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Relationship between personality and adolescent depression: the mediating role of loneliness and problematic internet use

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Abstract

Background Previous research has indicated that personality traits, loneliness, and problematic internet use (PIU) significantly contribute to the prevalence of adolescent depression. However, the specific interrelationships among these variables in explaining the occurrence of depression remain unclear. Drawing upon susceptibility theory and cognitive-behavioral theory, this study explored whether personality traits influences adolescent depression through loneliness and PIU.

Methods A total of 2476 adolescents (aged 12–18) from all over the country completed a psycho-social test, including the 10-Item Big Five Personality Inventory (BFI-10), three-Item Loneliness Scale (T-ILS), Problematic Internet Use Questionnaire-Short Form (PIUQ-SF-6) and the Patient Health Questionnaire-9 (PHQ-9). The mediation model was built and bootstrap method was used to test the mediating effect.

Results Results showed that neuroticism, conscientiousness, openness, and agreeableness have a direct role on depression. Loneliness and PIU partially mediated the relationship between neuroticism, conscientiousness, agreeableness and depression, and completely mediated the relationship between extroversion and depression.

Conclusions The results suggest that loneliness and PIU play important mediating roles in the relationship between personality traits and depression. This remind us that alleviating sense of loneliness and reducing overuse of the internet are a strategy for improve depression among adolescents.

Keywords Personality traits, Loneliness, Problematic internet use, Adolescent depression, Mediation analysis

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Introduction

Depression has a high incidence during adolescence. A previous meta-analysis reported that 34% of adolescents worldwide have experienced depression [1]. An epidemiological survey revealed that the prevalence of depression among Chinese adolescents is as high as 36.6% [2]. Adolescents with depression have different degrees of cognitive impairment, difficulty regulating emotions or sleep disturbance, and in severe cases, self-injury or suicidal behavior [3]. Depression has a profound impact on the physical and mental health of adolescents. Therefore, it is necessary to explore the potential factors and mechanisms of adolescent depression, in order to provide a theoretical basis for its prevention and treatment.

Previous studies have indicated that being bullied, parenting style, the level of self-esteem, attachment style and personality traits are possible determinants of adolescent depression [4, 5]. Among them, the role of personality traits on adolescent depression has attracted the attention of researchers. The predisposition model points out that personality traits is an independent risk factor for mental illness, such as depression [6]. Personality traits are relatively stable characteristics that organize and guide social beliefs and behavior. The Five-Factor Model (FFM) categorizes personality into five traits: neuroticism, extraversion, openness, agreeableness, and conscientiousness. A study by Gong found that neuroticism was positively correlated with depressive symptoms, whereas extraversion, openness, agreeableness and conscientiousness were negatively correlated [7]. Both Mourelatos and Zhou showed that neuroticism, agreeableness and conscientiousness were related to depression in adolescents, while extraversion and openness were unrelated to the depression [8, 9]. These findings suggested that the relationship between different personality traits and adolescent depression still needs further analysis. Therefore, the aim of this study is to explore the relationship between the big five personalities and adolescent depression based on a national survey.

The predisposition model also states that there are moderating or mediating factors between personality and depression. Loneliness is a subjective negative emotion, referring to the negative experience of a discrepancy between an individual's interpersonal relationships and their subjective social needs [10, 11]. According to the interpersonal theory, if adolescents have a sense of loneliness in their interpersonal relationships, it can lead to depression. For example, Erzen found that loneliness is an important predictor of depression [12]. On the other hand, there are various sources of loneliness, and personality is one of them. A meta-analysis by Buecker explores the relationship between personality and loneliness and results showed that extraversion, agreeableness, conscientiousness, openness was negatively correlated with

loneliness, while neuroticism was positively correlated with loneliness [13]. On this basis, this study proposes the hypothesis that loneliness plays a mediating role in personality traits and adolescent depression. To date, none have investigated the model proposed here, so this study attempts to explore this association.

