression, and stress) but also negatively affects academic performance, coping styles, interpersonal relationships, etc., (Clayton et al., 2015; Samaha and Hawi, 2016; Lu et al., 2021; Diotaiuti et al., 2022; Wang et al., 2022; Yang et al., 2022; Zhang et al., 2022). Adolescents are in an important stage of developing peer relationships, pursuing autonomy and individuality, and changing behavior (Laursen and Hartl, 2013; Mak et al., 2014). Their strong curiosity and low level of self-control make them more vulnerable to problematic smartphone use (Munno et al., 2017), and thus, they have a higher risk of smartphone addiction (Cha and Seo, 2018; Kim and Lee, 2022). Data from multiple countries show that the incidence of smartphone addiction among adolescents has exceeded 30% (Davey and Davey, 2014; Lee and Lee, 2017; Xiang et al., 2019). Adolescence is a critical period of individual development (Lee C. P. et al., 2018) and an important period of development to reach psychophysiological maturity (Papalia et al., 2007). Therefore, it is necessary and

urgent to explore the influencing factors and mechanism of smartphone addiction in adolescents to better prevent and control it.

A large number of studies have explored the influencing factors of smartphone addiction, among which self-esteem, self-control and social support are considered to be the three factors that are most closely related to smartphone addiction (Lee J. et al., 2018; Dou et al., 2020; Fu et al., 2020; Peng et al., 2020; Li et al., 2021). Self-esteem is a subjective evaluation of one's own ability, value and significance, which is conveyed by attitude and verbal behavior (Coopersmith, 1981). Adolescents with low self-esteem hold negative beliefs about the self and often have a low sense of safety and a low sense of identity in interpersonal communication (Passanisi et al., 2015). However, they have stronger desire for social recognition and respect (Cooper et al., 2017), and were more concerned with maintaining interpersonal relationships (Paz et al., 2017), and seem to prefer to technology-mediated communication (e.g., email; Joinson, 2004), which lead them to the massive use of the mobile phone to obtain reassurance in affective relationships (Billieux et al., 2015). Most studies support this view, namely, that self-esteem is negatively related to smartphone addiction. However, empirical findings on the strength of the association have been mixed. For example, Lee J. et al. (2018) found a strong negative correlation between self-esteem and smartphone addiction among adolescents ( $r = -0.35$ ), Peng et al. (2020) found a moderately negative correlation between self-esteem and smartphone addiction among adolescents ( $r = -0.22$ ), while Wang and Lei (2021) found a weak negative correlation between self-esteem and smartphone addiction among adolescents ( $r = -0.16$ ).

Self-control refers to the ability of an individual to resist internal desires and external temptations to adhere to long-term goals (Tangney et al., 2004). The Deficient Self-regulation Model posits that adolescents with insufficient self-control may not be able to suppress their inner desire to use smartphones (Tokunaga and Rains, 2010), which may lead to an uncontrolled increase in smartphone use time and eventually to smartphone addiction. Many studies have revealed that self-control can negatively predict smartphone addiction. However, the correlation coefficients of different research results are quite different. For example, Li et al. (2016) found a strong negative correlation between self-control and smartphone addiction among adolescents ( $r = -0.49$ ); Jeong et al. (2020) found

a moderately negative correlation between self-control and smartphone addiction among adolescents ( $r = -0.29$ ); and Li et al. (2021) found a weak negative correlation between self-control and smartphone addiction among adolescents ( $r = -0.07$ ).

Social support is defined as the social support behaviors that individuals receive from other individuals and social networks (Heller et al., 1986). Compensatory Internet Use Theory suggests that when people encounter psychosocial problems in the real world, they may turn to the internet or smartphones to escape pain (Kardefelt-Winther, 2014). Adolescents with a low level of social support cannot establish intimate interpersonal relationships in real life, so they rely more on smartphones to meet their social needs, leading to a serious dependence on smartphones. Most studies supported this view and found a significant negative correlation between social support and smartphone addiction among adolescents (Fu et al., 2020). However, some researchers have argued the opposite view. For example, Jiao (2020) found a positive correlation between social support and smartphone addiction among adolescents ( $r = 0.13$ ); Wang et al. (2018) found a nonsignificant correlation between social support and smartphone addiction among adolescents ( $r = 0.00$ ).

To date, there is little consensus on the extent to which self-esteem, self-control and social support is correlated with smartphone addiction. Therefore, the first purpose of this study was to explore the relationship between adolescents' smartphone addiction and self-esteem, self-control, and social support.

As a secondary goal, we explored the potential moderators of effect sizes. Age, gender, publication type and measurement tools were considered as potential moderators. First, several previous meta-analyses have confirmed the age-specific distinctions in smartphone addiction (Zhang et al., 2020; Ran et al., 2022). Age may have some influence on the differences observed among different research samples. Second, compared with male adolescents, female adolescents tend to have lower levels of self-esteem (Estevez et al., 2017), their self-control is more vulnerable to external factors (Jo and Bouffard, 2014), and they receive more emotional support from others (Liebler and Sandefur, 2002). In addition, previous studies have revealed gender differences in the pattern of smartphone use (Jiang and Zhao, 2016; Volkmer and Lermer, 2019). Therefore, it is necessary to examine the moderating effect of gender. Third, in terms of publication type, studies with significant results are usually more likely to be published, so journal articles may exaggerate the real relationship between variables (Sterne et al., 2000). Finally, the focus of different measurement tools is different. The Mobile Phone Addiction Index (MPAI; Leung, 2008), Mobile Phone Addiction Tendency Scale for College Students (MPATS; Xiong et al., 2012), and Smartphone Addiction Scale (SAS; Kwon et al., 2013) are widely used tools for measuring smartphone addiction. These three measurement tools assess different aspects of smartphone addiction. The Rosenberg Self-Esteem Scale (RSES;

Rosenberg, 1965) is widely used for measuring self-esteem. The scale assesses individuals' overall cognitive evaluation of themselves, while other measuring tools, such as the Adolescent Self-esteem Questionnaire (ASQ; Hafekost et al., 2016) assesses stressors related to adolescents' lives. The Self-control Scale (SCS; Tangney et al., 2004) and the Middle school students' Self-control Ability Questionnaire (MSAQ; Wang and Lu, 2004) are widely used tools for measuring self-control; the former is targeted toward college students and assesses two dimensions, i.e., cognition and behavior; the latter is targeted toward middle and high school students and assesses three dimensions, i.e., emotional self-control, behavior self-control and thinking self-control. In terms of tools for measuring social support, the Multidimensional Scale of Perceived Social Support (MSPSS; Zimet et al., 1988) assesses individuals' subjective feelings and evaluations of social support, while the Social Support Rating Scale (SSRS; Xiao and Yang, 1987) emphasizes not only individuals' subjective feelings and evaluations of social support, but also the investigation of objective support and the utilization degree of support.

## Methods

This meta-analysis followed the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Page et al., 2021; see the checklist in Supplementary material 1) and was registered at PROSPERO (registration number CRD 42022300061).

## Literature search

The PubMed, Web of Science, Embase, PsycINFO, PsycArticles, China National Knowledge Infrastructure (CNKI), WANFANG DATA, and Chongqing VIP Information Co., Ltd. (VIP) databases were searched for eligible studies published up to July 28, 2022. To minimize publication bias, there were no restrictions regarding the date of publication. Search terms used for smartphones included "cell phone," "mobile phone," "smart phone," "smartphone," and "cellular phone." Search terms used for addiction included "addiction," "dependence," "abuse," "dependency," "addicted to," "overuse," "problematic use," and "compensatory use." Search terms used for self-esteem included "self-esteem," "Self-Esteem," "self-concept," "self-perception," "Self-Perception," "Self-Confidence," and "self-respect." Search terms used for self-control included "self-control," "self-regulation," "self-discipline," "effortful-control," and "impulse control." Search terms used for social support included "social support," "social care," "online social support," and "perceived social support." A detailed search strategy is available in Supplementary material 2. Furthermore, the reference lists of

the included studies were searched, and Chinese and English key words were used to identify additional eligible studies.

## Inclusion and exclusion criteria

The inclusion criteria were as follows: (a) the type of literature was a cross-sectional survey; (b) a validated tool was used to assess smartphone addiction and self-esteem, self-control, and social support; (c) the correlation coefficient between smartphone addiction and self-esteem, self-control, and social support was reported, and if the correlation coefficient of the total score was not reported, the full factor correlation coefficient should be reported; (d) the subjects were healthy adolescents; (e) published in English or Chinese; and (f) both published articles and dissertations were included. The exclusion criteria were as follows: (a) editorial, commentary, conference abstracts, and review articles; (b) studies with the same data published repeatedly; (c) literature with poor quality; and (d) studies with samples containing individuals with physical diseases or mental disorders.

## Data extraction

All studies were coded independently by two independent reviewers (YMD and XW). Any doubts or disagreements were resolved by consulting a third researcher (CRC). The following data were extracted: first author and year of publication, sample size, proportion of females, age, publication type, correlation coefficient, smartphone addiction scale, self-esteem scale, self-control scale, and social support scale (see Table 1). For the input of the correlation coefficient, there are the following coding standards: (a) If the correlation coefficient between smartphone addiction and self-esteem, self-control, and social support is not reported but the values of  $F$ ,  $T$ , and  $\chi^2$  are reported, they are transformed into the  $r$ -value by the corresponding formula ( $r = \sqrt{\frac{t^2}{t^2 + df}}$ ,  $df = n_1 + n_2 - 2$ ;  $r = \sqrt{\frac{F}{F + df_e}}$ ;  $r = \sqrt{\frac{\chi^2}{\chi^2 + N}}$ ) (Card, 2015). (b) The study effect size was encoded as an effect size according to the independent samples. If the study contained multiple independent samples, the article effect size was coded separately. (c) If only the correlation coefficients of certain dimensions between smartphone addiction and self-esteem, self-control, and social support were reported, the average of each dimension was taken before coding.

## Quality assessment

The quality of the studies was assessed independently by two reviewers (YMD and GLL). Any doubts or disagreements were resolved by centralized discussion (at least three people)

or by consulting a third researcher (CRC). The methodological quality of the included studies was assessed by using the nine-item Joanna Briggs Institution Critical Appraisal Checklist for Studies Reporting Prevalence Data (Munn et al., 2015). The score for each item is zero (“no,” “unclear,” or “not applicable”) or one (“Yes”), and the highest score is nine. Higher scores reflected better methodological quality.

## Statistical analysis

Stata 16.0 was used for meta-analysis, and effect sizes were calculated as correlations ( $r$ ) in this study. Specifically, the correlations ( $r$ ) were first converted to the corresponding Fisher's  $Z$ -value by using the Fisher transform, weighted based on the sample size with 95% confidence intervals:  $Z = 0.5 \cdot \ln[(1+r)/(1-r)]$ , where the variance of  $Z$  is  $V_Z = 1/n-3$  and the standard deviation of  $Z$  is  $SE_Z = \text{square root of } (1/n-3)$ . The degree of association was interpreted through Gignac and Szodorai's criteria (Gignac and Szodorai, 2016) with effects of 0.10 deemed small, 0.20 deemed moderate, and equal to and larger than 0.30 interpreted as high. Moreover, we used meta-regression analysis for continuous moderators and subgroup analysis for categorical moderators. Publication bias was analyzed by funnel plots and Egger's linear regression test, and Cochran's  $Q$  and  $I^2$  statistics were used to assess heterogeneity. When the  $Q$  value was significant ( $p < 0.1$ ) and  $I^2 \geq 50\%$ , this indicated a heterogeneity in the study, and thus, the random effects model was used; otherwise, the fixed effects model was chosen (Higgins and Green, 2008). In addition, subgroup analysis was conducted to investigate the sources of heterogeneity.

## Results

### Study selection

The initial search yielded 2,231 studies. After duplicate records ( $n = 768$ ) were removed and 973 studies were excluded on the basis of title and abstract, the full texts of 490 papers were reviewed. A total of 434 studies were excluded for various reasons (listed in Figure 1). A total of 56 studies met the inclusion criteria and were included in the meta-analysis.

### Characteristics of the included studies and quality assessment

Fifty-six studies were included in the meta-analysis, which were published between 2011 and 2022. Collectively, 42,300 participants were enrolled in the included studies, and they were all recruited from schools, with sample sizes ranging from 291

TABLE 1 Characteristics of the 56 studies included in the meta-analysis.

First author (year)	N	Female %	Age	Publication type	SA measurement	Measurement instrument (Pearson's <i>r</i> )		
						Self-esteem	Self-control	Social support
Wang (2011)	664	58.1	3	D	Self-compiled	-	-	SSRS (-0.09)
Yu (2013)	484	60.3	2	D	WMPDS	SLCS-R (-0.27)	MSAQ (-0.54)	-
Xu and Bi (2014)	293	54.3	2	J	Self-compiled	-	-	SSRS (0.04)
Deng (2015)	1173	51.2	3	D	Self-compiled	-	MSAQ (-0.52)	-
Li et al. (2016)	913	53.5	3	J	MPATS	-	SCS (-0.49)	-
Pan (2016)	467	52.9	2	D	WMPDS	-	-	SSRS (-0.33)
Yang (2016)	403	54.8	3	D	MPAI	-	-	MSPSS (-0.41)
Wang et al. (2017)	768	56.0	2	J	SAS	RSES (-0.17)	-	-
Li (2017)	666	57.8	3	D	MPAI	-	MSAQ (-0.58)	-
Liu (2017)	533	53.3	3	D	DSDQ	-	SCS (-0.43)	PSSS (-0.13)
Jia (2018)	603	58.9	2	D	MPAI	RSES (-0.22)	-	-
Yu (2018)	1160	45.9	1	D	SAS-C	RSES (-0.21)	-	-
Liu (2018)	631	50.2	3	D	MPAI	-	MSAQ (-0.70)	-
Wang D. (2018)	958	49.8	2	D	WMPDS	-	MSAQ (-0.49)	-
Liu et al. (2018)	899	54.0	2	J	MPAI	-	DSCS (-0.39)	-
Duan (2018)	542	24.9	2	D	MPAI	-	-	SSRS (-0.14)
Wang et al. (2018)	655	45.0	2	J	SAS	-	-	MSPSS (0.00)
Wang Y. (2018)	1277	70.1	2	D	MPAI	-	-	SSRS (-0.10)
Zou (2018)	316	51.0	1	D	WMPDS	-	-	SSSUS (-0.04)
He (2019)	1075	44.7	3	J	MPATS	RSES (-0.36)	-	-
Li et al. (2019)	637	55.7	1	J	XSAI	RSES (-0.21)	-	-
Xiang et al. (2019)	643	52.7	3	J	SAS	-	SCS (-0.56)	-
Zheng (2019)	360	41.1	2	D	DSDQ	-	MSAQ (-0.51)	-
Zhu (2019)	407	50.9	1	D	WMPDS	-	MSAQ (-0.61)	-
Gao (2019)	447	1	2	D	MPAI	-	-	SSRS (-0.22)
Li (2019)	435	30.1	2	D	MPAI	-	-	SSRS (-0.13)
Wang et al. (2019)	772	56.0	3	J	SAS-SV	-	-	MSPSS (-0.03)
Gao (2020)	291	62.9	2	D	MPAI	RSES (-0.19)	-	-
Peng et al. (2020)	1912	63.2	3	J	MPAI	RSES (-0.22)	-	-
Li et al. (2020)	1102	51.5	3	J	MPPUS-10	-	ASCS (-0.55)	-
Xing (2020)	319	44.8	2	D	MPAI	-	MSAQ (-0.54)	-
Huang (2020)	736	51.6	1	D	MPATS	-	SCS (-0.46)	-
Ma (2020)	328	49.1	1	D	SAS-C	-	MSAQ (-0.65)	-
Gao et al. (2020)	642	46.4	1	J	MPAI	-	SCRC (-0.25)	-
(sample 1)								
Gao et al. (2020)	568	46.0	2	J	MPAI	-	SCRC (-0.32)	-
(sample 2)								
Ma et al. (2020)	981	48.5	1	J	MPAI	-	SCS (-0.34)	-
Niu et al. (2020)	726	48.6	3	J	MPAI	-	DSCS (-0.39)	-
Xiang et al. (2020)	947	48.4	3	J	SAS-SV	-	SCS (-0.54)	-
Jiao (2020)	373	54.8	2	D	MPATS	-	-	SSSUS (0.13)
Fu et al. (2020)	720	50.0	1	J	SAS-SV	-	-	MSPSS (-0.20)
Hu (2021)	413	52.1	1	D	MPAS	RSES (-0.30)	-	-

(Continued)

TABLE 1 (Continued)

First author (year)	N	Female %	Age	Publication type	SA measurement	Measurement instrument (Pearson's <i>r</i> )		
						Self-esteem	Self-control	Social support
Liu et al. (2021)	697	44.5	2	J	MPAI	RSES (−0.32)	-	-
Yang (2021)	1138	66.5	2	D	MPAI	RSES (−0.25)	SCS (−0.40)	-
Kong et al. (2021)	1201	52.8	3	J	SQAPMPU	RSES (−0.33)	-	-
Wang and Lei (2021)	762	56.0	1	J	SAS-SV	RSES (−0.16)	-	-
Wang (2021)	850	48.0	3	D	MPAI	-	SCS (−0.62)	MSPSS (−0.36)
Zhao (2021)	844	51.5	2	D	MPAI	-	SCS (−0.71)	-
Li et al. (2021)	1034	38.8	3	J	MPAI	-	DMSC-S (−0.07)	-
Cui (2021)	924	53.9	2	D	MPAI		MSAQ (−0.29)	
Tian (2021)	2517	47.7	1	D	MPPUS-10			PSSS (−0.29)
Zhang (2021)	636	54.1	1	D	MPAI			PSSS (−0.30)
Li (2022)	420	65.7	3	J	MPAI	RSES (−0.28)		
Chen and Xiao (2022)	764	59.3	3	J	SAS-SV		SCS (−0.43)	
Tian et al. (2022)	620	44.2	1	J	MPAI		SCS (−0.50)	
Hu and Wang (2022)	926	46.4	3	J	SAS-SV		DSCS (−0.36)	
Wang and Jiang (2022)	728	52.6	2	J	CAS		SEL (−0.24)	

NR, Not Reported; 1, Middle school students; 2, High school students; 3, sample consisted of both middle school students and high school students; D, Dissertation; J, Journal; WMPDS, Wang's Mobile Phone Dependency Scale for Middle School Students; MPATS, Mobile Phone Addiction Tendency Scale for College Students; SAS, Smartphone Addiction Scale; MPAI, Mobile Phone Addiction Index; DSDQ, Deng's Smartphone Dependency Questionnaire for Middle School Students; SAS-C, Smartphone Addiction Scale for College Students; SAS-SV, Smartphone Addiction Scale-Short Version; K-SAS, Korean Smartphone Addiction Proneness Scale for Youth and Adults; IAT, the modified version of Internet Addiction Test; XSAI, Xie's Smartphone Addiction Inventory; LSDI, Lee's Smartphone Dependency Instrument; SABAS, Smartphone Application-Based Addiction Scale; MPPUS-10, a short version of the Mobile Phone Problem Use Scale; COS, Cell-Phone Over-Use Scale; MPAS, Mobile Phone Addiction Scale; SQAPMPU, Self-rating Questionnaire for Adolescent Problematic Mobile Phone Use; SLCS-R, Self-Liking/Self-Competence Scale-Revised; RSES, Rosenberg Self-Esteem Scale; LSES, the Lifespan Self-Esteem Scale; CSEC = Coopersmith Self-Esteem Scale; ISLQ, Inventory of Subjective Life Quality; ASQ, Adolescent Self-esteem Questionnaire; MSAQ, the Middle school students' Self-control Ability Questionnaire; SCS, Self-Control Scale; K-SCS, Korean Self Control Scale; DSCS, Dong's Self-control Scale; BSCS, Brief Self Control Scale; ASCS, Adolescent Self-control Scale; SCRC, Self-Control Rating Scale; GF-SRS, Goal-Focused Self-Regulation Scale; DMSC-S, Dual-Mode of Self-Control Scale; SSRS, Social Support Rating Scale; MSPSS, Multidimensional Scale of Perceived Social Support; PSSS, Perceived Social Support Scale; SSSUS, Social Support Scale for University Students.

to 2,517. Of the 41,645 participants whose gender was reported, 51.2% were female. The MPAI was the most frequently used tool to assess smartphone addiction status among participants ( $n = 27$ ); the RSES was the most frequently used tool to assess self-esteem ( $n = 13$ ); the SCS was the most frequently used tool to assess self-control ( $n = 11$ ); and the SSRS was the most frequently used tool to assess social support ( $n = 7$ ; see Table 1). Overall, the quality of the included studies was at a medium or high level (total score  $\geq 6$ ). Detailed information about the quality assessment of each study can be found in Supplementary material 3.

## Effect size and heterogeneity test

A heterogeneity test was conducted on the included effect sizes, and the results showed that the Q values of self-esteem,

self-control and social support were 49.96 ( $p < 0.001$ ), 759.02 ( $p < 0.001$ ), and 231.91 ( $p < 0.001$ ), respectively, and the  $I^2$ -values were 74.0, 96.3, and 93.1%, respectively. These  $I^2$ -values were higher than the 50% rule proposed by Higgins et al. (2003), indicating a high level of heterogeneity among studies. Therefore, the random effects model was selected for meta-analysis. The results also show that it is necessary to explore the moderating variables that affect the relationship between them.

The random effects model showed that adolescents' smartphone addiction was moderately negatively correlated with self-esteem, strongly negatively correlated with self-control, and weakly negatively correlated with social support (self-esteem:  $r = -0.25$ , 95% CI =  $-0.29$  to  $-0.22$ ,  $p < 0.001$ ; self-control:  $r = -0.48$ , 95% CI =  $-0.53$  to  $-0.42$ ,  $p < 0.001$ ; social support:  $r = -0.16$ , 95% CI =  $-0.23$  to  $-0.09$ ,  $p < 0.001$ ; Table 2).

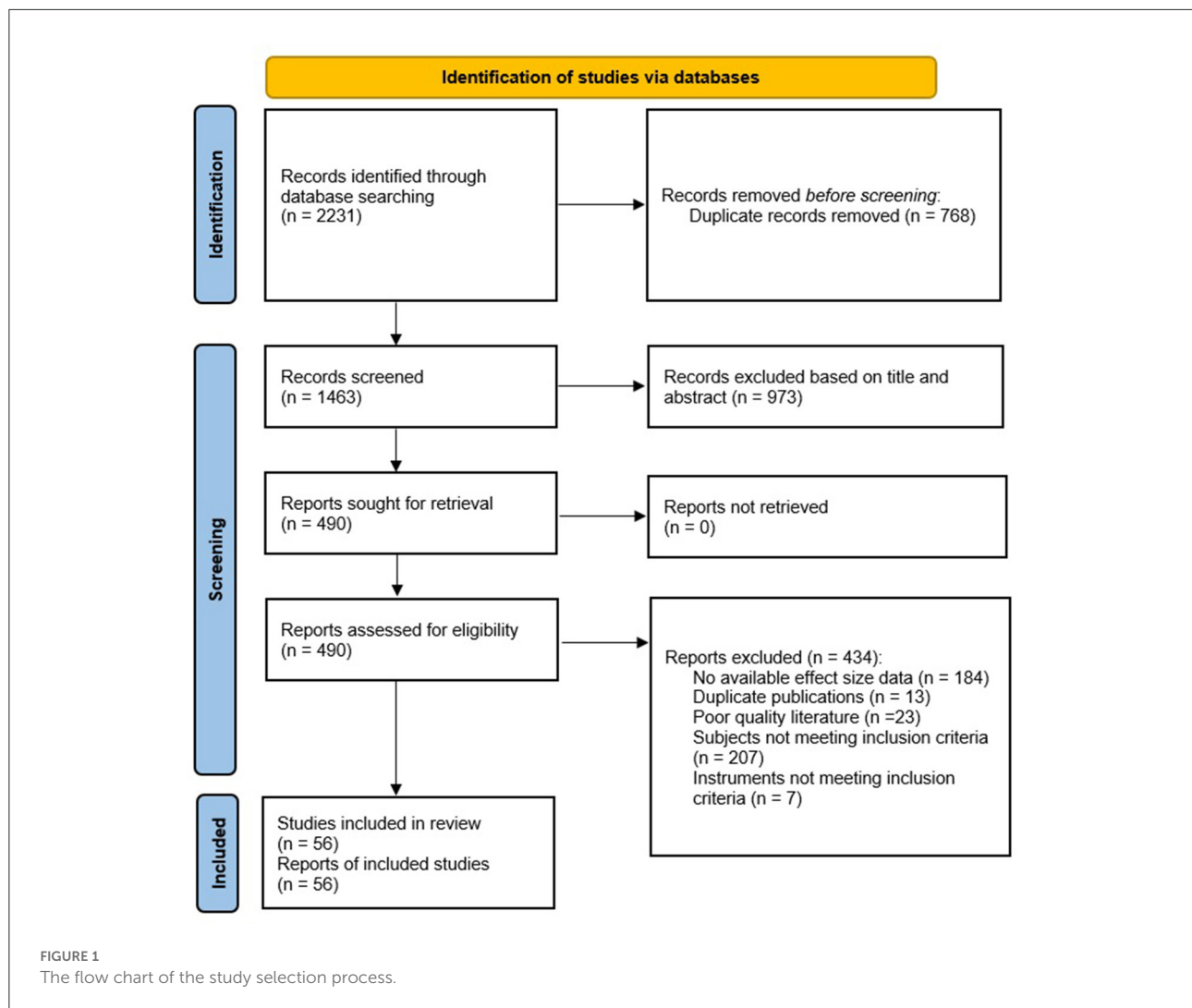


TABLE 2 Effect size and its heterogeneity test and publication bias test.

Outcome variable	<i>k</i>	<i>N</i>	<i>r</i>	95% CI for <i>r</i>	Heterogeneity test			Publication bias test			
					<i>Q</i>	<i>df</i>	<i>I</i> <sup>2</sup>	Egger's intercept	<i>SE</i>	95% CI	<i>p</i>
Self-esteem	14	11,561	−0.25	[−0.29, −0.22]	49.96***	13	74.0%	0.28	2.24	[−4.61, 5.16]	0.90
Self-control	29	21,844	−0.48	[−0.53, −0.42]	759.02***	28	96.3%	−7.66	5.72	[−19.40, 4.07]	0.19
Social support	17	11,900	−0.16	[−0.23, −0.09]	231.91***	16	93.1%	4.86	3.03	[−1.61, 11.32]	0.13

\*\*\**p* < 0.001.

## Moderation analysis

The heterogeneity of effects across studies was explored through moderation analysis. Subgroup analysis and meta-regression analysis were used to examine the moderating effects of categorical variables (age, publication type, tool for measuring

smartphone addiction, tool for measuring self-esteem, tool for measuring self-control and tool for measuring social support) and continuous variables (gender), respectively.

As shown in Tables 3, 4, the tool for measuring smartphone addiction significantly moderated the relationship between smartphone addiction and self-esteem (*p* < 0.001). In terms of

TABLE 3 Subgroup analyses of the summary correlation between smartphone addiction and self-esteem.

Moderators	<i>k</i>	<i>N</i>	<i>r</i>	95% CI	Between-group effect ( $Q_{BET}$ )	$I^2$ (%)	<i>p</i>
<b>Age</b>					0.59		0.443
Middle school students	4	2,972	−0.22	[−0.27, −0.17]		48.6	
High school students	6	3,981	−0.25	[−0.29, −0.20]		56.0	
<b>Article type</b>					0.43		0.511
Dissertation	6	4,089	−0.24	[−0.27, −0.21]		0.0	
Journal	8	7,472	−0.26	[−0.32, −0.21]		84.2	
<b>SA measurement</b>					28.09***		0.000
MPATS	1	1,075	−0.38	[−0.44, −0.32]		0.0	
MPAI	6	5,061	−0.25	[−0.29, −0.22]		40.6	
SAS/SAS-SV	2	1,530	−0.17	[−0.22, −0.12]		0.0	
Others	5	3,895	−0.27	[−0.33, −0.21]		68.4	
<b>Self-esteem measurement</b>					0.12		0.724
RSES	13	11,077	−0.26	[−0.30, −0.22]		0.0	
Others	1	484	−0.27	[−0.36, −0.18]		75.9	

\*\*\* $p < 0.001$ .

TABLE 4 Univariate regression analysis of continuous variables (random effect model).

Moderators	<i>k</i>	<i>SE</i>	<i>t</i>	95% CI	<i>p</i>
Female (%)					
Self-esteem	14	0.24	1.55	[−0.15, 0.89]	0.15
Self-control	29	0.01	−0.86	[−0.02, 0.01]	0.40
Social support	17	0.26	−0.19	[−0.60, 0.50]	0.85

the tool for measuring smartphone addiction, the correlation was strongest when the MPATS was used ( $r = -0.38$ , 95% CI =  $-0.44$  to  $-0.32$ ), followed by the use of other scales ( $r = -0.27$ , 95% CI =  $-0.33$  to  $-0.21$ ), the MPAI ( $r = -0.25$ , 95% CI =  $-0.29$  to  $-0.22$ ), and the SAS ( $r = -0.17$ , 95% CI =  $-0.22$  to  $-0.12$ ). However, the moderating effects of age, gender, publication type and tool for measuring self-esteem on smartphone addiction and self-esteem were not significant (all  $p > 0.05$ ).

The publication type and the tool for measuring self-control significantly moderated the relationship between smartphone addiction and self-control ( $p < 0.01$  and  $p < 0.01$ , respectively). In terms of publication type, the correlation for dissertations ( $r = -0.61$ , 95% CI =  $-0.70$  to  $-0.52$ ) was significantly stronger than that for journal articles ( $r = -0.42$ , 95% CI =  $-0.51$  to  $-0.33$ ). In the tool for measuring self-control, the correlation was strongest when self-control was measured with MSAQ ( $r = -0.62$ , 95% CI =  $-0.72$  to  $-0.51$ ), followed by the SCS ( $r = -0.56$ , 95% CI =  $-0.65$  to  $-0.46$ ) and other scales ( $r = -0.34$ , 95% CI =  $-0.46$  to  $-0.22$ ). However, age, gender and the tool for measuring smartphone addiction did not moderate the relationship between smartphone addiction and self-control (all  $p > 0.05$ ; Tables 4, 5).

The publication type and the tool for measuring smartphone addiction significantly moderated the relationship between

smartphone addiction and social support ( $p < 0.05$  and  $p < 0.001$ , respectively). In terms of publication type, the correlation for dissertations ( $r = -0.19$ , 95% CI =  $-0.27$  to  $-0.12$ ) was significantly stronger than that for journal articles ( $r = -0.05$ , 95% CI =  $-0.16$  to  $0.05$ ). In terms of the tool for measuring smartphone addiction, the correlation was strongest when smartphone addiction was measured with MPAI ( $r = -0.24$ , 95% CI =  $-0.34$  to  $-0.14$ ), followed by the other scales ( $r = -0.15$ , 95% CI =  $-0.27$  to  $-0.03$ ), MPATS ( $r = 0.13$ , 95% CI =  $0.03$  to  $0.23$ ), and the SAS ( $r = -0.08$ , 95% CI =  $-0.20$  to  $0.05$ ). However, age, gender, publication type, and tool for measuring social support did not differ between subgroups (all  $p > 0.05$ ; Tables 4, 6).

## Publication bias

Publication bias was detected using a funnel plot and Egger's linear regression test. First, Figures 2–4 showed that the effect sizes of the relationship between smartphone addiction and self-esteem, self-control, and social support were basically evenly distributed on both sides of the overall effect sizes, indicating that the risk of publication bias was small in the

TABLE 5 Subgroup analyses of the summary correlation between smartphone addiction and self-control.

Moderators	<i>k</i>	<i>N</i>	<i>r</i>	95% CI	Between-group effect ( <i>Q<sub>BET</sub></i> )	<i>I</i> <sup>2</sup> (%)	<i>p</i>
<b>Age</b>					1.76		0.185
Middle school students	7	4,558	−0.57	[−0.75, −0.40]		97.3	
High school students	9	6,378	−0.44	[−0.52, −0.36]		90.7	
<b>Article type</b>					9.02**		0.003
Dissertation	15	10,351	−0.61	[−0.70, −0.52]		95.2	
Journal	14	11,493	−0.42	[−0.51, −0.33]		95.7	
<b>SA measurement</b>					0.98		0.806
MPATS	2	1,649	−0.52	[−0.57, −0.47]		0.0	
MPAI	14	10,842	−0.49	[−0.62, −0.36]		97.8	
SAS/SAS-SV	4	3,280	−0.52	[−0.64, −0.40]		91.7	
Others	9	6,073	−0.56	[−0.66, −0.47]		92.5	
<b>Self-control measurement</b>					12.10**		0.002
SCS	11	8,969	−0.56	[−0.65, −0.46]		95.0	
MSAQ	10	6,250	−0.62	[−0.72, −0.51]		94.0	
Others	8	6,625	−0.34	[−0.46, −0.22]		96.1	

\*\**p* < 0.01.

TABLE 6 Subgroup analyses of the summary correlation between smartphone addiction and social support.

Moderators	<i>k</i>	<i>N</i>	<i>r</i>	95% CI	Between-group effect ( <i>Q<sub>BET</sub></i> )	<i>I</i> <sup>2</sup> (%)	<i>p</i>
<b>Age</b>					3.45		0.063
Middle school students	4	4,189	−0.22	[−0.32, −0.13]		86.9	
High school students	8	4,489	−0.10	[−0.19, −0.00]		89.6	
<b>Article type</b>					4.45*		0.035
Dissertation	13	9,460	−0.19	[−0.27, −0.12]		92.7	
Journal	4	2,440	−0.05	[−0.16, 0.05]		85.4	
<b>SA measurement</b>					27.65***		0.000
MPATS	1	373	0.13	[0.03, 0.23]		0.0	
MPAI	7	4,590	−0.24	[−0.34, −0.14]		91.5	
SAS/SAS-SV	3	2,147	−0.08	[−0.20, 0.05]		88.2	
Others	6	4,790	−0.15	[−0.27, −0.03]		92.7	
<b>Social support measurement</b>					0.54		0.763
SSRS	7	4,125	−0.14	[−0.22, −0.06]		83.2	
MSPSS	5	3,400	−0.21	[−0.38, −0.04]		95.9	
Others	5	4,375	−0.14	[−0.29, 0.02]		95.1	

\**p* < 0.05.\*\*\**p* < 0.001.

study. Second, Egger's linear regression tests found that the *p*-values of self-esteem (*p* = 0.90), self-control (*p* = 0.19), and social support (*p* = 0.13) were all >0.05, which further indicated that there was no publication bias in this study, and the estimated results of meta-analysis were relatively reliable (Table 2).

## Sensitivity analysis

To evaluate the robustness of our findings, we used the one-by-one elimination method for sensitivity analysis. As shown in Figures 5–7, the effect size after removing the studies one at a time is within the 95% CI value of the total effect size. Overall, the

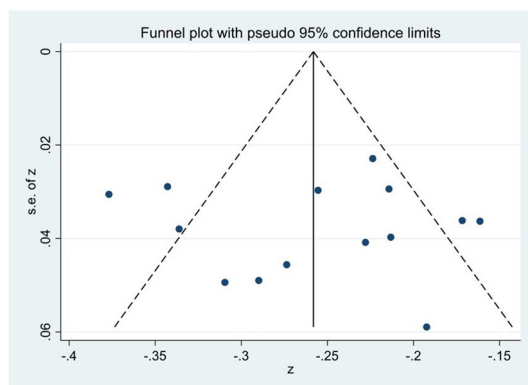


FIGURE 2  
Funnel plot of the correlation of smartphone addiction and self-esteem.

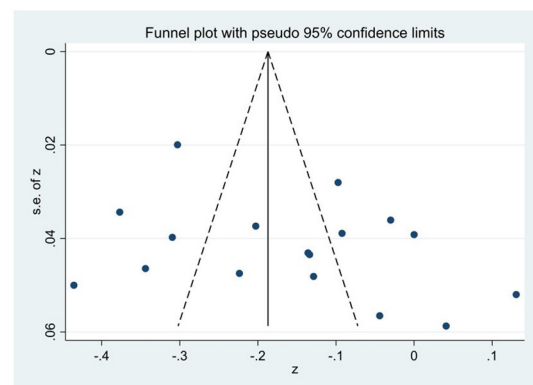


FIGURE 4  
Funnel plot of the correlation of smartphone addiction and social support.

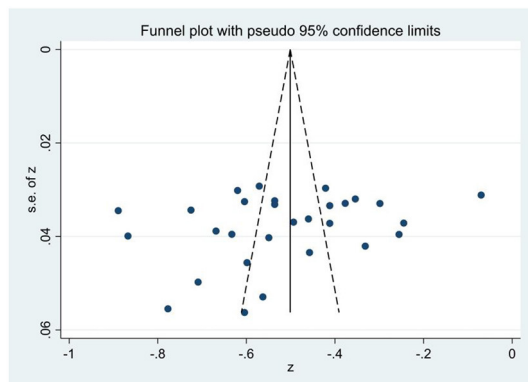


FIGURE 3  
Funnel plot of the correlation of smartphone addiction and self-control.

results were not significantly changed, suggesting that the results of this study were relatively stable.

## Discussion

### Relationship between smartphone addiction and self-esteem, self-control, and social support

This study clarifies the disagreement over the magnitude of the relationship between self-esteem, self-control and smartphone addiction and the magnitude and direction of the relationship between social support and smartphone addiction. The details were as follows. First, the results showed that adolescents' smartphone addiction had a moderately negative correlation with self-esteem ( $r = -0.25$ ,  $p < 0.001$ ), indicating

that with the decrease of self-esteem, smartphone addiction is more likely to occur, which is consistent with the conclusions of most previous studies. Yuchang et al. (2017) found that adolescents with low self-esteem are often at a disadvantage in social interactions and receive less social support, and they are more likely to feel extremely lonely; thus, they are more likely to develop smartphone addiction. You et al. (2019) found that adolescents with low self-esteem usually have cognitive distortions and maladaptive emotional regulation (Billieux, 2012), which leads to higher social anxiety, and have to overuse smartphones to obtain reassurance in affective relationships. Therefore, educators should pay attention to strengthening the improvement of adolescents' self-esteem. For example, group-assisted activities can not only improve the relationship between adolescents but also improve adolescents' self-cognition level in interpersonal communication to intervene in the formation of smartphone addiction.

Second, the results showed that adolescents' smartphone addiction had a strong negative correlation with self-control ( $r = -0.48$ ,  $p < 0.001$ ), indicating that adolescents with low self-control are more likely to be addicted to smartphones, which is consistent with the conclusions of most previous studies. Li et al. (2021) found that adolescents with lower self-control are at higher risk of developing smartphone addiction due to their escapist thoughts. Jiang and Zhao (2016) found that the short-term pleasure and satisfaction benefiting from the chat and shopping functions of smartphones to adolescents with low self-control will increase the likelihood of smartphone overuse. This suggest that educators should prioritize enhancing adolescents' self-control level when conducting smartphone addiction interventions. Group cognitive-behavioral therapy (Zeidi et al., 2020) and maintaining a regular academic study program (Oaten and Cheng, 2006) may be effective ways to

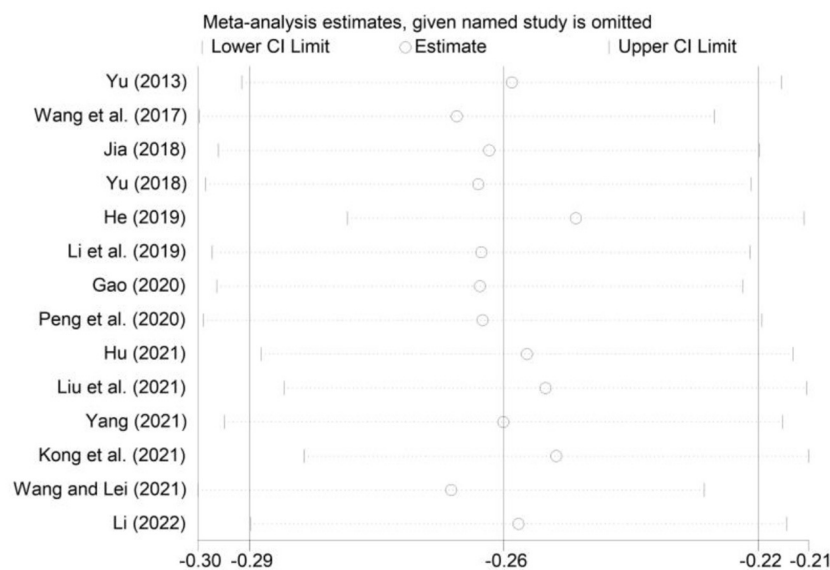


FIGURE 5  
Sensitivity analysis of the correlation between smartphone addiction and self-esteem.

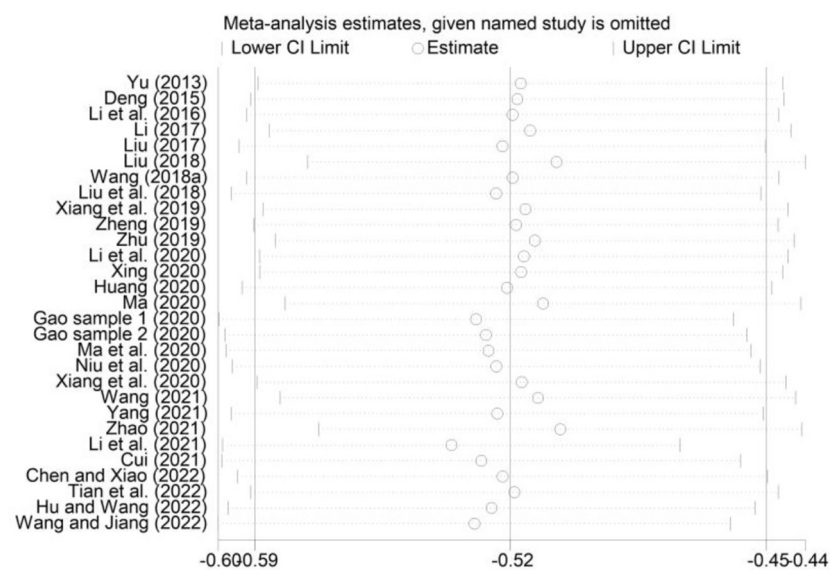
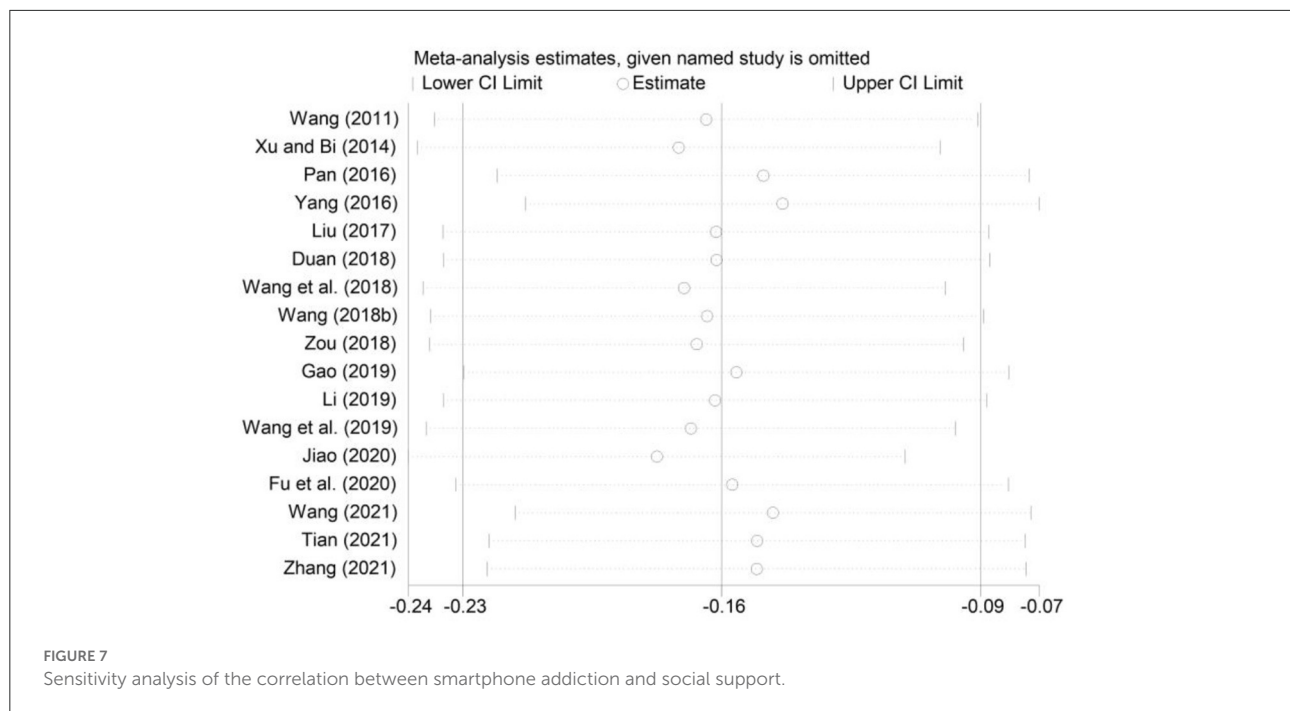


FIGURE 6  
Sensitivity analysis of the correlation between smartphone addiction and self-control.

improve self-control ability and help to reduce the possibility of adolescents' smartphone addiction.