The development of the internet brings convenience to people, but it also brings some problems, such as problematic internet use (PIU) [14]. PIU is characterized by excessive or poorly controlled preoccupations, urges or behaviors regarding computer use and internet access that lead to impairment or distress [15]. Kelley demonstrated that individuals who excessively use the internet tend to have worse physical health [16]. Park also demonstrated that PIU could predict depressive symptoms and suicidal ideation [17]. Recently, a systematic review confirmed that PIU was positively correlated with depression, anxiety and loneliness, while it was negatively correlated with subjective well-being [18]. Overall, PIU has negative effects on adolescents' physical and mental health. Furthermore, the relationship between personality and PIU has received extensive attention. Hidalgo-Fuentes had examined the associations between personality and PIU through a meta-analysis, and found that extroversion, openness, agreeableness and conscientiousness were negatively correlated with problem internet use, while neuroticism was significantly positively correlated [19]. Based on the above considerations, this study proposes the hypothesis that PIU plays a mediating role between the big five personalities and adolescent depression.

The cognitive-behavioral model suggests that individuals with intense loneliness are more prone to maladaptive cognition of the real world, and tend to seek fulfillment of their needs through the virtual world, thus increasing the risk of PIU [20]. Mamun also revealed that loneliness is a risk factor for PIU [21]. The stronger the sense of loneliness, the higher level of problematic internet usage. Therefore, these results lead us to hypothesize that loneliness and PIU are two possible mediators that explain the relationship between personality traits and adolescent depression in a sequential manner.

In summary, this study focuses on adolescents to explore the relationship between personality traits and depression, and whether the relationship was mediated by loneliness and PIU. We propose four hypotheses: H1: personality traits predict adolescent depression, and different personality traits may have different effects on depression. Specifically, higher neuroticism was associated with adolescent depression, while conscientiousness, agreeableness, extraversion, and openness had a protective effect against adolescent depression. H2: Loneliness may mediate the relationship between personality traits and depression. H3: PIU may mediate the relationship

between personality traits and depression. H4: Loneliness and PIU may have sequential mediating effects on the personality traits and depression. The hypothetical model is shown in Fig. 1. By testing these hypotheses, we hope to provide empirical evidence for the intervention of adolescent depression.

Methods

Participants and procedure

This study is a nationwide cross-sectional survey conducted from 20 June 2022 to 31 August 2022, with a multi-stage sampling of 148 cities from 23 provinces, 5 autonomous regions, and 4 municipalities. Quota sampling was utilized to select residents from 148 cities, the gender, age, and urban and rural distribution of the participants were basically in line with the population characteristics. Investigators were recruited and trained to enlist participants, with a total of 21,916 residents participating in this study. The research protocol has been registered with the China Clinical Trial Registration Center (registration number ChiCTR200061046). The investigation was carried out in accordance with the latest version of the Declaration of Helsinki and this study was approved by the Ethics Research Committee of the Health Culture Research Center of Shaanxi (No. JKWH-2022-02). All participants were informed of the purpose, significance and other details of the study and signed informed consent.

Inclusion criteria: (1) Aged from 12 to 18 years old; (2) Having the nationality of the People's Republic of China; (3) Permanent residents of China; (4) Participate in the

research voluntarily and fill in the informed consent form; (5) Participants can complete the network questionnaire survey by themselves or with the assistance of investigators; (6) Understand the meaning of each item in the questionnaire.

Exclusion criteria: (1) Individuals with cognitive impairment or mental disorders; (2) Those who were participating in other similar research projects.

The data were extracted according to the needs of this study (Fig. 2). After excluding those who were older than 18 years, 3222 questionnaires were obtained. Among them, 746 questionnaires with logical errors were eliminated (mainly due to contradictions or inconsistencies between important variables such as age, family type, educational level, marital status, etc.). Finally, 2476 questionnaires were obtained.

Measures

General demographic information: age; gender; one-child households; current educational stage; family type; family per capita monthly income.

Big five personality inventory-10 (BFI-10)

This scale was developed by Rammstedt selecting 10 questions from the BFI-44. It comprises five dimensions: neuroticism, agreeableness, extroversion, conscientiousness, and openness. The scale items are scored using the 5-point Likert scale (from 1 "strongly disagree" to 5 "strongly agree"). The range for each sub scale is from 2 to 10. Previous studies have shown that the scale exhibits good reliability and validity [22, 23].

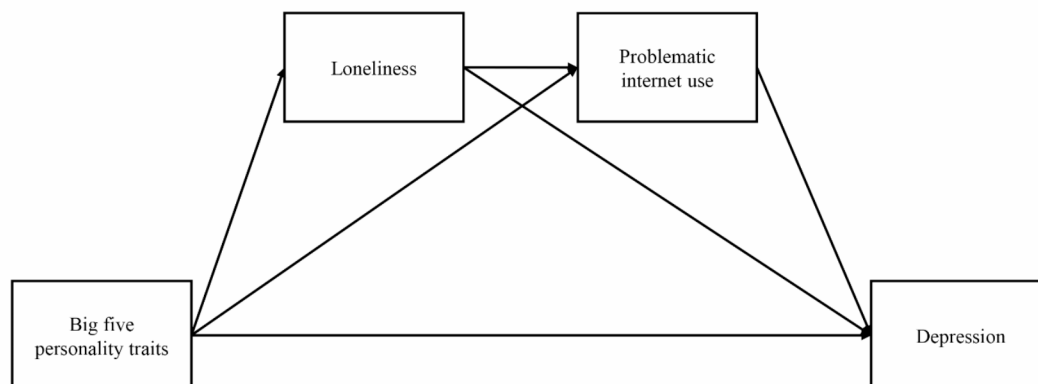


Fig. 1 Hypothetical model of the relationship between personality traits, loneliness, problematic internet use and depression