Moreover, the results showed that adolescents' smartphone addiction had a weak negative correlation with social support ( $r = -0.16, p < 0.001$ ), indicating that adolescents with low social

support are prone to smartphone addiction, which is consistent with the conclusions of most previous studies (Li, 2019; Fu et al., 2020). Additionally, these results reject the view that there is a positive correlation between social support and smartphone addiction (Jiao, 2020), and reject the view that there is no



significant association between social support and smartphone addiction (Wang et al., 2018; Zou, 2018). Furthermore, these results imply that to effectively prevent and reduce smartphone addiction among adolescents, it is necessary to establish a good social support system. It is worth noting that according to the cognitive-behavioral model of Davis (2001), an individual's addictive behavior is not entirely due to the lack of realistic social support but rather is due to individuals being unaware of the existing social support and thus being unable to make good use of the existing social support. Therefore, in addition to giving adolescents sufficient instrumental social support, attention should also be devoted to improving the level of adolescents' emotional social support and the utilization degree of support.

## Moderating effects

Publication type significantly moderated the relationship between adolescents' smartphone addiction, self-control, and social support. The effect of dissertations is significantly stronger than that of journal articles. This finding is inconsistent with previous studies. Generally, in meta-analysis studies with publication bias, the effect of journal articles is larger than that of dissertations (Pan et al., 2020). This difference may be related to the quality of the studies and the rigor of the review.

The tools for measuring smartphone addiction significantly moderated the relationship between adolescents' smartphone addiction and both self-esteem and social support. First, in terms of self-esteem, the MPATS (Xiong et al., 2012;  $r = -0.38$ ) had the

strongest effect. This may be due to the different perspectives of the MPATS and other scales. The MPATS is more based on the subjective experience of smartphone users' inner processing activities and social interaction. According to the sociometer theory, self-esteem is a measure of the state of social relationship status. Adolescents with low self-esteem show high social anxiety and interpersonal sensitivity (Leary et al., 1995), which makes it difficult for them to establish good interpersonal relations in the real world and have the psychological tendency of escapism, thus having a high level of smartphone addiction. Second, in terms of social support, the MPAI ( $r = -0.24$ ) had the strongest effect. The reason may be that the MPAI mainly focuses on describing the impact of smartphones on users' behavior and impairment of social functions. Studies have shown that adolescents using smartphones as a substitute for their contact with society will have lower levels of social functioning (Mynatt et al., 1998), and when the social support needs of adolescents cannot be met in reality, they will use smartphones to reduce the negative psychological effects of social exclusion (Schick et al., 2018), which further increases the possibility of smartphone addiction, so MPAI showed a stronger correlation.

The tools for measuring self-control significantly moderated the relationship between adolescents' smartphone addiction and self-control. The MSAQ (Wang and Lu, 2004) had the strongest effect size, followed by the SCS (Tangney et al., 2004) and the other scales. The reason may be due to the different perspectives of different measurement instruments. The MSAQ is applicable to adolescents, while the SCS and other scales are mainly applicable to college students. In comparison, the MSAQ scale is more targeted toward the subjects of the current study

(adolescents). Studies have shown that adolescents have lower levels of self-control than college students, and they are more prone to problematic behaviors, such as smartphone addiction (Chambers et al., 2003; Lopez-Fernandez et al., 2014; Kiss et al., 2020). Therefore, the use of the MSAQ showed a stronger effect.

## Limitations and prospects

Previous studies on the relationship between smartphone addiction and self-esteem, self-control, and social support among adolescents have been inconsistent. In this study, the meta-analysis was used to investigate the relationship between smartphone addiction and self-esteem, self-control, and social support among adolescents, and to clarify the controversy about the size of the correlation between them in the empirical study. However, this study also has some limitations. First, the data of this study were collected through a questionnaire survey, so information bias and reporting bias are inevitable, and more objective forms of data collection can be considered for future research. Second, the studies included in this meta-analysis mainly focused on adolescents. In the future, the subject group can be further expanded to explore whether there are differences in the relationship between smartphone addiction and self-esteem, self-control, and social support among different subject groups. Finally, the studies retrieved in this meta-analysis were all cross-sectional studies. Whether there is a causal relationship between the relevant factors found and smartphone addiction needs to be further verified by longitudinal studies in the future.

## Implications

This study is of great significance for the prevention and intervention of adolescents' smartphone addiction. First, the results describe the correlation between adolescents' smartphone addiction and self-esteem, self-control and social support, which can provide a reference for future studies. Additionally, this means that attaching great importance to the improvement of self-esteem, self-control, and social support may important for reducing the occurrence of smartphone addiction among adolescents. Second, there was no significant difference between age and genders in the problems of smartphone addiction accompanied by low self-esteem, low self-control and low social support. In future interventions, it will be important to pay attention to the comprehensiveness of group of adolescents of different ages and genders coverage. Third, the measurement tool of smartphone addiction significantly moderated the relationship between adolescents' smartphone addiction, self-esteem and social support. This reminds researchers and clinicians to use common criteria to define smartphone addiction whenever possible to reduce potential differences. Finally, there are differences in the predictive power obtained by

using different self-control measurement tools, which reminds researchers that they should choose appropriate self-control measurement tools according to the purpose and object of their own research as much as possible.

## Conclusion

The current meta-analysis found that adolescent smartphone addiction was moderately negatively associated with self-esteem, had a strong negative correlation with self-control, and had a weak negative correlation with social support, indicating that adolescents with low levels of self-esteem, self-control and social support were more likely to develop smartphone addiction. Therefore, in the prevention and intervention of smartphone addiction among adolescents, more attention should be given to adolescents with low levels of self-esteem, self-control and social support. Not only should sufficient social support be given to meet their psychological needs, but also to help them improve their self-esteem and self-control in daily life and study, learn to use smartphones reasonably and avoid the harm of addiction.

## Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding authors.

## Author contributions

YD and XW: study design and drafting of the manuscript. YD, CC, GL, HH, YL, and JY: analysis and interpretation of data and critical revision of the manuscript. GL and CC: data curation and supervision. All authors approved the final manuscript to be published.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2022.1029323/full#supplementary-material>

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# Smartphone addiction is more harmful to adolescents than Internet gaming disorder: Divergence in the impact of parenting styles

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**Background:** The adverse effects of smartphone addiction (SPA) and Internet gaming disorder (IGD) on adolescents' mental health have been widely recognized. However, the influence of parenting styles on these high-risk Internet use behaviors of adolescents still remain elusive. Aiming to identify preventable patterns for adolescents with SPA or IGD, this study compared the mental health status between adolescents with SPA and IGD and used path analysis to confirm actual effects of parenting styles on SPA and IGD.

**Methods:** Participants were enrolled at a junior high school in Hunan Province and a senior high school in Shanxi Province, China [ $n = 3,049$ , female (male): 50.5% (49.5%), mean age =  $15.68 \pm 1.54$ ]. All participants reported their socio-demographic characteristics and undertook standardized assessments of SPA, IGD, parenting styles, depression, anxiety, insomnia, self-control, and support utilization.

**Results:** High levels of parental care and low levels of parental overprotection benefited adolescents' mental health with SPA and IGD. However, despite having a more positive parenting style, adolescents with only SPA showed more severe mental health problems than adolescents with only IGD. Furthermore, the results showed that the parenting style of encouraging autonomy might be a protective factor against IGD, but it might reinforce SPA indirectly by reducing abilities of support utilization and self-control in whole sample.

**Conclusion:** Compared to IGD, SPA which included different kinds of Internet addiction behaviors, was more hazardous for adolescents' mental health. The divergent effects of an autonomy-encouraging parenting style on SPA and IGD may reflect the different impacts of self-control in different types of Internet addiction.

## KEYWORDS

smartphone addiction, Internet gaming disorder, adolescent, mental health, parenting styles

## Introduction

Internet gaming disorder (IGD), defined as problematic and impulsive use of Internet-based games, has a significant impact on physical and mental health (Kuss et al., 2014; van Rooij et al., 2014). IGD is associated with depression (Yen et al., 2019), anxiety (Bonnaire and Baptista, 2019), social difficulties (Lo et al., 2005), attention deficits (Swing et al., 2010), and poorer sleep quality (Sarda et al., 2016). Meanwhile, as a new portable device, the smartphone has opened a new era of mobile Internet (Cho, 2015), which leads more and more people becoming over-dependent on smartphones (Kwon et al., 2013). Researchers have proposed that the behavior of excessive use of smartphones can be characterized as smartphone addiction (SPA) (Pavia et al., 2016; Panova and Carbonell, 2018). Previous studies have also demonstrated that SPA is highly associated with depression and anxiety (Elhai et al., 2017; Elhai and Contractor, 2018; Pancani et al., 2020), emotional dysregulation (Rozgonjuk and Elhai, 2019), social deficits (Hawi and Samaha, 2017), and decreased sleep quality (Orzech et al., 2016). Importantly, IGD is different from SPA. For example, Petry et al. (2014) suggested that Internet gaming should be distinguished from other online activities. Moreover, smartphones are not solely carriers of gaming but a carrier of various online activities (e.g., socializing and shopping) (Montag et al., 2015a). Therefore, SPA is a concentrated manifestation of Internet addictive behaviors and may have disparate impacts on mental health compared with IGD. However, few studies have directly compared the effects of IGD and SPA on mental health in adolescents. Importantly, depression is regarded as the most severe psychological illness for individuals under 25 years old (Gore et al., 2011), which is usually accompanied by anxiety (Ko et al., 2012). Additionally, sleep quality has a remarkable impact on the physical and mental development of adolescents (Adams et al., 2013; Brand et al., 2014). Thus, this study aims to compare depression, anxiety, and insomnia between adolescents with IGD and adolescents with SPA.

Parenting style, as one of the vital family factors, has a critical impact on the development of adolescents. Furthermore, parenting styles closely relate to addictive behaviors in adolescents (Miller and Plant, 2010). Previous studies have shown that positive parenting styles (e.g., a caring parenting style) decrease smartphone dependence (Lian et al., 2016) and reduce the probability of IGD in adolescents (Floros et al., 2013). Meanwhile, negative parenting styles (e.g., an overprotective parenting style) increase smartphone dependence (Bae, 2015) and can result in IGD (Huang et al., 2010). However, the effects of encouraging autonomy (encouraging children to be independent and autonomous) on IGD and SPA remain elusive. Researchers have shown that parental encouragement of autonomy is associated with higher levels of well-being and fewer developments of behavioral problems in children

(Jungert et al., 2015), implying that encouraging autonomy may be as beneficial as caring in managing adolescents' high-risk Internet use behaviors. For example, a study on adolescents in Hong Kong showed that restricting adolescents' Internet use increased their probability of Internet addiction (IA) by 1.9 times (Wu C. S. T. et al., 2016), supporting the suggestion of giving adolescents freedom to use the Internet. However, a study based on Korean elementary schoolchildren found that a lack of restrictions on using the Internet was related to IA among boys (Lee and Ogbolu, 2018), indicating the importance of supervision over children's Internet use.

In addition, self-control is a protective factor against IGD (Kim et al., 2008) and SPA for adolescents (Gökçearsan et al., 2016). Self-control is a limited resource, and individuals with more self-control resources can more easily inhibit, change, or maintain activities to achieve their desired goals (Muraven and Baumeister, 2000). Dysfunctional self-control has been proposed as a core feature of IGD (Spada, 2014) and SPA (Kim et al., 2016). Critically, self-control is affected by parenting styles (Crosswhite and Kerpelman, 2012). Early experiences of parental acceptance (e.g., positive parenting styles) or rejection (e.g., negative parenting styles) have persistent effects on the development of self-control abilities in children (Hagger et al., 2010). Previous studies indicated that parenting styles are likely to influence IGD or SPA indirectly by altering self-control resources. Moreover, parenting styles also impact individuals' ability to utilize social support (de Vries et al., 2016). Social support utilization refers that an individual could integrate into his or her social system and accept support which helps their physical and psychological development in interactions with system members (e.g., friends and teachers) (Brown and Larson, 2009). With a stronger ability to use social support, an individual can be regulated by their social system, which can complement their self-control resources and reduce undesirable behaviors (Hirschi, 1977; Baker, 2010; Wright et al., 2010). Thus, the utilization of social support, influenced by parenting styles, affects the self-control of adolescents. More importantly, social support is a predictive variable for IGD (Young et al., 2012) and SPA (Mo et al., 2018) as well. Researchers proposed that when a third variable transmits the effect of one variable to another, it may play the mediation role between these two variables (MacKinnon, 2008). When there are more than a single variable that can transmit effects between those two variables, these variables may play the role of multiple mediation (Hayes, 2009). Therefore, the present study explores the potential multiple mediation roles of support utilization and self-control between parenting styles and IGD or SPA.

An immature brain and poor self-control (Hong et al., 2013) can easily lead adolescents falling into trouble with IGD (Spada, 2014) and SPA (Lopez-Fernandez et al., 2014), resulting in an increased risk of depression, anxiety, and

insomnia in adolescents. Therefore, it is of great significance to explore the pathways of parenting styles' influences on IGD and SPA, which can guide coping with these issues in adolescents. This study was conducted based on the following hypotheses. H1: There are significant differences in depression, anxiety, and insomnia between adolescents with IGD and adolescents with SPA. H2: Positive parenting styles negatively predict IGD and SPA, and negative parenting styles positively predict IGD and SPA. H3: Support utilization and self-control play multiple mediation roles in the relationship between parenting style and IGD or SPA.

## Materials and methods

### Participants

The questionnaires were distributed to a junior high school in Hunan Province and a senior high school in Shanxi Province, China, from March to April 2021 in the form of paper questionnaires and online questionnaires on the Wenjuanxing website.<sup>1</sup> After excluding participants with missing or omitted entries on the relevant scales and potentially irresponsible completion, the subsequent analysis included 3,049 samples. The overall sample consisted of 1,508 male subjects (49.5%) and 1,541 female subjects (50.5%), with a mean age of 15.68 years ( $SD = 1.54$ , age range 11–19) (Table 1).

### Measures

We used a multiple-choice question format to survey participants' smartphone usage to indicate potential types of Internet addiction behaviors for SPA (Supplementary Table 1). Socio-demographic characteristics were collected, including gender, age, whether they were an only child, living area, the parents' education degree, and the family socio-economic status degree.

#### Mobile phone addiction index (MPAI)

The MPAI scale measures the smartphone addiction degree of adolescents (Leung, 2008). The scale consists of 17 items. All items use a five-point Likert scale from 1 (never) to 5 (always). Total scores above or equal to 51 are considered smartphone addiction, with higher scores indicating a more severe level of smartphone addiction (Zhang et al., 2019). In this study, Cronbach's alpha coefficient of the scale was 0.907.

TABLE 1 Socio-demographic characteristics of junior and senior high school students.

Characteristic	Number	Percentage (%)
<b>Gender</b>		
Male	1,508	49.5
Female	1,541	50.5
<b>Age</b>		
11–13	321	10.53
14–16	1,877	61.56
17–19	851	27.91
<b>Being the only child</b>		
Yes	514	16.9
No	2,535	83.1
<b>Living area</b>		
Urban	1,257	41.2
Rural	1,792	58.8
<b>Education of mother</b>		
Lower than high school	2,841	93.2
High school or equivalent	145	4.8
Higher than high school	63	2.0
<b>Education of father</b>		
Lower than high school	2,776	91.0
High school or equivalent	187	6.10
Higher than high school	86	2.90
<b>Family socio-economic status</b>		
1–3	448	14.7
4–6	2,042	67.0
≥7	559	18.3
<b>Survey method</b>		
Paper-based survey	1,490	48.9
Online survey	1,559	51.1

The family socio-economic status were rated on a 10-point scale, with 1 indicating "very low degree of family income and social status" and 10 indicating "very high degree of family income and social status".

#### Internet gaming disorder scale (IGD)

The short-form IGD scale measures whether subjects meet the Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5) criteria for Internet gaming disorder (Sigerson et al., 2017). The scale consists of nine items scored 0 or 1 (yes = 1, no = 0), with total scores ranging from 0 to 9. In the present study, Cronbach's alpha coefficient of the scale was 0.861.

#### Parental bonding instrument (PBI)

The PBI measures the parenting styles that adolescents experience (Kazarian et al., 1987). The Chinese version of the father's and the mother's PBI contains 23 items for each, including the caring dimension (referring to parents' gentleness,

<sup>1</sup> <http://wjx.cn>

TABLE 2 Differences in psychological variables among the four groups ( $n = 3,049$ ).

Psychological variables	Groups	M $\pm$ SD	F	$\eta p^2$	P	95% CI	Post-hoc test
Depression	1.No SPA-No IGD	6.52 $\pm$ 5.18	140.91	0.122	<0.001	(0.10, 0.14)	1 < 2 < 3 < 4
	2.Only IGD	7.94 $\pm$ 5.90					
	3.Only SPA	10.44 $\pm$ 6.09					
	4.SPA-IGD	12.58 $\pm$ 6.58					
Anxiety	1.No SPA-No IGD	4.49 $\pm$ 4.51	121.64	0.107	<0.001	(0.09, 0.12)	1 < 2 < 3 < 4
	2.Only IGD	5.77 $\pm$ 4.85					
	3.Only SPA	7.54 $\pm$ 5.05					
	4.SPA-IGD	9.39 $\pm$ 5.72					
Insomnia	1.No SPA-No IGD	6.11 $\pm$ 4.04	51.60	0.048	<0.001	(0.04, 0.06)	1 < 2 < 3 (4)
	2.Only IGD	7.18 $\pm$ 5.10					
	3.Only SPA	8.24 $\pm$ 4.36					
	4.SPA-IGD	8.50 $\pm$ 5.32					
Self-control	1.No SPA-No IGD	63.76 $\pm$ 10.42	162.58	0.138	<0.001	(0.12, 0.16)	1 (2) > 3 > 4
	2.Only IGD	63.29 $\pm$ 11.43					
	3.Only SPA	54.93 $\pm$ 11.09					
	4.SPA-IGD	52.37 $\pm$ 11.24					
Support utilization	1.No SPA-No IGD	20.93 $\pm$ 6.28	22.18	0.021	<0.001	(0.02, 0.03)	1 (2) > 3 > 4
	2.Only IGD	20.88 $\pm$ 6.38					
	3.Only SPA	19.40 $\pm$ 6.39					
	4.SPA-IGD	18.02 $\pm$ 5.88					

TABLE 3 Differences in parenting styles among the four groups ( $n = 3,049$ ).

Parenting styles	Groups	M $\pm$ SD	F	$\eta p^2$	P	95% CI	Post-hoc test
Mother's care	1.No SPA-No IGD	21.30 $\pm$ 5.93	79.65	0.072	<0.001	(0.06, 0.09)	1 > 3 > 4 (2)
	2.Only IGD	17.28 $\pm$ 3.48					
	3.Only SPA	18.89 $\pm$ 5.43					
	4.SPA-IGD	17.44 $\pm$ 4.62					
Mother's encouragement of autonomy	1.No SPA-No IGD	10.25 $\pm$ 4.28	31.76	0.030	<0.001	(0.02, 0.04)	1 (3) (4) > 2
	2.Only IGD	7.44 $\pm$ 4.94					
	3.Only SPA	10.21 $\pm$ 4.03					
	4.SPA-IGD	10.26 $\pm$ 4.09					
Mother's overprotection	1.No SPA-No IGD	5.40 $\pm$ 3.79	76.58	0.070	<0.001	(0.06, 0.08)	1 < 2 (3) < 4
	2.Only IGD	6.78 $\pm$ 4.57					
	3.Only SPA	7.23 $\pm$ 4.15					
	4.SPA-IGD	8.77 $\pm$ 4.33					
Father's care	1.No SPA-No IGD	19.64 $\pm$ 6.03	31.63	0.030	<0.001	(0.02, 0.04)	1 > 2 (3) (4)
	2.Only IGD	17.03 $\pm$ 3.95					
	3.Only SPA	17.91 $\pm$ 5.47					
	4.SPA-IGD	17.34 $\pm$ 4.85					
Father's encouragement of autonomy	1.No SPA-No IGD	10.54 $\pm$ 4.38	23.44	0.023	<0.001	(0.01, 0.03)	1 (3) (4) > 2
	2.Only IGD	8.05 $\pm$ 5.05					
	3.Only SPA	10.46 $\pm$ 4.20					
	4.SPA-IGD	10.44 $\pm$ 4.08					
Father's overprotection	1.No SPA-No IGD	4.72 $\pm$ 3.94	86.15	0.078	<0.001	(0.06, 0.09)	1 < 2 (3) < 4
	2.Only IGD	7.15 $\pm$ 4.72					
	3.Only SPA	6.63 $\pm$ 4.59					
	4.SPA-IGD	8.26 $\pm$ 4.54					

TABLE 4 Multiple regression analysis on depression, anxiety and insomnia ( $n = 3,049$ ).

Dependent variable	Independent variable	Coef	SE	<i>t</i>	<i>P</i>	$\beta$	$R^2$	$R^2_{adj}$
Depression							0.410	0.407
	Gender	0.814	0.175	4.665	<0.001	0.069		
	Age	0.007	0.055	0.132	0.895	0.002		
	SPA	0.074	0.008	9.669	<0.001	0.165		
	IGD	0.140	0.034	4.111	<0.001	0.065		
	Self-control	−0.194	0.009	−21.856	<0.001	−0.377		
	Support utilization	−0.164	0.014	−11.400	<0.001	−0.176		
	Mother's care	−0.070	0.021	−3.292	0.001	−0.069		
	Mother's encouragement of autonomy	0.048	0.030	1.608	0.108	0.035		
	Mother's overprotection	0.077	0.031	2.475	0.013	0.054		
	Father's care	0.006	0.019	0.306	0.760	0.006		
	Father's encouragement of autonomy	−0.086	0.029	−2.948	0.003	−0.064		
	Father's overprotection	0.039	0.029	1.362	0.173	0.029		
Anxiety							0.325	0.322
	Gender	0.462	0.159	2.909	0.004	0.046		
	Age	−0.047	0.050	−0.939	0.348	−0.015		
	SPA	0.064	0.007	9.128	<0.001	0.166		
	IGD	0.128	0.031	4.124	<0.001	0.070		
	Self-control	−0.146	0.008	−18.166	<0.001	−0.336		
	Support utilization	−0.095	0.013	−7.310	<0.001	−0.121		
	Mother's care	−0.048	0.019	−2.499	0.012	−0.056		
	Mother's encouragement of autonomy	−0.008	0.027	−0.312	0.755	−0.007		
	Mother's overprotection	0.073	0.028	2.568	0.010	0.060		
	Father's care	0.018	0.018	1.021	0.307	0.021		
	Father's encouragement of autonomy	−0.056	0.026	−2.097	0.036	−0.049		
	Father's overprotection	0.040	0.026	1.514	0.130	0.035		
Insomnia							0.181	0.177
	Gender	0.301	0.154	1.960	0.050	0.034		
	Age	−0.192	0.049	−3.932	<0.001	−0.067		
	SPA	0.053	0.007	7.794	<0.001	0.156		
	IGD	0.075	0.030	2.485	0.013	0.047		
	Self-control	−0.093	0.008	−11.910	<0.001	−0.242		
	Support utilization	−0.068	0.013	−5.373	<0.001	−0.098		
	Mother's care	−0.023	0.019	−1.241	0.215	−0.030		
	Mother's encouragement of autonomy	−0.014	0.026	−0.518	0.605	−0.013		
	Mother's overprotection	−0.006	0.027	−0.231	0.817	−0.006		
	Father's care	−0.012	0.017	−0.685	0.494	−0.015		
	Father's encouragement of autonomy	−0.017	0.026	−0.673	0.501	−0.017		
	Father's overprotection	−0.008	0.025	−0.326	0.745	−0.008		

Before being placed in the regression equation, gender was virtualized (male = 0, female = 1).

understanding, and support for their children), the encouraging autonomy dimension (referring to parents' encouragement of their children's independence), and the overprotection dimension (referring to parents' strict restriction of their children's freedom) (Chu et al., 2009). In the present study, Cronbach's alpha coefficients for each dimension were 0.798 (mother's care), 0.875 (mother's encouragement of autonomy), 0.836 (mother's overprotection), 0.789 (father's care), 0.884

(father's encouragement of autonomy), and 0.883 (father's overprotection).

### Generalized anxiety disorder-7 (GAD-7)

The GAD-7 scale screens for anxiety symptoms (Yu et al., 2016). The scale consists of seven items, and all items use a 4-point scale. The total score ranges from 0 to 21, with higher scores indicating higher degrees of anxiety. In the present study, the Cronbach alpha coefficient was 0.927.

## Patient health questionnaire-9 (PHQ-9)

The PHQ-9 scale screens for depressive symptoms (Wang et al., 2014). The scale has nine items, and all items use a 4-point scale. The total score ranges from 0 to 27, with higher scores indicating more severe depressive symptoms. In the present study, Cronbach's alpha coefficient was 0.905.

## Athens insomnia scale (AIS)

The AIS screens for sleep disturbances (Chung et al., 2011). The scale has eight items and uses a 4-point scale. The total score ranges from 0 to 24, with higher scores indicating more severe sleep disturbances. In this study, Cronbach's alpha coefficient of the scale was 0.844.

## Self-control scale (SCS)

The SCS measures the self-control ability of adolescents (Tangney et al., 2004). The Chinese version consists of 19 items rated on a 5-point scale, with 1 indicating ere sleep disturbances. In this study, ing more severe depressive symptoms. In thehe better the self-control ability (Tan and Guo, 2008). In this study, Cronbach's alpha coefficient of the scale was 0.863.

## Social support rating scale (SSRS)

This SSRS includes 17 items of subjective support, objective support, and utilization of support in three dimensions (Wu X. S. et al., 2016). A 5-point scale was used, with 1 indicating rt, objective support, and 1 indicating ere sleep disturbances. In this study, ing moreutilization dimension indicate better use of social support. Cronbach's alpha coefficient for the support utilization dimension was 0.921.

## Statistical analysis

According to the criteria of the Chinese version of MPAI, 807 individuals (26.50% of the overall participants) had SPA in this study (MPAI total scores  $\geq 51$ ) (Zhang et al., 2019). This proportion matched the SPA proportions previously investigated in Chinese (21.3%) (Long et al., 2016) and Asian (14.0n matched Sohn et al., 2019) studies with the same age sample. Thus, we divided all participants into the No SPA group ( $< 51$ ) and SPA group ( $\geq 51$ ) based on the total MPAI score. A total IGD score  $\geq 6$  was used to for the IGD group (Lemmens et al., 2015). Subsequently, all participants were divided into the No SPA-No IGD group ( $n = 2,002$ ), SPA-IGD group ( $n = 257$ ), Only IGD group ( $n = 240$ ), and Only SPA group ( $n = 550$ ). Then, the following analyses were performed. (1) ANOVA was used to compare the differences in depression, anxiety, insomnia, self-control, support utilization ability, and parenting styles among the four groups. (2) A multiple regression analysis was conducted to identify the factors that influence depression, anxiety and insomnia. (3) Relative weight analysis was conducted to diagnose the factors that contribute most

TABLE 5 Relative weight analysis on depression, anxiety and insomnia ( $n = 3,049$ ).

Dependent variable	Independent variable	Raw relative weights	Relative weights	R <sup>2</sup>
Depression				0.410
	Gender	0.005	1.337	
	Age	0.001	0.186	
	SPA	0.083	20.20	
	IGD	0.019	4.750	
	Self-control	0.175	42.721	
	Support utilization	0.061	15.010	
	Mother's care	0.019	4.602	
	Mother's encouragement of autonomy	0.002	0.602	
	Mother's overprotection	0.020	4.860	
	Father's care	0.008	1.935	
	Father's encouragement of autonomy	0.002	0.414	
	Father's overprotection	0.014	3.390	
Anxiety				0.325
	Gender	0.003	0.856	
	Age	0.001	0.322	
	SPA	0.074	22.67	
	IGD	0.019	5.970	
	Self-control	0.138	42.55	
	Support utilization	0.036	11.215	
	Mother's care	0.015	4.517	
	Mother's encouragement of autonomy	0.002	0.466	
	Mother's overprotection	0.018	5.630	
	Father's care	0.005	1.442	
	Father's encouragement of autonomy	0.001	0.378	
	Father's overprotection	0.013	3.984	
Insomnia				0.181
	Gender	0.002	0.943	
	Age	0.006	3.526	
	SPA	0.049	26.98	
	IGD	0.009	5.139	
	Self-control	0.076	42.138	
	Support utilization	0.023	12.499	
	Mother's care	0.006	3.186	
	Mother's encouragement of autonomy	0.007	0.392	
	Mother's overprotection	0.003	1.721	
	Father's care	0.004	2.075	
	Father's encouragement of autonomy	0.001	0.359	
	Father's overprotection	0.002	1.043	

Before being placed in the regression equation, gender was virtualized (male = 0, female = 1).

to depression, anxiety and insomnia. (4) Another multiple regression analysis was conducted to single out parenting styles that influence SPA or IGD. (5) After controlling for gender

TABLE 6 Multiple regression analysis on SPA and IGD ( $n = 3,049$ ).

Dependent variable	Independent variable	Coef	SE	<i>t</i>	<i>P</i>	$\beta$	$R^2$	$R^2_{adj}$
SPA							0.293	0.291
	Gender	−1.081	0.408	−2.648	0.008	−0.041		
	Age	−0.197	0.135	−1.466	0.143	−0.023		
	Self-control	−0.511	0.019	−26.340	<0.001	−0.447		
	Support utilization	−0.069	0.035	−1.967	0.049	−0.033		
	Mother's care	−0.116	0.052	−2.253	0.024	−0.051		
	Mother's encouragement of autonomy	0.080	0.072	1.110	0.267	0.026		
	Mother's overprotection	0.230	0.076	3.033	0.002	0.072		
	Father's care	−0.009	0.047	−0.200	0.842	−0.004		
	Father's encouragement of autonomy	0.024	0.071	0.343	0.731	0.008		
	Father's overprotection	0.263	0.070	3.753	<0.001	0.087		
IGD							0.187	0.184
	Gender	−1.464	0.091	−16.003	<0.001	−0.266		
	Age	0.045	0.030	1.491	0.136	0.025		
	Self-control	−0.049	0.004	−11.212	<0.001	−0.204		
	Support utilization	0.001	0.008	0.184	0.854	0.003		
	Mother's care	−0.045	0.012	−3.894	<0.001	−0.095		
	Mother's encouragement of autonomy	−0.040	0.016	−2.451	0.014	−0.063		
	Mother's overprotection	0.009	0.017	0.542	0.588	0.014		
	Father's care	0.004	0.011	0.374	0.709	0.008		
	Father's encouragement of autonomy	−0.039	0.016	−2.447	0.014	−0.063		
	Father's overprotection	0.086	0.016	5.444	<0.001	0.135		

Before being placed in the regression equation, gender was virtualized (male = 0, female = 1).

and age, we used the maximum likelihood (ML) method to construct path models to test the multiple mediating roles of support utilization and self-control in the relationship between parenting styles and SPA or IGD. All statistical analyses were performed in SPSS 22.0, R 4.2.0 and Mplus 7.2. Estimation equations for multiple regression analysis, relative weight analysis, and multiple mediation analysis are detailed in [Supplementary Table 2](#).

## Results

### Differences in psychological variables among the four groups

There were significant differences among the four groups in depression, anxiety, insomnia, self-control, and support utilization.

*Post-hoc* tests showed that depression and anxiety levels increased sequentially among the groups (No SPA-No IGD group < Only IGD group < Only SPA group < SPA-IGD group). While the insomnia levels increased sequentially among the groups [No SPA-No IGD group < Only IGD group < Only SPA (SPA-IGD) group], there was no significant difference between the SPA-IGD and Only SPA groups. Similarly, although the self-control and support utilization levels

decreased sequentially among the groups [No SPA-No IGD (Only IGD) group > Only SPA group > SPA-IGD group], there was no significant difference between the No SPA-No IGD group and the Only IGD group ([Table 2](#)).

### Differences in parenting styles among the four groups

There were significant differences in the scores on all dimensions of parenting styles among the four groups.

*Post-hoc* tests showed that the mother's care level decreased sequentially among the No SPA-No IGD, Only SPA, and SPA-IGD (Only IGD) groups, while there was no significant difference between the SPA-IGD and Only SPA groups. The father's care level in the No SPA-No IGD group was the highest among the four groups, but there were no significant differences among the other three groups. The Only-IGD group had the lowest levels of the mother's encouragement of autonomy and the father's encouragement of autonomy among the four groups, with no significant differences among the other three groups. The levels of mother's overprotection and father's overprotection increased sequentially in the No SPA-No IGD, Only IGD (Only SPA), and SPA-IGD groups, but there were no significant differences between the Only IGD and Only SPA groups ([Table 3](#)).

TABLE 7 Effects of support utilization and self-control between parenting styles and SPA and IGD ( $n = 3,049$ ).

	Total effect			Indirect effect (self-control)			Indirect effect (support utilization)			Sequential indirect effect (support utilization→self-control)			Direct effect		
	$\beta$	<i>P</i>	95% CI	$\beta$	<i>P</i>	95% CI	$\beta$	<i>P</i>	95% CI	$\beta$	<i>P</i>	95% CI	$\beta$	<i>P</i>	95% CI
<b>SPA</b>															
MC	-0.291	<0.001	[-0.406 -0.175]	-0.109	<0.001	[-0.164 -0.054]	-0.018	0.070	[-0.038 0.001]	-0.053	<0.001	[-0.070 -0.037]	-0.110	0.031	[-0.211 -0.010]
MEA	0.258	0.007	[0.072 0.443]	0.156	<0.001	[0.074 0.237]	0.006	0.240	[-0.004 0.016]	0.017	0.085	[-0.002 0.037]	0.079	0.334	[-0.081 0.238]
MO	0.476	<0.001	[0.279 0.673]	0.210	<0.001	[0.122 0.298]	0.008	0.158	[-0.003 0.020]	0.024	0.021	[0.004 0.045]	0.233	0.006	[0.068 0.399]
FC	-0.171	0.001	[-0.275 -0.068]	-0.109	<0.001	[-0.158 -0.060]	-0.014	0.071	[-0.028 0.001]	-0.040	<0.001	[-0.054 -0.025]	-0.009	0.855	[-0.102 0.085]
FEA	0.226	0.011	[0.052 0.399]	0.131	0.001	[0.054 0.208]	0.017	0.078	[-0.002 0.036]	0.050	<0.001	[0.029 0.071]	0.029	0.709	[-0.121 0.178]
FO	0.219	0.018	[0.038 0.401]	-0.012	0.757	[-0.090 0.066]	-0.004	0.323	[-0.013 0.004]	-0.012	0.196	[-0.031 0.006]	0.248	0.002	[0.094 0.402]
<b>IGD</b>															
MC	-0.061	<0.001	[-0.082 -0.040]	-0.010	<0.001	[-0.016 -0.005]	0.001	0.738	[-0.003 0.004]	-0.005	<0.001	[-0.007 -0.003]	-0.046	<0.001	[-0.067 -0.026]
MEA	-0.023	0.153	[-0.055 0.009]	0.015	<0.001	[0.007 0.023]	<0.001	0.773	[-0.002 0.001]	0.002	0.086	[-0.001 0.003]	-0.039	0.014	[-0.071 -0.008]
MO	0.030	0.082	[-0.004 0.064]	0.020	<0.001	[0.011 0.029]	<0.001	0.756	[-0.002 0.002]	0.002	0.023	[0.001 0.004]	0.008	0.616	[-0.025 0.042]
FC	-0.010	0.298	[-0.028 0.009]	-0.010	<0.001	[-0.015 -0.005]	0.001	0.741	[-0.002 0.003]	-0.004	<0.001	[-0.005 -0.002]	0.004	0.677	[-0.014 0.022]
FEA	-0.023	0.128	[-0.054 0.007]	0.012	0.002	[0.005 0.020]	-0.001	0.742	[-0.004 0.003]	0.005	<0.001	[0.003 0.007]	-0.040	0.009	[-0.070 -0.010]
FO	0.087	<0.001	[0.056 0.118]	-0.001	0.758	[-0.009 0.006]	<0.001	0.792	[-0.001 0.001]	-0.001	0.200	[-0.003 0.001]	0.089	<0.001	[0.058 0.120]

The effects were tested by using the bootstrap method with 5,000 resamples. MC, mother's care; MEA, mother's encouragement of autonomy; MO, mother's overprotection; FC, father's care; FEA, father's encouragement of autonomy; FO, father's overprotection.

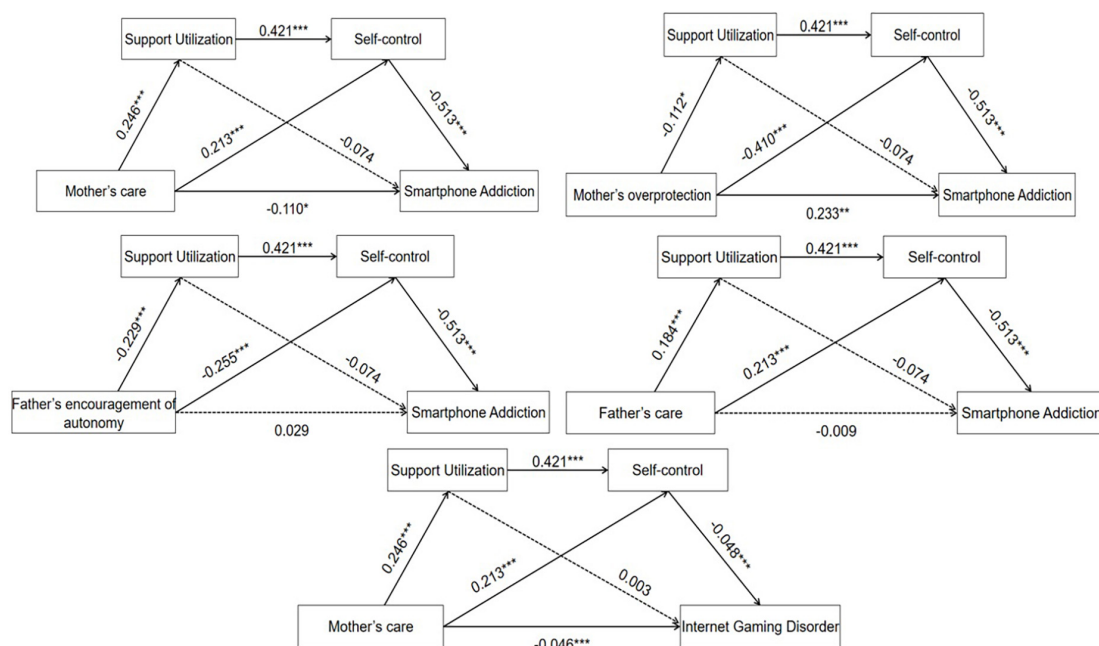


FIGURE 1

Path models of parenting styles dimensions which had significant sequential indirect effects through multiple mediation of support utilization and self-control on smartphone addiction and Internet gaming disorder. Dotted lines indicate non-significant relations. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

## Multiple regression analysis of depression, anxiety, and insomnia

**Table 4** shows the results of multiple regression analysis. After controlling for gender and age, both depression and anxiety showed negatively correlations with self-control, support utilization, the mother's care and the father's encouragement of autonomy, but showed positively relationship with SPA, IGD and the mother's overprotection. Insomnia showed negatively relationship with self-control and support utilization, but showed positively correlations with SPA and IGD. The result of checking for collinearity of multiple regression analysis of depression, anxiety, and insomnia are detailed in **Supplementary Table 3**.

## Relative weight analysis of depression, anxiety, and insomnia

**Table 5** shows the results of relative weight analysis. SPA, self-control and support utilization contributed most to the effects on depression, anxiety and insomnia.

## Multiple regression analysis of SPA and IGD

**Table 6** shows the results of another multiple regression analysis. After controlling for gender and age, SPA showed

negatively correlations with self-control, support utilization and the mother's care but showed positively relationship with parental overprotection. IGD showed negatively relationship with self-control, the mother's care and parental encouragement of autonomy but showed positively correlations with the father's overprotection. The result of checking for collinearity of multiple regression analysis of SPA and IGD are detailed in **Supplementary Table 4**.

## A test of the multiple mediating roles of support utilization and self-control between parenting styles and SPA or IGD

**Table 7** shows the path model results. When SPA was set as dependent variable, model fit index was good ( $\chi^2/df = 13.12$ , RMSEA = 0.063, CFI = 0.953, TLI = 0.858). When IGD was set as dependent variable, model fit index was good as well ( $\chi^2/df = 13.11$ , RMSEA = 0.062, CFI = 0.940, TLI = 0.821).

According to models, all parenting styles had no significant partially indirect effect on SPA or IGD through support utilization. In addition to the mother's encouragement of autonomy and father's overprotection, parental care, mother's overprotection, and father's encouragement of autonomy had a significant sequential indirect effect on SPA through the multiple mediation of support utilization and self-control. However, only the mother's care had a significant sequential indirect effect on

IGD through the multiple mediation. Specific path coefficients are detailed in [Figure 1](#).

## Discussion

By investigating depression, anxiety, insomnia as well as other psychological characteristics as proxies for adolescents' mental health and their past experienced parenting styles, the present study found that although both SPA and IGD threatened adolescents' mental health, adolescents with only SPA showed worse mental health status compared to adolescents with only IGD. Moreover, high levels of positive parenting styles and low levels of negative parenting styles were beneficial to adolescents' mental health overall, but it was less valid for adolescents with SPA. The impacts of parenting styles on adolescents' mental health were not direct, but rather indirectly manifested through the intrinsic psychological mechanisms of support utilization and self-control that influence high-risk Internet use behaviors. Importantly, encouraging autonomy showed negative and convergent effects with caring on adolescents' IGD, but revealed positive and divergent effects with caring on adolescents' SPA.

In this study, compared to adolescents in group no SPA-no IGD, adolescents with SPA or IGD had higher levels of depression, anxiety, and insomnia, which is consistent with previous studies ([Demirci et al., 2015](#); [Kircaburun et al., 2019](#)). In contrast, adolescents with SPA and IGD had lower levels of self-control and support utilization and that is consistent with prior studies showing that abilities of self-control and support utilization were protective factors against high-risk Internet use behaviors ([Spada, 2014](#); [Kim et al., 2016](#); [Wu X. S. et al., 2016](#); [Mo et al., 2018](#)). The IGD-SPA comorbidity group had the highest levels of depression, anxiety, and insomnia. A previous study showed that using smartphones for gaming increased the time length or frequency of smartphone usage and further increased the risk of smartphone addiction ([van Deursen et al., 2015](#)). Meanwhile, IGD may also reinforce SPA behavior ([Chou and Chou, 2019](#)). Thus, SPA and IGD comorbidity may have critically negative impacts on adolescents' mental health ([Chang et al., 2019](#); [Elhai et al., 2019](#)). We also found that the only SPA group had significantly higher levels of depression, anxiety, and insomnia degrees than the only IGD group. Adolescents are more susceptible to peer influence ([Steinberg and Monahan, 2007](#); [Somerville, 2013](#)) and pursue peer relationships even more than family relationships ([Lee and Kim, 2018](#)). Based on the finding that the usage of social software (QQ & WeChat) in the Only SPA group had the highest percentage among the four groups ([Supplementary Table 1](#)), we suggest that the other Internet addiction behaviors (e.g., virtual socialization) may cause adolescents to spend greater time on the Internet than gaming and result in worse mental health states ([Kuss et al., 2013](#); [Montag et al., 2015b](#); [Liu et al., 2018](#); [Sun et al., 2019](#)). The

adverse effects of IGD on mental health, well-being, and daily functioning have been widely recognized ([Sarda et al., 2016](#)). Although a consensus has been reached that SPA is harmful to adolescents' mental health, people may underestimate the actual damage of SPA to adolescents when they are not using smartphones for gaming. However, our study revealed that the mental health of adolescents with SPA but without IGD might be more vulnerable to depression, anxiety, and insomnia.

In this study, adolescents without SPA and IGD not only had lowest levels of depression, anxiety, and insomnia, but also associated with highest levels of the caring parenting styles, encouraging autonomy parenting styles and lowest levels of the overprotection parenting styles, consistent with previous finding that positive parenting styles can reduce the incidence of depression in adolescents ([Collishaw et al., 2016](#)). However, the only SPA group had a higher level of mother's care than the only IGD group but exhibited a worse mental health state. Further relative weight analysis showed that adolescents' mental health indexes mainly related to SPA, self-control and support utilization. This result indicated that effects of parenting styles on adolescents' mental health may need to be externalized indirectly by impacting adolescents' high-risk Internet use behaviors. Therefore, positive parenting styles should be used as a pre-emptive strategy to prevent adolescents from developing smartphone addictive behaviors, not as a remedy for improving the mental health of adolescents with SPA. Thus, simply emphasizing the defensive effects of positive family parenting styles alone would not achieve the desired interventions on mental health of adolescents with SPA.

In the present study, high levels of the caring parenting styles and low levels of the overprotection parenting styles might be protective factors for adolescents' SPA and IGD behaviors, consistent with previous findings that positive parenting styles negatively affect SPA and IGD, while negative parenting styles positively affect both of them ([Deng et al., 2015](#); [Lian et al., 2016](#)). By constructing a pathway model, we found that parental care and the mother's overprotection indirectly influenced SPA through the multiple mediation effects of support utilization and self-control, and the mother's care indirectly affected IGD through support utilization and self-control. This multiple mediation effects of support utilization and self-control highlighted the importance of family parenting styles in altering the self-control resources of adolescents. The positive effects of parental care on self-control were in line with the finding that children have higher levels of self-control when parents convey more warmth to their children ([Crosswhite and Kerpelman, 2012](#)). The negative effect of mother's overprotection on self-control was also in line with the finding that children with less self-control had limited effective parenting styles ([Ng-Knight et al., 2016](#)). In particular, negative parenting styles reduce adolescents' ability to utilize social support, and that may cause adolescents to feel low levels of social support ([Karaer and Akdemir, 2019](#)) and self-control

(Wu et al., 2017). When faced with negative parenting styles, adolescents do not necessarily have the opportunity to receive vicarious compensation or emotional buffers from a social support system to help them resist temptations from undesirable behaviors, such as online gaming or indulging in smartphone use.