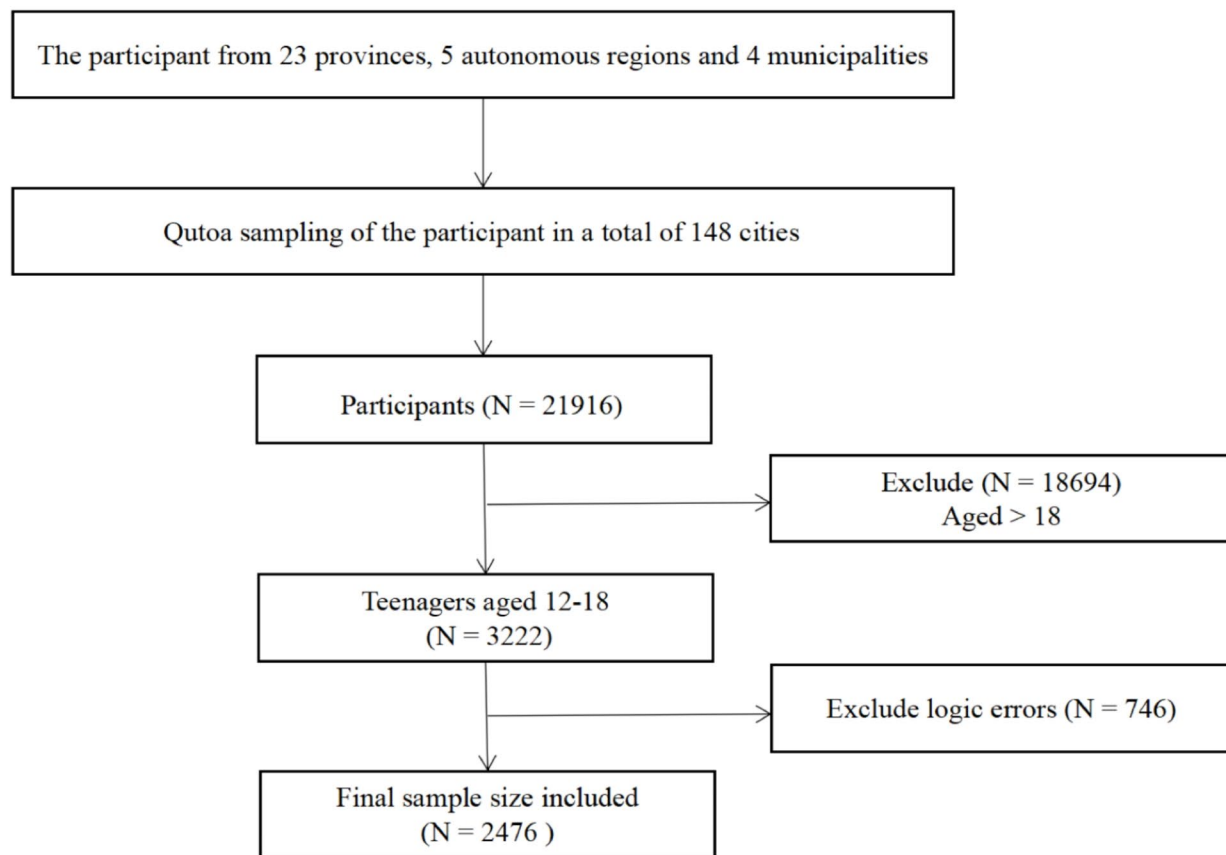


Fig. 2 Flowchart of participant enrollment

Patient health questionnaire-9 (PHQ-9)

The scale consists of a total of 9 items, using a 4-point scale (from 0 “Never” to 3 “nearly every day”). The higher the scores, the more severe the depressive symptoms. A score less than 5 means no depressive symptoms, while a score of 5 or higher suggests the presence of depressive symptoms. The specific classification includes: mild depression (5–9 points), moderate depression (10–14 points), moderately severe depression (15–19 points), and severe depression (20–27 points). The Chinese version of PHQ-9 has satisfactory psychometric properties [24]. The Cronbach’s α coefficient of the PHQ-9 is 0.84.

Three-item loneliness scale (T-ILS)

The scale was developed by Hughes in 2004 to measure individuals’ level of loneliness. It consists of three items: “How often do you feel left out?”, “How often do you feel isolated from others?” and “How often do you feel that you lack of companionship?”. Each item is assessed using 3-point Likert scale (from 1 “almost never” to 3 “often”). Higher scores indicate a greater level of loneliness. The Chinese version of T-ILS has good reliability and validity

[25]. In this study, the Cronbach’s α coefficient of this scale in this study is 0.88.

Problematic internet use questionnaire short form (PIUQ-SF)

The scale consists of 6 items within 3 domains (i.e., obsession, neglect, and control disorder) [26]. Each item is scored in the 5-point Likert scale (from 0 “Never” to 4 “Always”). Total scores can be obtained by adding points for each item. The higher points indicate the higher level of PIU. The Chinese version of PIUQ-SF has been found to have high applicability [27, 28]. The Cronbach’s α coefficient of this scale in this study is 0.91.

Statistical analyses

The data were analyzed using SPSS 21.0 (IBM, Armonk, NY, USA) and AMOS 24.0. First, we performed a descriptive analysis of the data, the categorical variables were described using frequency (proportion), and the quantitative data were described using median and inter-quartile range. And the rank-sum test was used to analyze the influencing factors of depression. Factors that affect depression were used as control variables in the subsequent to establish the mediation model. Second, the

Spearman's Rho. correlation test was used to analyze the correlations between variables that do not meet the normality test. Third, the mediation model was built to test the mediating role of loneliness and PIU, with neuroticism, agreeableness, extraversion, conscientiousness, and openness as independent variables, loneliness and PIU as mediator variables, and adolescent depression as dependent variable. Maximum likelihood estimation was used to examine the model parameters. The model fit was calculated and the model was considered appropriate when Goodness of Fit Index (GFI)>0.90, Comparative Fit Index (CFI)>0.90, Incremental Fit Index (IFI)>0.90 and Root Mean Square Error of Approximation (RMSEA)<0.08 [29]. The bootstrap method was used to test the mediating effect (sampling=10000). The direct, indirect, or total effect are statistically significant if the 95% confidence interval (95% CI) of the estimation of the path coefficient does not include 0. A p-value of 0.05 was considered statistically significant when a two-tailed test was used.

Results

Participant characteristics

A total of 2476 adolescents aged 12–18 were included in this study, with an average age of 16.08 ± 1.82 . There were 1173 males and 1303 females, and more than one-half of participants were non-only children, and 100 in primary school, 648 in junior high school, 1098 in high school or vocational school, and 630 in undergraduate or junior college. 88% of participants belonged to nuclear families, and 40.2% reported an per capita income of 3001–6000.

We assessed whether depression levels varied significantly by sociodemographic characteristics. The results showed that women had significantly higher level of depression than men. Non-only children had higher scores of depression than only children. Compared with those in junior school or below, those in senior high school or above had higher level of depression. In terms of family type, the single-parent family and other family types had higher depression scores. Besides, the participants with lower per capita income (≤ 3000) had higher depression scores. These results are summarized in Table 1.

Correlations between research variables

Correlation analysis was conducted on four variables of big five personality (extraversion, agreeableness, conscientiousness, neuroticism, and openness), loneliness, PIU, and depression. The results are shown in Table 2. The variables were all significantly associated with each other, except for openness, and its correlations with conscientiousness, loneliness, PIU, and depression. Specifically, neuroticism was positively correlated with loneliness, PIU and depression. Agreeableness, extraversion and conscientiousness were negatively correlated with loneliness, PIU and depression. Loneliness was positively correlated with PIU and depression. PIU was positively correlated with depression.

Mediation analysis

The fit indices were as follows: GFI=0.986, IFI=0.974, CFI=0.973, RMSEA=0.052 (90% CI=0.047–0.058,

Table 1 Demographic characteristics of the participants (N=2467)

Characteristics		N	(%)	Median PHQ-9 Score (IQR)	Test statistic	P
Gender	Men	1173.00	47.40	5 (1, 9)	-4.20	< 0.001
	Women	1303.00	52.60	6 (2, 10)		
One-child households	Yes	834.00	33.70	5 (1, 9)	-3.82	< 0.001
	No	1642.00	66.30	6 (2, 9)		
Current educational stage	Primary school	100.00	4.00	2.5 (0, 7)	63.66	< 0.001
	Junior high school	648.00	26.20	4 (1, 9)		
	Technical secondary or high school	1098.00	44.30	6 (2, 10)		
	Junior college or undergraduate	630.00	25.40	7 (3, 9)		
Family type	Nuclear family	2179.00	88.00	5 (2, 9)	47.73	< 0.001
	Skip-generation raising family	20.00	0.80	9 (4, 14.75)		
	Single parent family	150.00	6.10	8 (3, 13)		
	Joint family	47.00	1.90	7 (2, 9)		
Family per capita monthly income	Other forms of family type	80.00	3.20	8 (5, 14)	21.43	< 0.001
	≤ 3000	824.00	33.30	6 (2, 10)		
	3001–6000	995.00	40.20	5 (1, 9)		
	6001–9000	267.00	10.80	6 (2, 9)		
	9001–12,000	191.00	7.70	5 (2, 9)		
	$\geq 12,000$	199.00	8.00	5 (0, 10)		

Note. IQR=interquartile range

Table 2 Correlations matrix among tested variable

Variables	1	2	3	4	5	6	7	8
1. Neuroticism	1							
2. Agreeableness	-0.23**	1						
3. Extraversion	-0.18**	0.08**	1					
4. Conscientiousness	-0.14**	0.14**	0.14**	1				
5. Openness	-0.07**	0.20**	0.26**	0.03	1			
6. Loneliness	0.30**	-0.16**	-0.15**	-0.27**	0.04	1		
7. PIU	0.16**	-0.12**	-0.05*	-0.26**	0.04	0.42**	1	
8. Depression	0.31**	-0.21**	-0.14**	-0.32**	-0.02	0.65**	0.45**	1