Notably, the parenting style of encouraging autonomy showed surprising divergent effects on adolescents' IGD and SPA. The father's encouragement of autonomy positively influenced SPA in adolescents. However, parental encouragement of autonomy negatively predicted IGD in adolescents. Rossé (2012) argued that when parents hinder adolescents from seeking independence to reconstruct their self-identity, adolescents may avoid communication with their parents by becoming addicted to the Internet. Giving adolescents freedom may help them refine their self-identity and build closer relationships with their parents, reducing the risk of IGD (Deng et al., 2013). However, smartphones, as a media platform enabling various types of Internet behaviors, are likely to make individuals extremely dependent (Hoffner et al., 2015; De-Sola Gutiérrez et al., 2016). Giving adolescents freedom may push them to be prone to suffer in SPA. Especially, the father's encouragement of autonomy indirectly influenced SPA through the negative multiple mediation effects of support utilization and self-control. Therefore, emphasis on independence too early may trigger SPA in adolescents who are still in developmental stages, regardless of what purposes they use their smartphones for. More importantly, based on the outstanding contribution to adolescent's mental health of self-control, the negative impact of encouraging autonomy on self-control showed that the autonomy-encouraging parenting style had a similar effect with the overprotection parenting style not only in strengthening SPA behaviors in adolescents but also in damaging mental health of adolescents. Previous researches have considered encouraging autonomy and overprotection as two antagonistic parenting styles (Costa et al., 2016; Inguglia et al., 2018). However, when synergizing with low parental monitoring, adolescents exhibit a higher degree of internal psychological issues with autonomy-encouraging or overprotective parenting styles (Rodríguez-Meirinhos et al., 2020). Therefore, this study implied that both encouraging autonomy and overprotection parenting styles are detrimental to adolescents with SPA, and parental monitoring is necessary for controlling adolescents' smartphone use behaviors.

Additionally, lacking self-control can aggravate different behavioral problems and addictions (Dvorak et al., 2011; Oezdemir et al., 2014). SPA may have different addiction motives than IGD (Noë et al., 2019; Nie et al., 2020). Therefore, the psychological satisfaction sought by adolescents during SPA behaviors may not be the same as that sought in Internet games. Thus, the divergent effect of the encouraging autonomy parenting style on IGD and SPA may be due to self-control playing different roles in the

maintenance and formation process of various types of Internet addiction.

## Limitation

Although the questionnaires used in this study have been shown to have good reliability in previous studies, it should be noted that Cronbach' alpha coefficients for MPAAI, GAD, PHQ and the support utilization subscale were slightly above the recommended range (0.90) (Streiner, 2003) in this study. There may be over-high correlations among the items within each of these four questionnaires, meaning that participants' SPA, anxiety, depression and support utilization may only be measured from a narrow profile. Moreover, the participants for this study were junior and senior high school adolescents and the mental health status of adolescent is not homeostatic. Adolescents are in a critical developmental period with active emotional-behavioral function and risk for psychopathology, their mental health status can fluctuate (Costello et al., 2003). For example, depression in adolescents may vary with development (Prenoveau et al., 2011). Future researchers could use longitudinal design to increase the stability of results.

## Conclusion

In conclusion, this study found that adolescents with SPA and IGD comorbidity had the highest levels of depression, anxiety, and insomnia levels. Despite having a more positive parenting style, adolescents with SPA but no IGD showed more severe mental health problems than adolescents with only IGD. Moreover, the autonomy-encouraging parenting style protected against IGD but strengthened SPA in adolescents through the multiple mediation effects of support utilization and self-control. This study suggests that parents should adopt different supervisory strategies to deal with different types of Internet addiction.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of the School of Education, Hunan University of Science and Technology, China. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## Author contributions

Z-KL and L-JS developed the study concept and designed the study. Z-KL analyzed and interpreted the data. Z-KL, L-JS, and X-LC prepared the manuscript. L-JS provided critical revisions. All authors performed data collection, had full access to all data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis, and approved the final version of the manuscript for submission.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

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# Smartphone addiction and phubbing behavior among university students: A moderated mediation model by fear of missing out, social comparison, and loneliness

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**Introduction:** This article examines mediators and moderators that may explain the link between smartphone addiction and phubbing behavior using a sample of 794 university students.

**Methods:** A mediation model was tested to test the hypothesis that social comparison orientation and fear of missing out would mediate the link between smartphone addiction and phubbing behavior. Additionally, a moderated mediation model was leveraged to examine loneliness as a moderator within the hypothesized model. The data collected were analyzed using SPSS.

**Results and Discussion:** The findings show a significant positive relationship between smartphone addiction and phubbing behavior. The findings confirm the hypothesized associations and reveal that smartphone addiction is positively linked to phubbing behavior. The link, on the other hand, is partially and sequentially mediated by the fear of missing out and social comparison orientation. As a result, both mediators might be regarded as proximal variables of phubbing behavior. Moreover, the associations between both smart addiction and phubbing behaviors as well as social comparison orientation and phubbing behaviors are moderated by loneliness. These two effects were stronger for university students with high loneliness than for those with low loneliness. This study addresses a major gap in the clinical psychology literature through the attempt to explore the relationship between smartphone addiction and increased phubbing behavior among university students.

## KEYWORDS

smartphone addiction, phubbing behavior, university students, fear of missing out, social comparison orientation, loneliness

## 1. Introduction

Recently, there exist numerous discussions among the higher education (HE) community about smartphones. Universities and colleges are examining more and more ways to utilize smartphones to increase student engagement and to better captivate them. As stated by Nand et al. (2020), smartphone use has a significant impact on how HE students act in social and academic contexts. Furthermore, HE students frequently use their smartphones for academic purposes (Nand et al., 2020). Researchers have recently expressed their concern about smartphones' possible negative impacts on students' psychological and physical health, as well as the quality of their social interactions, despite the devices' clear benefits. The rise of "phubbing" (PHU), a new maladaptive behavior, is associated with smartphone usage's increase in popularity. PHU is defined as a modern form of social snubbing, where a person ignores another in social interaction by focusing on their smartphones instead of engaging in a conversation (Nazir, 2017). This behavior embodies the actual negative effects of poor communication that harm interpersonal relationships and feelings of personal well-being.

Higher education students exhibit the effects of excessive smartphone usage in the form of attention deficit hyperactivity disorder and concentration difficulties. Nonetheless, the role of PHU in contributing to these symptoms is practically unknown. Within the Pakistani scenario, smartphone use disorder among HE students is surging, indicating the possibility of PHU among HE students (Bajwa et al., 2021). Furthermore, even in this day and age of e-learning, only a small percentage of students use their smartphones to supplement their learning. The vast majority of them use smartphones for personal communication, indicating that PHU may have many predictable or attendant factors. Recent studies have proposed that these phenomena may have some impacts on HE students' academic outcomes, particularly those who engage in smartphone activities in class (e.g., Dontre, 2021). PHU has been found to cause psychological impairment or distress, loneliness, depressive states, insecurity, hopelessness, low self-esteem, somatization, and alexithymia (Fernández-Andújar et al., 2022). Such mental distresses may contribute to poor academic performance, personal relationships, social identity, and family relationships (Yang et al., 2019).

Against this backdrop, this present research aims to address the dearth of research on predictors of PHU behavior (PHUB) among HE students. This study's focus is on Pakistan, where smartphone overuse among HE students has contributed to the upsurge in PHUB cases. A growing literature indicates that smartphone addiction (SMA) harms Pakistani HE students' satisfaction with classroom connectedness (e.g., Tamura et al., 2017). Despite being a global phenomenon – not constrained within the context of Pakistan – very few studies have attempted to identify the predictive factors for PHUB in the HE setting. Based on past studies, some risk factors for PHUB include addictive behaviors (such as SMA), fear of missing out (FoMO), loneliness (Gong et al., 2019), and social comparison orientation

(SCO; Chotpitayasunondh and Douglas, 2016; Blanca and Bendayan, 2018). Proper identification and acknowledgment of these factors might be essential for ensuring that the right preventive measures and treatments are implemented to decrease pathological PHUBs and problematic smartphone usage. Furthermore, in most studies on smartphone use, addictive tendencies – most importantly, smartphone addiction – is among the top predictors of PHUBs (e.g., Blachnio and Przepiorka, 2019; Balta et al., 2020). The pathological use of smartphones – at the price of worsening relational connections brought about by PHUBs – has also been highlighted by Salehan and Negahban (2013) in the same vein. Recognizing the past findings in the literature, this current study highlights that SMA should be a strong predictor of PHUB.

FoMO and SCO have begun to be recognized as PHUB predictors by research on psychological aspects of PHU and SMA (Chotpitayasunondh and Douglas, 2016; Blanca and Bendayan, 2018; Franchina et al., 2018; Balta et al., 2020). On the other hand, loneliness has been proven to exhibit a strong correlation with PHUB. In recent times, loneliness is becoming more prevalent among the younger generation. According to Karadağ et al. (2015) HE students prefer to use their smartphones more often when they feel lonely, as they believe that doing so will mitigate their loneliness. Additionally, research has shown that high FoMO will promote problematic smartphone use, further increasing the risk of PHU. However, there has not exist much empirical study on the relationship between SMA and PHUB, particularly in the Pakistani context (Chotpitayasunondh and Douglas, 2016; Butt and Arshad, 2021; Lai et al., 2022). Additionally, there is not much knowledge about the factors that might explain this relationship. Acknowledging this gap in the literature, the current study investigates how SMA and PHUB are directly and indirectly related.

## 2. Theoretical background

This study employs the Social Comparison Theory (SCT; Festinger, 1964) and Compensatory Internet Usage Theory (TCIU; Kardefelt-Winther, 2014). TCIU depicts problematic usage as a coping or compensating mechanism for those who are going through destructive or deleterious psychological states (Wolniewicz et al., 2018). People with psychosocial issues may use their smartphones excessively to cope with life's stressful situations. According to this theory, people's excessive smartphone use may be a sign that they are experiencing distressful feelings like loneliness. Their interaction with smartphones serves to suppress these feelings (Elhai and Contractor, 2018). This fact might explain the connection between detrimental smartphone usage and negative emotional states like loneliness and FoMO (Chotpitayasunondh and Douglas, 2016; Dayapoglu et al., 2016; Bolkan and Griffin, 2017; Elhai et al., 2018), both of which are strongly associated with PHU (Chotpitayasunondh and Douglas, 2016). Nonetheless, some researchers feel that the TCIU presents

a limited perspective and does not provide a thorough outlook on the investigation of the hypothesized correlations. This is even though TCIU can explain negative emotional states as a feasible trigger to predict HE students' inclination for PHU. To complement this deficiency in the theory, the current study complements it with SCT to assess the associations between FoMO, social comparison (SC), SMA, loneliness, and PHU.

Additionally, SCT proposes that individuals may use upward or downward SCs, depending on their motives. The type of comparison that a person makes depends on their level of motivation (Talwar et al., 2019). For instance, a highly driven person might strive for personal development and perform upward SCs (Cramer et al., 2016). Prior research has revealed that users of social media (SM) sites may be prone to believing that other users are in comparatively better circumstances than they are. This will inevitably lead them to engage in upward SC (Latif et al., 2021). Inspired by the approach taken in past research, the current study uses SCT to investigate how SMA, FoMO, and PHU are related to SC in its upward version. Accordingly, in this study, individuals experiencing FoMO are also more prone to involve in upward SC, causing them to feel negative emotions like PHU. In acknowledgment of TCIU and SCT, this study constructs one moderator (loneliness) and two mediators (SCO and FoMO) to gain insights into the links between SMA and PHUB among Pakistani HE students.

## 2.1. Smartphone addiction and phubbing headings

According to several definitions, SMA is a behavioral addiction with four elements: compulsive smartphone usage, tolerance (defined as a person's diminished sensitivity to an addictive chemical or stimuli as the result of repeated use), withdrawal, and functional impairment. Consequently, SMA is acknowledged as being equivalent to the Diagnostic and Statistical Manual of Mental Disorder criteria for internet addiction (DSM-V; Nuckols, 2013). Researchers have discovered that both PHUB and SMA harm people's social functioning. According to earlier research, during the COVID-19 outbreak, HE students had to maintain their social distance, and may only gain information about the epidemic *via* smartphones. This has inevitably increased the amount of time and frequency spent on the device. As a result, many felt lonely and abandoned, making it harder for them to socialize with and build strong connections with others. When the movement restrictions placed on the students were eased – as the society transitioned into the endemic phase – undesirable behaviors such as phubbing began to surface.

Additionally, recent studies have shown that people will communicate with others online and use their smartphones more frequently to feel satisfied, raising the risks of SMA (Zhao et al., 2021; Diotaiuti et al., 2022). Lai et al. (2022), on the other hand, asserted that SMA is a predictor of PHUB in a sample of Chinese

HE students. It was discovered *via* prior research that technology addictions, such as SMA, may predict PHUB (Al-Saggaf and O'Donnell, 2019). However, little study has been done so far on how SMA among Pakistani HE students relates to PHUB.

## 2.2. Fear of missing out and social comparison as mediators

SCO and FoMO can be taken into consideration in a study that examines the nature of phubbing, due to their theoretical connection with SMA and PHUB. According to SCT – a theory that explains how people get insight into who they are through comparison with others – SCO symbolizes an individual's propensity to engage in SCs (Gibbons and Buunk, 1999). Additionally, in studying the relationship between SMA and PHUB, the psychological notion of FoMO – which may be viewed as a response variable of SC – may also be taken into account (Schmuck et al., 2019; He et al., 2020). FoMO is defined as “the need to always know what other people are up to” or “a continuous dread that one may be missing out on pleasant events while others are present” (Przybylski et al., 2013). Moreover, overusing smartphones can be linked to FoMO, which, in turn, may result in PHUBs (Hong et al., 2012).

A study has found that excessive smartphone usage and PHUB are both caused by FoMO in teenagers from Flemish communities while confirming the probable link between the two (Franchina et al., 2018). Later studies have also revealed that people with high levels of FoMO are more prone to abusing their smartphone usage and, as a result, indulge in PHUB fueled by their urge to be connected online (Balta et al., 2020). Additionally, certain empirical investigations suggest that SCO and FoMO may be linked to PHUB (Chotpitayasunondh and Douglas, 2016; Davey et al., 2018; Franchina et al., 2018; Balta et al., 2020). In a sample of 474 Italian adults, Servidio et al. (2021) revealed that the link between self-concept clarity and problematic smartphone use was explained by SCO and FoMO. To the best of our knowledge, no earlier research has studied how SCO and FoMO may have a mediation role in the connection between SMA and PHUB.

## 2.3. Loneliness as a moderator

Loneliness may be defined as the feeling a person gets when his/her social relationships are inadequate on either the qualitative or quantitative level (Peplau, 2022). According to an increasing number of studies, young individuals who are feeling lonely have a larger propensity to involve in internet-related addiction – such as problematic smartphone use (Liu et al., 2020). According to another meta-analysis, loneliness pushed people to use Internet-connected devices rather than vice versa (Song et al., 2014). Xu (2017), when studying the links between SMA, social anxiety, and loneliness among 195

high school students in Beijing, observed that people who use their phones excessively also suffer from increased loneliness. Various other studies have also looked at the mediation impact of loneliness in the linkages between other adverse family features – such as parental disagreement, technological indifference, and dysfunctional families – and Internet-related addiction behaviors (He et al., 2020). The link between PHUB and its determinants comprises one of the subjects of interest in this research. The decision to include this link within the current study is motivated by the fact that the function of loneliness as a moderator has received less attention in other studies.

## 2.4. The present study

Prior research has mostly concentrated on the association between SMA and students' PHUB scores. There are, however, very few studies that investigate the connection between SMA, loneliness, PHUB, SCO, and FoMO. It is unclear what mediating processes could explain this correlation and what moderating factors might have an impact on this relationship. In detail, the aims of the present study are several folds. Firstly, to explore if SCO and FoMO would affect HE students' PHUB. Secondly, to determine if, in a serial mediation model, SCO and FoMO would moderate the relationship between SMA and PHUB among students. Thirdly, to determine if loneliness would act as a moderator in the direct and indirect relationships between SMA and PHUB *via* SCO and FoMO. Figure 1 depicts a segregated moderated mediation model whereby loneliness – *via* parallel

pathways of SCO and FoMO – moderates the indirect effects of SMA on PHUB.

## 3. Materials and methods

### 3.1. Participants and procedures

A total of 800 university students participated in this study, and 794 usable questionnaires were returned (99.25% response rate). Participants were recruited *via* a multistage cluster random sampling technique. In South Punjab, Bahauddin Zakariya University and Islamia University Bahawalpur were randomly selected, and the faculties at each university were split into science and non-science groups. Three departments were selected randomly from each group, and two classes were selected from each department. 53% of the participants were female, aged 18–26, while 47% were male. All participants individually answered the questionnaires for around 20 min after giving informed consent to the researchers. The frequency of daily and weekly internet use was assessed. We found that 92% of the participants were identified as frequent users of the internet (almost every day). Additionally, 74% of participants prefer to use the internet from home.

### 3.2. Measures

The Smartphone Addiction Scale (Kwon et al., 2013) was employed to measure problematic smartphone use. It entails 10

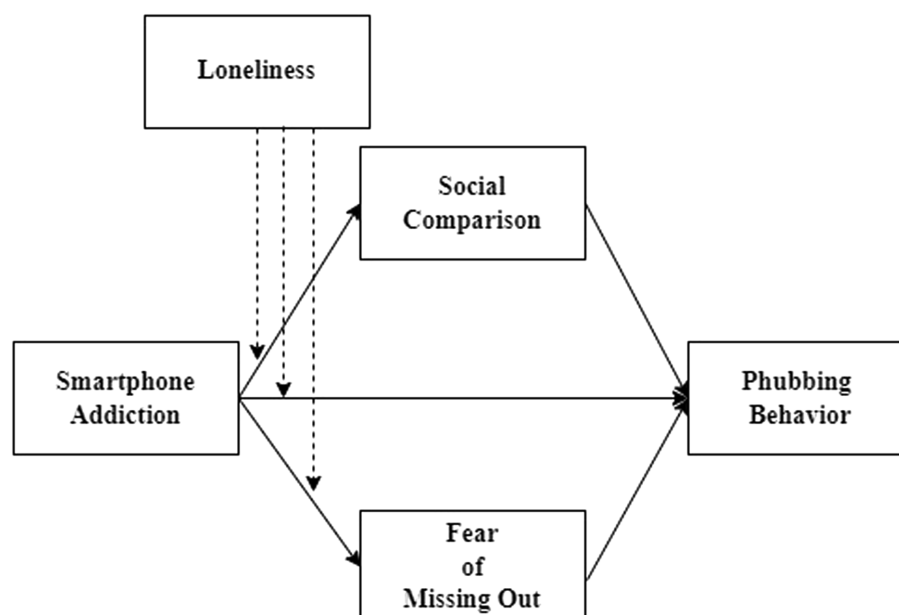


FIGURE 1  
Research framework.

items – such as “Missing scheduled work because of smartphone use” – measured using a 6-point Likert scale with 1 (never) to 6 (always). The higher average scores reflect teenage SMA. This scale has an excellent level of validity and reliability and is frequently used to evaluate problematic smartphone usage by Chinese youths (Wang et al., 2017). Furthermore, the Smartphone Addiction scale exhibits a Cronbach's alpha of 0.91.

On top of that, the Phubbing Scale (Karadağ et al., 2015) was employed to assess PHUB. This instrument contains 10 items – e.g., “I'm constantly on my phone while I'm with friends” – to which participants measure their response on a 5-point Likert scale ranging from 1 (never) to 5 (always). The scale has two dimensions: Communication Disturbance and Phone Obsession. In the original version of the measure, the internal consistency of the former subscale is 0.87, while the internal consistency of the latter is 0.85.

Moreover, the Social Comparison Scale was evaluated using an 11-item self-report scale derived from the INCOM (Gibbons and Buunk, 1999; Ruggieri et al., 2021). The scale measures the propensity for SC through the identification of key elements of the self, the other, and their psychological interactions. The items – e.g., “I usually prefer to know what others in a comparable circumstance would do” – are assessed on a five-point Likert scale ranging from 1 (I strongly disagree) to 5 (I strongly agree). Greater SC behaviors are indicated by higher scores. In the current investigation, Cronbach's alpha was 0.78.

Adolescents' loneliness, on the other hand, was measured using the 3-item Loneliness Scale (Hughes et al., 2004). This scale has been utilized with high reliability and validity in a previous study involving Chinese youths (Jiang et al., 2022). This scale consists of three items assessed on a 7-point scale ranging from 1 (never) to 7 (often) (always). The average scores for these items represent degrees of loneliness among adolescents, with a higher score indicating a greater sensation of loneliness. Cronbach's alpha coefficient for this scale was 0.92 for the current study.

Besides that, the Fear of Missing Out scale established by Przybylski et al. (2013) was used to measure FoMO. It consists of 10 items – e.g., “It irritates me when I miss a chance to see friends” – that are rated on a 7-point Likert scale ranging from 1 (never) to 7 (always). This scale has been widely used in research involving adolescents with good reliability and validity (Ma et al., 2021).

Higher average scores imply higher degrees of FoMO. Cronbach's alpha coefficient for this scale was 0.92.

## 4. Data analysis

The researchers carried out data entry using a personal computer (PC) and analyzed the data using SPSS 26.0. The data were then evaluated in five phases using the procedures of multiple mediations and moderated mediation analyses described in previous studies (e.g., Hayes, 2017; Wang et al., 2017). The first phase involved a factor analysis to investigate common variances to check for common technique biases. The second phase then entailed descriptive and correlation analyses to examine the results of the five surveys. In the next phase, Model 6 and a multiple mediation model were used to assess the mechanisms of SCO and FoMO in the relationship between SMA and PHUB. Finally, the study examined whether loneliness moderated the direct and indirect effects of SMA on PHUB by exploring the moderated mediation model *via* Model 8 of the PROCESS macro v3.0.

## 5. Results

### 5.1. Common method biases test

In the current study, common method deviations were systematically reduced by utilizing partial item reverse measurements and anonymous assessment. However, the literature suggests that the outcomes of self-reported surveys may be biased by common methods (Kenny, 2021). To ascertain if bias exists, the current study applied Harman's (1960) Single-Factor Test, as suggested by Kenny (2021). The research revealed that 14 factors had eigenvalues larger than one, with the first component accounting for less than 40% (17.608%) of the variance. As a result, no major common method bias was found in the study (Tables 1, 2).

### 5.2. Descriptive statistics and correlation analysis

TABLE 1 Comparative descriptive statistics of the main variables affecting students of both genders.

No.	Construct	$\alpha$	$M(SD)$	Male $M(SD)$	Female $M(SD)$	$t$
1	PHUB	0.91	2.27(1.01)	2.39(1.01)	2.17(1.01)	3.184***
2	FoMO	0.88	3.27(1.32)	3.16(1.30)	3.36(1.33)	-2.192**
3	LON	0.96	3.81(1.17)	3.78(1.22)	3.83(1.12)	-2.048**
4	SCO	0.95	3.51(1.22)	3.58(1.22)	3.45(1.21)	1.606
5	SMA	0.95	3.8(0.91)	3.79(0.91)	3.8(0.92)	-0.125

SMA, smartphone addiction; PHUB, phubbing behavior; SCO, social comparison orientation; FoMO, fear of missing out. \*\* $p < 0.01$  and \*\*\* $p < 0.001$ .

TABLE 2 Correlation among key variables.

No.	Construct	1	2	3	4	5
1	PHUB	1				
2	FoMO	0.089**	1			
3	SCO	0.104**	0.116**	1		
4	LON	0.187**	0.325***	0.134**	1	
5	SMA	0.240**	0.021	0.060	0.129**	1

SMA, smartphone addiction; PHUB, phubbing behavior; SCO, social comparison orientation; FoMO, fear of missing out. \*\* $p < 0.01$  and \*\*\* $p < 0.001$ .

### 5.3. Testing for mediating effect of social comparison orientation

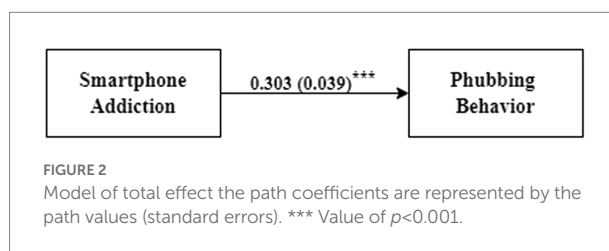
The overall impact of SMA on PHUB and the mediating role of SCO were examined by PROCESS macro (version III) for SPSS. The overall impact of SMA on PHUB is depicted in Figure 1 (total effect = 0.303,  $p = 0.000$ , 95% CI = [0.2263, 0.3811]). The results show that SMA is positively correlated with SCO ( $b = 0.236$ ,  $p = 0.000$ , 95% CI = [0.18, 0.29]), which is in turn positively related to PHUB ( $b = 0.50$ ,  $p = 0.000$ , 95% CI = [0.38, 0.61]). The direct residual impact was also significant ( $b = 0.19$ ,  $p = 0.000$ , 95% CI = [0.107, 0.26]). As a result, SCO partially mediated the relationship between SMA and PHUB (indirect effect = 0.118, 95% CI = [0.08, 0.15]). Around 5.7% of the variance in PHUB among Pakistani HE students was explained by this model.

### 5.4. Testing for mediating effect of fear of missing out

The mediating impact of self-control was also investigated via PROCESS macro for SPSS. Findings reveal that SMA was positively linked to FoMO ( $b = 0.092$ ,  $p = 0.037$ , 95% CI = [0.03, 0.15]), which, sequentially, was positively linked to PHUB ( $b = 0.402$ ,  $p = 0.000$ , 95% CI = [0.26, 0.46]). The residual direct impact was likewise significant ( $b = 0.27$ ,  $p = 0.000$ , 95% CI = [0.195, 0.34]). Therefore, the effect of SMA on PHUB was partially mediated by FoMO (indirect effect = 0.034, 95% CI = [0.01, 0.06]). This model explained 6.5% of the variance in PHUB among HE students in Pakistan.

### 5.5. Multiple mediation model test

The multiple mediation model was examined using the PROCESS macro for SPSS (Model 6). Figure 2 depicts the total effect of SMA on PHUBs (total effect = 0.31,  $p = 0.000$ , 95% CI = [0.236, 0.392]). Table 3; Figure 3 show that all pathways were significant. SCO and FoMO partially mediate the link between SMA and PHUB (SCO: indirect effect = 0.020, 95% CI = [0.004, 0.041]; FoMO: indirect effect = 0.078, 95% CI = [0.0471, 0.112]). The pathway of “SMA/SCO/FoMO/



PHUB” was significant (indirect effect = 0.013, 95% CI = [0.0038, 0.0256]), indicating that a higher level of SMA was associated with higher SCO ( $b = 0.201$ , 95% CI = [0.15, 0.25]), FoMO ( $b = 0.092$ , 95% CI = [0.03, 0.155]), and a higher tendency to PHUBs. The residual direct impact was likewise significant ( $b = 0.191$ , 95% CI = [0.12, 0.266]). Consequently, in the effect of SMA on PHUB, SCO, and FoMO only partially performed mediation functions. The multiple mediation model employed in the research contributed significantly to the explanation of the variation in PHUBs among Pakistani HE students ( $R^2 = 0.23$ ).

### 5.6. Moderated mediation model test

The current study anticipated that, through SCO and FoMO, loneliness would mitigate the direct and secondary impacts of SMA on PHUB. To investigate the moderated mediation hypothesis, the PROCESS macro v.3 for SPSS was utilized (Model 8). The findings are shown in Table 4. The findings indicate that the interaction between SMA and loneliness on SOC ( $b = 0.038$ , 95% CI = [-0.012, 0.0889],  $p = 0.137$ ) and on FoMO ( $b = 0.046$ , 95% CI = [-0.0028, 0.096],  $p = 0.064$ ) are insignificant. This suggests that loneliness does not influence the direct and indirect effects of SMA on FoMO and SOC.

The findings of the moderated mediation reveal that loneliness would moderate the indirect associations between SMA and PHUB, as shown in Table 4 (index = -0.02, boot SE = 0.01, 90% CI = [-0.05, -0.001]). Figure 4 displays further findings from a simple slope analysis. SMA has a substantial positive predictive influence on PHUB. However, this effect was less pronounced for participants with low levels of loneliness ( $M - 1SD$ ) ( $b_{\text{simple}} = 0.177$ ,  $t = 3.906$ ,  $p < 0.001$ ). For participants with high loneliness levels ( $M + 1SD$ ), job burnout also has a positive predictive effect on depression ( $b_{\text{simple}} = 0.450$ ,  $t = 10.13$ ,  $p < 0.000$ ), indicating that with the improvement of loneliness level, the predictive effect of SMA on PHUB gradually increases.

## 6. Discussion

The current study focused on Pakistani university students and sought to investigate the moderated mediation roles of SCO, FoMO, and loneliness in the association between SMA

and PHUB. Although the relationship between FoMO, SCO use, and/or SMA has been studied, this is the first known study that investigates the relationships among all these variables and probes into the mediating or moderating mechanisms. The findings indicated that SMA was positively associated with PHUB. Furthermore, FoMO and SCO sequentially mediated the relationship between PHUB and SMA, and that loneliness might act as a moderator between PHUB and SMA, implying that this relationship was stronger for university students with high loneliness than for those with low loneliness. Finally, the results revealed that SMA affected PHUB *via* FoMO and SCO with the increment of loneliness.

As expected, SMA's possible involvement as a contributor to PHUB dysfunction is corroborated by the fact that it has a positive relationship with PHUB. Furthermore, high scores on SMA are associated with higher scores of PHUBs, which is in

line with prior studies (Franchina et al., 2018; Blachnio and Przepiorka, 2019; Nazir and Bulut, 2019). One issue that appears in the digital age and needs many people's attention, including counselors and other education professionals, is PHUB. Therefore, complementary programs are needed to educate HE students on how to use their smartphones wisely. One possible idea is to develop awareness campaigns consisting of two-day workshops and lectures to comprehend the occurrence of PHUB and equip therapists with possible remedial tools. Through these awareness sessions, consular officials may acknowledge SMA and PHUB as real problems faced by students and raise awareness of the dangers of smartphone abuse among them.

Another possible remedy is to offer courses where students who are hooked to smartphones (and those who do not) may receive counseling services on campus. One of the best ways to prevent excessive smartphone usage is to give up the device for 1 day and engage in rejuvenating activities. This may help users cut down on their need for the device, foster offline social connections, and nurture relationships with new acquaintances (Zaremohzzabieh et al., 2015). This study also expects that PHUB may be overcome through the implementation of counseling services in the learning process (Afdal et al., 2018). These proposed remedies can therefore be used as the ideal solution to the entire issue, encouraging students to be more productive and healthier while using smartphones, to have a greater understanding of how real and virtual worlds interact, to exercise self-control while using smartphones, to further develop their sense of social responsibility, and to spread awareness of SMA.

Meanwhile, the results from the research on the mediation impacts of SCO and FoMO are consistent with previous research (Reer et al., 2019). According to the findings, the total effect of SMA on PHUB is distributed across both the direct and indirect association mechanisms of SCO and FoMO. This finding adds to our understanding of the mechanisms or pathways that lead to PHUB among HE students. HE students will be concerned about losing the emotional support that they receive from their smartphones if they leave them for an

TABLE 3 Path analysis of the multiple mediation model.

Path	<i>B</i> coefficient	95% CI	
		Lower	Upper
a. Total effect model			
SMA/PHUB	0.3128	0.236	0.392
b. Multiple mediation model			
Direct effects			
SMA/PHUB	0.191	0.115	0.267
SMA/SCO	0.201	0.15	0.25
SCO/PHUB			
SMA/FoMO	0.092	0.03	0.155
FoMO/PHUB	0.22	0.11	0.32
SCO/FoMO	0.38	0.31	0.44
Indirect effects			
SMA/SCO/PHUB	0.020	0.004	0.041
SMA/FoMO/PHUB	0.078	0.0471	0.112

SMA, smartphone addiction; PHUB, phubbing behavior; SCO, social comparison orientation; FoMO, fear of missing out.  $N=884$ .

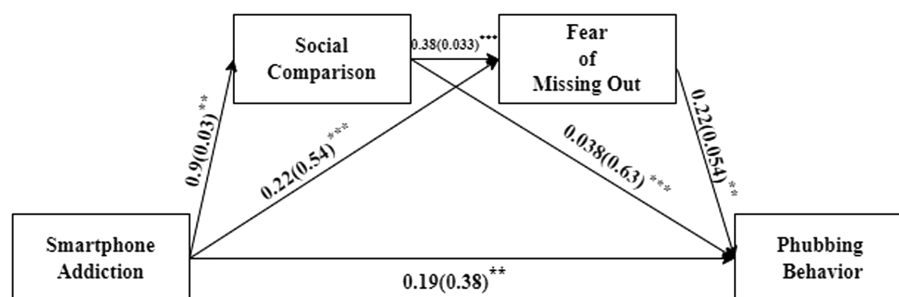


FIGURE 3

Model of multiple mediations. The path coefficients are the path values (standard errors). \*\*\* $p<0.001$ , \*\* $p<0.01$ .

TABLE 4 Moderated mediation analyses' results (PROCESS: model 8).

Model 1: Mediator variable model	Outcome: SCO				Bootstrapped CI (95%)	
	Coeff	SE	<i>t</i>	<i>p</i>	LL	UL
SMA	0.295	0.0421	7.003	0.000	0.212	0.377
LON	0.325	0.042	10.28	0.000	0.263	0.387
SMA × SC	0.038	0.025	1.488	0.137	−0.012	0.0889
Model 2: Mediator variable model	Outcome: FoMO					
					Bootstrapped CI (95%)	
	Coeff	SE	<i>t</i>	<i>p</i>	LL	UL
SMA	0.24	0.41	5.83	0.000	0.159	0.321
LON	0.202	0.031	6.52	0.000	0.141	0.262
SMA × LON	0.046	0.025	1.85	0.064	−0.0028	0.096
Model 3: Outcome variable model	Outcome variable: PHUB					
SMA	0.314	0.033	9.52	0.000	0.249	0.379
SCO	0.187	0.038	4.94	0.000	0.113	0.262
FoMO	0.044	0.038	1.14	0.254	−0.032	0.120
LON	0.125	0.025	4.87	0.000	0.075	0.176
SMA × LON	−0.0858	0.0193	−4.45	0.000	−0.123	−0.047
Conditional indirect effect ( <i>via</i> SCO and FoMO)					Bootstrapped CI (95%)	
	Coeff	SE	<i>t</i>	<i>p</i>	LL	UL
LON(+1 SD)	0.450	0.044	10.13	0.000	0.363	0.537
LON (−1 SD)	0.177	0.0455	3.906	0.0001	0.088	0.267
	Index	SE			LL	UL
Index of moderated mediation	−0.02	0.01			−0.05	−0.001

SMA, smartphone addiction; PHUB, phubbing behavior; SCO, social comparison orientation; FoMO, fear of missing out; LON, loneliness.

extended period, effectively developing a FoMO. The Pakistani population has a collectivistic culture with a lifestyle that emphasizes increased socialization and interdependence. This means that Pakistani people tend to have large social networks with whom they feel strongly affiliated and obligated to keep in touch (Curnutt, 2007). They see themselves as a part of their social circles – missing any event or conversation can make them feel as though they are missing out (Butt and Arshad, 2021). Additionally, according to Butt and Arshad (2021), a smartphone can be viewed as a status symbol due to SC orientation, a tool of connection due to extended social groups, and an essential component of life for people living in Pakistan to maintain virtual connections with their social group.

As a result, FoMO may increase HE students' insecurity and encourage them to overuse their smartphones to alleviate negative moods, eventually leading to PHUB (Franchina et al., 2018). This finding also indicates that HE students with high levels of SCO are more likely to engage in more intense SC behaviors. This would in turn increase their fear of being left behind in social contexts. Moreover, the risk of an escalating relationship between SMA and PHUB is even more likely. It should be noted that such mediation

was found to be partial given that the direct path from HE students' predispositions to SMA and PHUB linkage remains significant.

It is important to note that lecturers frequently utilize SM platforms to advertise role models at work, encourage students to socially compare themselves to exceptional students, and promote learning from them. The current research suggests that lecturers should exercise caution when adopting this approach since doing so might lead students to experience ego depletion and unanticipated performance problems. By exercising more caution, teachers may sensibly encourage students to prevent peer pressure brought on by SC. To properly manage this material with a more at ease mind, lecturers must also have a right view of the significance of shared information on smartphones and frequently remind themselves that the content posted on social platforms should be beneficial and good.

Finally, the findings imply that loneliness moderates the indirect relationships between SMA and PHUB. The authors of this study believe that these positive moderation effects may be attributed to the fact that HE students – who experience higher levels of loneliness while using smartphones – may

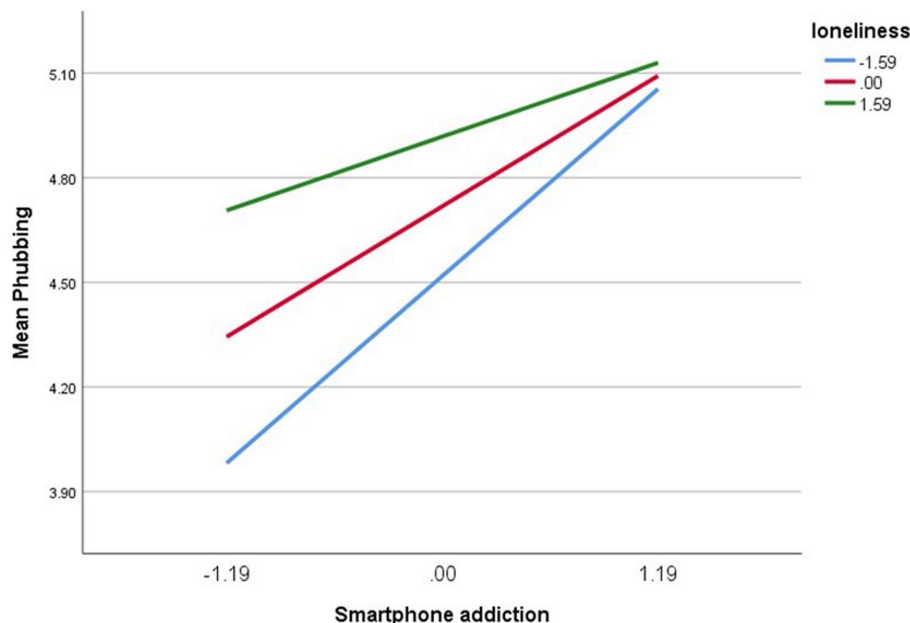


FIGURE 4

The moderating impact of loneliness on the relationship between SMA and PHUB.

be anxious about missing potential likes or social rewards for their posts in comparison with others (Rosenthal-von der Pütten et al., 2019). Subsequently, these students tend to engage in SCO and FoMO-driven internet usage to avoid being alone. In addition, HE students who feel lonely will have an increased likelihood of PHUB, as the world of smartphones makes them feel connected to other students (Savci and Aysan, 2017). In reality, the PHU phenomenon does not help HE students to alleviate their loneliness. It increases their levels of loneliness through a reduced sense of community (Ang et al., 2019). Awareness-raising training may be given to parents and educators to reduce HE students' feelings of loneliness. In this way, they may better understand the typical conflicts faced by young adults similar to them. These measures, which may reduce students' feelings of loneliness, will also contribute to the reduction of their SMA and PHUB.

## 7. Conclusion

Given the rising concern about SMA and how it impacts HE students in Pakistan, this research adds considerably to the body of knowledge on its negative consequences. The goal of the current study is to better understand how SMA affects PHUB. Additionally, this study provided proof for the moderating influence of loneliness as well as evidence for the partial mediation effects of SCO and FoMO. Therefore, the study's conclusions have significant consequences for both theory and practice.

## 8. Limitations and direction for future studies

Several significant limitations of the present study must be recognized, despite the findings providing encouraging empirical evidence for our integrative model incorporating SMA, PHUB, SCO, FoMO, and loneliness. Firstly, a proper cause-and-effect conclusion cannot be established, as the current study is cross-sectional. This is because psychological symptoms can contribute to loneliness, PHUB, FoMO, and SCO. Secondly, it would be beneficial to assess this model's applicability in a clinical sample. The degree of the additive and interaction effects of FoMO, SCO, and loneliness on PHUB in a clinical setting may be considerably different from what was observed in the current sample. This is although we would typically have the same or comparable set of expectations for assessing PHUB in a clinical sample.

Researchers may also examine how sociodemographic characteristics may have an impact on PHUB. Fourthly, the current study relies on self-reported data from a particular nation (Pakistan), limiting its findings' generalizability. To get more generalizable insights into the correlations being studied, the current study's approach might be reproduced using samples from varied sociodemographic groups and nations. Last but not least, the study used a cross-sectional methodology, which leaves the findings open to potential biases. Future research may focus on longitudinal and observational research to eliminate such biases and to examine how these factors interact while considering temporal effects.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

RS: data collection. HA and ZZ: supervision and draft. ZZ: data analysis and review. AA and WW: visualization. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# The relationship between anxiety and depression with smartphone addiction among college students: The mediating effect of executive dysfunction

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Smartphone addiction symptom is increasing globally. Many studies have found that negative emotion is associated with smartphone addiction, but few explore the mediating effect of executive dysfunction. In a large-scale, cross-sectional survey, 421 Chinese college students completed measures on anxiety, depression, smartphone addiction, and executive dysfunction. We surveyed the prevalence of depression, impaired executive function, and smartphone addiction. A confirmatory factor analysis was performed on the questionnaire structure, and the mediation models were used to examine the relationship between anxiety, depression, impaired executive function, and smartphone addiction. The main finding indicated that anxiety, depression, and executive dysfunction were positively and significantly associated with smartphone addiction. Executive dysfunction plays a mediation role between anxiety and depression with smartphone addiction. Specifically, executive dysfunction completely mediates the pathway of anxiety and smartphone addiction and partly mediates the path of depression and smartphone addiction. Depression directly predicted smartphone addiction positively but anxiety did not. The sample consisted of Chinese college students, which limits generalizability and self-reported lack of objectivity. The result suggests that we should pay more attention to the mediating role of executive dysfunction between negative emotion and smartphone addiction.

## KEYWORDS

**anxiety, smartphone addiction, depression, executive function, I-PACE model, CIUT model**

## 1. Introduction

According to 46% of smartphone users, they “could not live without their smartphones” (Smith, 2015). By June 2022, the number of smartphone network users in China had reached 1.047 billion, which is ~74.1% of the Chinese population (China Internet Information Center, 2022). By May 2022, 93~97% of U.S. adults had smartphones, up from 35% in 2013 (Statista, 2022).

While the smartphone offers several benefits (Bertschek and Niebel, 2016; Lee et al., 2017), it also has plenty of negative consequences (Lin et al., 2014). For example, excessive smartphone use can lead to neck, shoulder, and low back pain (Hakala et al., 2006) as well as hearing and vision problems (Meo and Al-Drees, 2005). People even use the smartphone when driving, regardless of the relevant ban and danger (Caird et al., 2014). With increasing harmful effects, the new term “smartphone addiction” emerged (Lin et al., 2014).

Smartphone addiction is defined as “a new type of behavioral addiction caused by over-dependence and abuse of smartphones, resulting in psychological and behavioral problems” (Kwon et al., 2013b; Lee et al., 2014; Lin et al., 2014). A volume of research indicates that smartphone addiction is related to negative influences that have penetrated various aspects of life, such as musculoskeletal pain (Xie et al., 2016; Salvi and Battin, 2018), poor sleep quality (Li et al., 2020; Mei et al., 2022), loneliness (Liu et al., 2019), decreased life satisfaction (Lepp et al., 2014), interpersonal problems (Dwyer et al., 2018; Nayak, 2018), and poor academic performance (Yang Z. et al., 2019; Sapci et al., 2021). To the best of our knowledge, despite a vast array of negative consequences, the smartphone addiction rate is still rising. Recently, Olson et al. (2022) conducted a meta-analysis of studies published between 2014 and 2020 and discovered that the prevalence of smartphone addiction is increasing globally. Meanwhile, the highest smartphone addiction levels were in China and Saudi Arabia, where 36.6% of college students are particularly susceptible to smartphone addiction (Mei et al., 2022). Their daily average screen time has risen dramatically from 3.75 h in 2012 to 5.78 h in 2017 (Kim et al., 2019). Thus, it is necessary to investigate smartphone addiction formation among Chinese college students.