Note. * $P < 0.05$; ** $P < 0.01$; PIU=Problematic Internet Use

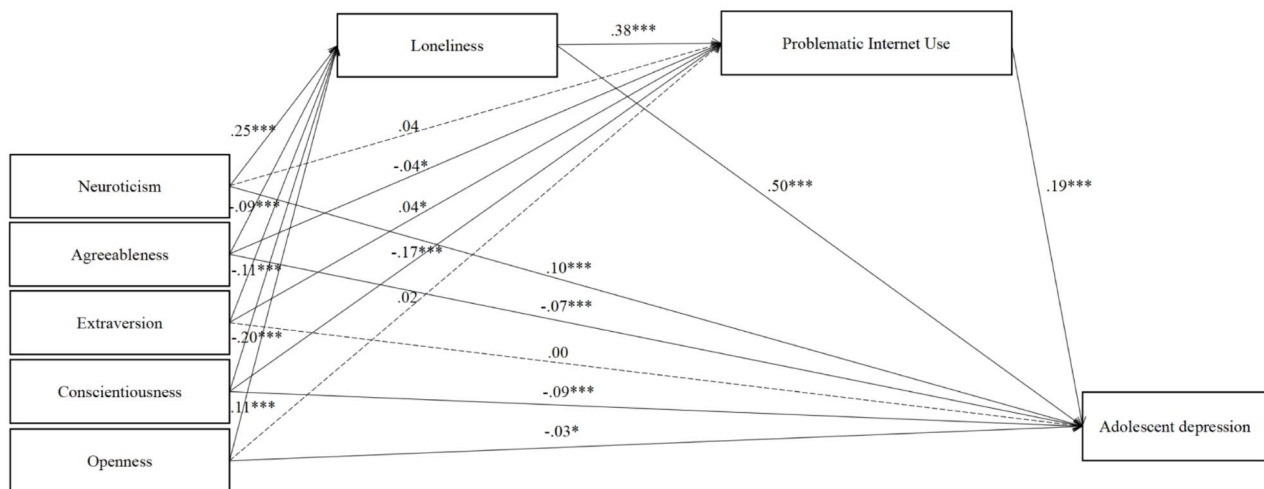


Fig. 3 Path diagram and direct effect estimates between the Big Five personality, loneliness, problematic internet use and depression. Solid lines indicate significant effects ($P < 0.05$, *** $P < 0.001$), whereas dotted lines indicate insignificant effects ($P > 0.05$). Control variables predicting depression (i.e. gender, current education stage and family per capita monthly income) are not presented for simplicity reasons

$P = 0.241$), and the overall model fit was adequate. The specific path coefficient between variables is shown in Fig. 3.

As a predictor in the model, higher neuroticism was associated with adolescent depression ($\beta = 0.10$, $P < 0.001$). Neuroticism positively predicted loneliness ($\beta = 0.25$, $P < 0.001$) but not PIU ($\beta = 0.04$, $P = 0.062$), loneliness positively predicted PIU ($\beta = 0.38$, $P < 0.001$), and PIU in turn positively predicted depression ($\beta = 0.19$, $P < 0.001$). Loneliness (indirect effect = 0.124, 95% BootLLCI = 0.101, BootULCI = 0.146) played a mediating role in the relationship between neuroticism and depression, while PIU (indirect effect = 0.007, 95% BootLLCI = -0.00008, BootULCI = 0.015) did not. Loneliness and PIU played a chain mediating role between neuroticism and depression (indirect effect = 0.018, 95% BootLLCI = 0.013, BootULCI = 0.024).

As an independent variable in the model, agreeableness had a protective effect against adolescent depression ($\beta = -0.07$, $P < 0.001$). Agreeableness negatively predicted loneliness ($\beta = -0.09$, $P < 0.001$) and PIU ($\beta = -0.04$,

$P < 0.05$), loneliness positively predicted of PIU ($\beta = 0.38$, $P < 0.001$), and PIU can also positively predict depression ($\beta = 0.19$, $P < 0.001$). Loneliness (indirect effects = -0.045, 95% BootLLCI = -0.066, BootULCI = -0.025) and PIU (indirect effects = -0.008, 95% BootLLCI = -0.016, BootULCI = -0.001) independently mediated the relationship between personality traits and depression. Loneliness and PIU played a chain mediating role between agreeableness and depression (indirect effects = -0.006, 95% BootLLCI = -0.010, BootULCI = -0.004).

As an independent variable in the model, extraversion had no significant impact on adolescent depression ($\beta = 0.00$, $P = 0.781$). Extraversion negatively predicted loneliness ($\beta = -0.11$, $P < 0.001$) and positively predicted PIU ($\beta = 0.04$, $P < 0.05$), loneliness positively predicted of PIU ($\beta = 0.38$, $P < 0.001$), and PIU can also positively predict depression ($\beta = 0.19$, $P < 0.001$). Loneliness (indirect effects = -0.057, 95% BootLLCI = -0.079, BootULCI = -0.037) and PIU (indirect effects = 0.008, 95% BootLLCI = 0.001, BootULCI = 0.016) independently mediated the relationship between extraversion and

depression. Loneliness and PIU played a chain mediating role between extraversion and depression (indirect effects = -0.008, 95% BootLLCI = -0.012, BootULCI = -0.005).

As an independent variable in the model, conscientiousness had a protective effect against adolescent depression ($\beta = -0.09$, $P < 0.001$). Conscientiousness negatively predicted loneliness ($\beta = -0.20$, $P < 0.001$) and PIU ($\beta = -0.17$, $P < 0.001$), loneliness positively predicted of PIU ($\beta = 0.38$, $P < 0.001$), and PIU can also positively predict depression ($\beta = 0.19$, $P < 0.001$). Loneliness (indirect effect = -0.098, 95% BootLLCI = -0.118, BootULCI = -0.078) and PIU (indirect effect = -0.032, 95% BootLLCI = -0.043, BootULCI = -0.023) independently mediated the relationship between conscientiousness and depression. Loneliness and PIU played a chain mediating role between conscientiousness and depression (indirect effect = -0.014, 95% BootLLCI = -0.019, BootULCI = -0.010).

As the independent variable in the model, the total effect of openness on adolescent depression was not significant (total effect = 0.030, 95% BootLLCI = -0.010, BootULCI = 0.070). The total direct effect (direct effect = -0.030, 95% BootLLCI = -0.070, BootULCI = -0.002) and indirect effect (indirect effect = 0.070, 95% BootLLCI = 0.040, BootULCI = 0.090) were significant. But the effects operated in opposite directions. This reminds us that loneliness and PIU played a masking effect, rather than mediating role, between openness and depression.

Discussion

This study explored the relationship between personality traits and depression, and the role of loneliness and PIU in this relationship. Among the influencing factors of adolescent depression, personality traits are undoubtedly very important. Our findings suggested that different traits have different effects on depression, which is consistent with the results of other studies. Among them, neuroticism positively predicted depression. Neurotic adolescents are more likely to have more ruminative thinking and emotional regulation difficulties, which makes adolescents more likely to have depression [30, 31]. Agreeable individuals are able to establish good relationships with friends and classmates and have more social support, which can protect against depression [32]. The conscientious individual is able to view stress as a challenge and respond flexibly, which is a protective factor for mood disorders [33]. Several studies have shown that extroversion is a protective factor for depression. But this study found that extroversion did not directly predict depression. Study showed that extroversion involves several facets and different facets have different relationships with depression [34]. When individuals belong to the

facets of the warmth, gregariousness, activity and excitement-seeking, it will probably not be protective factors for depression.

Previous studies have indicated that there is an intrinsic link between personality traits, loneliness and depression. Vanhalst has shown that neuroticism regulates the relationship between loneliness and depression [35]. And Schutter suggested that depression plays a mediating role between personality traits and loneliness [36]. Unlike the above studies, this study proposed an alternative account in which loneliness is an important factor in the relationship between personality traits and depression. Adolescent with high neuroticism experience more loneliness, which lead to depression, suggested that we should pay attention to the loneliness of high neuroticism adolescents to reduce their emotional pressure and promote their healthy growth.

Studies have shown that personality traits and depression are important factors in PIU [37]. Koronczai found that neuroticism can affect PIU through depressive symptoms [38]. Przepiorka also confirmed the mediating role of depression in personality traits and PIU, in which depression completely mediates the association between neuroticism, extraversion, agreeableness and PIU [39]. This study confirmed that PIU plays a mediating role between personality traits and depression, but this link has only been shown to exist in agreeableness, extroversion and conscientiousness. These results suggested that we should pay attention to the internet use of adolescents with low levels of agreeableness, extroversion and conscientiousness.