To capture the formational mechanism of smartphone addiction, we used a battery of theories and models, including the compensatory Internet use theory (CIUT) (Kardefelt-Winther, 2014), the Integrative Pathways Model (IPM) (Billieux et al., 2015), and the interaction of person-affect-cognition-execution model (I-PACE) (Brand et al., 2016, 2019). Although CIUT and I-PACE were initially used to describe Internet use disorder, smartphone addiction shares many common features with this disorder (Kwon et al., 2013a; Lin et al., 2014). It is even considered a special type of Internet addiction (Montag et al., 2021). In terms of CIUT, smartphone addiction is an unhealthy coping way to escape real life and adverse emotions and obtain emotional compensation in the virtual world. IPM offers three pathways to account for smartphone addiction. One of them, the path of excessive reassurance-seeking, indicates that psychologically vulnerable individuals keep using their smartphones to maintain relationships and seek reassurance from others. I-PACE emphasizes the interaction of the person, affective and cognitive responses to external or internal stimuli, and executive functions. Personal factors increase the risk of

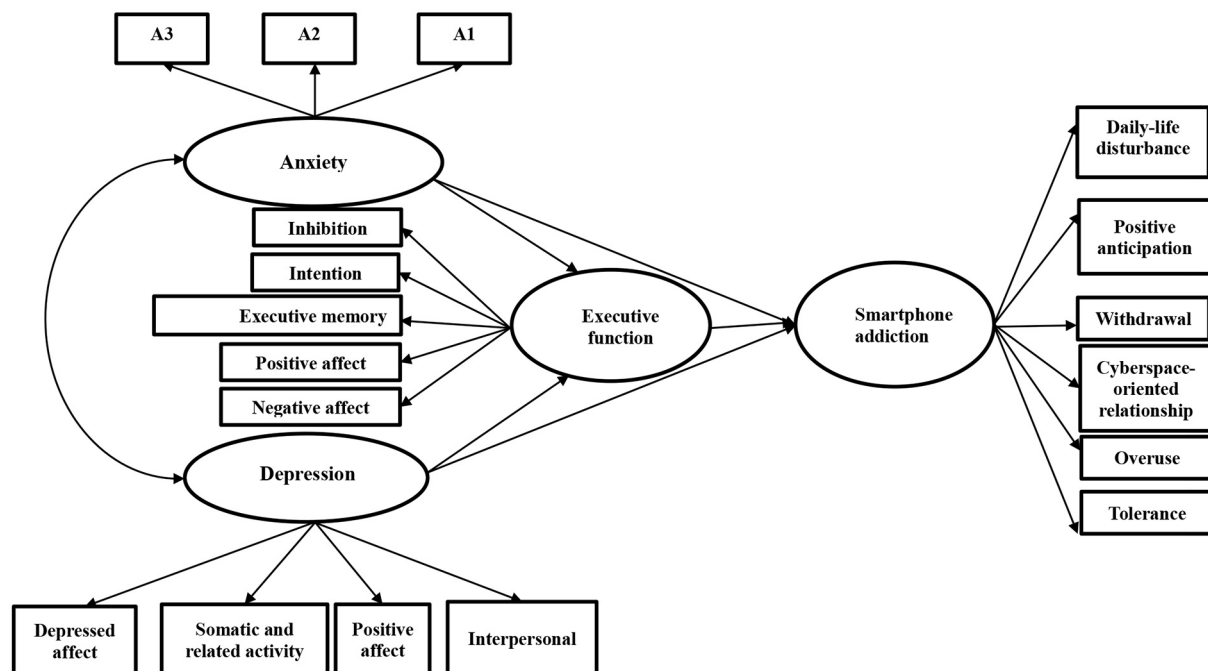
smartphone addiction, such as biopsychological constitution, psychopathological features (e.g., depression and anxiety), and personality. Affective and cognitive responses and executive function are mechanistic variables between the personal factor and smartphone addiction.

Mounting studies yielded insights into the relationship between negative emotions and smartphone addiction, especially anxiety and depression (Elhai et al., 2017a; Yang J. et al., 2019; Li et al., 2020). Additionally, the notion that anxiety and depression lead to smartphone addiction is consistent with CIUT, IPM, and I-PACE. Anxiety and depression give rise to smartphone addiction, a coping strategy to seek pleasure. Furthermore, some researchers explored the mediation mechanism underlying the relationship between anxiety and depression with smartphone addiction, for instance, boredom proneness (Wolniewicz et al., 2019; Wang et al., 2020), rumination (Elhai et al., 2018; Wang et al., 2020; Vally et al., 2021), and FoMO (fear of miss out) (Elhai et al., 2019, 2020; Vally et al., 2021). However, few empirical studies explored the mediation role of executive function between them, which is an essential component of the development of addiction behavior (Brand et al., 2016; Dominguez-Salas et al., 2016).

Executive function is a series of interactive higher cognitive functions whose core components are inhibitory control, cognitive flexibility, and working memory (Miyake et al., 2000). Negative affect is involved at the executive dysfunction level. On the one hand, existing studies demonstrate that anxiety impairs executive function (Darke, 1988; Derakshan et al., 2009; Ansari and Derakshan, 2010; Shields et al., 2016). According to the attention control theory (ACT) (Eysenck et al., 2007), anxiety occupies cognitive resources and leads to executive dysfunction. On the other hand, depression and cognitive disorders often coexist [American Psychiatric Association (APA), 2013]. A meta-analysis investigated the performance of depressed individuals using the n-back task and found significant working memory deficits (Nikolin et al., 2021). Another study found that antidepressants can improve cognitive function among depressed individuals (Prado et al., 2018).

In addition, executive dysfunction is not only a result variable of negative affect but also a robust predictor of addiction behavior (Brand et al., 2016). As expected, existing empirical studies also indicate that executive dysfunction and smartphone addiction are intercorrelated (Hadlington, 2015; Chen et al., 2016; Gao et al., 2020). Wilmer et al. (2017) also discussed the relationship between mobile technology habits and cognitive function in a review and considered it as nonsignificant.

In terms of our study variables integrated with I-PACE, anxiety and depression were conceptualized as personal factors and psychopathological features. Executive function was a crucial part of the model and a mediator between personal factors and addictive behavior. Addiction behavior is the outcome variable in the I-PACE. We focus on the specific addiction behavior, i.e., smartphone addiction. CIUT, IPM, and



**FIGURE 1**  
Hypothetical model concerning the mediation effect of executive dysfunction in the relationships between anxiety and depression with smartphone addiction.

ACT also provide theoretical foundation for the hypothesized model. Given the theory and empirical evidence presented above, we speculate that executive dysfunction may play a mediation role in the relationship between anxiety and depression with smartphone addiction.

Thus, the objective of the present study was to examine, first, associations between anxiety, depression, and smartphone addiction, and, second, the mediation of executive functions between them. The hypotheses are as follows:

- Hypothesis 1. Anxiety (*H1a*) and depression (*H1b*) are positively related to smartphone addiction.
- Hypothesis 2. Anxiety (*H2a*) and depression (*H2b*) are positively related to executive dysfunction.
- Hypothesis 3. Executive dysfunction is positively related to smartphone addiction.
- Hypothesis 4. Anxiety and depression affect smartphone addiction through executive dysfunction.

The hypothetical model is shown in [Figure 1](#).

The study has some meaningful contributions. First, we tested the validity of CIUT, IPM, and I-PACE. Second, we explored the executive function as the mediator between anxiety and depression with smartphone addiction, filling the research gap. Finally, the finding may provide valuable and

complementary insights into smartphone treatment and help find the underlying reason for smartphone addiction formation to act appropriately.

## 2. Materials and methods

### 2.1. Participants

The participants were recruited from Chongqing Normal University. Out of 450 questionnaires, 29 invalid questionnaires were excluded. The response rate was 93.6%. A total of 421 college students participated in our survey. The sample size met the requirement put forward by [James \(2016\)](#). The mean age of the participants was 19.29 years ( $SD = 1.85$ , range = 16–24 years). Of the participants, 290 students were female students (68.9%) and 131 were male students (31.1%). In addition, 168 students were from the countryside (39.9%), 67 students were from the township (15.9%), and 186 students were from the city (44.2%). They all completed the questionnaire measuring anxiety, depression, executive function, and smartphone addiction. The local research ethics committee of Chongqing Normal University approved this study, and all participants signed informed consent.

## 2.2. Measures

### 2.2.1. Smartphone addiction

Smartphone addiction was measured using the smartphone addiction scale (SAS; Kwon et al., 2013b), consisting of 33 items. It includes the following six components: daily-life disturbance, positive anticipation, withdrawal, cyberspace-oriented relationship, overuse, and tolerance. The participant rated each item on a 6-point scale ranging from 1, strongly disagree, to 6, strongly agree, with higher scores indicating more smartphone addiction. The Cronbach's  $\alpha$  of the SAS was 0.943.

The short version of the smartphone addiction scale (SAS-SV; Kwon et al., 2013a) is included in the full version and consists of 10 items. Like the full version, it adapts a Likert-type scale. According to SAS-SV, the cutoff value is 31 for boys and 33 for girls. The Cronbach's  $\alpha$  of the SAS-SV was 0.877.

### 2.2.2. Anxiety

Anxiety was measured using the trait version of the State-Trait Anxiety Inventory (STAI-T) (Spielberger, 1983) consisting of 20 items. Each item was rated on a 4-point scale ranging from 1, not at all to 4, always, with higher scores indicating higher anxiety levels. In the current study, Cronbach's  $\alpha$  of the STAI-T was 0.878.

### 2.2.3. Depression

Depression was measured using the Center for Epidemiological Studies Depression Scale (CES-D, Radloff, 1977), consisting of 20 items. Respondents indicate how often within the last week they experienced the symptoms on a 4-point scale (1 = "rarely or none of the time"; 2 = "some or little of the time"; 3 = "occasionally or a moderate amount of time"; 4 = "most or all of the time"). The scores for the 20 items are added, with higher scores representing worse conditions of depression. According to a meta-analysis of 23 studies (Vilagut et al., 2016), point 20 is more appropriate as the cutoff point than 16 (Radloff, 1977). The Cronbach's  $\alpha$  for the CES-D was 0.881.

### 2.2.4. Executive dysfunction

Executive dysfunction was measured by the Dysexecutive Questionnaire (DEX; Chan, 2001) consisting of 20 items. It includes the following five components: inhibition, intention, executive memory, positive affect, and negative affect. Each item was rated on a 5-point scale ranging from 0, never to 4, often. A higher score indicates a more impaired executive function. A DEX total score of  $\geq 20$  implies mild executive dysfunction,  $\geq 28$  implies moderate executive dysfunction, and  $\geq 36$  implies strong executive dysfunction (Bodenburg and Dopschaff, 2008). In this study, Cronbach's  $\alpha$  of the DEX was 0.919.

## 2.3. Procedure

Students were invited to answer a questionnaire that included anxiety, depression, executive dysfunction, and smartphone addiction, which could be completed in  $\sim 15$  min. All students received the same test and instructions.

## 2.4. Analysis

This study adapted SPSS 15.0 and Amos 26.0 software for the data analysis. First, confirmatory factor analysis (CFA) was used to examine whether the items within a construct are valid. Then, we performed a descriptive statistical analysis to identify the distribution of all variables and Pearson's correlation analysis to estimate the correlation coefficients between all variables. Subsequently, we conducted a Harman single-factor test to test possible common method biases. Finally, we examined the mediation role of executive dysfunction using the structural equation model.

## 3. Results

### 3.1. Preliminary analyses

The CFA was used to ensure the construct validity of the questionnaire. To the best of our knowledge, a model index fit of  $\chi^2/df < 3$ , RMSEA  $< 0.08$ , SRMR  $< 0.10$ , and TLI and CFI  $> 0.90$  is acceptable (Hu and Bentler, 1999). The preliminary analysis results revealed that there was an apparent four-factor structure for this questionnaire:  $\chi^2/df = 2.94$ , CFI = 0.95, NFI = 0.92, IFI = 0.95, RMSEA = 0.07, and SRMR = 0.05.

The descriptive statistical analysis of 421 college students is presented in Table 1. Correlation analysis showed that all self-report measures were significantly positively correlated.

We identified the mental health of college students based on the aforementioned cutoff scores of measurement tools. There are 46.3% of college students with smartphone addiction (SAS-SV, female students  $> 33$ , male students  $> 31$ ) (Kwon et al., 2013a), 39.4% of them with depression (CES-D  $\geq 20$ ) (Vilagut et al., 2016), and 59.6% of them with executive dysfunction (DEX  $\geq 20$ ) (Bodenburg and Dopschaff, 2008). With attention to detail, there are 24.0% of college students with mild executive dysfunction ( $28 > \text{DEX} \geq 20$ ), 18.3% of them with moderate executive dysfunction ( $36 > \text{DEX} \geq 28$ ), and 17.3% of them with strong executive dysfunction (DEX  $\geq 36$ ).

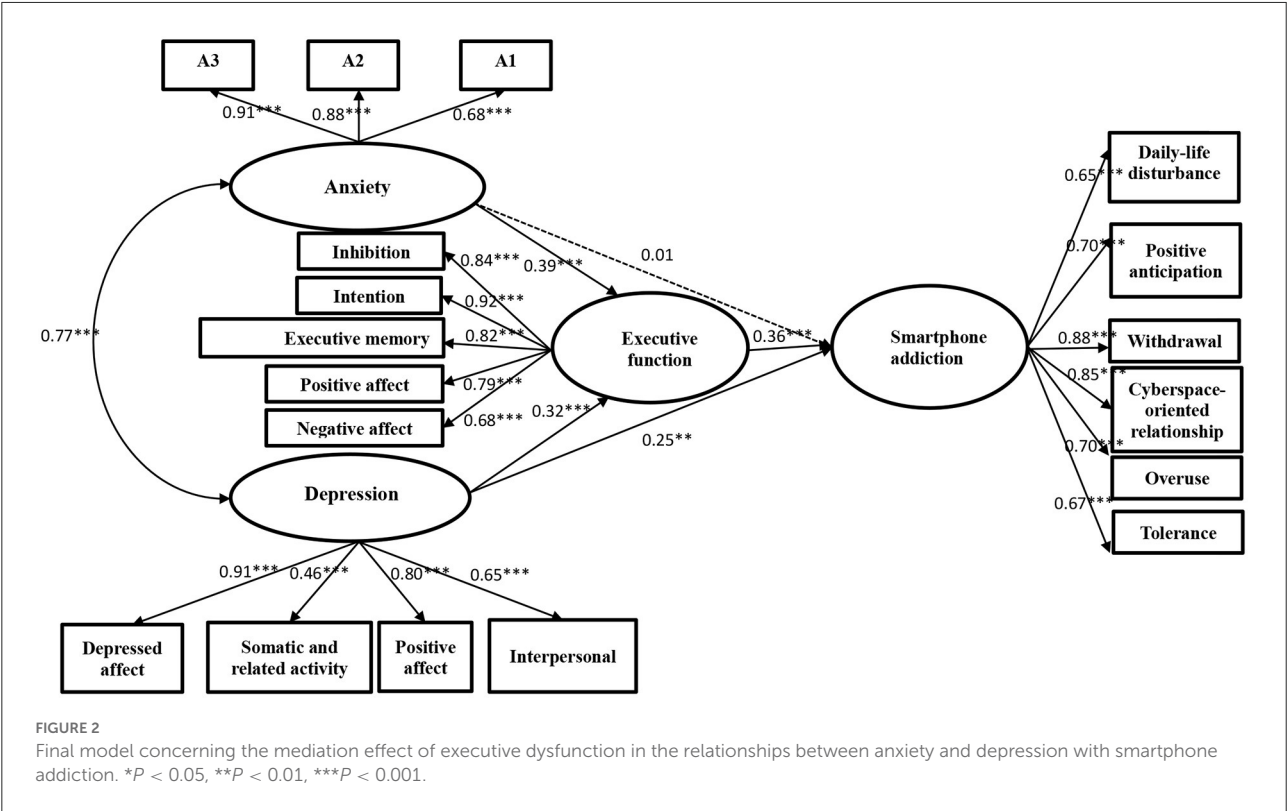
### 3.2. Common method biases test

The Harman single-factor test was used to test possible common method biases (Podsakoff et al., 2003) of the collected

TABLE 1 The correlation analysis between study variables.

	M	SD	1	2	3	4
1. Anxiety	43.57	8.99	1			
2. Depression	17.54	9.11	0.70**	1		
3. Executive dysfunction	23.86	12.46	0.56**	0.59**	1	
4. Smartphone addiction	102.61	27.34	0.36**	0.41**	0.46**	1

\*\* $P < 0.01$ .



data. The unrotated exploratory factor analysis results extracted a total of 19 factors with an eigenvalue  $>1$ , and the maximal items load onto a single factor was 23.29%, far  $<40\%$ . Therefore, there was no serious common method bias in the data of this study.

3.3. Structural equation modeling

For path analysis, anxiety and depression were employed as the predictor variables, smartphone addiction as the outcome variable, and executive dysfunction as the mediating variable based on the hypothetical model. The result is shown in Figure 2. The fit indices are as follows:  $\chi^2/df = 2.97$ , CFI = 0.94, NFI = 0.92, IFI = 0.95, RMSEA = 0.07, and SRMR = 0.05. The fitness statistics are within a reasonable range (Hu and Bentler, 1999).

From the perspective of the model path, depression directly predicted smartphone addiction ( $r = 0.25$ ,  $P = 0.007$ ), but anxiety did not ( $r = 0.01$ ,  $P = 0.92$ ). In the mediation test of executive dysfunction, in one path, anxiety predicted executive dysfunction ( $r = 0.39$ ,  $P < 0.001$ ), and executive dysfunction predicted smartphone addiction ( $r = 0.36$ ,  $P < 0.001$ ), whereas in another path, depression predicted executive dysfunction ( $r = 0.32$ ,  $P < 0.001$ ). Using bias-corrected percentile bootstrap to test the ratio of the mediating effect to the total effect size, indirect path 1 (anxiety  $\rightarrow$  executive dysfunction  $\rightarrow$  smartphone addiction) was 28.2%, and the 95% interval was [0.25, 0.80]. Therefore, executive dysfunction is the complete intermediary variable of anxiety and smartphone addiction. Indirect path 2 (depression  $\rightarrow$  executive dysfunction  $\rightarrow$  smartphone addiction) was 22.4%, and the 95% interval was [0.14, 0.72]. Therefore, executive dysfunction is the part intermediary variable of depression and smartphone addiction.

## 4. Discussion

The hypotheses have been verified in the present study. We mainly found that negative emotion influences smartphone addiction through the mediator role of executive dysfunction, which is shown in two pathways. Executive dysfunction fully mediated the relationship between anxiety and smartphone addiction but partially mediated the relationship between depression and smartphone addiction.

The theoretical importance of the study results is two-fold. First, the results provide support for their application in terms of CIUT, IPM, and I-PACE. Second, we investigated the relationships between depression and anxiety with smartphone addiction and better understood the process of smartphone addiction development. Specifically, all hypotheses above were supported.

The results verified CIUT, IPM, and I-PACE once again (Elhai et al., 2019; Wang et al., 2020). According to CIUT, the motivation for Internet use is based on unmet real-life needs or psychological imbalance. In our study, individuals with anxiety and depression may suffer negative emotions in the real world, which leads to compensatory behavior, causing them to seek relief in the virtual world and increasing the possibility of smartphone addiction. Meanwhile, as explained by the excessive reassurance pathway of IPM, smartphone addiction is driven by maintaining the relationship and seeking reassurance. Individuals with anxiety or depression are prone to have this tendency. In addition, in terms of I-PACE, personal factors (e.g., anxiety and depression) may lead to addictive behavior. Poor executive function will decrease the ability to make wise decisions, promoting the development of addiction behavior. Executive dysfunction is a mechanistic variable that accounts for relationships between personal factors and smartphone addiction. On the whole, CIUT, IPM, and I-PACE can advance a reasonable understanding of smartphone addiction.

We explored the mechanisms of addiction formation through four hypotheses. As predicted by H1, depression and anxiety were associated with smartphone addiction. The results have been consistently demonstrated in many studies (Elhai et al., 2017a; Yang J. et al., 2019; Li et al., 2020). Our results are consistent with CIUT, IPM, and I-PACE, suggesting that individuals with negative emotions or existing psychopathological features may react to smartphone addiction instead of directing it toward the trouble source.

The study also found that anxiety and depression are positively related to executive dysfunction, thus supporting H2. The result is consistent with previous research (see reviews by Chen et al., 2014 and Wilmer et al., 2017). For example, Derakshan et al. (2009) found that the high-anxiety group showed poor performance in switching tasks compared with the control group. Levens and Gotlib (2010) used the n-back task to measure the updating of working memory, and the data revealed that patients with depression have

difficulty in updating. Research conducted by Hartanto and Yang (2016) found that cognitive flexibility, working memory capacity, and inhibitory control are all impaired when anxiety is increased. In another study, Shields et al. (2016) induced anxiety in participants through self-reporting and found that the participants performed poorly on executive function tasks compared with the control group. The results can be explained as negative emotions exhausting cognitive resources and leading to executive dysfunction (Eysenck et al., 2007; Mitchell and Phillips, 2007).

Hypothesis H3 also was validated, and executive dysfunction is related to smartphone addiction based on previous research (Hadlington, 2015; Chen et al., 2016; Gao et al., 2020). Moreover, executive dysfunction is the mediation variable between anxiety and depression with smartphone addiction. H4 was supported. First, smartphone use has penetrated all aspects of our life. When in difficulties, we can depend on smartphones to seek information, to communicate with others, for entertainment, and for others as a coping strategy. Besides, anxiety and depression occupy cognitive resources, leading to executive dysfunction. In the process, executive dysfunction will cause failure to inhibit smartphone use and promote addiction formation. In summary, the role of executive dysfunction cannot be underestimated.

Moreover, it is worth noting that anxiety did not directly predict smartphone addiction and that executive dysfunction was completely mediating, contrary to previous findings (Elhai et al., 2020; Vally et al., 2021). We suspect that the result is due to two aspects. First, generalized anxiety may not directly increase smartphone addiction, and anxiety should be divided into more specific types, such as social anxiety (Przepiorka et al., 2021) and attachment anxiety (Han et al., 2017). In particular, smartphone addiction is associated with social anxiety (Ran et al., 2022). Second, the result fits attention control theory: smartphone addiction is the consequence of executive dysfunction promoted by anxiety-occupied cognitive resources, and executive dysfunction is the essential link that needs to be highlighted.

The study contributes to existing research on the underlying mechanisms of smartphone addiction formation. Executive dysfunction plays a mediated role between anxiety and depression with smartphone addiction. The finding supports I-PACE, IPM, and CIUT. In future studies, anxiety can be further subdivided into more specific types, such as attachment anxiety (Han et al., 2017; Liu et al., 2019), social anxiety (Hong et al., 2019; Kong et al., 2020), state anxiety (Shen et al., 2019), and academic anxiety (Yang Z. et al., 2019). In addition, except for executive dysfunction mentioned in the present study, more cognitive variables need to be explored between anxiety and depression with smartphone addiction.

Furthermore, it is essential to advocate using smartphones appropriately. The relationship between smartphone use and adaptive functioning is an inverse U-curve (Montag and Walla,

2016). Some researchers studied how to relieve smartphone addiction (Schmuck, 2020; Holte et al., 2021). Recently, 63 participants were asked to keep their smartphone screens in grayscale until their second visit. The result displays a significant decrease in smartphone addiction and anxiety levels (Holte et al., 2021). Another study found that digital detox apps (the apps used to monitor and limit smartphone use) may be useful for preventing the harmful effects of smartphone addiction (Schmuck, 2020).

This study has some limitations. The sample involves Chinese college students, which limits generalizability, and differences among different age groups and countries may exist. Furthermore, the purpose of usage and usage pattern of the smartphone are associated with smartphone addiction (Elhai et al., 2017b; Park, 2019), which needs further exploration. For instance, smartphone addicts are known to focus extensively on the social usage purpose of the smartphone (van Deursen et al., 2015). Furthermore, many people deny suffering from smartphone addiction (Park, 2019), and the measurement is done based on a lack of objectivity through self-reporting (Ryding and Kuss, 2020). Finally, Lim (2019) found that smartphone addiction predicts impaired executive function. Smartphone addiction may be involved in a vicious cycle of executive dysfunction. Our study is cross-sectional, and there are restrictions on examining causal relationships between factors, and more longitudinal studies are needed in the future.

In conclusion, we found that anxiety and depression are related to smartphone addiction in college students and that their link was mediated by executive dysfunction. Specifically, executive dysfunction completely mediated the pathway of anxiety and smartphone addiction and partly mediated the pathway of depression and smartphone addiction. Although the limitations of this study must be considered in future research, the tentative findings can inform research on treatment mechanisms of smartphone addiction and relieve the smartphone addiction from the source or the part.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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## Ethics statement

The studies involving human participants were reviewed and the local research Ethics Committee of Chongqing Normal University approved this study and all participants signed informed consent. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## Author contributions

JG conducted data collection and analysis, under the supervision of YL. All authors drafted the manuscript, provided critical revisions to the manuscript, and contributed to the conception of the work and research design.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# The more academic burnout students got, the more problematic mobile phone use they suffered? A meta-analysis of mainland Chinese adolescents and young adults

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**Introduction:** In recent years, the relationship between academic burnout (AB) and problematic mobile phone use (PMPU) has become the hot issue of scholars, and a lot of related research has been carried out, but the results are different. Most studies showed that there was a significant positive correlation between AB and PMPU. However, some studies showed that the relationship between AB and PMPU was not significant. While this study aimed at exploring the relationship between AB and PMPU, as well as the influence of some moderating factors (region, age, gender, publication year, the measurement instrument) on them.

**Methods:** According to the searching process for studies of PRISMA, we searched the related studies on AB and PMPU in Mainland China from January 2012 to November 2022 from CNKI, Wanfang Data, Chongqing VIP Information Co., Ltd. (VIP), Baidu scholar, ProQuest dissertations, Taylor & Francis, Springer, Web of Science, Google Scholar, EBSCO and PsycINFO. Eventually, 50 studies were included in the meta-analysis, involving 38,488 subjects, with the sample size ranging from 193 to 2,260. CMA 3.0 was used to analyze the overall effect and test the moderating effect.

**Results:** The result shows that the relationship between AB and PMPU can be considered as a moderate correlation ( $r = 0.414$ , 95%CI [0.384, 0.443]), and moderator analysis shows that the relationship between AB and PMPU was moderated by the measurement instrument and publication year.

**Discussion:** Specifically, when the Mobile Phone Addiction Tendency Scale and the Smartphone Addiction Scale for College Students were used as PMPU measurement tools, the correlation coefficients between AB and PMPU were higher. When the publication year was used as a moderating variable, the relationship between AB and PMPU increased over the years.

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academic burnout, problematic mobile phone use, mainland China, adolescents and young adults, meta-analysis

## Introduction

As of June 2022, the number of mobile Internet users in China was 1.047 billion, accounting for 99.6% of the total Internet users. The popularity of mobile phones has brought a lot of convenience to people's life. People can use mobile phones to communicate, as well as getting news and making online payment, webcast and car booking, etc. [CNNIC, 2022]. However, excessive use of mobile phones brings about some new social problems, such as Problematic Mobile Phone Use (PMPU).

PMPU is also termed mobile phone addiction, mobile phone overuse, and mobile phone dependence (Wang C. et al., 2021; Zhong et al., 2021; Liu Q. et al., 2022). Scholars did not get a consensus on the definition of PMPU, which can be generally divided into two types. On the one hand, PMPU was treated as addictive behavior. For example, based on the addiction literature, especially technological and behavioral addiction literature, Bianchi and Philips developed the Mobile Phone Problem Usage Scale (MPPUS) with internal consistency reliability of 0.93 (Bianchi and Phillips, 2005). The MPPUS includes tolerance, withdrawal, escaping from other problems, craving, and negative life situations in the areas of social, working, familial, and financial difficulties (Bianchi and Phillips, 2005). The publication of this questionnaire has laid a foundation for subsequent research. Leung, a scholar from Hong Kong, China, believed that mobile phone addiction was an impulse control disorder, similar to the characteristics of pathological gambling (Leung, 2008). Based on MPPUS and referring to Young's measurement criteria for Internet addiction and the criteria for assessing substance dependence in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), Leung developed the mobile phone addiction index (MPAI) for adolescents (14–20 years old). The scale with 17 items consists of four dimensions: inability to control craving, withdrawal and escape, feeling anxious and lost, and productivity loss. The internal consistency coefficient of this scale is 0.90 (Leung, 2008). Besides, Xiong compiled the Mobile Phone Addiction Tendency Scale (MPATS) by referring to MPPUS and the primary symptoms of Internet addiction proposed by Young. The scale focused on the mobile phone users' internal processing activities and subjective experience of social interactions, which is suitable for college students in mainland China. The MPATS'

coefficient of internal consistency is 0.83. The scale contains 16 items, divided into four dimensions: withdrawal symptoms, social comfort, salience, and mood changes, which are widely used in mainland China (Xiong et al., 2012). Previous scholars did not clearly distinguish between smartphones and non-smartphones when studying mobile phone addiction. Kwon et al. went further in their research on phone addiction, explicitly targeting the smartphone theme and developing the Smartphone Addiction Scale (SAS) as well as the short version of the Smartphone Addiction Scale (SAS-SV) for adolescents. The SAS with 33 items contains six dimensions (daily-life disturbance, withdrawal, overuse, tolerance, positive anticipation, and cyberspace-oriented relationship). The Cronbach's alpha of this scale is 0.967. The SAS-SV includes 10 items, and its internal consistency reliability is 0.91 (Kwon et al., 2013a,b). Su, a scholar from mainland China, considered that the definition of SAS scale for smartphones was not clear enough and the sample size was limited, therefore combining with the research on smartphone application (App) addiction to compile the Smartphone Addiction Scale for College Students (SAS-C), which has an alpha coefficient of 0.86 and contains 22 items and six dimensions (withdrawal behavior, salience behavior, adverse effects, social comfort, use of App, and renewal of App; Su et al., 2014).

Other researchers believe that PMPU is a non-addictive behavior. Toda et al. assuming that PMPU is not an addictive behavior but a dependent behavior. They regarded PMPU as the excessive use of mobile phones in the aspects of time and morality (Toda et al., 2004). Considering that excessive use of mobile phones would come with risks to people's health, they began to pay attention to PMPU (Toda et al., 2004). In 2004, they developed the world's first PMPU questionnaire with female college students as the research object, namely the cellular phone dependence questionnaire (CPDQ). The scale had an alpha coefficient of 0.86 and contained 20 items and six dimensions (Investment in mobile IP connection services, overuse of call services, anxiety about not being able to use mobile phones, lack of publicity in mobile phone use, emphasis on mobile phones, and requirements for others to hold mobile phones; Toda et al., 2004). Some scholars also believe that PMPU is a non-addictive behavior. For example, Lopez-Fernandez et al. indicated that other types of addictive behaviors should not be confused with smartphone addiction (Lopez-Fernandez et al., 2017). Although some phone users consider

themselves addicted to their phones, the essence of their addiction is not the phone itself (Balakrishnan and Griffiths, 2019), but the user's engagement through the phone, the drive to engage in the activity, and the satisfaction of participating in the activity (Jeong et al., 2016). Therefore, the problem is not phone addiction, but the problematic use of the phone, a maladaptive use of the smartphone that damages the user's functionality (Hao et al., 2022). A large number of researchers have discussed the accuracy of the term PMPU from different perspectives, but no consistent conclusion has been reached so far.

Although the traditional definition of phone addiction has similarities to PMPU, the current severity of PMPU is much lower than that of addiction, so using the term "phone addiction" is inappropriate (Panova and Carbonell, 2018). In addition, the DSM-5 and ICD-11 did not formally define PMPU (American Psychiatric Association, 2013; World Health Organization, 2018). Hence the researchers chose to use the term "phone addiction" with caution (Roig-Vila et al., 2020; Hao et al., 2021). The subjects in this study are regular students, so it is appropriate to use the term PMPU. Previous studies have found that the detection rate of PMPU among students is relatively high. For example, the detection rate of PMPU among Spanish 12–18 year-old students is about 14.8% (De-Sola Gutiérrez et al., 2016), and the detection rate of PMPU among college students in mainland China is 13.8% (Zhan et al., 2020). Other studies have found that the level of PMPU would be higher year by year (Jun, 2019). What's more, PMPU can lead to some adverse effects on students, such as learning distraction, anxiety sleep disorders, and even suicidal ideation and non-suicidal self-injury, etc. (Li et al., 2019; Arrivillaga et al., 2020; Yang et al., 2020; Jin et al., 2021; Troll et al., 2021). Therefore, how to restrain and reduce students' PMPU has become a hot issue for scholars.

Researchers have discussed the formation mechanism of PMPU from neurophysiological, sociocultural, and individual psychological perspectives (Jamaluddin et al., 2020; Li et al., 2021; Hao et al., 2022; Liu Q. et al., 2022). In addition, some scholars have conducted related research from individual psychology, such as exploring the relationship between Academic Burnout (AB) and PMPU. AB, also known as academic boredom, learning burnout and student burnout (Olwage and Mostert, 2014; Feng et al., 2019; Shen et al., 2021). "AB" means the negative attitude and behavior of feeling bored with learning due to pressure or lack of interest in learning (Mao et al., 2015), mainly appeared as emotional exhaustion, cynicism and academic inefficiency (Kendall and Castro-Alves, 2018; Aguayo et al., 2019; Hao et al., 2022). At first, scholars did not pay more attention to AB but studied job burnout and gradually expanded to the field of learning. In 1981, Maslach and Jackson developed the first burnout inventory, the Maslach Burnout Inventory (MBI; Maslach and Jackson, 1981), containing three dimensions (emotional exhaustion, personal accomplishment, and depersonalization), to study burnout in human services professionals. Schaufeli et al. expanded the field of MBI's research subjects, defined burnout more general, and, based on MBI, developed the Maslach Burnout Inventory-General Survey (MBI-GS; Schaufeli et al., 1996), which

includes three dimensions: exhaustion, cynicism, and professional efficacy. With the research studied further, some scholars have proposed that burnout also appears among students, and students' academic tasks can be understood as work tasks in the academic environment (Schaufeli et al., 2002; Shin et al., 2011). AB is the feeling of students exhausted from learning, with some features (cynical, detached, and incompetent) in the study. To study the burnout degree of students, based on MBI-GS Schaufeli et al. compiled the Maslach Burnout Inventory-Student Survey (MBI-SS), which contains three dimensions: exhaustion, efficacy, and cynicism (Schaufeli et al., 2002).

MBI has also been widely used in mainland China. For example, Lian et al. developed the Learning Burnout Scale (LBS) suitable for Chinese college students regarding MBI, which includes three dimensions, dejection, improper behavior and reduced personal accomplishment (Lian et al., 2005). The LBS has been widely used in mainland China. Wu et al. drew on Maslach's Three-factor Theory to compile the Student Burnout Inventory, which is suitable for Chinese junior high school students. This scale is divided into three dimensions: exhaustion, cynicism, and reduced efficacy (Wu et al., 2007). Several years later, based on their research, primary and high school students were included in the discussion scope and Wu et al. compiled the Adolescent Student Burnout Inventory (ASBI) which is suitable for elementary to high school students. It contains three dimensions: exhaustion, reduced efficacy, and learning cynicism (Wu et al., 2010).

Scholars have conducted many studies on the relationship between AB and PMPU. Among them, some scholars believe that AB can positively predict PMPU, and there is a significant positive correlation between AB and PMPU (Shen et al., 2021; Hao et al., 2022). If students are in the state of AB for a long time, they will have mental health problems such as anxiety and depression (Cheng et al., 2020; Fiorilli et al., 2020), decrease of sleep quality (Yan et al., 2018), poor academic performance (Yune et al., 2018). Individuals with psychological symptoms, sleep disorders and academic difficulties are more likely to present PMPU (Hawi and Samaha, 2016; Chen et al., 2019; Hao et al., 2021; Wang et al., 2021b). This point supports the compensatory Internet use theory, which states that in negative life situations, individuals create incentives to use the Internet to alleviate negative emotions, compensating for problems in real life (Kardefelt-Winther, 2014). Due to the continuous development of mobile phone functions, mobile phones have become common tools for teenagers to surf the Internet (Liu et al., 2020). Students with AB tend to overuse mobile phones to get rid of emotional difficulties (Walburg et al., 2016; Hao et al., 2021). Besides, social bonding theory believes that if an individual realizes that the greater the expectations of the environment (such as school, family and society), the more important the environmental order is to him, and the stronger the connection between the individual and the environment, so the less problematic behavior occurred (Hirschi, 1969). However, if students have AB, their school engagement will be reduced, and their behavior tends to deviate from school norms and expectations, thus leading to problematic behaviors, such as PMPU

(Zhu et al., 2015; Chen Y. et al., 2021). Not only can AB predict PMPU, but also PMPU can predict AB. Supposing that students have PMPU, their self-esteem, psychological capital and family intimacy will be reduced, and alexithymia, family conflict and life pressure etc. will be increased (Kim and Lee, 2012a; Mei et al., 2018; You et al., 2019; Chen H. et al., 2022; Lai et al., 2022). Students with higher psychological symptoms, interpersonal barriers and life pressure are more likely to produce AB (Kim and Lee, 2012b; Lin and Huang, 2014; Romano et al., 2019; Luo et al., 2020; Wang et al., 2021a). According to the job demands-resources model, low job resources and high job demands will lead to job burnout (Schaufeli and Bakker, 2004). Students' excessive use of mobile phones will reduce their learning engagement, thus reducing work resources, leading to job burnout (Schaufeli et al., 2002). Therefore, students with PMPU will produce AB.

However, some scholars have inconsistent conclusions that AB does not predict PMPU, and the relationship between them is insignificant. First of all, it may be related to the happy experience that mobile phones can bring to users. No matter what kind of service experienced by mobile phones, the experiential activities will bring users more happiness and more durable (Dunn et al., 2011). The higher the happiness, the lower the AB (Lee and Yang, 2016). In the meanwhile, some learning apps also refer to this when developing, making learning apps more interesting. Learning apps will reflect the characteristics of games, which relieve the boredom during students' learning process, then enhance students' learning motivation (Deng and Shao, 2012). However, the students with higher learning motivation have lower AB (Yu X. et al., 2022). Secondly, it may be related to the fact that mobile phone use can improve students' attention and memory. Compared with teenagers who do not use mobile phones, those who use mobile phones show higher levels of attention, processing speed of attention process, and short term memory (Lee et al., 2001, 2003; Smythe and Costall, 2003). While, individuals with higher levels of attention and memory are more likely to have higher academic performance (Perez-Lloret et al., 2013; Lee et al., 2014). And the higher the students' academic performance, the lower their AB (Usán Supervía and Salavera Bordás, 2020). Besides, maybe it is related to the function of mobile media. Research shows that mobile phones have many media functions, such as search engines, learning websites, web browsing, applications, audio, video, and e-reading (Shao and Wang, 2020). They make it easier for students to obtain learning resources, playing a significant positive impact on students' learning outcomes (Shao and Wang, 2020). So the students with better learning effects may have a lower level of AB (He, 2011).

In addition, the inconsistent results of previous studies may be due to the moderating variables affecting the relationship between AB and PMPU, such as measurement instrument, region, age, gender, and publication year. Therefore, we hypothesized that the moderating variables that have an impact on the relationship between AB and PMPU are (a) measurement instrument, (b) region, (c) age, (d) gender, and (e) publication year.

Measurement instruments may affect the reliability of meta-analysis findings. When analyzing the relationship between AB

and PMPU, it can be found that the tools used by researchers are different. The following tools are mainly used to measure PMPU: MPATS designed by Xiong et al. (2012), SAS-C prepared by Su et al. (2014), MPAI compiled by Leung (2008), SAS designed by Kwon et al. (2013b) and other self-made PSU questionnaires, such as MPD-M (Wang, 2011). The following instruments are used primarily to measure AB: LBS compiled by Lian et al. (2005), ASBI prepared by Wu et al. (2010), and other self-made AB questionnaires, such as LBS-M (Hu and Dai, 2007). Different measurement tools have different theoretical basis, dimension construction, and the number of questions, which affect the relationship between AB and PMPU to a certain extent. Therefore, this study intends to analyze the moderating effect of measurement tools on AB and PMPU.

Regional differences may lead to significant differences in the relationship between AB and PMPU. The Chinese mainland can be divided into three major regions: east, center, and west (Lei and Cui, 2016). Previous studies have shown that there is a low correlation between AB and PMPU among students in central China (Nie, 2014), and a moderate positive correlation in both eastern and western regions (Cheng, 2021; Deng, 2021). While other researchers found that AB was moderately positively correlated with PMPU among students in eastern, central, and western China (He et al., 2022; Li C. et al., 2022). Therefore, this study hypothesized that the relationship between AB and PMPU is obviously different between different regions.

Differences in age may be related to the differences in the relationship between AB and PMPU. Some studies have found that there is a low positive correlation between AB and PMPU in senior high school students (Nie, 2014), and a moderate positive correlation in junior high school students and college students (Lu, 2017; Cheng, 2021). In addition, studies have shown that the AB of college, high school, and junior high school students are positively correlated with PMPU to a moderate degree (Wan, 2020; He et al., 2022). Therefore, this study will analyze whether there is a significant age difference between AB and PMPU.

The gender differences may cause distinct differences in the relationship between AB and PMPU. Previous studies have found that there is a low positive correlation between AB and PMPU in female students (Nie, 2014) and a moderate positive correlation in male students (Ge, 2013). What's more, some researchers found that there was a moderate positive correlation between AB and PMPU in both male and female students (Zhang et al., 2019; Ma et al., 2020). Given this, the study will analyze whether there is a significant gender difference between AB and PMPU.

Finally, the publication year is a moderating variable that affects the relationship between AB and PMPU. Previous studies have shown that the correlation between AB and PMPU increases with the years (Zhang et al., 2019; Zhang F. et al., 2020; Ye, 2021). Other studies have shown that the correlation between AB and PMPU decreases over growing years (Wang, 2020; Liu et al., 2021; He et al., 2022). Therefore, this study will explore the differences in AB and PMPU among students in different years.

Thus, the relationship between AB and PMPU is still unclear. Maybe previous studies have used small samples, which caused

the deviation. Therefore, this study adopted the meta-analysis method to explore the relationship between AB and PMPU by taking Chinese mainland adolescents as samples. Two research questions guided this study:

1. What is the size and direction of the relationship between AB and PMPU?
2. Will the study characteristics (measurement tools, region, age, gender, publication year) affect the relationship between AB and PMPU?

## Materials and methods

This meta-analysis would be carried out following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009, 2015).

In order to increase transparencies and prevent unintended duplication of effort, the protocol of this meta-analysis was preregistered at the International Prospective Register for Systematic Reviews (PROSPERO) (CRD:42022347277).

## Literature search

We used databases to search the related studies on AB and PMPU in Mainland China from January 2012 to November 2022, including CNKI, Wanfang Data, Chongqing VIP Information Co., Ltd. (VIP), Baidu scholar, ProQuest dissertations, SAGE Online Journals, Elsevier SDOL, Taylor & Francis, Springer, Web of

Science, Google Scholar, EBSCO, PsycINFO, Medline, Scopus Database, PubMed Central, Embase, The Cochrane Library. In Figure 1 (Miller et al., 2018; Scott et al., 2018), the specific search terms are listed next to AB, PMPU and students. This paper studies the relationship between AB and PMPU of students.

The literature was screened according to the following criteria: (1) The AB scale and the PMPU scale were used simultaneously, and the Pearson product-moment correlation coefficient or the *t*-value and *f*-value that could be converted into *r* were reported; (2) The sample size is reported; (3) The subjects were students in mainland China, excluding other groups such as patients and criminals; (4) If data were repeatedly published, we only adopted professional academic journals. After excluding papers with no data, repeated publication, and no clear sample size, a total of 50 articles met the meta-analysis criteria. Figure 2 depicts the PRISMA flow chart of the systematic search.

## Coding variables

The collected articles were coded with features, including author's name, publication year, regional distribution, literature type, age of subjects, sample size, the correlation coefficient between AB and PMPU, measurement tools of AB and PMPU, and the percentage of female students in the total population (see Table 1). Effect values were extracted according to the following criteria: (1) The correlation coefficient between AB and PMPU was included in the coding; (2) Independent samples were coded once; (3) When calculating the effect size of each category, each original datum appeared only once in each category to ensure the independence of the effect value calculation.

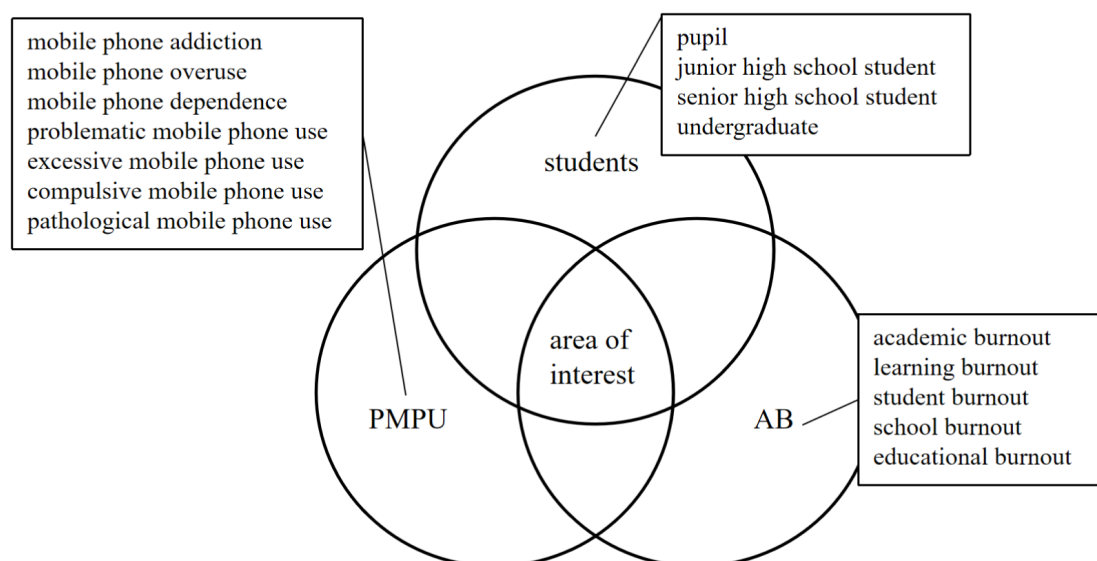
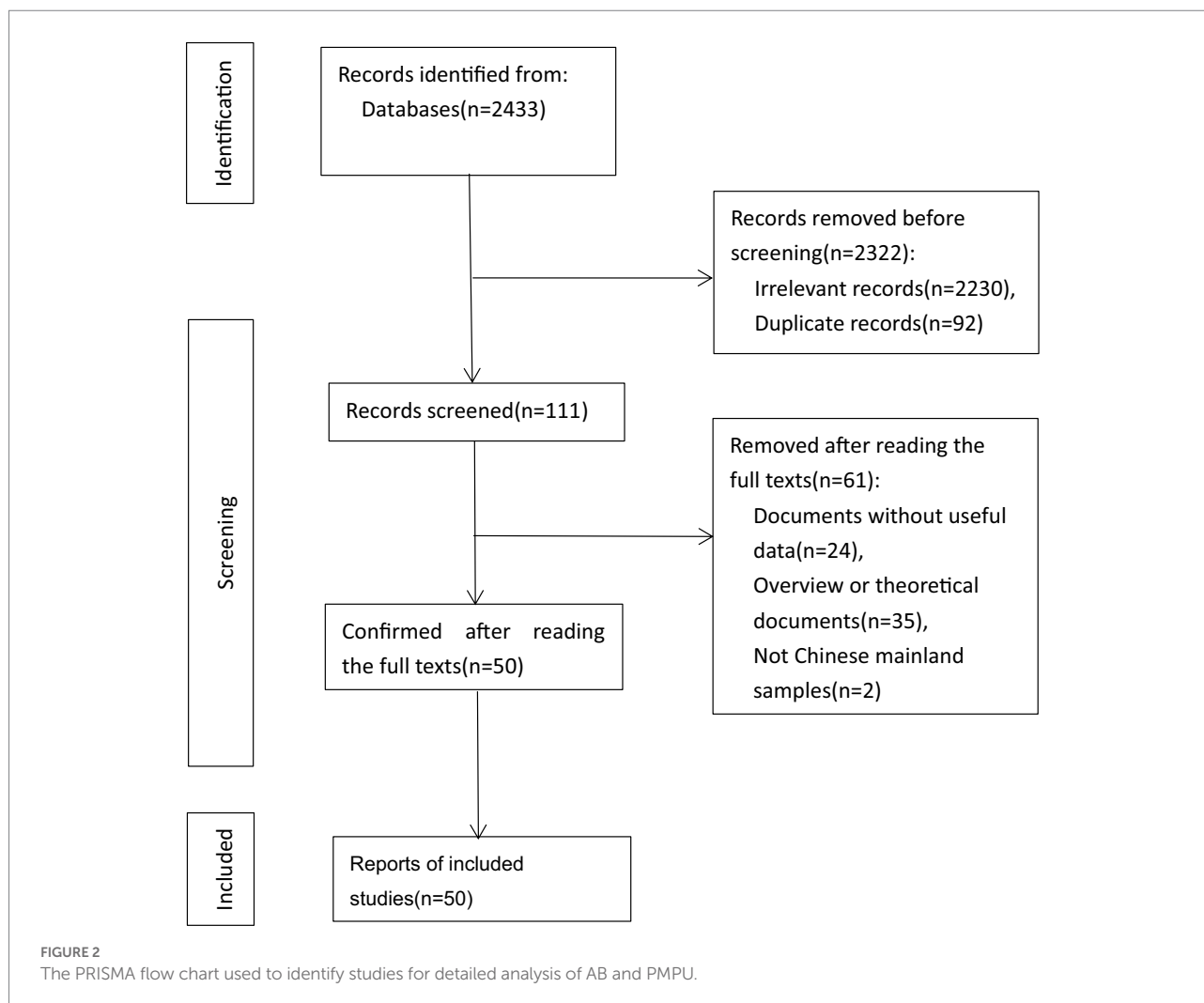


FIGURE 1  
Diagram of search term clusters.



## Effect size calculation

This study used the meta-analysis method of Person product difference correlation coefficient  $r$  to calculate the effect value (Borenstein et al., 2009). Fisher's  $Z$  transformation was applied to  $r$ , and weights and 95% confidence intervals were calculated based on the sample size. Conversion formula:  $Zr = 0.5 \ln[(1+r)/(1-r)]$ ,  $VZ = 1/n - 3$ ,  $SEz = \sqrt{1/n - 3}$ , where  $Zr$  represents the converted value of the corresponding  $r$ ,  $VZ$  is the variance, and  $SEz$  is the standard error.

## Data processing and analysis

A homogeneity test is required to test whether each study result represents a sample estimate of the overall effect size. Firstly, the homogeneity test provides a basis for whether the outcome adopts a fixed effect model or a random effect model. If the test results showed that the effect values were homogeneous, the fixed effect model should be used. If the heterogeneity is considerable, the random effect model was selected. Secondly, the homogeneity

test also provides the basis for analyzing the moderating effect, and the large heterogeneity indicates the existence of the moderating effect (Lipsey and Wilson, 2001).

## Results

### Effect size and the homogeneity test

Among the literature included in the meta-analysis of this study, 50 pieces of literature reflected the relationship between AB and PMPU, involving 38,488 subjects, with the sample size ranging from 193 to 2,260. Table 2 shows the homogeneity test of AB and PMPU in 50 independent samples, with  $Q$  statistic value of 591.365,  $p < 0.001$ ,  $I^2 = 91.714$ , indicating the heterogeneity of the included literature. This may be due to the use of different measurement tools, sources of subjects, and different sample sizes in the literature. That is, there may be a moderating effect. According to the method provided by Lipsey and Wilson, the included papers are highly heterogeneous and must be analyzed by random models (Lipsey and Wilson, 2001).

TABLE 1 Characteristics of the 50 studies included in the meta-analysis.

Name (year)	Journal	Region	Age	<i>N</i>	<i>r</i>	AB scale	PMPU scale	Female%
Bai et al. (2020)	General	Mixed	Younger	1794	0.168	Others	MPAI	49.00
Cao (2018)	General	Western	Undergraduate	193	0.348	LBS	SAS-C	54.92
Chen (2019)	Dissertation	Eastern	Younger	323	0.44	Others	SAS-C	33.13
Chen X. et al. (2021)	General	Eastern	Undergraduate	812	0.47	LBS	MPATS	65.52
Chen Y. et al. (2022)	General	Mixed	Undergraduate	1791	0.47	LBS	SAS-C	76.27
Cheng (2019)	Dissertation	Eastern	Undergraduate	673	0.51	LBS	MPAI	49.78
Cheng (2021)	General	Western	Undergraduate	885	0.402	LBS	MPAI	73.79
Cheng et al. (2018)	General	Eastern	Undergraduate	607	0.27	LBS	MPAI	60.96
Deng (2021)	General	Eastern	Younger	296	0.33	LBS	MPAI	34.46
Feng and Tao (2019)	General	Center	Undergraduate	704	0.466	LBS	SAS-C	54.26
Ge (2013)	General	Eastern	Younger	211	0.305	ASBI	MPATS	24.17
Gu et al. (2021)	General	Eastern	Undergraduate	389	0.481	LBS	MPATS	62.21
Hao et al. (2021)	General	Eastern	Undergraduate	748	0.348	LBS	SAS	76.20
Hao et al. (2022)	General	Eastern	Undergraduate	766	0.244	LBS	SAS	74.41
He et al. (2022)	General	Mixed	Younger	1,191	0.41	ASBI	MPAI	49.45
Hu (2022)	Dissertation	Mixed	Younger	576	0.47	Others	MPAI	51.56
Li et al. (2020)	General	Eastern	Undergraduate	825	0.215	LBS	MPAI	74.67
Li et al. (2021)	General	Eastern	Younger	2077	0.503	LBS	Others	86.52
Li B. et al. (2022)	General	Center	Younger	1,505	0.6	ASBI	MPAI	49.04
Li C. et al. (2022)	General	Mixed	Undergraduate	511	0.463	LBS	MPATS	77.50
Liang (2019)	Dissertation	Western	Younger	807	0.209	ASBI	MPATS	72.24
Liu Y. et al. (2019)	General	Center	Undergraduate	881	0.45	Others	MPATS	50.06
Liu et al. (2021)	General	Mixed	Undergraduate	323	0.471	ASBI	MPATS	78.02
Liu J. et al. (2022)	General	Western	Undergraduate	239	0.463	LBS	MPATS	63.60
Liu and Jin (2018)	General	Eastern	Undergraduate	397	0.52	LBS	MPAI	44.08
Lu (2017)	General	Eastern	Younger	1,010	0.363	ASBI	Others	50.00
Lu and Zhou (2019)	General	Eastern	Undergraduate	1,095	0.379	LBS	MPATS	95.07
Ma (2019)	Dissertation	Western	Younger	274	0.514	ASBI	SAS-C	60.95
Ma et al. (2020)	General	Eastern	Undergraduate	357	0.43	LBS	MPAI	90.20
Nie (2014)	Dissertation	Center	Younger	352	0.103	ASBI	MPAI	71.02
Nong (2022)	General	Western	Undergraduate	786	0.517	LBS	MPAI	62.34
Qin et al. (2020)	General	Western	Undergraduate	964	0.4	LBS	MPATS	55.60
Qu et al. (2017)	General	Eastern	Undergraduate	582	0.399	LBS	MPATS	77.32
Shen et al. (2021)	General	Center	Younger	631	0.46	Others	Others	46.75
Tian (2020)	General	Center	Undergraduate	300	0.4	LBS	MPATS	56.67
Wan (2020)	Dissertation	Mixed	Mixed	1,158	0.41	ASBI	MPAI	49.30
Wang (2020)	Dissertation	Mixed	Undergraduate	388	0.673	LBS	MPATS	55.67
Wang et al. (2022)	General	Western	Younger	2,260	0.39	Others	SAS	50.35
Wu et al. (2022)	General	Eastern	Undergraduate	883	0.474	LBS	MPATS	76.10
Ye (2021)	Dissertation	Center	Younger	312	0.548	ASBI	MPAI	50.64
Yu M. et al. (2022)	General	Eastern	Undergraduate	196	0.44	LBS	MPATS	85.20
Zhang et al. (2019)	General	Western	Undergraduate	239	0.348	LBS	MPAI	32.22

(Continued)

TABLE 1 (Continued)

Name (year)	Journal	Region	Age	<i>N</i>	<i>r</i>	AB scale	PMPU scale	Female%
Zhang F. et al. (2020)	General	Eastern	Undergraduate	910	0.442	LBS	SAS-C	46.48
Zhang Y. et al. (2020)	General	Western	Undergraduate	635	0.338	LBS	SAS	61.42
Zhang et al. (2021a)	General	Western	Undergraduate	1,475	0.38	LBS	MPATS	67.73
Zhang et al. (2021b)	General	Western	Undergraduate	1,062	0.368	LBS	MPATS	60.26
Zhang and Miao (2021)	General	Eastern	Undergraduate	840	0.36	LBS	MPAI	56.79
Zhang and Shen (2015)	General	Eastern	Undergraduate	218	0.404	LBS	MPATS	46.33
Zhou (2021)	Dissertation	Eastern	Undergraduate	592	0.45	LBS	MPAI	78.04
Zhou et al. (2022)	General	Center	Undergraduate	1,445	0.431	LBS	SAS	50.00

TABLE 2 Random model of the correlation between AB and PMPU.

<i>k</i>	<i>N</i>	Mean <i>r</i>	95% CI for <i>r</i>	Homogeneity test			Tau-squared			Test of null
				<i>Q</i> ( <i>r</i> )	<i>p</i>	<i>I</i> <sup>2</sup>	<i>Tau</i> <sup>2</sup>	SE	<i>Tau</i>	<i>Z</i> -value
50	38,488	0.414	[0.384, 0.443]	591.365	0.000	91.714	0.015	0.004	0.121	24.272***

\**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001, the same as follows.

The stochastic model was used to analyze the correlation between AB and PMPU, and it showed that AB was significantly correlated with PMPU, with a correlation coefficient of 0.414, 95%CI [0.384, 0.443]. This relationship between AB and PMPU can be considered as a moderate correlation (Lipsey and Wilson, 2001). The *Z*-value of the relationship between AB and PMPU was 24.272, *p* < 0.001, indicating that the relationship between AB and PMPU was stable.

## Moderator analysis

As mentioned above, random effects models should also be used in moderating effects analysis. Meta-ANOVA analysis is suitable for analyzing the moderating effects of categorical variables, such as the type of measurement tool, subject group, regional differences, etc. In contrast, meta-regression analysis is suitable for analyzing the moderating effect of continuous variables, such as proportion of females and publication year.

### Meta-ANOVA analysis

In order to further analyze the moderating effect of the relationship between AB and PMPU, Meta-ANOVA analysis was used to analyze the moderating effect of categorical variables (Table 3). In terms of region, the results of the homogeneity test (*Q* = 1.914, *df* = 3, *p* > 0.05) showed that region did not have a moderating effect on this correlation, and the relationship between AB and PMPU was not affected by region.

In terms of age, the results of the homogeneity test (*Q* = 0.469, *df* = 2, *p* > 0.05) showed that age did not have a moderating effect on this correlation, and the relationship between AB and PMPU was not affected by age.

In terms of the measurement tool of AB, the results of the homogeneity test (*Q* = 0.241, *df* = 2, *p* > 0.05) showed that the measurement tool of AB did not have a moderating effect on this correlation, and the relationship between AB and PMPU was not affected by measurement tool of AB.

In terms of measurement tool of PMPU, the results of homogeneity test (*Q* = 11.478, *df* = 4, *p* < 0.05) showed that measurement tool of PMPU had a moderating effect on this correlation, and the correlation coefficients between AB and PMPU in MPAI, SAS-C, MPATS and SAS research were 0.400(95% CI = [0.330, 0.466]), 0.458(95% CI = [0.430, 0.484]), 0.427(95% CI = [0.384, 0.469]) and 0.355(95% CI = [0.295, 0.412]) respectively, which illustrates  $r_{SAS} < r_{MPAI} < r_{MPATS} < r_{SAS-C}$ .

### Meta-regression analysis

To examine whether continuous variables (gender and publication year) moderate the effect sizes between AB and PMPU, the *r* effect size was meta-regressed onto the percentage of female participants and publication year in each sample. In Table 4, meta-regression ( $Q_{Model[1, k=50]} = 0.15$ , *p* > 0.05) demonstrated that the relation between AB and PMPU was not moderated by gender. Meta-regression ( $Q_{Model[1, k=50]} = 6.87$ , *p* < 0.01) demonstrated that the relation between AB and PMPU was moderated by publication year. It means with the increase of publication year, the correlation coefficient between AB and PMPU also increases.

### Publication bias

To examine whether the results were biased due to effect sizes from various sources, a funnel plot was drawn, indicating

TABLE 3 Region and age and measures moderators of the association between AB and PMPU.

	$Q_{between}$	$k$	$N$	Mean $r$	SE	95% CI for $r$		$Q_{within}$
						LL	UL	
<i>Region</i>	1.914							
Eastern		22		0.402	0.004	0.363	0.440	161.643***
Center		8		0.443	0.014	0.353	0.524	117.658***
Western		12		0.390	0.004	0.346	0.433	64.951***
Mixed		8		0.449	0.019	0.346	0.541	198.392***
<i>Age</i>	0.469							
Undergraduate		34		0.421	0.003	0.393	0.449	225.522***
Younger		15		0.396	0.014	0.319	0.468	363.395***
Mixed		1		0.410	0.000	0.361	0.457	0.000
<i>Measures of AB</i>	0.241							
LBS		34		0.420	0.003	0.390	0.448	249.678***
ASBI		10		0.403	0.018	0.305	0.493	198.762***
Others		6		0.398	0.017	0.291	0.496	112.050***
<i>Measures of PMPU</i>	11.478*							
MPAI		18		0.400	0.012	0.330	0.466	370.697***
SAS-C		6		0.458	0.001	0.430	0.484	5.765
MPATS		18		0.427	0.005	0.384	0.469	125.346***
SAS		5		0.355	0.004	0.295	0.412	24.989***
Others		3		0.445	0.010	0.352	0.528	20.283***

TABLE 4 Meta-regression analysis of gender and publication year.

Variables	Parameter	Estimate	SE	Z-value	95% CI for $b$	
					LL	UL
Female (%)	$\beta_0$	-0.0469	0.1205	-0.39	-0.2830	0.1893
	$\beta_1$	0.4687	0.0753	6.22	0.3211	0.6163
$Q_{Model} (1, k=50) = 0.15, p > 0.05$						
Publication year	$\beta_0$	0.0229	0.0087	2.62	0.0058	0.0400
	$\beta_1$	-45.7433	17.6146	-2.60	-80.2672	-11.2193
$Q_{Model} (1, k=50) = 6.87, p < 0.01$						

that the 50 effect sizes were symmetrically distributed on both sides of the average effect size, and an Egger's regression (Egger et al., 1997) revealed no significant bias ( $t_{(48)} = 0.214$ ,  $p = 0.832 > 0.05$ ). This result showed that in the overall correlation between AB and PMPU was stable in this study (Figure 3).

## Discussion

The results of the meta-analysis showed that there was a moderate positive association between AB and PMPU. The higher the AB, the higher the risk of PMPU, which is consistent with previous research (Qu et al., 2017; Shen et al., 2021). It

supports the compensatory Internet use theory. According to this theory, individuals in negative life situations tend to use the Internet to compensate for their negative emotions (Kardefelt-Winther, 2014). Kardefelt-Winther, considering problematic Internet use from the perspective of compensation rather than forcing, thought that the problematic use of the Internet is a response based on positive or negative motivation, in which the individual's response to negative life situations is the reason for compensatory Internet use, and the response can compensate for negative emotions through using the Internet to generate positive feelings (Kardefelt-Winther, 2014). Suppose students in the learning situation have negative emotions such as burnout. In that case, their learning desire will be reduced, resulting in a decline in academic performance, so they tend to use mobile

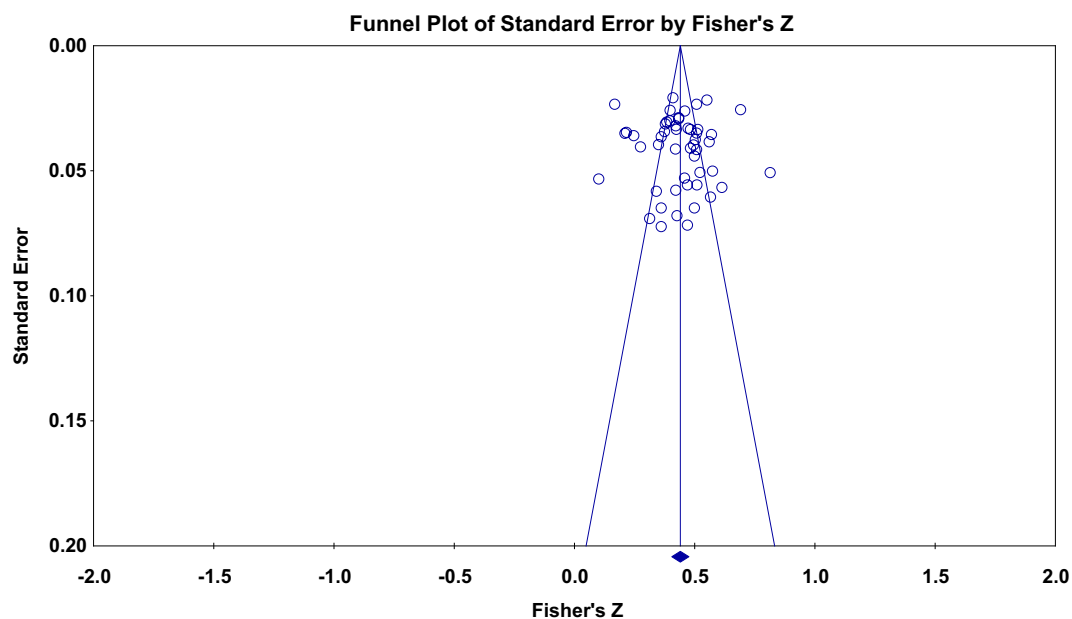


FIGURE 3  
Funnel plot of effect sizes of the correlation between AB and PMPU.

phones excessively to alleviate the burnout, resulting in PMPU (Fiorilli et al., 2017; Wei et al., 2021). In addition, students who overuse mobile phones develop AB further (Zhen et al., 2020). It supports the job demands-resources model, which thinks that any type of working condition is composed of job demands and job resources, and the increase of job demands and the decrease of job resources will lead to job burnout (Schaufeli and Bakker, 2004). Job demands refers to the physical or mental effort made by individuals to work; job resources include the physical, psychological, social and organizational aspects that support and help people in their work (Schaufeli and Bakker, 2004). For students, their academic tasks actually is working tasks in an academic environment (Schaufeli et al., 2002). If students have PMPU, they will occupy a large amount of physical and psychological resources (such as personal energy, time and cognition) in using mobile phone, and less disposable resources engage in learning, resulting in low work resources, thus producing AB (Samaha and Hawi, 2016; Palos et al., 2019). On the other hand, if students spend a lot of time on mobile phones, the less time they spent on study, they will not be able to keep up with the progress of study and academic performance will be decreased, gradually losing interest in study, eventually result in the emergence of AB (Qu et al., 2017). In addition, previous studies have proved that PMPU can have negative effects on health (anxiety, sleep disorders, and even suicidal ideation; Arrivillaga et al., 2020; Yang et al., 2020; Jin et al., 2021), which will consume students' energy according to the severity, leading to low concentration in learning, then producing AB.

The positive relationship between AB and PMPU is moderated by the PMPU measures used. Specifically, SAS-C and MPATS had

the higher impact on the relationship between AB and PMPU, MPAI and SAS lower. There are two possible reasons for this. Firstly, it may be related to cultural adaptation. For example, MPATS and SAS-C were developed by Chinese mainland scholars for Chinese mainland students, while MPAI was developed by scholars for students in Hong Kong, China, SAS was developed by scholars for students in South Korea. Therefore, MPATS and SAS-C can more accurately measure the PMPU of Chinese mainland students. Secondly, it may be related to whether the questionnaire is compiled for a specific learning stage. MPATS and SAS-C are developed for college students, while MPAI and SAS do not target specific study periods. Therefore, MPATS and SAS-C are more accurate in measuring college students, adjusting the relationship between AB and PMPU.

So far, studies have found that publication year moderates the relationship between AB and PMPU. This means that the relationship between AB and PMPU increases with increasing years. There are four possible reasons. Firstly, the report of CNNIC from 2012 to the latest 2022 shows that the number of mobile Internet users has increased from 420 million to 1.047 billion (CNNIC, 2013, 2022). It means that with the year's progress, mobile phones are becoming more and more popular. According to the Internet availability hypothesis, availability has an essential impact on addictive behaviors (Mann, 2005; Su et al., 2019), which increases the likelihood of PMPU, thereby moderating the relationship between AB and PMPU. Secondly, research shows that during the COVID-19 epidemic, the use of digital technologies by people is on the rise (Montag and Elhai, 2020). Also, online learning will aggravate students' AB (Liu and Cao, 2022). These factors will adjust the relationship between AB

and PMPU. Thirdly, compared with the previous use of mobile phones, the 5G network is faster and mobile phones have more powerful functions. Through mobile phones people can communicate, learn, entertain, shop and so on (CNNIC, 2022), which will cause individuals to spend more time using mobile phones, thus adjusting the relationship between AB and PMPU. Fourthly, many studies have shown that AB increases over time (Lee, 2010; Kim et al., 2015), so publication year affects the relationship between AB and PMPU.

## Implications

From the study on the relationship between AB and PMPU, it implied that targeted measures can be taken to reduce students' PMPU in the future. On the one hand, PMPU can be reduced by alleviating students' AB. According to ecological systems theory, students, schools and families can make efforts together to alleviate students' AB (Bronfenbrenner, 1992). First of all, from the perspective of students, it can improve students' self-efficacy, self-concept, self-esteem and resilience to rebuild positive self-image, enhance participation and adaptability to have a higher level mental health (Mikaeeli et al., 2013; Luo et al., 2016; Safarzaie et al., 2017; Oyoo et al., 2018). And then, AB could be alleviated. Secondly, teachers can activate the intrinsic motivation resources of students by meeting their independent needs, so as to motivate and attract students (Reeve, 2006). Specifically, teachers can coordinate teaching activities according to students' preferences, interests, enjoyment and choices, so as to alleviate students' AB (Shih, 2015). Third, schools can provide professionals to reduce students' AB, such as school health nurses, school doctors, school counselors, school psychologists, etc., to provide more professional help for students with learning difficulties (Kim et al., 2018). Finally, parents need to create a good family environment for their children. Students living in a warm, emotional environment can gain more support and understanding, resulting in a more positive attitude toward learning and less AB (Luo et al., 2020). Through the joint efforts of students, teachers, schools and parents, students' AB can be alleviated and PMPU can be reduced.

On the other hand, positive coping strategies are needed to adopt for reducing students' PMPU. The study found that students with psychological symptoms such as anxiety, depression and stress were more likely to get PMPU, while students with mild psychological symptoms were less likely to get PMPU (Augner and Hacker, 2012; Zou et al., 2019; Kong et al., 2021). Therefore, schools can regularly screen students with mental problems and provide professional mental health services for them (Liu R. D. et al., 2019; Ohrt et al., 2020). In addition, family members should also take measures to reduce the influence of mobile phones and other media on children. For example, parents monitor the time their children spend on their mobile phones, and parents communicate with their

children about Internet contents to reduce the influence of media on their children. When these measures were associated with good parenting, the effect of PMPU prevention was more significant (Hefner et al., 2019). At the same time, communication between families and schools needs to be strengthened to educate students about the potential dangers of excessive cell phone use and guide them to set goals to control the frequency and duration of their phone use (Chun, 2018). These strategies may help students to use their phones in a healthy way.

## Limitations and future studies

This study applied Egger's publication bias test to the meta-analysis results. It was revealed that the included studies had no obvious publication bias and that the meta-analysis results were stable. This indicates that, compared with the results of studies based on a single sample group, our results were more reliable, representative, and authentic. Future studies should explore the following aspects. Firstly, our data are based on self-reporting of the samples, suggesting that future researchers introduce other assessment methods to determine the relationship between AB and PMPU. Secondly, future research samples can be selected from a wider range of people, to improve the universality of research results. Thirdly, this meta-analysis only tested the moderating effects of the measurement instrument, region, age, gender and publication year. Future research can be analyzed from the perspective of other related moderator variables. Lastly, the researches included in this meta-analysis are mainly cross-sectional studies. Therefore, it is recommended to include longitudinal studies in future studies.

## Conclusion

We conducted a meta-analysis of data from 38,488 Chinese mainland students surveyed in 50 previous studies. The results showed a moderate positive correlation between AB and PMPU. That is, the higher the AB level is, the higher the PMPU level is. Conversely, the lower the AB level is, the lower the PMPU level is. The relationship is moderated by the measurement of PMPU and publication year. Specifically, firstly, the relationship between AB and PMPU is regulated by the measurement of PMPU. When the MPATS and the SAS-C were used as PMPU measurement tools, the correlation coefficients between AB and PMPU were higher, while when the MPAI and the SAS were used as PMPU measurement tools, the correlation coefficient between AB and PMPU were lower. Secondly, the relationship between AB and PMPU was moderated by publication year. When the publication year was used as a moderating variable, the relationship between AB and PMPU increased over the years.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

## Author contributions

SL designed and supervised the study, and did all statistical analyses. MX did the literature search and drafted the first version of the article. YZ and XW contributed to review and revision. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# Physical activity reduces internet addiction among “post-00” college students: The mediating role of coping styles

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**Objective:** To explore the role of coping styles (CS) in mediating the relationship between physical activity (PA) and internet addiction (IA), and to provide a theoretical basis for the prevention and treatment of IA among Chinese “post-00” college students.

**Methods:** A total of 410 university students from five universities in Anhui Province were surveyed using the Chinese Internet addiction scale, the Coping Styles Scale for Chinese University Students, and the International Physical Activity Scale Short Form.

**Results:** (1) Boys are better than girls in PA. However, there was no significant difference between male and female students on CS and IA. (2) PA was positively correlated with CS ( $r=0.278$ ,  $p<0.01$ ), PA was negatively correlated with IA ( $r=-0.236$ ,  $p<0.01$ ), CS was negatively correlated with IA ( $r=-0.560$ ,  $p<0.01$ ). (3) PA was negatively predicted IA ( $B=-0.198$ ,  $p<0.01$ ), PA was positively predicted CS ( $B=0.986$ ,  $p<0.01$ ), CS was negatively predicted IA ( $B=-0.065$ ,  $p<0.01$ ). (4) CS plays a partially mediating role between PA and IA, with a mediating effect proportion of 48.33%.

**Conclusion:** PA can improve IA not only directly for university students, but also indirectly by increasing CS. The intervention for IA of “post-00” college students can start by increasing PA and improving CS.

## KEYWORDS

physical activity, internet addiction, mediating role, “post-00” college students, coping styles

## Introduction

With its unique communication advantages, the Internet has become the most popular information dissemination platform and is gradually affecting all aspects of people's lives. While the Internet has brought convenience to people, it has also produced negative effects that cannot be ignored. Among them, internet addiction (IA) has attracted the attention of

all sectors of society. By December 2021, the number of Chinese Internet users had reached 1.032 billion, and the proportion of Internet users using mobile phones to access the Internet was as high as 99.7% [China National Network of Industries (CNNIC), 2022]. The International Classification of Diseases, Eleventh Revision (ICD-11), officially classifies “Gaming disorder” as a disorder (ICD-11, 2019). IA is a pathological form of Internet use or deviant behavior, which refers to a chronic or cyclical state of obsession caused by repeated use of the Internet, accompanied by psychological symptoms of addiction such as increased tolerance and withdrawal reactions (Spada, 2014). IA has a particularly negative impact on university students, such as affecting sleep quality, limiting leisure activities, lowering school grades, increasing absenteeism, increasing psychological and social stress, increasing loneliness and depression, and even increasing suicide thoughts (Ding et al., 2011, 2018; Wei et al., 2020; Ye et al., 2021; Du and Zhang, 2022; Lu et al., 2022; Zewde et al., 2022).

The “post-00” university students are those born between January 1, 2000 and December 31, 2009, and a high percentage of them are students by profession, mainly only children (Ma, 2019). They have the following characteristics: growing up in China’s mobile network era, they are more dependent on the Internet; they have a higher standard of living, but they are less able to control themselves; they are under greater academic and psychological pressure, and some of them lack interest in learning or are even bored with school (Lv, 2019; Ho, 2021). 2018, the “post-00s” college students officially entered the university campus, and after entering the university, they face an unfamiliar environment and a change in their lifestyle. In 2020, after the explosion of COVID-19, almost all university students were isolated at home in order to stop the spread of the epidemic. The internet has become the most important tool for communication, entertainment and learning for university students living at home (Chang and Hou, 2022). The study found that IA was more likely to occur during COVID-19 due to increased network use (Nagaur, 2020). In addition, the fear and uncertainty of the epidemic has led to more severe depression, anxiety, and fear among university students, causing them to need to seek safety from cyberspace, resulting in IA (Shader, 2020). In order to overcome the negative effects of IA, scholars have proposed different countermeasures. The three main methods of treatment regarding IA are psychological intervention, medical and pharmaceutical interventions. University students are more resistant to psychological treatment and often give up treatment because of the limitations of pharmaceutical interventions, such as long lead times, high costs and side effects. Physical activity (PA) has advantages in IA treatment as a low-cost and easily available tool.

## Theories and hypotheses

By analyzing the causes and dangers of IA, we found that the mechanisms of PA influence on IA are very complex, including personality traits, biological factors, environmental factors and other factors. Theories that combine these factors to explain IA

include the ACE model, the Cognitive-Behavioral model and the Theories of Usage and Gratification. Davis proposed the Cognitive-Behavioral Model, which divides the influences of IA into distal necessary and proximal sufficient conditions, with distal necessary conditions including vulnerability and life events, and proximal sufficient conditions including non-adaptive cognition, social isolation and lack of social support (Davis et al., 2011). Parker thinks that when individuals use the Internet, they will get different levels of satisfaction according to their psychological needs, such as socializing and entertainment, which will prompt them to use their mobile phones and other Internet devices more frequently, which will lead to IA in the long run (Parker and Plank, 2015). In addition, PA can reduce the frequency of Internet use by university students by improving their emotional state (Slla et al., 2020; Sheng et al., 2022). From a neurobiological perspective, PA can modulate the concentration of neurotrophic factors and glucocorticoid levels in college students, improve the structure and function of specific regions of the central nervous system, regulate dopamine and its receptors in both directions, and effectively correct college students’ IA behavior (Irene et al., 2020). In addition, appropriate PA stimulates the pituitary gland to secrete endorphins, which bring positive emotional experiences and improve the coping style (CS) of college students, thus alleviating the discomfort of being away from the Internet (Hu and Zhang, 2016; Jenin et al., 2019). From the perspective of personality traits, meta-analysis found that PA was significantly associated with personality traits such as extra-version, dutifulness and neuroticism (Kathryn, 2015). Active participation in PA helps university students to develop stable personality traits and to face the effects of perceived stress with proper CS. In addition, PA can reduce problems in peer interaction and difficult behaviors (Yan et al., 2022), improve interpersonal relationships and life satisfaction, and increase self-awareness and self-efficacy among IA students (Guan et al., 2019).

CSs are a means for individuals to deal with stressful situations and maintain psychological balance during stress (Sheng et al., 2018a). Sawyer et al. (2009) found that negative CS increased the likelihood of depression. Liu et al. (2019) found that CS in adolescents had a greater effect on the onset of anxiety. Thus, CS may be a key variable influencing IA, with positive coping improving IA; poor coping triggering IA. Previous studies have mostly explored the effects of PA on IA, and few studies have explored the mediating role of CS in the process of PA influencing IA.

Based on the above discussion, the following hypothesis is proposed in this paper (the hypothetical model is shown in Figure 1):

H1: PA is negatively correlated with IA among university students.

H2: CS plays a mediating role in the influence of PA on IA.

H2a: PA was positively correlated with CS among university students.

H2b: CS is negatively correlated with IA in university students.

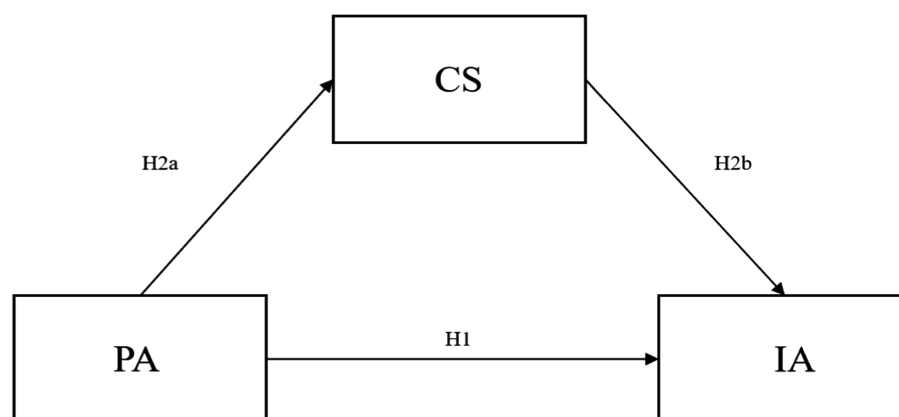


FIGURE 1  
Hypothetical model diagram.

## Materials and methods

### Participants

The study was conducted in strict accordance with the Declaration of Helsinki and was approved by the Ethics Review Committee of Huabei Normal University for the anonymous survey procedures involved. Informed consent was provided to all participants by members of the research team prior to the formal commencement of the survey. Students were informed of: the purpose of the study, its significance and the use of the data.

In March 2022, we randomly selected 80 “post-00s” university students from Huaibei Normal University to conduct a pre-survey by means of an on-site questionnaire. The pre-survey process was strictly anonymous and confidential, with the same person reading out the instructions and explaining how to answer the questions and the precautions to be taken throughout the test. The questionnaires were collected promptly after completion. The collected data were used to evaluate the reliability and validity of the questionnaire. The official questionnaire was distributed from April to July 2022, using a convenience sampling method, and was administered to “post-00s” university students at five universities in Anhui Province through the Questionnaire Star online platform, where the learning environment was restricted to the school. One hundred questionnaires were distributed to each university. Ten subjects were covered: literature, engineering, science and art. The questionnaire was introduced with basic precautions, “login verification” and “one answer only,” to ensure that respondents did not repeat the question and that no duplicate data would appear.

In terms of questionnaire quality control, we screened the data quality of the questionnaire based on the external and internal characteristics of the questionnaire. Referring to Liu (2015) study, proper questionnaire completion time is a basic guarantee of questionnaire completion quality. Therefore, we took the questionnaire completion time as an important external characteristic to measure the data quality of the questionnaire and

eliminated those questionnaires with too short response time. In terms of the internal characteristics of the questionnaire, we identify the logical relationships between the different questions within the questionnaire, using a combination of data detection and automatic jumping functions provided by the web questionnaire system. For mutually exclusive questions in the web questionnaire, unless a neutral answer is chosen (e.g., “generally”), the same participant’s answers to mutually exclusive questions should also be mutually exclusive. If the answers of the same participant do not conform significantly to the internal characteristics of a web-based questionnaire, then it is likely that the questionnaire was not read and completed carefully by the respondent and is therefore defined as a low quality questionnaire.

For the purposes of the study, we used the G-Power to estimate the sample size needed for this study. According to Francesco et al. (2014), the lower limit for the sample size of the pre-test is 3–5 times the number of items in the most extensive sub-scale. A total of 500 questionnaires were distributed, and after excluding invalid questionnaires with missing answers, wrong answers, and obvious discrepancies in feedback, 410 questionnaires were valid, with a validity rate of 82%, which basically met the above requirements.

### Measures

#### Chinese internet addiction scale

The scale was developed by Chen et al. (2003), consists of 26 questions using a Likert 4-point scale and contains five dimensions, namely tolerance ( $\alpha = 0.863$ ), compulsive ( $\alpha = 0.876$ ), withdrawal symptoms ( $\alpha = 0.881$ ), interpersonal health problems ( $\alpha = 0.874$ ) and time management problems ( $\alpha = 0.885$ ). The higher the total score, the higher the trend of IA. According to the CIAS-R diagnostic criteria. If the total score was  $\geq 58$ , the initial screening was for potential IA. If the total score was  $\geq 68$ , the person was diagnosed as an Internet addict. The scale has

high reliability and validity, with a retest reliability of 0.86. The CFA model showed a satisfactory fit ( $\chi^2/df=4.328$ , GFI=0.926, AGFI=0.937, RMSEA=0.031, CFI=0.951, NFI=0.963, RFI=0.957, SRMR=0.033).

### Coping styles scale for Chinese university students

The scale was developed by Liu (2009) and consists of 64 questions using a Likert 5-point scale, ranging from “1-basically all use this approach” to “5-no use this approach.” It consists of 3 dimensions: the problem orientation pathway ( $\alpha=0.87$ ), the emotional orientation pathway ( $\alpha=0.83$ ) and the avoidance pathway ( $\alpha=0.86$ ). For a given dimension, a high score indicates less use of this CS and a low score indicates more use of this style. The scale has high reliability and validity, with a retest reliability of 0.84. The CFA model shows a satisfactory fit ( $\chi^2/df=3.915$ , GFI=0.981, AGFI=0.943, RMSEA=0.03, CFI=0.912, NFI=0.943, RFI=0.946, SRMR=0.023).

### International physical activity scale short form (IPAQ)

The scale was revised by Qu and Li (2004) and consists of seven questions. Except for the last question which investigates the subject's sedentary status, the first 6 questions investigate the individual's PA. The IPAQ has been widely used in studies related to PA and has high reliability and validity (Li and Zhang, 2015). Referring to Zhang et al. (2020) study, subjects were divided into 3 groups of high, medium and low exercise according to the grouping criteria in Table 1. During data processing, the energy expenditure value (referred to as MET) of each university student PA was calculated by strictly following this scale to deal with outliers as well as the weights of different intensity physical activities. The MET was used to reflect the PA of university students, with the higher the value taken, the higher the level of PA. In order to make the MET variable more normally distributed, its natural logarithm is taken to construct a continuous variable that conforms to a normal distribution. In this study, the scale has high reliability and validity, with a retest reliability of 0.87. The CFA model showed satisfactory

fit results ( $\chi^2/df=4.136$ , GFI=0.932, AGFI=0.951, RMSEA=0.05, CFI=0.981, NFI=0.954, RFI=0.976, SRMR=0.033).

## Statistical methods

Data processing and analysis were performed using SPSS 25.0 and Amos 24.0 software. Firstly, a one-way ANOVA was conducted for PA, CS and IA using SPSS 25.0; Pearson's  $r$  correlation coefficient was used to analyse the correlation between the dimensions of PA, CS and IA. Secondly, structural equation modeling was conducted using Amos 24.0 software and a mediating effect model was fitted. Finally, mediating effects were calculated using a macro procedure in SPSS 25.0 with a Bootstrap repeated 5,000 times sample correction with 95% confidence intervals, where the 95% confidence interval did not contain 0. The significance level for this study was set at  $p < 0.05$ .

## Results

### Common method bias test

As this study used questionnaires to collect research data, there may be common method biases, which may affect the statistical results. Therefore, the results of this study were tested using the one-way test. The results showed that there were six factors with eigenvalues greater than one, and the percentage of variance explained by the first common factor was 31.48%, which was less than the critical threshold of 40%, so it was concluded that there was no serious common method bias in this study.

### Descriptive statistical analysis

In the sample selected for this study, the majority of university students had moderate to high PA and possessed good exercise habits. Out of 410 questionnaires, 47 met the criteria for IA, with

TABLE 1 Criteria for grouping individual physical activity levels.

Grouping	Standards
High exercise group	Satisfy any of the following:
	1. Three days or more of all types of high intensity physical activity with a total weekly physical activity level greater than or equal to 1,500 MET-min/w
	2. Three levels of physical activity at a combined intensity of $>7$ days and a total weekly physical activity level of $\leq 3,000$ MET-min/w
Intermediate exercise group	Satisfy any of the following:
	1. 20 min or more of all types of vigorous physical activity per day for a total of 3 days or more
	2. 30 min or more of all types of moderate intensity and/or walking activity per day for a total of 5 days or more
	3. Three physical activity of 3 intensities for a total of 5 days or more with a weekly total physical activity level greater than 600 MET-min/w
Low exercise group	Failure to report any exercise, or level of exercise that does not meet the criteria for the medium and high groups

a detection rate of 11.46% for IA. There was a statistically significant difference in PA between college students of different genders ( $p < 0.01$ ), with male students having a higher amount of PA; there was no significant difference in CS and IA between college students of different genders ( $p > 0.05$ ), as shown in Table 2.

## Differential analysis of university students' PA on CS and IA

The subjects were divided into 3 groups according to the amount of PA, high, medium and low, and the effects of different amounts of PA on CS and IA were analyzed. The results showed that there was a statistically significant difference ( $p < 0.01$ ) between the CS and IA of university students in the different exercise participation groups. The test results showed that the CS scores of the high exercise participation group were significantly higher than those of the other two groups. At the same time, the IA scores in the high exercise participation group were also significantly lower than those in the low and moderate exercise participation groups (see Table 3).

PA, CS and IA were all statistically significantly correlated with each other, which provided the basis for the mediating effect test. A negative correlation was found between CS and IA ( $r = -0.560$ ), indicating that the stronger the CS, the lower the degree of IA. A negative correlation was also found between PA and IA ( $r = -0.236$ ), indicating that the greater the amount of PA, the lower the degree of IA. A positive correlation was found between the amount of PA and CS ( $r = 0.278$ ), indicating that an increase in the amount of PA promotes an increase in CS as shown in Table 4. Thus, PA not only influences CS in university students, but also has a positive effect on IA, i.e., as the amount

of PA increases, the stronger CS follows and the degree of IA decreases.

## Test for mediating effects of CS

To explore whether CS plays a mediating role in the effect of PA on IA among university students, the magnitude of the mediating effect was explored with PA as the independent variable, IA as the dependent variable and CS as the mediating variable. A mediating effects regression analysis of CS was conducted according to the mediating effects test procedure proposed by Wen and Ye (2014) (see Table 5). PA negatively predicted IA ( $B = -0.198$ ,  $p < 0.01$ ). The negative predictive effect of PA on IA remained significant after the inclusion of mediating variables ( $B = -0.119$ ,  $p < 0.01$ ). In addition, PA positively predicted CS ( $B = 0.986$ ,  $p < 0.01$ ) and CS negatively predicted IA ( $B = -0.065$ ,  $p < 0.01$ ).

As can be seen from Table 6, the direct path effect value for PA  $\rightarrow$  IA is -0.093. 95% confidence interval is  $[-0.139, -0.038]$ , which does not contain 0. This indicates that the path effect is significant, i.e., PA can directly affect IA. While the indirect path effect value for PA  $\rightarrow$  CS  $\rightarrow$  IA is -0.087. 95% confidence interval is  $[-0.103, -0.057]$ , which does not contain 0. This indicates that the pathway effect is also significant. This suggests that PA not only improves IA among college students directly, but also reduces IA by enhancing CS. CS partially mediates the effect between PA and IA among college students, with the mediating effect accounting for  $-0.087/[-0.093 + (-0.087)] = 48.33\%$  of the total effect, and the mediating model for CS is shown in Figure 2.

## Discussion

### The impact of PA on university students' IA

The results of this study showed that college students were moderately physically active overall. This result is consistent with previous studies (Chen and Zhang, 2021). A study by Dong and Mao (2021) found that a significant number of university students were occupied with Internet use and sedentary time during their leisure time, and they were reluctant to go for PA, leading to a decrease in the amount of PA (Harvey and Chastin, 2013). Another study found that low-intensity PA, such as slow walking and strolling, has become the main form of PA performed daily

TABLE 2 Descriptive statistical analysis of age, PA, CS and IA.

Variable	Gender	$M \pm SD$	$t$	$p$
Age	M	19.93 $\pm$ 1.57	2.568	0.782
	F	19.22 $\pm$ 1.09	2.391	0.994
PA	M	1990.06 $\pm$ 134.89	10.834	0.001
	F	1357.03 $\pm$ 111.42	9.236	0.004
IA	M	55.47 $\pm$ 13.28	4.534	0.431
	F	55.31 $\pm$ 9.96	5.657	0.767
CS	M	60.17 $\pm$ 10.80	4.281	0.363
	F	60.38 $\pm$ 9.27	3.546	0.859

TABLE 3 One-way ANOVA for the effect of different amounts of PA on CS and IA.