This study also found that there is a sequential relationship between loneliness and PIU. Neuroticism, extraversion, conscientiousness, and agreeableness can influence feelings of loneliness, which in turn affect adolescents' internet use behavior, thus leading to depression. Kim found that individuals with a stronger sense of loneliness are more likely to overuse the internet [40]. A longitudinal study also showed that loneliness can predict PIU [41]. However, previous research has shown that PIU can also predict loneliness [42]. These studies indicated that the relationship between PIU and loneliness is likely to be reciprocal, so more longitudinal studies are needed to confirm the causal relationship.

To note, we found openness negatively predicts adolescent depression in a direct way. At the same time, openness can positively predict depression through the mediation effect of loneliness or the causal chain of loneliness and PIU. Feelings, one facet of openness, may explain the conflicting results [43]. The facet of feelings represents the individual's perception and acceptance of their own inner emotions, which includes positive and negative aspects. Experiencing more positive emotions may be a protective factor for negative emotions. We

should pay attention to the feelings of openness, promote their positive experience, and make them free from negative emotions.

The study also has some limitations. First, this is a cross-sectional study, causal inference between variables is limited. According to the compensatory internet use theory, PIU might be an expression of coping behavior because of depression. And this is different from the results of the current study, so the relationship between the variables should be tested using a longitudinal design in the future. Second, the research population was limited to the Chinese people, and whether the conclusion applies to other countries remains to be determined. Third, we have controlled for the relevant variables to make the relationship between them as accurate as possible, but whether other variables will affect this relationship also needs to be explored.

Clinical implications

This research results have certain theoretical and practical significance. Firstly, theoretical significance, this study elucidated that personality traits can influence adolescent depression through loneliness and problematic internet use, which enriches the related research between personality traits and adolescent depression. In practical sense, the results of this study suggest that for adolescents with high neuroticism, low extroversion, conscientiousness and agreeableness, on the one hand, alleviating loneliness can promote their mental health and increasing peer support or encouraging adolescents to participate in outdoor activities can be considered as implementable intervention programs [44, 45]. At the same time, improving problem internet use is another important way to prevent adolescent depression. Han showed that game coding education can effectively improve adolescents' problematic internet use, and carrying out game coding courses may be a potentially valuable intervention approach to prevent problematic internet use [46].

Conclusions

In this study, we found that personality traits, with the exception of openness, in adolescents can affect depression through the role of loneliness and PIU. This study expands our understanding of adolescent depression, guiding adolescents with higher neuroticism and lower extroversion, conscientiousness, agreeableness to establish good social connections and moderate their internet use. These strategies can serve as targets for alleviating depression.

Abbreviations

PIU	Problematic internet use
BFI-10	10-Item Big Five Personality Inventory
T-ILS	three-Item Loneliness Scale
PIUQ-SF-6	Problematic Internet Use Questionnaire-Short Form

PHQ-9	Patient Health Questionnaire-9
GFI	Goodness of Fit Index
CFI	Comparative Fit Index
IFI	Incremental Fit Index
RMSEA	Root Mean Square Error of Approximation
IQR	Interquartile range
95%CI	95%Confidence interval

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12888-024-06131-1>.

Supplementary Material 1

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Author contributions

CRF, CL, YBW, JH: Study design and manuscript writing. XMZ, ZQW, CL: Data collection. SXZ, HCL: Statistical analysis. WJQ, ZQW: Data interpretation. YBW, JH: Study supervision and manuscript critical revisions. JH, CRF: Funding acquisition. All authors reviewed the manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests

The authors declare no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

The research protocol has been registered with the China Clinical Trial Registration Center (registration number ChiCTR200061046). This study was approved by the Ethics Research Committee of the Health Culture Research Center of Shaanxi (No. JKWH-2022-02). All participants gave informed consent before enrollment.

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