Variable	Low exercise participation group ( $n=113$ )	Medium exercise participation group ( $n=163$ )	High exercise participation group ( $n=134$ )	$F$	$p$
CS	56.64 $\pm$ 10.17	60.10 $\pm$ 8.93	63.47 $\pm$ 10.04	15.34	<0.01
IA	59.23 $\pm$ 13.78	55.58 $\pm$ 10.87	51.96 $\pm$ 11.18	11.78	<0.01

by most university students (Zhang, 2018). Therefore, college students' PA levels are at an intermediate level.

The results of this study showed that there was a statistically significant difference between the PA levels of male and female university students, in terms of gender differences. This result is consistent with previous studies (Li et al., 2018). The reason for this is that most female university students prefer low-intensity, non-confrontational PA, such as walking, jogging, yoga and aerobics. Male university students prefer moderate-to-high intensity, competitive PA, such as ball games and HIIT (Zhang and Lei, 2015). In addition, gender role conflict is considered to be an important factor influencing female university students' participation in PA. Compared to male university students, female university students are more likely to develop negative emotions such as anxiety and distress. Male university students showed significantly higher levels of interpersonal support and exercise identity when participating in exercise than female university students (Li et al., 2015; Zhang and Lei, 2015). Therefore, male college students had relatively higher levels of PA than female college students.

The results of this study showed that the IA detection rate was about 11.46%, a result similar to that of previous studies. However, differences in sample size, differences in scale selection and judgment criteria, or differences in testing time and region can affect the detection rate of addiction. Some studies have shown that the prevalence of IA is higher among boys than girls (Zhang and Lei, 2015), especially in the category of online gaming addiction (Cuhadar, 2012). Some studies have also found the opposite, showing that the relationship between gender and IA is not significant (Bi, 2016). However, overall, male students' interest in online games and money management and female students' preference for shopping and dating apps are significant factors in the increase of IA (Long et al., 2016). Other studies have found that

college freshmen have the lowest rates of IA, and that the rate of IA among college students increases with grade level (Brand et al., 2014). As "post-00" college students enter school independently, the unfamiliar environment can easily bring about emotional and psychological problems, prompting them to turn to other alternatives for inner satisfaction. As a result, university freshmen are at a high risk of IA, and the proportion of IA shows a gradual increase as the year progresses. In addition, the increasing convenience and cheapness of Internet access for university students, influenced by a combination of factors such as the upgrading of smartphones, the popularity of online games and decreasing Internet tariffs, are also important factors in the increase of IA.

The results of this study showed a significant negative effect of PA on IA. This result is consistent with previous studies (Qin et al., 2020; Guo et al., 2022) and also verifies hypothesis H1. The higher the level of PA, the less likely IA will occur. This suggests that PA, as an economic and effective measure to improve IA, has a preventive and curative effect on IA. PA and the Internet serve as an important part of university students' life and entertainment. The difference between the two is that the internet provides a virtual world for university students, while PA is a means of entertainment and health promotion for university students in the real world. Exercise intervention therapy argues that PA can crowd out time spent using the Internet and to some extent replace the gaming and dating functions of the Internet. Currently, fitness apps are being introduced to promote PA among university students to a certain extent. Therefore, PA is not only effective in improving IA among university students, but also helps to promote physical and psychological health, increased willpower and more self-discipline (Ma and Huang, 2020).

## The mediating effect of CS between PA and IA

The results of the mediating effect in this study show that, on the one hand, PA can directly influence IA, indicating that college students can divert their attention, squeeze time for Internet use and satisfy their psychological needs through PA, thus reducing IA. On the other hand, PA can also indirectly influence college students' IA through CS, which plays a mediating role between PA

TABLE 4 Results of the correlation analysis of PA volume, CS and IA for university students.

Variable	PA	CS	IA
PA	1.000		
CS	0.278**	1.000	
IA	-0.236**	-0.560**	1.000

\*\* $p < 0.01$ .

TABLE 5 Regression analysis results.

Dependent variable	Independent variable	B	t	R <sup>2</sup>	F
IA	Sex	0.083	2.105*	0.052	4.217**
	PA	-0.198	-4.311**		
CS	Sex	0.052	1.086	0.003	5.427*
	PA	0.986	1.121**		
IA	Sex	0.145	2.754	0.287	214.669**
	PA	-0.119	-2.741**		
	CS	-0.065	-7.337**		

B, standardized coefficients; R<sup>2</sup>, R square change; F, F change; \* $p < 0.05$ ; \*\* $p < 0.01$ .

and college students' IA, and the proportion of the mediating effect to the total effect is 48.33%. The hypothesis *H2* was verified. Specifically, PA significantly and positively predicted CS, which is consistent with previous studies (Fedewa and Ahn, 2011; Sheng et al., 2018b), i.e., confirming the association between PA and CS in university students, and hypothesis *H2a* was verified. Fedewa and Ahn (2011) argued that long-term PA could promote changes in cognitive function and thus coping ability in college students, and Sheng et al. (2018a,b) showed that PA can directly influence individuals' CSs and improve their self-confidence; Wang and Gao (2018) concluded that fitness qigong can improve individuals' CSs. The above research results support the positive effect of PA on CS. However, differences in the effects of different exercise programs on CS intervention can be studied comparatively in the future.

The results of the present study showed that CS significantly and negatively predicted IA, which is consistent with previous research (Wei et al., 2022), i.e., confirming the association between CS and IA in university students, while hypothesis *H2b* was tested. In the field of clinical psychology, IA is considered an impulse control disorder. IA is an addiction to coping behavior and is a form of negative coping. The results of the study showed that Internet-addicted college students scored low on CS choices such as problem solving and help seeking, and high on self-blame and avoidance. This suggests that Internet-addicted college students tend to adopt relatively negative CSs in their coping strategies. This result is similar to previous research (Slla et al., 2020). For Internet-addicted students, the virtual world created by the Internet is used as a tool for emotional catharsis

and escape from reality. The internet is used to vent negative emotions and to escape from the difficulties and frustrations they face in real life, thus maintaining psychological balance. However, negative CSs can not only bring about a variety of psychological problems, but also affect the physical health of university students. On the contrary, if students are supported and guided to develop positive ways of coping, it will be conducive to the healthy physical and mental development of Internet addicted students and will have positive implications for the prevention and cessation of IA.

The results of this study show that CS can play a mediating role between PA and IA in university students, further enriching the previous research findings. The mediating effect of CSs lies in the fact that the improvement of individuals' physiological indicators through a period of PA will promote individuals to choose more positive CSs, thus achieving prevention and improvement of IA. This result can be explained by the psychological stress theory as well as the theory of internet use and satisfaction. The psychological stress theory (Zhang et al., 2021) suggests that when individuals are exposed to stressful situations, two different psychological responses are generated, with positive psychological responses facilitating the production of correct cognitive evaluations and negative psychological responses preventing normal coping abilities from being developed. Internet use and satisfaction theory further states that individuals using the Internet can satisfy their psychological needs and promote positive attitudes toward the Internet, which can lead to IA in the long run. Some researchers argue that Internet-addicted college students often tend to adopt a single standard of evaluation to assess their abilities and values, which leads to biased conclusions and even to enter the virtual world of the Internet to seek psychological comfort (Chu et al., 2016). Some researchers have also suggested that individuals with higher scores on the IA Measure may use the services and functions of the Internet as a tool to relieve stress and accordingly engage in less PA (Zhang et al., 2022).

Through the above discussion, we found that PA can not only influence college students' IA directly, but also indirectly through CS as a mediating pathway. Therefore, in the daily life

TABLE 6 Bootstrap analysis of the mediating effect test.

Paths	Effect	Boot SE	Bias-corrected 95% CI		Effect size ratio
			Lower limit	Upper limit	
PA → IA	−0.093	0.029	−0.139	−0.038	51.67%
PA → CS → IA	−0.087	0.012	−0.103	−0.057	48.33%
Total effect	−0.180	0.033	−0.215	−0.106	100%

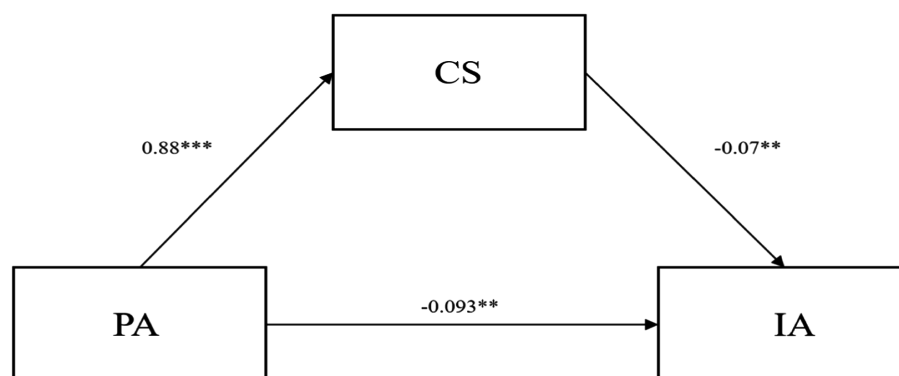


FIGURE 2  
Diagram of the CS mediation model. \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

of college students, schools should develop more abundant and effective forms of physical activities to encourage and guide college students to PA. This will help to alleviate the discomfort and negative emotions that arise when students are away from the Internet and to prevent and improve IA among students.

## Limitations

It is important to note the limitations of this study. This study is a cross-sectional study, which may have implications for revealing the causal relationships between variables. In future studies, longitudinal studies could be used to reveal the mechanism of the effect of PA on IA. An experimental approach could also be used to better control for the effects of other variables. In addition, potential mediating and moderating variables between PA and IA could be further explored. In future studies, the scope of investigation can be expanded to make a more prominent theoretical contribution to the study of the effects of PA on IA.

## Conclusion

A high level of moderate PA is more likely to reduce IA symptoms and problems across all dimensions in college students. A high level of moderate PA was more likely to increase CS in college students, and more positive CS was more likely to reduce IA symptoms in college students. CS partially mediated the relationship between PA and IA. These findings may provide insight into the prevention and treatment of IA among Chinese university students.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding authors.

## Ethics statement

The studies involving human participants were reviewed and approved by Huaibei Normal University. The patients/participants provided their written informed consent to participate in this study.

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## Author contributions

M-cC designed the study and wrote the manuscript. YW and RZ collected and analyzed the data. M-cC and SW revised the manuscript. L-kQ provided significant revision input and fund support. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

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# Family functioning and mobile phone addiction in university students: Mediating effect of loneliness and moderating effect of capacity to be alone

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**Background:** With the increasing popularity of smartphones, mobile phone addiction in university students has attracted widespread societal attention. Previous studies showed that family functioning and mobile phone addiction are related. However, the potential mechanisms involved in this relationship are unknown. This study examined the mediating effect of loneliness and the moderating effect of capacity to be alone on the relationship between family functioning and mobile phone addiction.

**Methods:** A total of 1,580 university students were recruited. A cross-sectional study design and online questionnaire survey were employed to measure demographic variables, family functioning, loneliness, capacity to be alone, and mobile phone addiction in university students.

**Results:** Family functioning is a significantly negative predictor of mobile phone addiction in university students, and loneliness has a mediating effect on the relationship between family functioning and mobile phone addiction. The capacity to be alone has moderating effects on the relationship between family functioning and loneliness and between family functioning and mobile phone addiction, and these correlation is stronger in university students with a low capacity to be alone.

**Conclusion:** The moderated mediation model in this study improves understanding of the correlation between family functioning and mobile phone addiction in university students. Education professionals and parents should pay particular attention to family functioning in mobile phone addiction, particularly university students with low capacity to be alone.

## KEYWORDS

mobile phone addiction, family functioning, capacity to be alone, loneliness, moderated mediation model

## 1. Introduction

With technological advancement, mobile phone usage has become more and more widespread. For example, the number of mobile phone users in China reached 987 million in December 2020, while the ratio of Internet users who surf the Internet using mobile phones was 99.7%, and these numbers are continuously increasing (China Internet Network Information Center, 2021).

Smartphones are ubiquitous, and they can be used as mobile communication devices, Internet portals, social network platforms, personal organizers, and even mobile banks. Thus, smartphones have become part of the mainstream lifestyle in modern society (Lian et al., 2021). However, although mobile phones provide convenience, people are spending more and more time on mobile phones to satisfy certain needs, and some even cannot live without their mobile phones, resulting in mobile phone addiction (Kwon et al., 2013). Young people, particularly university students, are prone to mobile phone addiction. Compared with older social groups, university student populations are not emotionally mature and lack self-control (Long et al., 2016). In addition, most university students today are “data natives” and are born into a world where mobile phones are ubiquitous. These environmental factors cause them to be more prone to mobile phone addiction (Li L. et al., 2018; Li et al., 2020). Mobile phone addiction is a kind of behavioral addiction which has both similarities and differences with drug addiction. Using the concept of technology addiction as a reference, the researchers believe that mobile phone addiction is a non-biochemical (behavioral) impulse control disorder involving human-computer interaction (Leung, 2008). In addition, some studies have confirmed that mobile phone addiction is the users’ non-adaptive dependence and compulsive use of mobile phones (Zou et al., 2017). A meta-analysis showed that the incidence of mobile phone addiction in university students in China is around 23% (Tao et al., 2018). Therefore, there is a need to understand the risk factors and potential mechanisms of mobile phone addiction to better prevent and treat mobile phone addiction in university students.

The bioecological model states that the family is the most direct and influential factor in the ecological environment during the growth of an individual (Bronfenbrenner and Ceci, 1994). A poor family environment may obstruct the healthy physical and mental development of an individual. Among many family environmental factors, family functioning has an extremely important role. Family functioning refers to the overall quality of family life. A good family should have two important characteristics: cohesion and adaptability. Cohesion refers to emotional bonding that family members have toward one another, while adaptability refers to the ability of the family system to adapt to the environment and develop (Olson, 2000). If an individual perceives that there is a lack of emotional communication between family members and that family cohesion is low when he/she is growing up, then that individual will seek emotional support from the external world (such as the Internet; Chng et al., 2015). In addition, if family members lack the adaptability to solve problems together, then adolescents are prone to abnormal behavior and behavioral addiction when they are growing up (Li J. et al., 2018). Inspired by this theory, many studies have examined the role of family functioning in mobile phone addiction in adolescents. The results have shown that a lack of family functioning is an important predictor of mobile phone addiction in adolescents (Kim et al., 2018; Liu et al., 2020).

It should be stated that adolescents were the study subjects in most of the aforementioned studies, and very few studies examined the relationship between family functioning and mobile phone addiction in university students. In actuality, although the campus environment plays an important role in the lives of university students, family functioning still has important effects on the physical and mental health of university students (Yan et al., 2014; Zhai et al., 2016). More importantly, previous studies have paid less attention to the potential mediating effects and moderating mechanisms between family functioning and mobile phone

addiction. This means that the mechanism through which family functioning affects mobile phone addiction is still unknown. Therefore, this study proposed a moderated mediation model to explain the intrinsic mechanisms between family functioning and mobile phone addiction. As loneliness is considered to be associated with psychological health problems and risky behavior in normal populations (Stickley and Koyanagi, 2016; Klein et al., 2021), this study uses loneliness as a mediating variable to analyze the relationship between family functioning and mobile phone addiction in university students. In addition, the capacity to be alone has been proven to be an effective buffer that can alleviate the effects of adverse external factors on risky behavior in individuals (Larson and Lee, 1996; Lian et al., 2021). Therefore, the capacity to be alone is used as a moderating variable in this study to examine the direct and indirect effects of family functioning on loneliness and mobile phone addiction.

## 1.1. Mediating effect of loneliness

Loneliness means that belongingness, a basic need of an individual, is not satisfied by the individual’s environment, resulting in a perception of social isolation or social disconnect (Hughes et al., 2004; Hawkey and Cacioppo, 2010). Loneliness is a subjective feeling that is not necessarily related to the number of times that one is alone but is related to the quality of interpersonal relationships (Hughes et al., 2004). Interpersonal relationship is the intimacy, satisfaction and trust that an individual can gain from others or a group after communicating their feelings, thoughts and emotions to them. The core experience of relationships is being socially isolated and lacking connections or being connected to a social group (Willems et al., 2020). As a result, a complex feeling of loneliness can arise when a person’s social needs are not fully met. In recent years, more and more individuals have experienced loneliness. According to different samples and measurement methods, around 11–40% of the general population experiences varying degrees of loneliness (Hawkey and Capitanio, 2015; Stickley and Koyanagi, 2016). Loneliness is a risk factor that causes poor physical and mental health and poor quality of life. This phenomenon has attracted widespread attention from researchers (Tzouvara et al., 2015; Klein et al., 2021). Many behavioral addiction studies show that loneliness is significantly positively correlated with excessive mobile phone usage and is an important predictor of mobile phone addiction (Tan et al., 2013; Jafari et al., 2019; Li et al., 2021). In addition, family functioning is one of the factors affecting loneliness in individuals. A study showed that family functioning is significantly negatively correlated with loneliness, and low family functioning is predictive of high loneliness (Sharabi et al., 2012).

With in-depth study, loneliness was found to play a mediating effect on the relationship between the environment and physical and mental health in individuals. For example, previous studies found that loneliness has a mediating effect on the relationship between child abuse and mobile phone addiction in adolescents (Ma et al., 2020), on the relationship between family cohesion and children’s effort (Feldman et al., 2018), and on the relationship between family functioning and psychological health in secondary vocational students (Pan et al., 2021). As family functioning has a strong direct effect on loneliness, and loneliness is a predictor of mobile phone addiction, this suggests that loneliness has a mediating effect. Therefore, this study hypothesizes that loneliness may have a mediating effect on the relationship between family functioning and mobile phone addiction.

## 1.2. Moderating effects of capacity to be alone

The capacity to be alone was first studied by psychologist Winnicott (1958). He found that this capacity not only has direct deterministic effects on improvement in a patient's condition but is also a marker of mature emotional development in an individual. Although Larson and Lee (1996) classified solitude as involuntary solitude and constructed solitude, researchers usually use "capacity to be alone" to mean the ability of an individual in solitude to handle stress and perceive emotional comfort (Larson and Lee, 1996; Lian et al., 2021). Individuals with a high capacity to be alone may benefit the most from solitude, as they have better psychological adaptability and a positive and healthy lifestyle, including a negative correlation with depression and physical symptoms and a positive correlation with satisfaction with life (Larson and Lee, 1996; Cramer and Lake, 1998; Detrixhe, 2011). More importantly, a study showed that solitude has both cognitive functions and emotional functions, as it allows an individual to assess the adverse situation he/she is facing and provides opportunities to establish positive emotions (Winnicott, 1958; Lian et al., 2021). Hence, the capacity to be alone may have positive effects on psychological adaptation in an individual through cognitive and emotional processes.

In addition, a study by Wu and Chen (2006) found that the capacity to be alone can alleviate the adverse effects of objective life stress on psychological health. Compared with individuals with a high capacity to be alone, the effects of objective life stress are greater on individuals with a low capacity to be alone. Lian et al. (2021) showed that the capacity to be alone has moderating effects on the relationship between mobile phone addiction and psychological distress and the relationship between mobile phone addiction and rumination. Considering that a lack of family functioning will increase loneliness in individuals (Sharabi et al., 2012) and increase the risk of mobile phone addiction (Liu et al., 2020), while the capacity to be alone has positive effects (Winnicott, 1958) on psychological adaptation and healthy behavior through cognitive and emotional processes. Given that the ability to be alone can alleviate the adverse impact of life pressure on individual mental health, it can be inferred that people with strong ability to be alone have better mental ability to adapt to and bear the pressure brought by life when facing difficulties. Therefore, the capacity to be alone can alleviate both the effects of a lack of family functioning on loneliness and the effects of a lack of family functioning on mobile phone addiction. This means that the capacity to be alone has moderating effects on the relationship between family functioning and loneliness and the relationship between family functioning and mobile phone addiction.

## 1.3. The present study

The objective of this study is to examine the relationship between family functioning and mobile phone addiction in university students and further examine the mediating and moderating mechanisms involved to construct a moderated mediation model (as shown in Figure 1). Specifically, we proposed 3 study hypotheses: (1) Family functioning is a significant negative predictor of mobile phone addiction. (2) Loneliness has a mediating effect on the relationship between family functioning and mobile phone addiction. (3) The capacity to be alone has moderating effects on the relationship between family functioning and loneliness and the relationship between family functioning and mobile phone addiction.

## 2. Methods

### 2.1. Participants and processes

Convenience sampling was employed, and students from 5 universities in Guangzhou in southern China were recruited as study subjects. In order to ensure sample diversity, students were recruited from different types of universities, of which 3 were key universities (Cultivate talents in multiple fields) and 2 were normal universities (Specialized in training talents in the field of education). The study period was from January to March 2021. A questionnaire platform<sup>1</sup> was used to design online questionnaires. Local lecturers distributed hyperlinks or QR codes of the questionnaire to university students on WeChat for them to fill in. After the student entered the main page of the survey, an online informed consent form was displayed. If the student did not disagree with the survey objective in the informed consent form, he/she clicked "Next" to start the survey. The student could stop the survey if he/she objected to it. This Internet-based online questionnaire survey was completely anonymous, voluntary, and non-commercial. For this study, we invited 2,215 university students to participate in the survey, of whom 1,633 completed the questionnaire. The response rate was 73.72%. After removing 53 questionnaires with short answering durations (<120s) or those with significant abnormalities, 1,580 valid questionnaires were collected. The ratio of male to female subjects was 50% each, the age range was 18–27 years, and the mean age was  $20.38 \pm 1.98$  years.

### 2.2. Measurements

#### 2.2.1. Demographic variables

As previous studies showed that the age, gender, family structure, and family financial situation of university students are correlated with mobile phone addiction (Zulkefly and Baharudin, 2009; Long et al., 2016), these demographic variables were controlled in the subsequent analysis. Specifically, the variables included gender (1 = male, 2 = female), age, whether the subject was an only child (1 = yes, 2 = no), family structure (1 = both parents present, 2 = reconstituted, 3 = single parent), living with whom (1 = parents, 2 = 1 of the parents, 3 = other family members or alone), and place of residence (1 = urban, 2 = rural). The subjects were required to report the socioeconomic status of their family, including the education levels of their parents and mean family monthly income. In the analysis, the family socioeconomic status was converted to a factor score (mean = 0, standard = 1). The higher the score, the higher the family socioeconomic status.

#### 2.2.2. Family functioning

The Family Adaptability and Cohesion Evaluation Scale (FACES II) was used to assess family functioning (Olson et al., 1983). This scale was translated into the Chinese version (FACESII-CV) and was verified to have good validity and reliability (Fei et al., 1991). The Chinese version (FACESII-CV) is suitable for Chinese subjects and has good validity and reliability (He et al., 2021). The scale contained 30 questions, including adaptability and cohesion dimensions. A 6-point Likert scale (1, almost never, 6: almost always) was used for all items. The higher the score, the

<sup>1</sup> www.wjx.cn

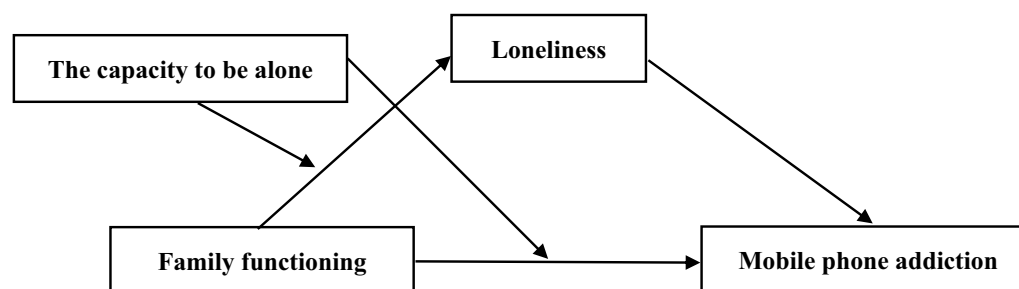


FIGURE 1  
The proposed moderated mediation model.

better the family cohesion and the stronger the adaptability. The Cronbach's  $\alpha$  coefficient of this scale was 0.965.

### 2.2.3. Loneliness

The UCLA loneliness scale developed by Russell et al. (1980) was used to measure loneliness. The Chinese translated version of this scale is widely used in China and has good validity and reliability (Li et al., 2021; Pan et al., 2021). The scale consists of 20 questions rated on a 4-point Likert scale (1: never, 4: often). The higher the score, the higher the level of loneliness. The Cronbach's  $\alpha$  coefficient of this scale was 0.947.

### 2.2.4. Capacity to be alone

The Chinese version of the capacity to be alone scale (Wu and Chen, 2006) was used to measure capacity to be alone and was revised based on the original version (Larson, 1990). This scale has been used on Chinese students and has high validity and reliability (Lian et al., 2021). The scale consists of two mutually correlated 10-item scales, the solitude coping and solitude comfort scales. A 4-point Likert scale was used (1: never, 4: always). The Cronbach's  $\alpha$  coefficient of this scale was 0.951.

### 2.2.5. Mobile phone addiction

The Chinese version of the smartphone addiction scale (SAS-SV) formulated by Kwon et al. (2013) and translated into Chinese by Xiang et al. (2019) was used to measure mobile phone addiction. Prior study showed that SAS-SV is also suitable for college students (Zhao et al., 2022). This scale has a single dimension and includes 10 questions. A 6-point Likert scale (1, extremely disagree, 6: extremely agree) was used. The higher the score, the greater the severity of mobile phone addiction. The Cronbach's  $\alpha$  coefficient of this scale was 0.895.

## 2.3. Data analysis

All data analysis was performed using SPSS 28.0. A value of  $p$  of 0.05 indicated statistical significance. First, frequency (percentage) or mean (standard deviation) were used to calculate demographic variables, including gender, age, whether the subject was an only child, family structure, living with whom, and family socioeconomic status. Independent  $t$ -test (two-tailed), One-way ANOVA or Pearson's correlation analysis were used to examine the relationship between these demographic variables and mobile phone addiction based on the study objective and data type. Second, we entailed descriptive and Pearson's

correlation analyses to examine the results of the four surveys. Third, we used the SPSS PROCESS macro (model 8) proposed by Hayes (2013) to validate the moderated mediation model. A bootstrapping procedure was selected with 5,000 bootstrap samples used to calculate bias corrected 95% confidence intervals (CIs). A significant effect was considered to exist if the CIs did not include zero. In addition, all potential significant interactions were analyzed using simple gradients (Toothaker, 1994).

## 3. Results

### 3.1. Descriptive statistics and comparative analysis

Table 1 shows that a total of 1,580 subjects were included in the data analysis, and the ratio of male and female subjects was 50% each. In this population, 577 (36.5%) of university students were the only child, 782 (49.5%) had families that lived in urban areas, and 798 (50.5%) had families that lived in rural areas. With regard to family structure, 1,128 (71.4%) lived in intact families, 228 (14.4%) lived in divorced families, and 224 (14.2%) lived in reconstituted families. Furthermore, 776 (48.5%) university students lived with both parents, 468 (29.6%) university students lived with 1 parent, and 346 (21.9%) university students lived with other relatives or alone. Comparative analysis found that family socioeconomic status was negatively correlated with mobile phone addiction in university students ( $r = -0.156$ ,  $p < 0.001$ ). Mobile phone addiction was higher in only children than in subjects with siblings ( $t = 5.775$ ,  $p < 0.001$ ) and higher in university students from urban families than in those from rural families ( $t = 3.044$ ,  $p = 0.002$ ). Meanwhile, mobile phone addiction was lower in university students living with both parents compared with those who lived with one parent or other relatives (or alone) ( $p < 0.05$ ).

### 3.2. Common method bias test

Harman's single factor method was used for common method bias test (Harman, 1960). The test result showed that the maximum factor variance interpretation rate is 21.2%, which is below the threshold value of 40%. It was thus inferred that there were no serious common method bias problems in this study.

TABLE 1 Participants' sociodemographic characteristics and smartphone addiction scores.

	Mean $\pm$ SD or n (%)	SAS-SV scores Mean $\pm$ SD	r/t/F	p
Age	20.38 $\pm$ 1.98		r = 0.009	0.71
Socioeconomic status	0 $\pm$ 1		r = -0.156	<0.001
Gender			t = 1.783	0.082
Female	790 (50%)	40.66 $\pm$ 10.29		
Male	790 (50%)	39.71 $\pm$ 11.39		
Only child			t = 5.775	<0.001
Yes	577 (36.5%)	42.24 $\pm$ 11.774		
No	1,003 (63.5%)	39.00 $\pm$ 10.118		
Family residence			t = 3.044	0.002
City	782 (49.5%)	41.02 $\pm$ 11.01		
Rural	798 (50.5%)	39.36 $\pm$ 10.66		
Family structure			F = 0.048	0.958
Integrated	1,128 (71.4%)	40.21 $\pm$ 10.87		
Divorced	228 (14.4%)	40.28 $\pm$ 9.79		
Reconstituted	224 (14.2%)	39.99 $\pm$ 11.83		
Living with parent(s)			F = 3.718	0.025
Both parents (1)	766 (48.5%)	39.43 $\pm$ 10.98	1 < 2, 1 < 3	
One parent (2)	468 (29.6%)	40.75 $\pm$ 10.88		
Other relatives or alone (3)	346 (21.9%)	41.09 $\pm$ 10.48		

TABLE 2 Descriptive statistics of means, SD, and Pearson's correlations.

	M	SD	1	2	3	4
1. Family functioning	99.84	16.17	1			
2. The capacity to be alone	51.75	5.044	0.092**	1		
3. Loneliness	49.56	4.985	-0.087**	-0.113**	1	
4. Mobile phone addiction	40.18	10.862	-0.220**	-0.031	0.190**	1

\*\* $p < 0.01$ .

### 3.3. Correlation analyses

Table 2 depicts correlations between the metric variables family functioning, the capacity to be alone, loneliness and mobile phone addiction. Family functioning was negatively associated with loneliness and mobile phone addiction, but positively associated with the capacity to be alone; The capacity to be alone and loneliness was negatively related; Loneliness and mobile phone addiction was positively related.

### 3.4. Moderating and mediating effect test

The SPSS PROCESS macro (model 8) proposed by Hayes (2013) was used to test the moderated mediation model. The results are shown in Table 3 and Figure 2. The mediation variable model [ $F(12,1,567) = 16.08$ ,  $R^2 = 0.118$ ,  $p < 0.001$ ] and dependent variable model [ $F(13,1,566) = 34.83$ ,  $R^2 = 0.21.2$ ,  $p < 0.001$ ] reached statistical significance. After controlling for demographic variables, family functioning was found to be a significant negative predictor of mobile phone addiction ( $\beta = -0.218$ ,  $p < 0.001$ ), supporting hypothesis 1. At the

same time, family functioning was a significant negative predictor of loneliness ( $\beta = -0.084$ ,  $p < 0.001$ ), while loneliness was a significant positive predictor of mobile phone addiction ( $\beta = 0.183$ ,  $p < 0.001$ ). More important, the moderated mediation index (a direct quantification of the linear association between the indirect effect and the putative moderator of that effect) was significant [index = -0.041, Standard error (SE) = 0.009, 95% CI = -0.072 to -0.010], showing that family functioning indirectly affects mobile phone addiction through loneliness. This result provides strong evidence for loneliness being a significant mediator of the relationship between family functioning and mobile phone addiction and supports hypothesis 2.

In order to further validate hypotheses 3, we further analyzed the interactions between two variables in this study. The results showed that the interaction between family functioning and capacity to be alone in the mediating variable model is a significant positive predictor of loneliness ( $\beta = -0.063$ ,  $p < 0.01$ ). In the dependent variable model, the interaction between family functioning and capacity to be alone is also a significant positive predictor of mobile phone addiction ( $\beta = 0.045$ ,  $p < 0.05$ ). The interactions in the two models were significant, showing that the capacity to be alone has moderating effects on the relationship between family functioning and loneliness and the relationship between

TABLE 3 Testing for the moderated mediation effect.

Model	Outcome	Predictions	R	R <sup>2</sup>	F	$\beta$	t	95%CI
Mediator variable	Loneliness		0.34	0.118	16.08***			
		Family functioning				−0.084	−3.393***	[−0.133, −0.036]
		The capacity to be alone				−0.080	−3.236***	[−0.128, −0.031]
		Family functioning×The capacity to be alone				0.063	2.775**	[0.019, 0.108]
Dependent variable	Mobile phone addiction		0.46	0.212	34.83***			
		Family functioning				−0.218	−8.958***	[−0.266, −0.171]
		Loneliness				0.183	7.422***	[0.135, 0.232]
		The capacity to be alone				−0.020	−0.813	[−0.067, 0.028]
		Family functioning×The capacity to be alone				0.045	1.987*	[0.001, 0.088]

N = 1,580. Unstandardized regression coefficients are reported. Bootstrap sample size = 5,000. CI, confidence interval. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .

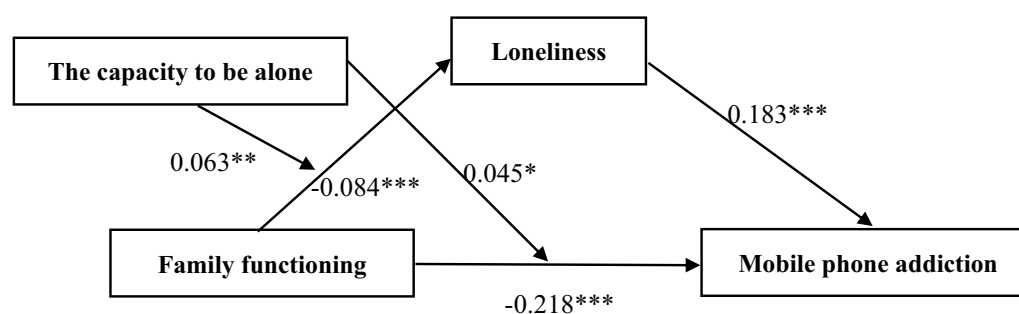


FIGURE 2

The path coefficients in the moderated mediation model. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .

family functioning and mobile phone addiction. This supports hypothesis 3.

Furthermore, this study used simple slope analysis to further clarify these significant interactions and examine whether the slope of the low capacity to be alone group (1 standard deviation lower than the mean) was higher than that of the high capacity to be alone group (one standard deviation higher than the mean). The results are shown in Table 4 and Figures 3, 4. From Table 4 and Figure 3, it can be seen that in university students with a low capacity to be alone, family functioning affected loneliness ( $\beta = -0.027$ , 95% CI =  $-0.051$  to  $-0.008$ , excluding 0), but family functioning did not affect loneliness in university students with a high capacity to be alone ( $\beta = -0.004$ , 95% CI =  $-0.027$  to  $0.018$ , including 0). From Table 4 and Figure 4, it can be seen that the effect of family functioning on mobile phone addiction was higher in students with a low capacity to be alone ( $\beta = -0.263$ , 95% CI =  $-0.327$  to  $-0.199$ , excluding 0) than in students with a high capacity to be alone ( $\beta = -0.174$ , 95% CI =  $-0.239$  to  $-0.108$ , excluding 0). The presence of interactions between family functioning and capacity to be alone means that university students with high capacity to be alone experience less

loneliness or mobile phone addiction regardless of their family functioning status, while university students with low capacity to be alone will experience more loneliness or greater mobile phone addiction.

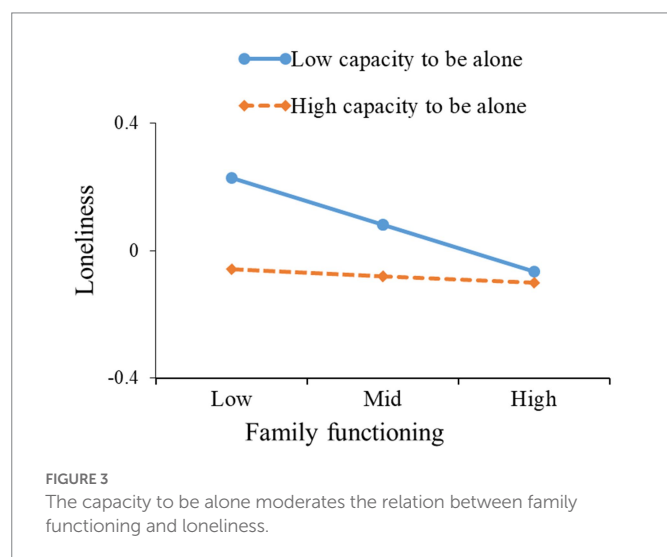
## 4. Discussion

The aim of this study was to examine the effects of family functioning on mobile phone addiction in university students and the effects of loneliness and capacity to be alone on the relationship between family functioning and mobile phone addiction. Our study found that family functioning is a significantly negative predictor of mobile phone addiction in university students, and loneliness has a mediating effect on the relationship between family functioning and mobile phone addiction. More importantly, the capacity to be alone has moderating effects on the relationship between family functioning and loneliness and the relationship between family functioning and mobile phone addiction.

TABLE 4 Conditional effect analysis at values of the self-control variable.

Conditional direct effect analysis at values of the capacity to be alone ( $M \pm SD$ )				
	$\beta$	SE	LLCI	ULCI
M-SD	-0.263	0.033	-0.327	-0.199
M	-0.218	0.024	-0.266	-0.171
M + SD	-0.174	0.033	-0.239	-0.108
Conditional indirect effect analysis at values of the capacity to be alone ( $M \pm SD$ )				
	$\beta$	BootSE	BootLLCI	BootULCI
M-SD	-0.027	0.011	-0.051	-0.008
M	-0.015	0.006	-0.029	-0.006
M + SD	-0.004	0.011	-0.027	0.018

N = 1,580. Bootstrap sample size = 5,000. LL, low limit; CI, confidence interval; UL, upper limit.



#### 4.1. Effects of family functioning on mobile phone addiction in university students

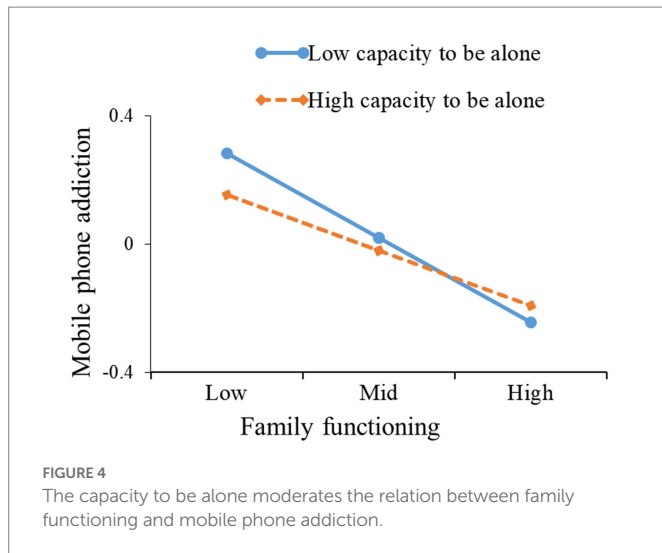
The results of the study showed that family functioning is a negative predictor of mobile phone addiction in university students. This means that good family functioning, such as harmonious and loving family relationships, is associated with low mobile phone addiction. However, university student growing up in dysfunctional family, defined as “family in which relationships or communication are impaired and members are unable to achieve intimacy and self-expression” (Munro, 1985), such as outbreak of conflicts within the family, breakdown of emotional connection, lack of communication between family members and abnormal behavior of some family members, are prone to mobile phone addiction. Due to the lack of emotion, college students might not find a vent for their emotions, and the family atmosphere is dignified, so they tend to place their emotions on materials, such as mobile phones. With the convenience of mobile devices and the ability to meet most of people’s life needs, college students might seek spiritual comfort and temporarily forget their family’s misfortune. Specifically, parents’ low emotional involvement may lead college students to overuse cell phones as a strategy for coping with the resulting psychological distress. This

matches the results of previous studies on adolescents (Kim et al., 2018; Liu et al., 2020). This result supports the McMaster family functioning model (Miller et al., 2000) and family functioning process model (Skinner et al., 2000). These two models state that the realization of various family functions will directly affect the physical and mental health and emotional behavior of individuals. If family functioning is successfully achieved and a good state is reached, then the health behavior of family members is improved. Otherwise, family members are prone to risky behavior, such as mobile phone addiction and Internet addiction (Chng et al., 2015; Liu et al., 2020).

The family functioning model holds that the basic function of the family is to provide good environmental conditions for developing physiological, psychological, and social health in family members (Pan et al., 2021). This means that family factors and individual health behavior problems are intimately associated. Although the life of university students includes the family and campus environment, they are still emotionally immature and are still deeply affected by family functioning. Good family functioning will help alleviate anxiety and unease and enable students to better cope with learning and social life events, thereby improving their psychological and behavioral problems. Conversely, a child growing up in a family environment that lacks cohesion and adaptability is unable to experience enough caring. Therefore, they may seek that missing emotion through social networks as a form of compensation (Chng et al., 2015). Smartphones are convenient tools for online socializing and obtaining emotional comfort. Therefore, the risky behavior of seeking emotional support on mobile phones may extend to campus life.

#### 4.2. Moderating and mediating effects

Our study shows that loneliness has a mediating effect on the relationship between family functioning and mobile phone addiction in university students. This means that family functioning indirectly affects mobile phone addiction in university students through loneliness. This provides a new perspective on how family functioning can affect mobile phone addiction. Many studies have found that family functioning is associated with loneliness (Sharabi et al., 2012; Pan et al., 2021). This shows that family functioning is an important factor that affects loneliness in university students. Poor family functioning will cause family members to have poor interpersonal skills, poor communication, emotional problems, and interpersonal communication barriers. This ultimately results in tense interpersonal relationships and increases loneliness (Yang et al., 2011). More importantly, the incidence of mobile phone addiction is higher when loneliness is greater (Tan et al., 2013; Jafari et al., 2019; Li et al., 2021). However, in a good family functioning environment, university students can positively communicate with family members to obtain emotional support and decrease loneliness, thereby decreasing the occurrence of mobile phone addiction. In addition, the results of this study also support the basic psychological need theory (Vansteenkiste et al., 2020). This theory states that satisfying the basic psychological needs of autonomy, competence, and belongingness are basic motivations for behavior and basic assurances for growth in individuals. If the basic psychological needs of an individual cannot be satisfied, this will produce a strong desire to satisfy these needs, thereby forcing the individual to turn to other scenarios that can satisfy these needs (Deci and Ryan, 2000; Vansteenkiste et al., 2020). Specifically, poor family functioning environments will result in poor cognition in university students, thereby resulting in more negative



emotions and decreased social support. In order to satisfy their needs of love and belongingness, they will use mobile phones to enter a virtual world to cope with loneliness and receive emotional support.

An important finding of this study is the relationships of family functioning with the mediating variable loneliness and the dependent variable mobile phone addiction are both moderated by capacity to be alone. These effects are greater in individuals with a low capacity to be alone compared with those with a high capacity to be alone. This indicates that the capacity to be alone is a positive psychological, emotional, and behavioral factor that can effectively alleviate the adverse effects of low family functioning on loneliness and mobile phone addiction.

Previous studies showed that we are able to shift our attention from the external environment to the mind. During solitude, we are better able to understand and assess ourselves (Larson, 1990). University students with a high capacity to be alone may actively seek solitude to regulate and cope with loneliness caused by low family functioning. At the same time, they can distance themselves from emotional attachment to the virtual world through cognitive and emotional adjustment to cope with mobile phone addiction induced by low family functioning. Unfortunately, university students with a low capacity to be alone cannot benefit from solitude. When they are alone, they often spend more time on activities that distract their attention, and solitary feelings are described as anxious, lonely, and depressed (Long et al., 2003). Therefore, university students with a low capacity to be alone may be prone to loneliness and mobile phone addiction when family functioning is dysregulated, resulting in a vicious cycle.

### 4.3. Limitations and applications

Even though this study provided valuable findings on how family functioning affects loneliness and mobile phone addiction, the following limitations are present in this study. First, a cross-sectional design was used for this study. Even though the cross-sectional design is widely used in mobile phone addiction studies (Long et al., 2016; Liu et al., 2020; Lian et al., 2021), cross-sectional data cannot determine causality and individual developmental differences.

Therefore, a longitudinal design can be used in future studies to better validate the moderated mediation model and examine the causal relationships between family functioning, loneliness, and mobile phone addiction. Second, the data in this study was self-reported by university students. Even though these self-reported scales have been verified to have good validity and reliability, other evaluation methods (such as parent evaluation) and objective records from mobile apps of time spent by university students on mobile phones can be used in future studies to validate this study model. Third, this study emphasizes the effects of family functioning on mobile phone addiction. As family functioning may be influenced by different cultures, it remains to be verified whether the results of this study could be generalized to other countries and cultures. In addition, the mobile phone functions that university students were addicted to were not examined. In the future, the effects of family functioning on specific mobile phone addiction behaviors can be further examined.

Despite its limitations, this study has important theoretical and practical significance. First, the study examined how a family factor (family functioning) and an individual factor (capacity to be alone) in university students interact with mobile phone addiction and expands on previous studies. The study results provide evidence that an interaction between environmental factors and individual factors jointly determines the psychological behavior adaptation in university students. Second, this study revealed moderating and mediating mechanisms between family functioning and mobile phone addiction. These findings can aid in better understanding of how and when family functioning is related to mobile phone addiction in university students. Third, this study provides important recommendations for prevention of and intervention in mobile phone addiction in university students. For example, parents can construct a supportive environment with open exchange, low family conflict, and positive interactions between family members for university students so that students can feel family intimacy and belongingness and decrease loneliness, thereby decreasing mobile phone addiction. Considering that the capacity to be alone is a protective factor of poor family functioning, loneliness, and mobile phone addiction, some psychological interventions, such as mindfulness training (Brown et al., 2007), could be employed to improve university students' capacity to be alone, thereby decreasing the negative effects induced by a lack of family functioning.

## 5. Conclusion

Our study found that family functioning is a significant negative predictor of mobile phone addiction in university students, and loneliness has a mediating effect on the relationship between family functioning and mobile phone addiction. In addition, the capacity to be alone has moderating effects on the relationship between family functioning and loneliness and the relationship between family functioning and mobile phone addiction. This relationship is stronger in university students with a low capacity to be alone compared with university students with a high capacity to be alone. The moderation and mediation model in this study helps to better understand the correlation between family functioning and mobile phone addiction in university students. The effects of the interaction between an environmental factor (family functioning) and an individual factor (capacity to be alone) on mobile phone addiction in university students are emphasized.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

## Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of the Guangzhou Sport University. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

X-HH, M-QX, and JS: conceptualization. G-RL and J-NY: data curation. G-RL, J-NY, and M-QX: methodology and writing – review and editing. X-HH and JS: supervision. G-RL and M-QX: writing – original draft. All authors contributed to the article and approved the submitted version.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# Mixed comparison of interventions for different exercise types on students with Internet addiction: a network meta-analysis

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**Background:** Internet addiction (IA) has a significant negative impact on students. The condition of students with IA can be improved by exercise, which has been identified as an effective intervention strategy. However, the relative effectiveness of different exercise types and the most effective ones remains unknown. This study presents a network meta-analysis to compare six exercise types (team sport, double sport, single sport, team + double sport, team + single sport, and team + double + single sport) based on their effectiveness in reducing Internet addiction and maintaining mental health.

**Methods:** Systematic searches were conducted in PubMed, EMBASE, Cochrane Library, CNKI, Wan Fang, CQVIP, Web of Science, CBM, EBSCO, APA PsycNet, and Scopus, and all relevant studies from the beginning to 15 July 2022 were included on. According to the Cochrane Handbook 5.1.0 Methodological Quality Evaluation Criteria, the listed studies' bias risk was assessed, while the network meta-analysis was performed using STATA 16.0.

**Results:** A total of 39 randomized controlled trials that met all inclusion criteria including 2,408 students with IA were examined. The meta-analysis results showed that compared with the control group, exercising significantly improved loneliness, anxiety, depression, and interpersonal sensitivity ( $p < 0.05$ ). Specifically, the network meta-analysis discovered that the single sport, team sport, double sport, team + double sport, and team + double + single sport had significant effects on improving Internet addiction as compared to the respective control group ( $p < 0.05$ ); the single sport, team sport, and double sport tend to be effective compared with controls in improving mental health ( $p < 0.05$ ). Compared with the other five types of sports, the double sport was ranked first and showed the greatest potential to be the best choice (cluster ranking value = 3699.73) in improving Internet addiction (SUCRA = 85.5) and mental health (SUCRA = 93.1).

**Conclusion:** Exercise could be suggested as the best alternative when treating IA in students, based on the extensive positive effects of exercise on IA, anxiety, depression, interpersonal sensitivity, loneliness, and mental health in IA students. Double sport may be the best type of exercise for Internet-addicted students. However, to further examine the benefits of exercise for IA students, more research is required.

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## KEYWORDS

student, internet addiction, mental health, physical activity, treatment

# 1. Introduction

Internet addiction (IA) has become a serious physical and mental health problem among students (Hu and Ma, 2010). Internet addiction is defined as the inability to control the use of the Internet and is a condition that leads to severe impairments of various life functions (Young and Rogers, 1998; Griffiths, 1999; Mok et al., 2014). With the popularity of smartphones and computers, students have become a high-risk group for IA, with the prevalence ranging from 0.8 to 26.7% in different countries or regions (Kuss et al., 2014; Ma et al., 2022a). IA endangers students' physical and mental health and academic performance by triggering a series of mental illnesses, crimes, and self-harming behaviors (Gentile et al., 2011; Lam, 2014; Spada, 2014; Fang et al., 2015). Especially since the outbreak of COVID-19, closed living environments and online courses have increased the use of electronic devices such as mobile phones, resulting in a continued increase in students with IA (Li et al., 2021; Shehata and Abdeldaim, 2021; Besalti and Satici, 2022). Psychotherapy and pharmacotherapy are two common methods used to treat IA (Shao et al., 2020; Zhai et al., 2020; Zhang Z. et al., 2022). However, due to the limitations of psychotherapy and pharmacotherapy such as stigma, long cycle time, high cost, and side effects, students often refuse treatment (Ma et al., 2022b). As a result, both treatments are typically slower and less desirable (Sun et al., 2010). Therefore, there is an urgent need to find a more scientifically effective and easier-to-implement intervention method.

Due to its simplicity and effectiveness, exercise is widely accepted among students as a way to improve physical function (Bu et al., 2010). In recent years, studies have suggested that exercise can effectively reduce IA (Li et al., 2009; Yu and Xie, 2010; Li M. et al., 2014; Park et al., 2016; Wu et al., 2019; Liu et al., 2022). Researchers found that running, as a single sport, can effectively reduce anxiety and depression, as well as IA symptoms (Gordon et al., 1986; Nicholson et al., 2011; Oriel et al., 2011). Additionally, double sport with certain interactivity and avoiding physical collision is more suitable for IA students who have poor fitness due to long-term Internet addiction to alleviate IA by alleviating loneliness (Gao and Chen, 2006; Zhang et al., 2015; Li et al., 2022). Moreover, team sports, and mixed sports as alternating different sports types, are thought to reduce IA by relieving interpersonal sensitivity (Wang, 2016; Yang, 2021). From the above evidence, different types of exercise based on respective psychological benefits can effectively reduce IA (Miller et al., 2020). The relationship between participants during the intervention has been considered a factor for IA (Yu et al., 2021). Therefore, from an interpersonal perspective, it is reasonable to hypothesize that there are relatively large differences in the anti-internet addiction effects of different exercise types. Even though researchers have conducted correlational studies, randomized controlled trials, and meta-analyses on exercise interventions for IA students (Wu et al., 2018, 2019; Liu et al., 2019; Qiao et al., 2020; Zhang Z. et al., 2022), no study has comprehensively compared the effects of different exercise types on IA students, nor has it proposed the optimal exercise type to help IA students.

Network meta-analysis (NMA) is considered a useful method to compare more than two interventions (Lumley, 2002; Jansen and Naci, 2013; Li L. et al., 2014). Meanwhile, NMA allows the use of indirect comparison methods to quantitatively compare different interventions for the treatment of similar conditions and thus select the best treatment regimen (Bucher et al., 1997; Tian et al., 2013). We used NMA to investigate the differential effects of different exercise types on IA students. Moreover, mental health is a key factor in IA (Ko et al., 2012; Babadi-Akashe et al., 2014). IA students scored higher on their loneliness, anxiety, depression, and interpersonal sensitivity than healthy controls on subjective (Long et al., 2021; Zhang et al., 2021; Qiu et al., 2022; Yang et al., 2022). Thus, treatment should not only focus on whether the level of IA is decreased but also on the improvement of mental health indicators related to IA (Li et al., 2017; Zhang et al., 2018). We integrated the effects of interventions on IA and mental health and explore the utility of the interventions and relevant intervention mechanisms. We used the two-dimensional clustered ranking map of NMA to comprehensively rank the effects of different exercise types and identified the best treatment for IA students.

Accordingly, the goals of this network meta-analysis were to (1) quantitatively compare the effect of different exercise types for Internet-addicted students by comprehensively considering the improvement of IA and mental health; and (2) screen out the most suitable intervention project for IA students by the comprehensive evaluation and ranking of the effects of different sports types. Specifically, we hypothesized that (1) the exercise intervention would have positive effects on loneliness (H1a), anxiety (H1b), depression (H1c), and interpersonal sensitivity (H1d) on IA students; (2) the double sport with some interaction would have the best intervention effects for Internet addiction (H2a) and mental health (H2b); and (3) the double sport would be the optimal exercise type under the combined consideration of IA and mental health (H3).

## 2. Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement extension for systematic reviews incorporating network meta-analysis (PRISMA-NMA) was used to report this systematic review and network meta-analysis (Hutton et al., 2016). This review was registered with the International Prospective Register of Systematic Review (PROSPERO) (CRD42022377035).

### 2.1. Search strategy

The databases of Web of Science, CNKI, Cochrane Library, EBSCO, EMBASE, Wan fang, CQVIP, Scopus, PubMed, CBM, and APA PsycNet were searched from the beginning to 15 July 2022. Search terms included "exercises" and "internet addiction" along with numerous other related terms. The language of the literature was not limited to the searches. The full search strategies are detailed in the [Supplementary material](#).

## 2.2. Eligibility criteria

Inclusion and exclusion criteria for the literature were (1) inclusion of studies related to students with IA and exclusion of studies about animals, elderly, and special population groups; (2) inclusion of randomized controlled trials (RCT) and exclusion of review literature, review literature, systematic evaluation literature, and qualitative studies; (3) inclusion of studies related to exercise interventions and exclusion of studies combining other interventions; (4) inclusion of studies where reporting data can be integrated; and (5) inclusion of different forms of IA with similar effects (Young, 1999; Chi and Chiu, 2013).

## 2.3. Exercise types

Seven types were designed according to the number of participants and the interrelationship of participants in the exercise to classify the interventions of the included studies (Han et al., 2014), along with a control team was used in this research:

1. Team Sport: A team is made up of multiplayer who work together in a planned manner, and the competitive contest between the team and the team is carried out according to the corresponding activity rules. The overall level is determined by their cooperation rather than individual ability, such as in basketball and soccer.
2. Double Sport: A competitive sport in which two people compete against each other, such as table tennis, badminton, and tennis.
3. Single Sport: A sport of a single person is mainly individual performance, with skill leading performance difficulty and physical ability leading performance items, such as Ba Duan Jin, Tai Chi, and yoga.
4. Team + Double Sport: The combined exercise arrangement of team sport and double sport, such as badminton + basketball.
5. Team + Single Sport: The combined exercise arrangement of team sport and single sport, such as badminton + running.
6. Team + Double + Single Sport: The combined exercise arrangement of team sport, double sport, and individual sport, such as basketball + badminton + running.
7. No intervention; Control team.

## 2.4. Study selection and data extraction

Two researchers (Geng LI and Chenzhen LIU) independently worked according to the pre-developed literature screening criteria. First, NoteExpress software was used to find duplicate title information. Second, two researchers evaluated the potential eligibility of each abstract generated by the search strategy, and the full text of the research will be available unless both reviewers determine that an abstract is ineligible. Third, each full-text report was independently evaluated for final study inclusion.

We extracted the following data from various studies: (1) sample size; (2) year of publication; (3) first author; (4) sample source; (5) outcome indicators; (6) intervention type; (7) intervention duration; (8) exercise intensity; (9) gender and age of participants; (10) location and language of study; (11) frequency

of a week; and (12) length of a session. The above information was extracted using a pre-developed form, and the extracted data were cross-checked by two researchers. Disagreements regarding the inclusion of extracted information were decided by the third researcher (Zifu SHI).

## 2.5. Risk of bias assessment

The risk of bias was independently assessed according to the Cochrane Handbook 5.1.0 Methodological Quality Evaluation Criteria (Higgins et al., 2011) by two researchers. The relevant indicators in this assessment were divided into random sequence method, allocation concealment, blinding by researchers and subjects, selective reporting, completeness of outcome data, and other biases. Different colors (green, red, and yellow) represented the judgment of “low-risk bias”, “high-risk bias”, and “unclear”. Every disagreement was discussed and finally was decided by the third researcher.

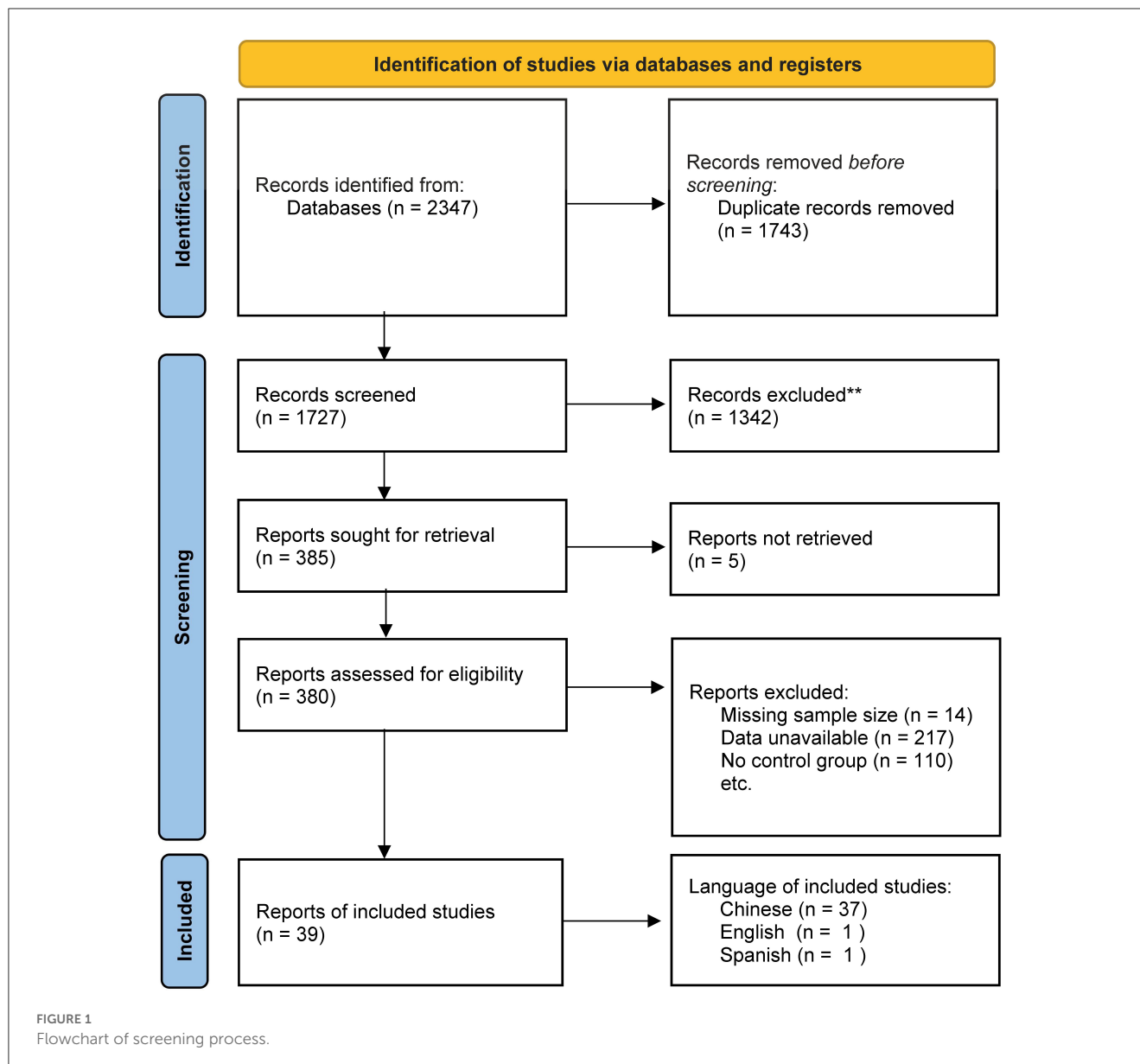
## 2.6. Statistical analysis

The network meta-analysis based on the frequency-based framework was performed by Stata 16.0. Means and standard deviations as outcome indicators were used to compare the effects of different exercise interventions on IA students. Among the outcome indicators of this study, IA, loneliness, and anxiety were measured by different questionnaires. To combine the effect sizes, the standardized mean difference (SMD) was used (Qiao et al., 2020). Mental health, depression, and interpersonal sensitivity were measured by the same questionnaire. Thus, the weighted mean difference (WMD) was used to combine the effect sizes. The inconsistency test was performed using nodal analysis. If the difference between direct and indirect comparisons was not statistically significant ( $P > 0.05$ ), the consistency model was selected for analysis; conversely, the inconsistency model was selected (Fei et al., 2022). The surface under the cumulative ranking probability plot (SUCRA) was selected to compare and rank the effects of different exercise types. In the SUCRA, the larger the area under the curve, the greater the likelihood of being the best intervention (Salanti et al., 2011). Based on the SUCRA of different exercise types in IA and mental health, the two-dimensional clustered ranking map was constructed to determine the best treatment choice.

## 3. Results

### 3.1. Literature selection

A total of 2,347 results were identified by the search strategy, from CNKI (327), Wan Fang (672), VVIP (232), CBM (9), Web of Science (156), PubMed (687), Cochrane Library (70), EBSCO (33), EMBASE (145), APA PsycNet (7), and Scopus (9). After deduplication, 1,743 studies were excluded, followed by 1,342 studies after preliminary screening. After seeking studies screened, five studies not retrieved were excluded. After reading full texts,



14 studies were excluded as missing sample size, 217 studies were excluded as data unavailable, and 110 studies were excluded as no control group. Finally, 39 studies were included in the final analysis (Figure 1). To reconfirm the completeness of included studies for this study, we manually screened reference lists of related published reviews and meta-analyses for additional relevant studies (Wu et al., 2019; Zhang C. et al., 2022). Our careful examination revealed that included studies in this study not only contained all included studies in the relevant published literature but also a significant number of new studies.

### 3.2. Characteristics of the included studies and risk of bias assessment

There were 2,408 students with IA being examined in 39 studies. There were six types of exercise interventions (team sport,

double sport, single sport, team + double sport, team + single sport, and team + double + single sport), and all interventions in the control group were in a no-intervention manner, and the basic characteristics of the included studies are shown in Table 1. Six studies were a three-armed trial, one study was a four-armed trial, and the others were all two-armed trials. The studies all mentioned randomized grouping and only 27 described the specific randomized sequence method; the remaining studies did not describe the allocation method in detail (Figure 2). The summary of the risk of bias judgments for each included study was presented in the Supplementary File.

### 3.3. Meta-analysis

Due to the number of included studies in indicators (loneliness, anxiety, depression, and interpersonal sensitivity) being insufficient

TABLE 1 Summary of studies included in network meta-analysis indicating the exercise intervention used and the outcome measure.

Yang (2021)	Hengyang, China (Chinese)	College student (NR)	28/14	60/24	12	2-3/week Moderate intensity (130-150b/ min) Length NR	Team Sport (Basketball)	Internet addiction (CIAS); Loneliness (UCLA)
			28/14				Single Sport (Running)	
Ren et al. (2014)	Jiamusi, China (Chinese)	College student (20-24)	4/4	6/2	12	3/week Moderate intensity 90-120 min/session	Single Sport (Yoga)	Internet addiction (YIAS); Mental health (SCL-90)
Zhu (2008)	Nanjing, China (Chinese)	College student (20.12)	6/6	NR	12	3-4/week Moderate intensity (100-120b/ min) Length NR	Team Sport (Basketball)	Internet addiction (YIAS); Mental health (SCL-90)
Zhang (2013)	Kun ming, China (Chinese)	College student (NR)	30/30	NR	16	2/week Moderate intensity Length NR	Team + Double Sport (Basketball + Tennis)	Internet addiction (YIAS)
Gao et al. (2012)	Changchun, China (Chinese)	College student (NR)	35/34	36/33	8	5/week Intensity NR 90 min/session	Single Sport (Running)	Internet addiction (YDQ); Mental health (SCL-90)
Liao (2008)	Zhuzhou, China (Chinese)	College student (NR)	8/14	1/11	10	3/week Intensity NR 70 min/session	Single Sport (Dance)	Internet addiction (CIAS); Mental health, Depression, Interpersonal sensitivity and Anxiety (SCL-90)
Deng (2003)	Nanchang, China (Chinese)	College student (NR)	14/14	NR	10	3/week Moderate intensity (VO2 max 50-80%) 50 min/session	Team + Double Sport (Basketball + Bad minton)	Internet addiction (CIAS); Mental health, Depression, Interpersonal sensitivity and Anxiety (SCL-90)
Li et al. (2009)	Shijiazhuang, China (Chinese)	College student (NR)	16/16	0/32	8	3/week Intensity NR 40-60 min/session	Double Sport (Bad minton)	Internet addiction (YIAS); Mental health, Depression, Interpersonal sensitivity and Anxiety (SCL-90)

(Continued)

TABLE 1 (Continued)

Lou (2011)	Shengyang, China (Chinese)	Middle school	18/18	36/0	12	3/week Intensity NR 90-120 min/session	Team Sport (Basketball)	Internet addiction (YIAS); Mental health, Depression, Interpersonal sensitivity and Anxiety (SCL-90)
Li M. et al. (2014)	Shijiazhuang, China (Chinese)	Middle school student (15.51 ± 1.62)	27/24	51/0	10	3/week High intensity (VO2 max 90%) 60-70 min/session	Single Sport (HIIT)	Internet addiction (YDQ)
Li et al. (2021)	Xiangtan, China (Spanish)	Middle school student (NR)	59/62	58/63	12	5/week Intensity NR 40 min/session	Single Sport (Dance)	Internet addiction (IADDS)
Fu and Liu (2016)	Changchun, China (Chinese)	College student (20.41 ± 1.37)	42/42	34/50	16	3/week Intensity NR 50 min/session	Team Sport (Football)	Internet addiction (YDQ)
Yang and Zeng (2017)	Fuzhou, China (Chinese)	College student (19.65 ± 1.3)	26/26	NR	16	4/week Intensity NR 60 min/session	Single Sport (Tai Chi)	Internet addiction (CIAS)
Zhang (2011)	Shangqiu, China (Chinese)	College student (NR)	18/18	NR	12	3/week Intensity NR 90-120 min/session	Team Sport (Basketball)	Internet addiction (YIAS); Mental health, Depression, Interpersonal sensitivity and Anxiety (SCL-90)
Ji (2017)	Beijing, China (Chinese)	College student (NR)	10/10	11/9	12	3/week Moderate intensity 60 min/session	Team + Single Sport (Basketball + Running)	Internet addiction (YIAS); Mental health (SCL-90)
Fan (2017)	Zhengzhou, China (Chinese)	College student (NR)	15/15	22/8	12	3/week Moderate intensity (130-150b/ min) 60 min/session	Team Sport (Basketball)	Internet addiction (CIAS)
Wang (2016)	Taiyuan, China (Chinese)	College student (NR)	36/37	23/50	12	3/week Intensity NR 45 min/session	Team + Double Sport Sport (Basketball + Table Tennis)	Internet addiction (SAS-C)

(Continued)

TABLE 1 (Continued)

Ge et al. (2015)	Nanchang, China (Chinese)	College student (20.13 ± 1.35)	18/18	24/12	18	3/week Low intensity 120 min/session	Team Sport (Volleyball)	Internet addiction (MPAI)
Yang (2021)	Fuzhou, China (Chinese)	College student (NR)	90/15	38.7/61.3	8	2/week Moderate intensity 60 min/session	Single Sport (Running + Tai Chi)	Internet addiction (MPATS)
			90/15				Double Sport (Table tennis + Bad minton)	
Zhang et al. (2015)	Loudi, China (Chinese)	College student (NR)	40/40	54.6/45.4	8	2/week Intensity NR 45 min/session	Team Sport (Group outdoor sport games)	Internet addiction (MPATS)
Liao et al. (2022)	Guangzhou, China (Chinese)	College student (20.12 ± 1.54)	8/4	NR	6	2/week Intensity NR Length NR	Team Sport (Basketball)	Internet addiction (MPAI); Loneliness (UCLA)
			8/4				Single Sport (Running)	
Liu et al. (2022)	Wuhan, China (Chinese)	College student (NR)	31/17	76/20	10	2/week Moderate intensity 60 min/session	Team Sport (Basketball)	Internet addiction (MPAI)
			31/17				Single Sport (Ba Duan Jin)	
Yu and Xie (2010)	Hangzhou, China (Chinese)	College student (18-22)	15/15	30/0	8	3/week Moderate intensity (130-150b/ min) 40-60 min/session	Team + Double + Single Sport (Basketball + Bad minton + Running)	Internet addiction (YIAS); Mental health (SCL-90)
Wang F. (2021)	Guangzhou, China (Chinese)	Middle school student (12-13)	17/16	17/16	9	2/week Moderate intensity 40 min/session	Team Sport (Basketball)	Internet addiction (SAS)

(Continued)

TABLE 1 (Continued)

Reference	Location (Language)	Participant characteristics			Experiment group			Outcome variables (Assessment tools)
		Sample source (Age)	Sample size (T/C)	Gender (female/male)	Exercise program duration (week)	Frequency/ Does/Length	Intervention type	
Xu (2019)	Fuzhou, China (Chinese)	College student (NR)	22/15	29/31	16	3/week Intensity NR 60 min/session	Single Sport (Running)	Internet addiction (MPATS)
			8/15				Team + Double Sport (Basketball + Bad minton)	
Zhu (2017)	Hangzhou, China (Chinese)	College student (18-23)	30/30	26/34	8	3/week Moderate intensity (130-140b/ min) 60 min/session	Team + Double + Single Sport (Ball games + yoga)	Internet addiction (MPATS)
Wang L. (2021)	Jinan, China (Chinese)	College student (NR)	21/21	20/22	8	3/week Intensity NR Length NR	Team + Single Sport (Volleyball + Dance)	Internet addiction (MPATS)
Bu (2014)	Zhengzhou, China (Chinese)	College student (18-21)	30/30	NR	24	3-5/week Moderate intensity (VO2 max 60-80%) 30-90 min/session	Team + Double + Single Sport (Basketball + Bad minton + Running)	Internet addiction (MPATS)
Zhang (2012)	Beijing, China (Chinese)	College student (20.4)	17/13	NR	10	3/week Moderate intensity (VO2 max 50-80%) Length NR	Team + Double + Single Sport (Ball games + Dance + Running)	Internet addiction (CIAS)
Zhou et al. (2011)	Zhengzhou, China (Chinese)	College student (20.3 ± 1.64)	20/18	20/18	12	3/week Intensity NR 60 min/session	Team + Double + Single Sport (Basketball + Bad minton + Bicycle)	Internet addiction (MPDQ)
Fu and Liu (2010)	Jiujiang, China (Chinese)	Middle school (16.4)	16/16	8/8	12	3/week Moderate intensity (130-150b/ min) 40 min/session	Team + Double + Single Sport (Basketball + Bad minton + Dance)	Internet addiction (YIAS); Mental health (SCL-90)
Yu (2017)	Guangzhou, China (Chinese)	College student (NR)	26/26	40/60	8	2/week Intensity NR 120 min/session	Team + Double + Single Sport (Basketball + Bad minton + Weight lifting)	Internet addiction (YIAS)

(Continued)

TABLE 1 (Continued)

Reference	Location (Language)	Participant characteristics			Experiment group			Outcome variables (Assessment tools)
		Sample source (Age)	Sample size (T/C)	Gender (female/male)	Exercise program duration (week)	Frequency/ Does/Length	Intervention type	
Yang et al. (2022)	Yangzhou, China (Chinese)	Middle school student (16.28 ± 1.67)	36/18	62/46	12	3/week Moderate intensity (123-140b/ min) 45 min/session	Single Sport (Dance)	Internet addiction (MPAI)
			36/18				Double Sport (Bad minton)	
Liu et al. (2022)	Taiyuan, China (Chinese)	Primary school student (9-12)	70/70	72/68	10	2-4/week Intensity NR 120 min/session	Team + Double Sport (Basketball + Bad minton)	Internet addiction (SAS)
Chi (2012)	Changchun, China (Chinese)	College student (NR)	10/10	11/9	8	5/week Moderate intensity (130-150b/ min) 90 min/session	Single Sport (Running + Bicycle)	Internet addiction (YIAS)
Liu et al. (2019)	Wuhan, China (Chinese)	College student (19.29 ± 1.22)	31/17	70/26	12	3/week Intensity NR 90 min/session	Team Sport (Basketball)	Internet addiction (MPAI); Mental health (SCL-90)
			31/17				Single Sport (Ba Duan Jin)	
Fan et al. (2021)	Jurong, China (Chinese)	College student (20.13 ± 1.02)	32/32	32/32	14	3/week Intensity NR 90 min/session	Team + Double + Single Sport (Volleyball + Table tennis + Dance)	Internet addiction (SAS-C)
Xiao et al. (2021)	Shenzhen, China (English)	College student (19.08 ± 1.22)	31/17	71/25	12	3/week Moderate intensity (120-150b/ min) 90 min/session	Team Sport (Basketball)	Internet addiction (MPAI); Loneliness (UCLA); Anxiety (SRAS)
			31/17				Single Sport (Ba Duan Jin)	
Zheng et al. (2019)	Yiyang, China (Chinese)	College student (17-20)	50/49	NR	8	5/week Intensity NR 60 min/session	Team Sport (Basketball)	Internet addiction (AMPUD)

T, treatment group; C, control group; YIAS, Comprehensive Internet Addiction Diagnostic Questionnaire; YDQ, Internet Addiction Damage Scale; CIAS, Chinese Internet Addiction Scale; SAS-C, Smartphone Addiction Scale for College Students; MPAI, Mobile Phone Addiction Inventory Scale. MPATS, Mobile Phone Dependence Scale for College Students; IADDS, Internet Addiction Determination Scale for Secondary School Students; MPDQ, Mobile Phone Dependence Questionnaire for College Students; AMPUD, Self-Assessment Questionnaire for Adolescent Mobile Phone Use Dependence; SAS, Smartphone-Based on Diagnostic Criteria for Internet Addiction; UCLA, UCLA Loneliness Scale; SCL-90, 90-item Symptom Checklist 90; SRAS, Self-Assessment Anxiety Scale. ① Internet addiction; ② Mental health; ③ Loneliness; ④ Depression; ⑤ Interpersonal sensitivity; ⑥ Anxiety.

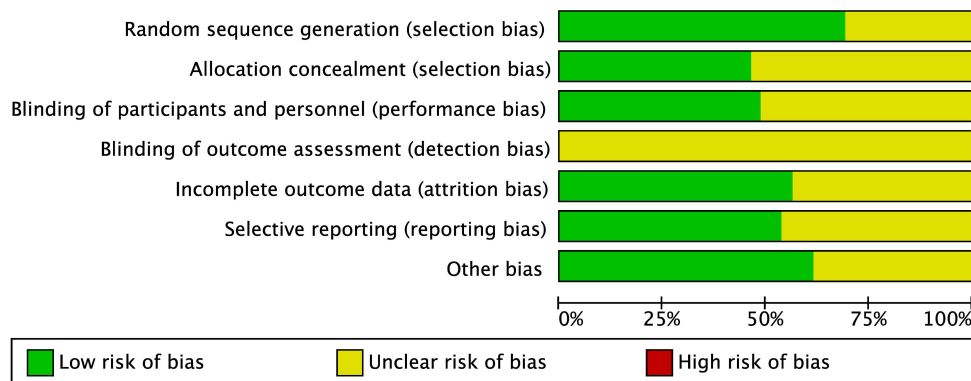


FIGURE 2  
Bias risk of the included studies.

to conduct a network meta-analysis, only a meta-analysis was performed. The detailed data of the meta-analysis are in the [Supplementary material](#). The results of the meta-analysis showed that  $I^2 = 77.8\%$ , for loneliness;  $I^2 = 81.2\%$ , for anxiety;  $I^2 = 75.7\%$ , for depression;  $I^2 = 77.5\%$ , for interpersonal sensitivity, so we only report the random-effects results.

### 3.3.1. Loneliness

To test H1a that IA students in exercise intervention have a positive effect on loneliness, four studies with 478 subjects were included in this study. The result showed that exercise in IA students had a significant effect on improving loneliness compared to no intervention ( $SMD = -0.96$ , 95% CI  $-1.5$  to  $-0.41$ ,  $p < 0.05$ ).

### 3.3.2. Anxiety

To test H1b that IA students in exercise intervention have a positive effect on anxiety, seven studies with 377 subjects were included in this study. The study showed that exercise in IA students had a significant effect on improving anxiety compared to no intervention ( $SMD = -1.79$ , 95% CI  $-2.37$  to  $-1.22$ ,  $p < 0.05$ ).

### 3.3.3. Depression

To test H1c that IA students in exercise intervention have a positive effect on depression, five studies with 182 subjects were included in this study. The results showed that exercise in IA students had a significant effect on improving depression compared to no intervention ( $SMD = -1.5$ , 95% CI  $-2.19$  to  $-0.81$ ,  $p < 0.05$ ).

### 3.3.4. Interpersonal sensitivity

To test H1d that IA students in exercise intervention have a positive effect on interpersonal sensitivity, five studies with 182 subjects were included in this study. The study showed that exercise in IA students had a significant effect on improving interpersonal sensitivity compared to no intervention ( $SMD = -1.34$ , 95% CI  $-2.05$  to  $-0.64$ ,  $p < 0.05$ ).

## 3.4. Network meta-analysis

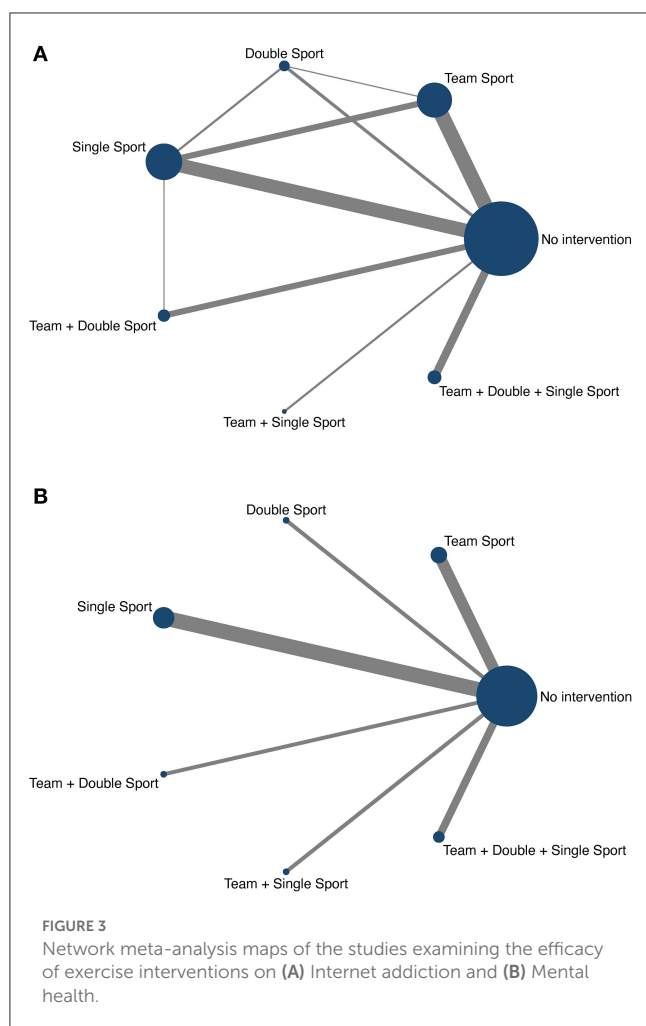
To test H2 that the double sport with some interaction has the best intervention effects on IA students for Internet addiction (H2a) and mental health (H2b), 39 studies were included in the network meta-analysis to examine the improvement of exercise for IA ([Figure 3A](#)), and 12 studies were included to examine the benefits for mental health ([Figure 3B](#)), both including six exercise intervention types and one no intervention. In the network meta-analysis map, each node represents an intervention type, and the connecting lines indicated studies with direct comparisons between intervention types. The thickness of the connecting lines correlates with the number of studies between measures, while the size of the nodes was proportional to the number of studies per node.

### 3.4.1. Internet addiction

This network map showed closed loops, and the consistency of each closed loop needs to be further evaluated ([Figure 3A](#)). The inconsistency test of the results of each closed loop using nodal analysis showed that the values of the inconsistency factors ranged from 0.483 to 1.827, and the lower limit of 95% CI was 0. The consistency of each closed loop was good, indicating that the constituted network relationship map met the consistency assumption.

The results of the two-by-two comparison are shown in [Table 2](#). Compared with the no-intervention team, the team sport, the double sport, the single sport, the team + double sport, and the team + double + single sport in reducing IA were statistically significantly different. In the comparison of different exercise types, the double sport, the team + double + single sport, and the team + double sport had a better effect than the single sport in reducing IA, and the differences between other comparisons were not statistically significant.

According to the SUCRA method, the effectiveness of different exercise types in reducing IA was ranked. A SUCRA graph of the effectiveness of interventions was formed and is shown in [Figure 4](#). The results showed that the rank of the effectiveness of different exercise types was double sport (SUCRA = 85.5) > team + double



+ single sport (SUCRA = 80) > team + double sport (SUCRA = 78.9) > team sport (SUCRA = 43.2) > team + single sport (SUCRA = 31.3) > single sport (SUCRA = 29.4) > no intervention (SUCRA = 1.7).

### 3.4.2. Mental health

This network map has no closed loops, so there is no need to further evaluate the inconsistency. The results of the pairwise comparison are shown in Table 2. Compared to the no intervention, the differences were statistically significant for the team sport, the double sport, and the single sport in improving the mental health of IA students. In the pairwise comparison of different exercise types, the double sport was a more significant effect than the team + double + single sport and the team + double sport. The differences between the other comparisons were not statistically significant.

According to the SUCRA method, the effectiveness of different exercise types in IA students' mental health was ranked in Figure 5. The results showed that the rank of the effectiveness of different exercise types was double sport (SUCRA = 93.1) > team sport (SUCRA = 86.9) > single sport (SUCRA = 58.6) > team + single sport (SUCRA = 52.3) > team + double + single sport (SUCRA = 31.3) > team + double sport (SUCRA = 19.3) > no intervention (SUCRA = 8.4).

### 3.4.3. Internet addiction vs. mental health

To test H3 that the double sport is the optimal exercise type under the combined consideration of IA and mental health, a two-dimensional clustered ranking map was performed to show the comprehensive superiority of different exercise types in improving Internet addiction and mental health (Figure 6). According to the analysis, the double sport showed the greatest potential to be the most effective therapeutic exercise type for reducing IA and improving mental health (cluster ranking value: 3699.73).

## 3.5. Publication bias and sensitivity analysis

We assessed the publication bias of this research of every outcome by funnel plots. The horizontal coordinate is the effect size, and the vertical coordinate is the standard error. The studies were evenly distributed on both sides of the midline and were more symmetrical in distribution, but some fell outside the funnel, indicating possible publication bias and small sample effects. Simultaneously, the data remained unchanged following the sensitivity analysis, indicating that the results of this study were stable. Thus, the current analysis results were regarded as reliable (see Supplementary material).

## 4. Discussion

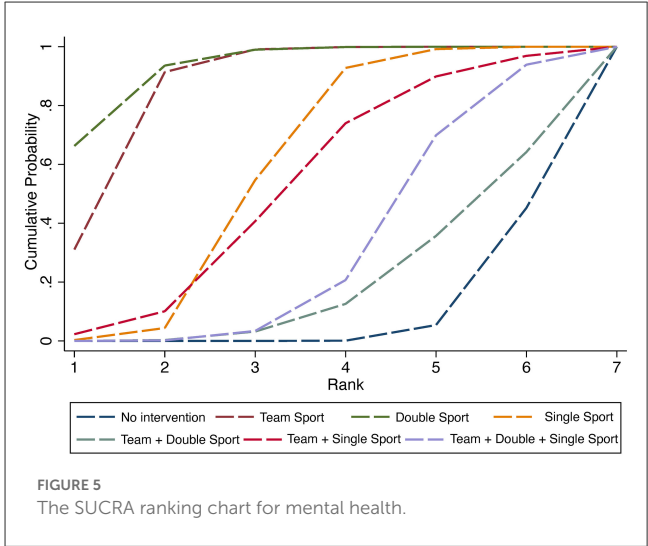
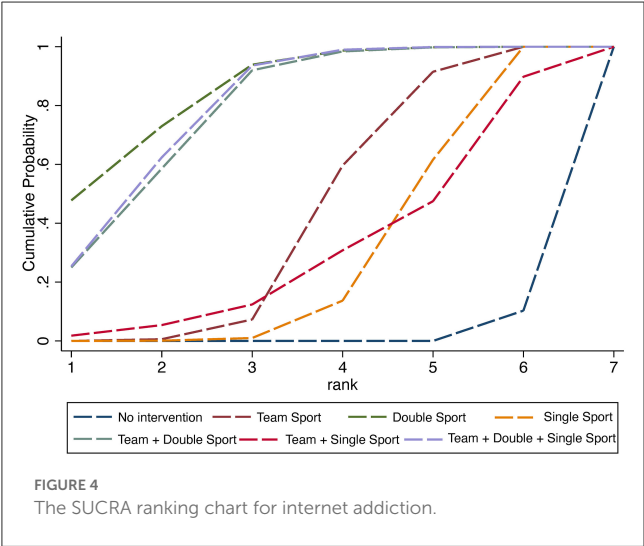
This is the first network meta-analysis of the improvement effect of exercise interventions on IA students. A total of 39 RCTs of exercise interventions and 2,408 IA students were included in the network meta-analysis, our study compensated for the lack of sample size in Internet addiction research. The results from our meta-analysis confirmed the importance of exercise in the intervention of IA students. Specifically, the results showed that single sport, team sport, double sport, team + double sport, and team + double + single sport all significantly reduced IA compared with the control group. In terms of improving mental health in IA students, the single sport, team sport, and double sport produced a significant positive effect. Interestingly, the double sport showed the greatest potential to be the best choice for reducing IA and improving mental health. Taken together, these findings provided robust evidence that exercise is effective in reducing IA in students, with the double sport being the most effective.

Our study found that team sport, double sport, and single sport are significantly effective compared to the control group in both reducing IA and improving mental health for IA students by the network meta-analysis. One very important argument for exercise's beneficial effect on IA is that exercise significantly improved mental health. Recent research has suggested that the scores of loneliness, anxiety, depression, and interpersonal sensitivity of IA students were significantly higher than those of ordinary students (Long et al., 2021; Zhang et al., 2021; Qiu et al., 2022; Yang et al., 2022). Specifically, students with high interpersonal sensitivity have often suffered from loneliness, anxiety, and depression, and progressively increased engagement in the Internet that offered emotional support and expression (Young, 1996; Ang et al., 2012; Gámez-Guadix et al., 2012). It has been reported that exercise can relieve IA by decreasing interpersonal sensitivity, loneliness, anxiety, and

TABLE 2 League table for head-to-head comparisons.

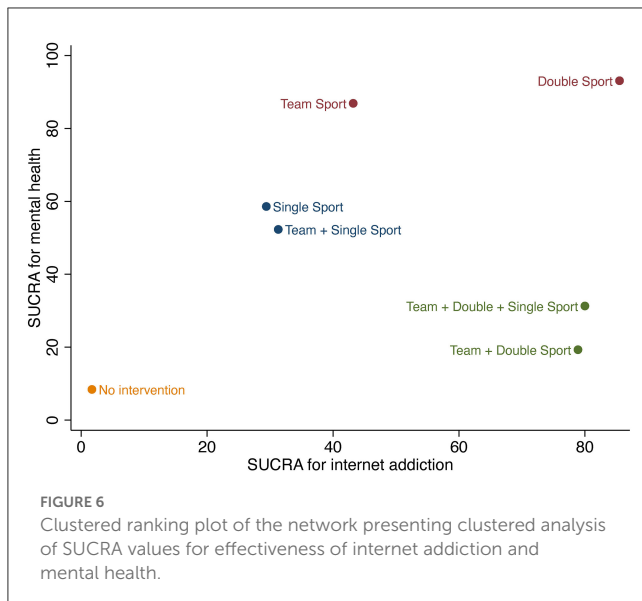
Double Sport	−84.68* (−143.21, −26.16)	−98.44 (−166.87, 30.01)	−13.72 (−72.19, 44.76)	−59.74 (−132.23, 12.75)	−53.23 (−108.62, 2.16)	−107.1* (−155.54, −58.66)
−0.27 (−2.13, 1.59)	Team + Double + Single Sport	−13.76 (−72.19, 44.68)	−70.97* (−117.64, −24.29)	−24.94 (−88.09, 38.20)	−31.45 (−74.00, 11.09)	−22.42 (−55.26, 10.43)
−0.30 (−2.22, 1.61)	−0.03 (−1.61, 1.55)	Team + Double Sport	−84.72* (−143.11, −26.34)	−38.70 (−111.12, 33.72)	−45.21 (−100.50, 10.08)	−8.66 (−56.99, 39.67)
−1.51 (−3.13, 0.12)	−1.24 (−2.52, 0.05)	−1.20 (−2.58, 0.17)	Team Sport	−46.02 (−109.12, 17.08)	−39.51 (−80.83, 1.80)	−93.38* (−126.14, −60.63)
−2.06 (−4.65, 0.53)	−1.79 (−4.14, 0.56)	−1.76 (−4.16, 0.64)	−0.55 (−2.77, 1.66)	Team + Single Sport	−0.14 (−2.36, 2.08)	−47.36 (−101.29, 6.57)
−1.92* (−3.50, −0.34)	−1.65* (−2.95, −0.35)	−1.62* (−2.97, −0.27)	−0.41 (−1.32, 0.49)	0.14 (−2.08, 2.36)	Single Sport	−53.87* (−80.73, −27.01)
−3.42* (−4.94, −1.89)	−3.14* (−4.20, −2.08)	−3.11* (−4.29, −1.94)	−1.91* (−2.64, −1.18)	−1.35 (−3.45, 0.74)	−1.49* (−2.24, −0.75)	No intervention

\* $p < 0.05$ . Mental health (upper) and Internet addiction (lower) are reported as Hedges'  $g$  and 95% confidence intervals. Negative scores indicate a greater decrease in depressive symptoms for the column group.



depression (Van der Aa et al., 2009; Kheyrkhah et al., 2010). Meanwhile, it has also been found that self-efficacy also improves IA through improved mental health (Cao et al., 2010). However, these studies all suffer from the problem of a small sample size. Instead, we addressed this issue by a meta-analysis, based on a large number of studies and large samples. Our study identified positive effects of exercise interventions on psychological factors related to IA students, that is, exercise interventions improved loneliness, anxiety, depression, and interpersonal sensitivity. Taken together, given that exercise can reduce IA by improving interpersonal sensitivity, loneliness, anxiety, and depression in IA students, it would be appropriate to determine whether exercise intervention is effective. Our study bridges a gap in the lack of a large sample in studies for IA students and conducts an innovative use of network meta-analysis to further examine the intervention effects of different exercise types. From the discussion above, mental health is an important factor in IA (Ko et al., 2012; Babadi-Akash et al., 2014), thus treatment should not only focus on whether IA is reduced but also on the improvement of mental health (Li et al., 2017; Zhang et al., 2018).

Exercise-improving IA has been revealed in previous studies by meta-analysis (Wu et al., 2019), but whether differences in the intervention effect existed between different exercise types are unknown. The most interesting finding is that the double sport was the most effective exercise type for IA students, based on the effect of combinedly reducing IA and improving mental health by the two-dimensional clustered ranking map of the network meta-analysis. This finding is contrary to previous studies which have suggested that team sport is the best exercise type (Liu, 2013). Their result was explained by the relationship between the stimulation of social support and individual mental health. Social support refers to the influence that individuals obtain through social contacts that can reduce psychological stress, and relieve mental tension (Barrera Jr and Ainlay, 1983). But our research argues that the double sport not only gains social support but also enables addicts to increase the blood flow in the body with continuous double sport exercise. This way causes a certain good stimulation of the central nervous system of the body and promotes the formation of positive emotions in IA students and achieves the purpose of reducing IA



(Fu and Liu, 2016; Yang et al., 2016; Shi et al., 2017). Meanwhile, the double sport can bring more stimulation and pleasure generated by competition. It can satisfy the human body's pursuit of changing, novel, and complex sensations and experiences and produce more effective intervention effects (Deng, 2003; Liu et al., 2010; Ma, 2010; Wang, 2012; Hu and Zhang, 2016). It can, therefore, be assumed that double sport should be the main type when doctors or teachers choose a suitable exercise type for IA students. Our study bridges a gap in the lack of studies for seeking the best effective exercise type in IA students and conducts an innovative use of the two-dimensional clustered ranking map to further examine the comprehensive effects of different exercise types in IA and related mental factors.

## 4.1. Practical implications

With consideration of the projected growth of IA students and the consequential intervention demand, the findings from this network meta-analysis offer support for exercise prescription to reduce IA in students. IA damages students' physical and mental health and triggers a series of serious consequences, which is an urgent problem for families, schools, and society (Beutel et al., 2011; Zhou et al., 2011; Li et al., 2015). Thus, our study has practical implications for society, schools, and families in dealing with IA in students. This study concluded that double sport is the best effective exercise type for IA students. Exercise has shown superiority and significance as a low-cost, easily disseminated, and highly adherent intervention for the treatment of substance addiction and behavioral addiction (Bu et al., 2010). Studies found that exercise can promote the adaptive remodeling of reward circuits and reduce recurrent Internet-addictive behaviors in adolescents (Ma et al., 2022b). On the one hand, exercise can activate the same reward circuits as IA, causing adolescents to feel euphoria and satisfaction similar to Internet use, effectively reducing the positive reinforcement of addiction sources (Liu and Wang, 2020). On the other hand, high dopamine levels underlie psychiatric dependence

and addiction relapse (Wang et al., 2011), and exercise can reduce dopamine release and receptor utilization, inhibiting adolescents' reward expectations (Zhao et al., 2018). Taken together, schools, as the main place where most students conduct their social life have the mission and responsibility to intervene in the IA problem. Schools should make full use of their teachers and facilities to cultivate students' interest in exercise to reduce the occurrence of IA behaviors. Meanwhile, family and society should regulate youth behavior and eventually correct IA effectively by cultivating their interest in exercise, establishing the concept of healthy living, and creating a good family relationship and growth environment.

## 4.2. Limitation

The current network meta-analysis is not without limitations. First, the results of the meta-analysis on loneliness, anxiety, depression, and interpersonal sensitivity showed significant heterogeneity. This was due to the small number of included studies. Therefore, we conducted sensitivity analyses through screened-out one-by-one included studies and found that none of the data changed substantially, indicating some stability in the results of this study. Second, we only compared different exercise types and did not compare the exercise intensity and exercise strength. It is because most of the included studies used the same intensity and had no differences to compare. The included studies were different in terms of exercise duration, but we found no common classification in duration, so only the exercise type classification was used for comparison in this study. However, we conducted regression analyses for frequency, length of a session, duration, and length of a week on the effect of reducing IA, and the results of the study showed no significant differences (see the [Supplementary material](#)). Third, most of the included studies in this study were self-reported by scales. The term "addiction" may be inaccurate when used without a diagnosis by a psychiatrist. But scale-based self-reports can reduce interviewers' prejudices, are anonymous, allow thoughtful answers instead of immediate responses, and can be used for a wider range of samples to support us in solving urgent problems (Kuss et al., 2014). Studies on other psychological problems found no significant differences between self-reported and clinical assessments (Polaino and Senra, 1991). However, we suggest that the study findings should be viewed with caution. Fourth, the included study in this study includes mobile phone addiction. Internet addiction and mobile phone addiction are quite similar, both are behavioral addictions (Kwon et al., 2013; Mok et al., 2014) with similar attributes and characteristics (Chen et al., 2022), and similar items of measurement instruments are used (Chi and Chiu, 2013; Kuss et al., 2014; Hadlington, 2015). We believe that the smartphone, as a means of accessing the internet, can lead to addictive behavior related to Internet use. But we still need to clarify the distinction that was thought to exist in previous studies. Smartphone addiction has unique characteristics that distinguish it from Internet addiction in terms of behavioral patterns, addiction groups and characteristics (Petry and O'Brien, 2013; Mok et al., 2014; Jeong, 2016), and addiction possibilities (Salehan and Negahban, 2013). However, we suggest that the study findings should be viewed with caution.

### 4.3. Future direction

First, further research is still needed to focus on influence factors in IA, such as loneliness, anxiety, depression, and interpersonal sensitivity. Second, exercise intensity homogeneity should be avoided in future studies, which is beneficial to explore the effects of different intensities in IA. Third, exercise intervention studies in AI students diagnosed by clinician-administered interviews are still needed in further. Fourth, a unified classification of exercise duration should be established in the future to better investigate the effects of different duration in AI. Fifth, the mechanisms of IA should be explored in the future and thus clearly distinguish the boundaries between IA and related addiction problems.

### Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

### Author contributions

YZ conceived the study design and drafted the manuscript. GL and CL participated in data collection and analysis. ZS, HC, and JG conceived the study design, assisted in revising the manuscript, and reviewed the first and final versions of the manuscript. All authors contributed to the manuscript and agreed to the submitted version of the manuscript.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1111195/full#supplementary-material>

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# Family cohesion and adaptability reduces mobile phone addiction: the mediating and moderating roles of automatic thoughts and peer attachment

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With the popularity of mobile Internet devices, the incidence of mobile phone addiction has been increasing, which has aroused the concern of all sectors of society. Due to the difficulty of eliminating the risk factors of mobile phone addiction, it's significant for researchers to examine the function and underlying mechanisms of positive environmental factors in reducing individuals' mobile phone addiction. Thus, the current study aimed to examine the relationship between family cohesion and adaptability and mobile phone addiction among university students and analyzed the mediating role of automatic thoughts as well as the moderating role of peer attachment in this link. The sample consisted of 958 Chinese university students. Participants completed self-report questionnaires assessing family cohesion and adaptability, mobile phone addiction, automatic thoughts, and peer attachment. PROCESS model 8 was significant (the total effect model ( $F(5, 952) = 19.64, R^2 = 0.09, p < 0.001$ )). Results indicated that family cohesion and adaptability could not only negatively predict mobile phone addiction directly, but also indirectly through the mediating effect of automatic thoughts. Moreover, both the direct association between family cohesion and adaptability and mobile phone addiction as well as the indirect effect of automatic thoughts were moderated by peer attachment. Findings emphasized the beneficial role of peer attachment on the effect of family cohesion and adaptability on automatic thoughts and mobile phone addiction.

## KEYWORDS

family cohesion and adaptability, mobile phone addiction, automatic thoughts, peer attachment, adolescence

## 1. Introduction

With the rapid development of digital technology and the widespread use of mobile Internet devices, mobile phones have been ubiquitously used around the world and become an essential part of modern daily life (Hu et al., 2020; Liu et al., 2022). According to the report by the China Internet Network Information Center, the number of people who reported accessing the Internet

through mobile phones has reached 1065 million, and the population of mobile phone users has grown rapidly (China Internet Network Information Center, 2023). Unfortunately, this universal and extensive use of mobile phones has coincided with the emergence of problematic behaviors such as mobile phone addiction (Geng et al., 2021). Mobile phone addiction refers to excessive or uncontrolled mobile phone use in daily life, which can exert an adverse influence on both physiological and psychological health (Scott et al., 2020). Growing evidence has revealed that mobile phone addiction is closely related to a variety of problems such as social isolation (Al-Kandari and Al-Sejari, 2020), poor sleep quality (Liu et al., 2017), and psychological distress (Lian et al., 2020). At the same time, this non-substance addiction is especially prominent among adolescents and young adults, so it is necessary to examine the addiction of mobile phone addiction and its mechanism of action among college students in depth (Diotaiuti et al., 2022a,b).

Previous researchers revealed plenty of risk factors for mobile phone addiction, such as peer victimization (Liu et al., 2020a), parental rejection (Chen Y. et al., 2021), and loneliness (Liu et al., 2021). As more and more risk factors of mobile phone addiction have been found, researchers have examined the protective factors of mobile phone addiction from the perspective of reducing risk factors (Liu et al., 2019). However, due to the multiformity and complexity of risk factors, it was difficult for us to eliminate the risk factors of mobile phone addiction and reduce the possibility of individuals being addicted to mobile phones. Therefore, an increasing number of people suggest that it is better to tell them what to do rather than telling them not to do it. Furthermore, researchers have increasingly emphasized the importance of examining the role and underlying mechanisms of positive environmental factors, such as creating supportive family or peer interaction environments, in reducing mobile phone addiction (Liu et al., 2020a; Zhang R. et al., 2021). It provides a new perspective on intervention research, that is, guiding individuals, families, or schools to build a positive development environment that can promote rational mobile phone use and reduce mobile phone addiction. Building on this perspective, the present study attempts to explore the association between positive family environmental factors (family cohesion and adaptability) and mobile phone addiction as well as the underlying mechanisms that could effectively reduce the risk of mobile phone addiction.

## 1.1. Family cohesion and adaptability and mobile phone addiction

Ralph Waldo Emerson, a famous ideologist and philosopher in the nineteenth century, wrote that *The family is the father's kingdom, the mother's world, and the children's paradise*, expressing high praise for a family and emphasizing the important role of family for every family member. Similarly, plenty of ancient Chinese literati and artists also created countless immortal works to convey the thoughts of a family and their yearning for harmonious and beatific family life, such as *jollification of reuniting family, such kindness of warm sun, cannot be repaid by grass*. All of these manifested that the positive meaning of family to individuals' development has cross-cultural universality. In addition, previous studies have revealed the positive effects of family factors on individuals' emotional and behavioral adaptation, such as family support (Wills et al., 1992), parent-child interaction

(Zimmer-Gembeck, 2011), and family socioeconomic status (Sarsour et al., 2011). The positive role of family cohesion and adaptability in individuals' psychological and behavioral development has also drawn the attention of many researchers (Ye et al., 2021; Li M. et al., 2021).

Family cohesion and adaptability have been considered as a comprehensive measure of the degree of family functioning (Bakken and Romig, 1989). Cohesion refers to "the emotional bond between members and the degree of autonomy experienced by a person in the family system." Adaptability refers to "the ability of the marriage or family system to change its power structure, role relationships, and relationship rules based on context and development pressure." Prior studies have shown that family cohesion and adaptability might be protective factors in mitigating both the risk of indulging in the Internet and the negative consequences associated with Internet addiction (Yen et al., 2007; Liu et al., 2020b).

First, family cohesion and adaptability could reduce the risk of individuals being entangled in emotional problems and thereby reduce the possibility of individuals indulging in mobile phones. Previous studies have demonstrated that emotional problems such as loneliness and anxiety are important triggers for individuals to indulge in mobile phones (Liu et al., 2021; Li J. et al., 2021). Family cohesion and adaptability could provide emotional communication, psychological comfort and support to help family members overcome the emotional difficulties they encounter (Arató et al., 2021). The love and warmth offered by the family would reduce the possibility of loneliness and other emotional problems, as well as the potential adverse consequences associated with emotional problems (Lei and Kantor, 2021). Therefore, families with higher cohesion and adaptability could satisfy individuals' emotional needs and reduce the risk of individuals being addicted to mobile phones.

Besides, family cohesion and adaptability could help individuals to shape positive personality traits and enhance their social adaptability (Yan et al., 2014). Positive personality traits and good social adaptability may also help individuals reduce the possibility of escaping from reality due to frustration and indulging in the virtual world. According to the ACE model (Young, 1998), escapism is an important motivation for mobile phone addiction. A previous study has also stated that individuals who grow up in families with poor cohesion and adaptability were more likely to escape from reality when encountering setbacks, and then show a higher tendency to indulge in mobile phones (Arató et al., 2021). Whereas individuals with stronger adaptability will seek assistance from others rather than escaping from reality or getting lost in the mobile phones when faced with setbacks and difficulties (Lanfranchi and Vianello, 2012).

Moreover, family cohesion and adaptability could act as a security base to reduce individuals' behavioral problems, such as mobile phone addiction. Previous studies have stated that family cohesion and adaptability could promote individuals' emotional security, which helps individuals to form positive behavior habits and effective stress-coping styles (Bakken and Romig, 1989; Sela et al., 2019). In addition, emotional safety is significantly negatively correlated with mobile phone addiction (Hong et al., 2020). According to Olson's Circumplex Model (Schweitzer, 1992), strong emotional bonds within the family can help individuals maintain stable physical and mental health, and reduce their internalizing or externalizing problems. Conversely, dysfunctional and conflict-ridden families could increase the social adjustment problems of adolescents, which contributes to engagement in mobile phone addiction (Liu et al., 2020b). Above all, we supposed

that family cohesion and adaptability would be negatively associated with mobile phone addiction (Hypothesis 1).

## 1.2. Automatic thoughts as the mediator

Automatic thoughts refer to automatic, recurring negative thinking patterns caused by cognitive schema or core belief (Beck, 1967). They have been identified as crucial risk factors for maladaptive coping strategies and problematic behaviors (Hjemdal et al., 2013; Hou et al., 2020; Nie et al., 2021). Individuals with higher automatic thoughts are more likely to develop negative and self-defeating thoughts that are often activated by negative life experiences (Yapan et al., 2020). Once activated, automatic processes run to fulfillment and are difficult to alter or suppress (Irfan and Zulkefly, 2021). These intrusive thoughts can induce emotional problems, such as depression and anxiety. To relieve such negative emotions, individuals may turn to the virtual world (e.g., mobile phones). Over time, they become more and more addicted to mobile phones and find it difficult to extricate themselves (Liu et al., 2021). Prior studies have shown that mobile phones have been widely used as a tool to pass time and eliminate negative emotions (Khang et al., 2013). Therefore, the higher the frequency of automatic thoughts, the easier it is to fall into negative emotional states such as anxiety and depression. These negative emotions make it more likely to use mobile phones to escape from the real world, thus inducing mobile phone addiction. Besides, negative automatic thoughts are closely correlated with individuals' way of mindsets and interpretations of situations, which in turn, lead to maladaptive coping strategies such as escape and mobile phone addiction. Previous studies have demonstrated that automatic thoughts play a key role in escaping from reality and indulging in the Internet (Geng et al., 2009; Nie et al., 2021). Specifically, individuals with high automatic thoughts are more likely to create automatic and passive thoughts when they encounter frustration, which may prompt their escapist behaviors and further induce mobile phone addiction. Moreover, it has been confirmed that individuals with higher automatic thoughts are more prone to Internet addiction (Geng et al., 2009). As another manifestation of Internet addiction in the mobile Internet era (Billieux et al., 2015), mobile phone addiction may also be a potential adverse consequence of automatic thoughts. Therefore, this study speculated that automatic thoughts may increase the risk of individuals being addicted to mobile phones.

Researchers have also indicated that automatic thoughts are closely correlated with the family environment (Kazdin, 1990). According to the ecological system theory, family is the primary place for individuals' socialization, which relates to the formation of their cognitive styles, behavior habits, and values (Swartz and Martin, 1997). Empirical studies have shown that individuals from families with conflict-indifferent relationships report more negative automatic thoughts than those from harmonious families (Burgess and Haaga, 1994). That is, family cohesion and adaptability may reduce individuals' automatic thoughts. Additionally, there is evidence that automatic thoughts play an intermediary role in the association between family environments and problem behaviors (Irfan and Zulkefly, 2021). Therefore, it was hypothesized that automatic thoughts may mediate the effect of family cohesion and adaptability on mobile phone addiction (Hypothesis 2).

## 1.3. Peer attachment as the moderator

Peer attachment refers to an enduring and close affectionate bond between individuals and their peers, which can provide warmth and support to each other (Bowlby, 1969; Li et al., 2022). As a social support resource, it has protective and beneficial effects on negative thinking styles and behavior adaptation (Armsden and Greenberg, 1987; Saija et al., 2022).

When facing conflicts and the pernicious impact of the family, individuals with high-quality attachment can constantly adjust their cognition and develop a positive cognition model which could reduce the possibility of being involved in negative automatic thoughts (Pace et al., 2011; Hou et al., 2020). In addition, they will seek assistance from peers and acquire more attention and comfort when facing negative emotions brought by undesirable families (Lei and Wu, 2009; Chen and Feng, 2013). Therefore, they may employ more valid and effective emotional coping strategies to regulate negative emotions and reduce the adverse effects of detrimental emotions, and ultimately reduce the risk of falling into externalizing problems such as indulging in mobile phones.

According to the development environment theory (Yarrow and Zaslow, 1981), individuals' multiple environments do not independently relate to their development, but jointly determine the developmental outcomes through some interactions. Individuals who enter the university gradually move away from the close-knit family environment, and begin to interact with peers. Previous studies have shown that peer attachment can weaken the adverse effects of parental marital conflict and childhood abuse (Armsden and Greenberg, 1987; Yang et al., 2016). Therefore, peer attachment, as a positive environmental factor, can interact with the family environment to influence individuals' psychological and behavioral development. The protection-protection factor model indicated that one protective factor can amplify or enhance the beneficial effects of another factor (Brook et al., 1986). Previous studies have demonstrated that family cohesion and adaptability and peer attachment were two important and effective protective factors that could reduce the cognitive and behavioral adaptation problems (Ko, 2009; Qing et al., 2018; Badenes-Ribera et al., 2019; Sela et al., 2019). Therefore, high-quality peer relationships may enhance the beneficial effects of high family cohesion and adaptability on individuals' development. Empirical studies have observed that secure peer attachment could improve individuals' emotional responses and thinking modes, which could enhance the positive impact of a satisfactory family environment on their thinking patterns (Li et al., 2017). Prior studies have also shown that high-quality peer attachment relationships could develop and reinforce individuals' positive coping styles and thinking models, and this beneficial effect was greater in an intimate family environment (Badenes-Ribera et al., 2019). In addition, intimate families provide parental emotional warmth and support, coupled with high-quality peer attachment relationships, which could greatly increase individuals' social adaptability and reduce the occurrence of problematic behaviors, such as mobile phone addiction (Qing et al., 2018). Prior studies have also indicated that parental emotional warmth is positively correlated with peer attachment, and they are both negatively associated with mobile phone addiction (Gao et al., 2022). Therefore, this study hypothesized that peer attachment could enhance the positive effects of family cohesion and adaptability, and

further mitigate the risk of automatic thoughts on mobile phone addiction (Hypothesis 3).

## 1.4. The present study

Considering the prevalence and perniciousness of mobile phone addiction, and the protective role of family functions on individuals' behavioral adaptation, it is imperative to examine the relationship between family cohesion and adaptability and mobile phone addiction. The current study attempts to examine the mediating effect of automatic thoughts and the moderating role of peer attachment in the association between family cohesion and adaptability and mobile phone addiction. This study provides a new perspective on the protective mechanisms of mobile phone addiction. The findings of this study would offer valuable suggestions for parents on how to cultivate intimate and harmonious family relationships, as well as guide individuals in developing high-quality peer attachment, thereby reducing the risk of mobile phone addiction.

## 2. Method

### 2.1. Participants and procedure

Convenience sampling was employed to recruit 958 students (59.3% female) from two universities located in the center of China (Wuhan and Jingzhou). Students who possessed smartphones and used them for both personal activities and professional studies were invited to participate in the study. All of the participants were informed of the study's requirements by acquainting standard instructions carefully and were encouraged to answer truthfully and independently within 30 min in their classroom. The mean age of the participants was 19.90 years old ( $SD = 1.22$ ). Three hundred and fifteen (32.9%) of them were freshmen; three hundred and forty-two (35.7%) of them were sophomores; and three hundred and one (31.4%) of them were juniors. The study obtained both Ethics Committee approval prior to conducting the study and informed consent from each student.

## 2.2. Measurements

### 2.2.1. Family cohesion and adaptability

Family cohesion and adaptability were assessed by the Chinese version of the Family Adaptability and Cohesion Scale (Olson et al., 1985) and had shown good reliability and validity among Chinese college students (Ye et al., 2021). This scale is mainly applied to assess two aspects of family function including cohesion (e.g., emotional connection between family members) and adaptability (e.g., family system's capabilities to overcome difficulties). Examples of items are "Family members are familiar with each other's close friends." The scale consists of 30 items (16 items for family cohesion and 14 items for family adaptability). Participants respond to the 30 items on a Likert-type scale ranging from 1 (never) to 5 (always). All scores are added together and averaged, higher scores represent more stable and harmonious family relationships. In the current study, the items demonstrated high reliability (Cronbach's  $\alpha = 0.91$ ).

### 2.2.2. Mobile phone addiction

Mobile phone addiction was measured by the Mobile Phone Addiction Index (MPAI; Leung, 2008). This scale consists of four dimensions including avoidance, inefficiency, out of control, and withdrawal (e.g., "You spend a lot of time on your mobile phone and are unable to control yourself"). Participants respond to the 17 items on a Likert-type scale ranging from 1 (never) to 5 (always). All scores are added together and averaged, higher scores represent severe mobile phone addiction. In the current study, the items demonstrated high reliability (Cronbach's  $\alpha = 0.85$ ).

### 2.2.3. Automatic thoughts

Automatic thoughts were assessed by the Automatic Thought Questionnaire (Hollon and Kendall, 1980) and had shown good reliability and validity among Chinese students (Yao et al., 2003). This scale consists of four dimensions including maladjustment and eagerness for change, negative self-concepts and expectations, lack of self-confidence, and helplessness (e.g., "I am very dissatisfied with myself"). Participants respond to the 30 items on a Likert-type scale ranging from 1 (did not emerge this thought at all) to 5 (continue to occur frequently). All scores are added together and averaged, higher scores reflect a higher tendency to automatically think of the negative life experience. In the current study, the items demonstrated high reliability (Cronbach's  $\alpha = 0.97$ ).

### 2.2.4. Peer attachment

Peer attachment was assessed by a shortened version of the Peer Attachment Inventory (Armsden and Greenberg, 1987). The reliability and validity of the Chinese version of this questionnaire have been tested and verified (Chen X. et al., 2021). The scale has 12 items scored on a 5-point Likert scale (1 = definitely not to, 5 = absolutely yes). Examples of items used are "If I want to tell my friends something, they hear me carefully." All scores are added together and averaged, higher scores indicate more experience of companionship, love, security, and acceptance from friends. In the current study, the items demonstrated acceptable reliability (Cronbach's  $\alpha = 0.73$ ).

### 2.2.5. Control variables

Gender, age, grade, and years of owning a mobile phone were included as control variables in the current study, as prior researchers found that they were closely related to the main variables in this current study (Pavia et al., 2016; Liu et al., 2021; Zhang Y. et al., 2021).

## 2.3. Statistical analyses

Firstly, we conducted descriptive statistics to examine the means and standard deviations for gender, age, grade, years of owning a mobile phone, family cohesion and adaptability, mobile phone addiction, automatic thoughts, and peer attachment. We employed Pearson correlations to test the bivariate associations for all observed variables. Secondly, the SPSS macro PROCESS (model 8) was used to test the proposed moderated mediation model which was suggested by Hayes (2013) and has been widely used to test mediating and moderating models by several researchers (Liu et al., 2017, 2020a, 2021). Thirdly, simple slopes analyses were used to decompose the significant interaction effects in this study.

### 3. Results

#### 3.1. Preliminary analyses

The observed variables' means, standard deviations, and correlations are displayed in Table 1. As hypothesized, family cohesion and adaptability were negatively associated with automatic thoughts ( $r = -0.28, p < 0.01$ ) and mobile phone addiction ( $r = -0.24, p < 0.01$ ). Automatic thoughts were positively associated with mobile phone addiction ( $r = 0.38, p < 0.01$ ). Peer attachment was positively associated with family cohesion and adaptability ( $r = 0.19, p < 0.01$ ) while negatively associated with automatic thoughts ( $r = -0.08, p < 0.01$ ) and mobile phone addiction ( $r = -0.07, p < 0.01$ ).

#### 3.2. Testing for the proposed moderated mediation model

Hayes's (2013) SPSS macro PROCESS was adopted to examine the proposed moderated mediation model. Table 2 presented the main results.

As expected, the total effect model ( $F(5, 952) = 19.64, R^2 = 0.09, p < 0.001$ ), the mediator variable model ( $F(7, 950) = 24.30, R^2 = 0.11, p < 0.001$ ) and dependent variable model ( $F(8, 949) = 30.06, R^2 = 0.21, p < 0.001$ ) were all significant after controlling gender, age, grade and years of owning a mobile phone. Specifically, family cohesion and adaptability were negatively associated with automatic thought ( $B = -0.38, p < 0.001$ ) and mobile phone addiction ( $B = -0.11, p < 0.001$ ). Automatic thoughts were positively associated with mobile phone addiction ( $B = 0.26, p < 0.001$ ). Furthermore, we employed the Sobel test to examine the significance of the indirect effect of family cohesion and adaptability on mobile phone addiction via automatic thought. The results indicated that automatic thoughts significantly mediated the relationship between family cohesion and adaptability and mobile phone addiction ( $z = 10.91, p < 0.001$ ). These results provided compelling evidence that family cohesion and adaptability were associated with decreasing mobile phone addiction and this relation was mediated by automatic thoughts. Thus, Hypotheses 1 and 2 were supported.

In order to examine Hypothesis 3, Hayes's (2013) PROCESS macro (Model 8) was adopted to analyze the two interaction effects. There were a significant family cohesion and adaptability  $\times$  peer attachment interaction effect on automatic thoughts ( $B = -0.20, p < 0.01$ ) in the mediator variable model and a significant family cohesion and adaptability  $\times$  peer attachment interaction effect on

mobile phone addiction ( $B = -0.13, p < 0.05$ ) in the dependent variable model. These findings indicated that both the association between family cohesion and adaptability and mobile phone addiction and the association between family cohesion and adaptability and automatic thoughts were moderated by peer attachment.

Additionally, we conducted simple slope analyses to illustrate these significant interactions and explore whether slopes for the high-peer attachment group (1 SD above the mean) were different from slopes for the low-peer attachment group (1 SD below the mean) in the two models. The results were plotted in Figures 1, 2. As shown in Figure 1, the negative effect of family cohesion and adaptability on automatic thoughts was stronger for students with higher peer attachment ( $B = -0.30, t = -7.53, p < 0.001$ ) than for those with lower peer attachment ( $B = -0.12, t = -2.71, p < 0.01$ ). Similarly, as shown in Figure 2, the negative effect of family cohesion and adaptability on mobile phone addiction was stronger for students with higher peer attachment ( $B = -0.48, t = -10.39, p < 0.001$ ) than for those with lower peer attachment ( $B = -0.28, t = -4.48, p < 0.001$ ). In other words, family cohesion and adaptability interacted with peer attachment, so students with low levels of peer attachment had fairly similar automatic thoughts and mobile phone addiction across high and low levels of family cohesion and adaptability. However, students with higher levels of peer attachment reported lower levels of automatic thoughts and mobile phone addiction when they had higher family cohesion and adaptability. Likewise, students with lower levels of peer attachment reported higher levels of mobile phone addiction and automatic thoughts.

Furthermore, the two conditional analyses showed that no matter what levels of peer attachment are, all of the direct and indirect effects were negatively and significantly different from zero. Namely, both the direct effect of family cohesion and adaptability on mobile phone addiction and the indirect effect of automatic thoughts in this link were stronger for students with higher peer attachment.

### 4. Discussion

The present study examined the association between family cohesion and adaptability and mobile phone addiction, and the mediating role of automatic thoughts in this link. In addition, peer attachment was tested as a moderator in this mediation process. The results showed that family cohesion and adaptability were negatively associated with mobile phone addiction. Hypothesis 1 was supported. The moderated mediation analysis revealed that automatic thoughts mediated the association between family cohesion and adaptability

TABLE 1 Descriptive statistics and interrelations among all of the observed variables.

Variables	<i>M</i>	<i>SD</i>	1	2	3	4	5	6
1. Age	19.90	1.22	1					
2. Years of owning a mobile phone	5.93	2.51	0.14**	1				
3. Family cohesion and adaptability	3.14	0.53	-0.01	-0.01	1			
4. Automatic thoughts	2.11	0.81	-0.02	0.07*	-0.28**	1		
5. Peer attachment	3.07	0.49	-0.04	-0.006	0.19**	-0.08*	1	
6. Mobile phone addiction	2.60	0.59	-0.05	0.11**	-0.24**	0.38**	-0.07*	1

*N* = 970. \*\* $p < 0.01$ , \* $p < 0.05$ .

TABLE 2 Regression results for the conditional direct and indirect effects.

<i>Model: Total effect model</i>									
<i>R</i>	<i>R</i> <sup>2</sup>	<i>F</i>	<i>df</i> <sub>1</sub>	<i>df</i> <sub>2</sub>	<i>p</i>	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
0.30	0.09	19.64	5	952	< 0.001				
Constant						3.69***	0.45	8.23	<0.001
Gender						0.17***	0.04	4.31	<0.001
Age						−0.04	0.02	−1.56	>0.05
Grade						0.02	0.03	0.51	>0.05
Years						0.03***	0.01	3.35	<0.001
Family cohesion and adaptability						−0.26***	0.03	−8.32	<0.001
<i>Model: Mediator variable model</i>									
<i>R</i>	<i>R</i> <sup>2</sup>	<i>F</i>	<i>df</i> <sub>1</sub>	<i>df</i> <sub>2</sub>	<i>p</i>	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
0.33	0.11	24.30	7	950	< 0.001				
Constant						2.38***	0.59	4.02	<0.001
Gender						−0.21***	0.05	−3.88	<0.001
Age						0.002	0.03	0.59	>0.05
Grade						−0.05	0.05	−1.09	>0.05
Years						0.02*	0.01	2.18	<0.05
Family cohesion and adaptability						−0.38***	0.05	−8.29	<0.001
Peer attachment						−0.01	0.06	−0.24	>0.05
Family cohesion and adaptability × peer attachment						−0.20**	0.06	−3.30	<0.01
<i>Model: Dependent variable model</i>									
<i>R</i>	<i>R</i> <sup>2</sup>	<i>F</i>	<i>df</i> <sub>1</sub>	<i>df</i> <sub>2</sub>	<i>p</i>	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
0.46	0.21	30.06	8	949	<0.001				
Constant						2.20***	0.39	5.62	<0.001
Gender						0.22***	0.04	6.07	<0.001
Age						−0.03	0.02	−1.56	>0.05
Grade						0.03	0.03	0.89	>0.05
Years						0.02*	0.007	2.57	<0.05
Automatic thoughts						0.26***	0.24	10.64	<0.001
Family cohesion and adaptability						−0.11***	0.31	−3.68	<0.001
Peer attachment						0.003	0.04	0.07	>0.05
Family cohesion and adaptability × peer attachment						−0.13*	0.06	−2.36	<0.05
<i>Conditional direct effect analysis at values of peer attachment (M ± SD)</i>						<i>B</i>	<i>Boot SE</i>	<i>Boot LLCI</i>	<i>Boot ULCI</i>
<i>M − 1SD (2.58)</i>						−0.05	0.04	−0.13	0.04
<i>M (3.07)</i>						−0.11	0.03	−0.17	−0.05
<i>M + 1SD (3.56)</i>						−0.18	0.04	−0.26	−0.10
<i>Conditional indirect effect analysis at values of peer attachment (M ± SD)</i>						<i>B</i>	<i>Boot SE</i>	<i>Boot LLCI</i>	<i>Boot ULCI</i>
<i>M − 1SD (2.58)</i>						−0.07	0.02	−0.11	−0.04
<i>M (3.07)</i>						−0.10	0.01	−0.13	−0.07
<i>M + 1SD (3.56)</i>						−0.12	0.02	−0.16	−0.10

*N* = 970. Unstandardized regression coefficients are reported. Bootstrap sample size = 5,000. LL, low limit, CI, confidence interval, UL, upper limit. \**p* < 0.05. \*\**p* < 0.01. \*\*\**p* < 0.001.

and mobile phone addiction. Hypothesis 2 was supported. Moreover, the direct and indirect effects of family cohesion and adaptability on mobile phone addiction could be moderated by peer attachment. Specifically, individuals with higher levels of peer attachment could successfully enhance the positive effects of family cohesion and

adaptability on automatic thoughts and mobile phone addiction. Hypothesis 3 was supported. By shedding light on both how and when family cohesion and adaptability are negatively associated with mobile phone addiction, this study could deepen our understanding of the role of family function in mobile phone addiction. To our knowledge,

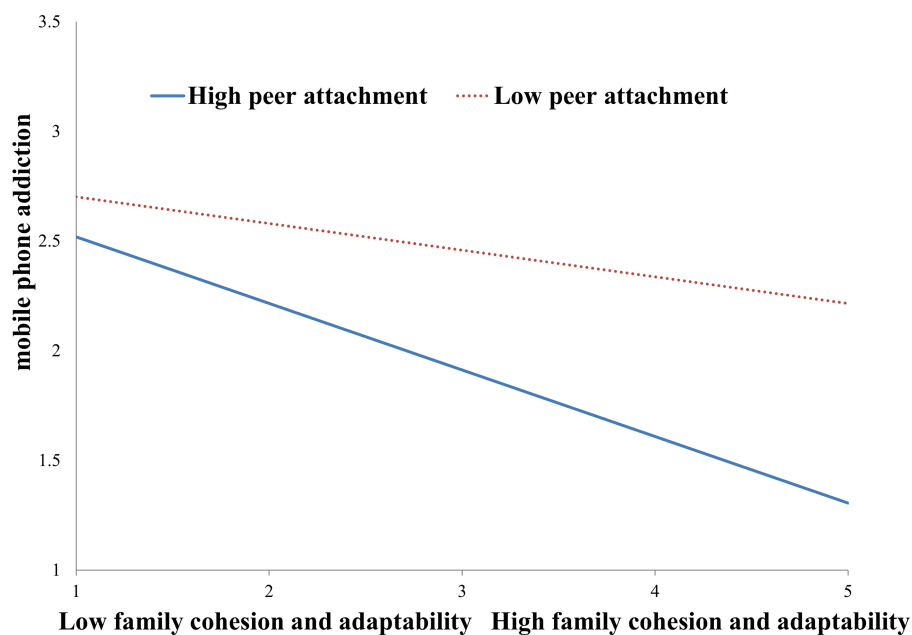


FIGURE 1

Peer attachment moderated the relationship between family cohesion and adaptability and mobile phone addiction.

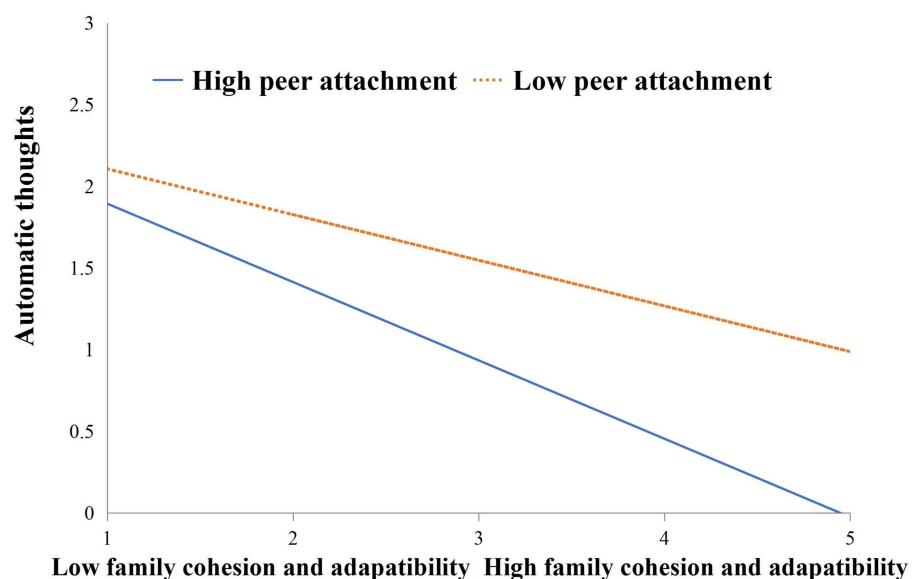


FIGURE 2

Peer attachment moderated the relationship between family cohesion and adaptability and automatic thoughts.

this is the first study that tested both the mediation and moderation mechanisms underlying the link between family cohesion and adaptability and mobile phone addiction. Moreover, the present study may inform the design of intervention programs aimed at reducing mobile phone addiction among college students.

Consistent with previous studies, individuals who grow up in intimate families and feel more emotional warmth can develop secure attachments and regard family members as faithful friends, thereby

reducing the likelihood of mobile phone addiction (Liu et al., 2020b). On the contrary, individuals who live in families with low levels of cohesion and adaptability for a long time may experience more anxiety and loneliness (Gao et al., 2022). They may fail to establish intimate relationships with others and fear being abandoned constantly, and thus treat mobile phones as attachment objects and be addicted to mobile phones ultimately (Parent et al., 2021). This conclusion coincided with the pathway model of mobile phone

addiction (Billieux et al., 2015), such that mobile phone addiction was caused by cognitive dissonance or the need for relationship maintenance due to insecure attachment. Besides, individuals living in high-intimacy families tend to be harmonious, humorous, and supportive, experience more fun and self-worth, have a stronger sense of control and life meaning (Cheng et al., 2019). They would have a clear sense of purpose and tend to live in accordance with their values or goals, thus being less addicted to mobile phones (Zhang et al., 2019). Conversely, individuals who grow up in isolated and dysfunctional families have a low sense of meaning in life, have no clear direction for life, and often experience negative emotions such as loneliness and anxiety. Therefore, they seek entertainment and the meaning of life and alleviate negative emotions by escaping from reality in the virtual mobile world, which increases the risk of mobile phone addiction (Chen Y. et al., 2021).

Besides, our findings were consistent with previous studies, showing that automatic thoughts acted as a mediating role that linked family cohesion and adaptability to mobile phone addiction (Irfan and Zulkefly, 2021; Nie et al., 2021). This finding indicated that individuals living in families with low cohesion and adaptability tended to develop negative, automatic, irrational beliefs, and negative emotions, which eventually led to problematic behaviors such as mobile phone addiction. This conclusion coincided with Beck's cognitive theory of mood disorders (Beck, 1976), emphasizing the important role of thoughts and beliefs in behavior and dysfunction. Our mediation model of automatic thoughts was also consistent with previous studies indicating that automatic thoughts are an important proximal factor, through which an undesirable family environment was linked to physical and mental development (Kazdin, 1990; Hou et al., 2020). Individuals from families with more parental conflicts and undesirable parent-child relationships were more likely to develop characteristics such as low self-evaluation and low self-esteem, which were reflected through individuals' negative automatic thoughts (Irfan and Zulkefly, 2020). These negative cognitive styles would enhance individuals' negative internal working model, it may motivate individuals to employ negative coping skills such as escaping from reality and indulging in virtual mobile phones when they make excessive inferences about negative stimuli (Hjemdal et al., 2013; Irfan and Zulkefly, 2021).

Furthermore, a most important finding in the present study was the individual differences in the effects of family cohesion and adaptability on automatic thoughts and mobile phone addiction. Specifically, both the direct effect that family cohesion and adaptability itself exerted on mobile phone addiction and the indirect effect via automatic thoughts were moderated and enhanced by peer attachment, with these effects being stronger for individuals with a higher level of peer attachment. Individuals can feel more secure and being loved when they possess both high-cohesion and adaptability families and high-quality peer relationships, which could alleviate negative thoughts and the risk of mobile phone addiction by reducing negative emotional experiences (Liu et al., 2020a; Gao et al., 2022). The result was consistent with the protection-protection factor model that high-quality peer attachment as a protective factor could enhance the beneficial effects of family cohesion and adaptability (Brook et al., 1986). Moreover, studies have shown that peer attachment, as an important social resource, could influence how individuals get along with the surrounding environment and how they cope with difficulties (Qing et al., 2018). Individuals with low peer

attachment tend to exhibit negative emotions and behaviors in peer relationships. Due to the low levels of acceptance and lack of social support from peers, they feel that they are not worthy of being loved and tend to have negative representations of themselves and others. Thus, they doubt and distrust both themselves and the external environment. Therefore, individuals with low peer attachment are more likely to develop negative automatic thoughts and also exhibit a non-adaptive coping style when perceiving stressors or the lure of addictive cues such as mobile phones, which increases their risk of indulging in mobile phones. Conversely, high peer attachment could enhance individuals' positive cognition and problem-solving skills, which reduces the risk of developing automatic thoughts and indulging in mobile phones (Yang et al., 2016). The protective role of peer attachment in our study was also consistent with the social main effect model indicating that social support has a generally beneficial effect, regardless of the current levels of social support. As long as social support is increased, it will inevitably lead to the improvement of individuals' cognition and social adaptability (Higgins and Kruglanski, 1996). Specifically, peer attachment enhanced the protective role of family cohesion and adaptability as a significant social resource. Individuals who live in high family cohesion and adaptability would possess social resources to develop a positive cognitive model and be less indulged in mobile phones, and this effect is greater especially when they have a high-quality peer attachment relationship. Therefore, individuals with high peer attachment could enhance the positive effects of family cohesion and adaptability on individuals' thinking styles and problem-solving skills, which, in turn, could help them alleviate automatic thoughts and reduce the occurrence of problematic behaviors.

## 5. Limitations and implications

Several limitations should be considered when interpreting these results. First, the social desirability of the self-report method used in this study may lead to imprecise data and possible common method biases. In the later stage, multiple methods such as parent or peer reports and diary methods should be considered to obtain more comprehensive data to make the results more accurate. Second, our study mainly focused on the effects of environmental (family, peers) and cognitive factors (automatic thoughts) on university students' mobile phone addiction. In addition to these factors, emotions were found to be closely related to individuals' family and behavioral problems (Pan and Yang, 2021). Future research should extend this model to examine the multiple mediating effects of cognitive and emotional factors.

Despite these limitations, this study expanded our knowledge of family functioning theory, cognitive emotion theory, and the protective-protective factor model which enriched our understanding of the relationship among family cohesion and adaptability, automatic thoughts, peer attachment, and mobile phone addiction. Specifically, based on these theories mentioned above, this study constructed a moderated mediation model in which family cohesion and adaptability was associated with mobile phone addiction, automatic thoughts were considered as a mediator, and peer attachment was treated as a moderator. The results not only investigated the underlying mechanism of how family cohesion and adaptability reduced

individuals from indulging in mobile phones but also illustrated for whom this mediation mechanism was more prominent. The results were helpful for us to understand that family cohesion and adaptability and peer attachment can contribute to reducing individuals' negative automatic thoughts and mobile phone addiction.

In addition, our findings also have several applications. First, faced with the detrimental effect of mobile phone addiction, educators and parents should try their best to create a positive family environment. It can promote children's positive cognitive modes, enhance their ability to resist the lure of mobile phones, and then reduce their possibility of indulging in mobile phones. Creating a harmonious family atmosphere is better than preventing children from using mobile phones or eliminating the triggers for mobile phone addiction. Only in this way can children improve their ability to resist the lure of digital devices and better accommodate the living environment full of digital devices in the era of mobile Internet. Specifically, we also should pay more attention to individuals with low family cohesion and adaptability, formulate preventive intervention plans to encourage their parents to understand the prominent role of family function on their children's development, and guide them to improve the family environment, so as to promote their children's psychological adaptation. Besides, the findings of the present study reminded educators and guardians to promote individuals' adaptive cognition through school education, community publicity, and media, so as to reduce the occurrence of problematic behaviors. Moreover, young people should be encouraged to communicate with their peers and establish close relationships or secure peer attachment to gain more peer acceptance and social support and enhance their ability to cope with setbacks. High-quality peer attachment can not only enhance the protective impact of positive family environments on individuals' cognitive patterns but also could reduce their problematic behaviors, such as mobile phone addiction. Last but not least, our research indicated that whether it is peer attachment or family cohesion and adaptability, as long as it increases, it will have a positive impact on individuals' development. Specifically, for individuals with conflicting family relationships, it is particularly important to cultivate high-quality peer attachment for them to develop their positive cognitive styles and promote their behavioral adaptation. Therefore, educators should guide or help them to establish a secure peer attachment relationship and train them in the skills to obtain peer social support.

## Data availability statement

The original contributions presented in the study are publicly available. This data can be found at: [https://figshare.com/articles/dataset/Data\\_sav/23513964](https://figshare.com/articles/dataset/Data_sav/23513964).

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## Ethics statement

The studies involving human participants were reviewed and approved by Central China Normal University, Ethic Committee, EC, Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

S-LL, X-XC, and Q-LX contributed to conception and design of the study. X-XC and Q-LX organized the database. S-LL performed the statistical analysis. X-XC wrote the first draft of the manuscript. Q-LX wrote sections of the manuscript. X-WZ, CY, and Q-QL supervised the study. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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