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ORIGINAL ARTICLE

The Influence of Stressful Life Events on Adolescents' Problematic Internet Use: the Mediating Effect of Self-worth and the Moderating Effect of Physical Activity

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Abstract
Although prior studies have investigated the association between stressful life events and adolescents' problematic Internet use, the underlying mechanism remains unclear. The self-worth orientation theory assumes that self-worth is the ultimate motivation of human behavior, and it derives from a self-worth supporting system, including trust or support from significant others and personal achievement, among others. Therefore, stressful life events might predict adolescents' problematic Internet use by undermining their self-worth. However, physical activity might moderate the effect of stressful life events on self-worth. To examine these hypotheses, 2058 Chinese adolescents (M_{age} = 14.03 years, SD = 0.83 years) were recruited to complete a series of questionnaires. The results showed that self-worth partially mediated the relationship between stressful life events and problematic Internet use, and physical activity moderated the association between stressful life events and self-worth. In addition, the negative relationship between stressful life events and self-worth was stronger for adolescents with higher levels of physical activity, in line with the reverse risk-buffering model. Further multigroup analysis showed that the current theoretical model was robust in both male and female groups. This study has certain theoretical and practical significance for the prevention of adolescents' problematic Internet use.

Keywords Stressful life events · Adolescents · Problematic Internet use · Self-worth orientation theory · Physical activity

The Internet has become an essential part of everyday life, changing the ways people live, study, and entertain. However, Internet use is a double-edged sword. The excessive and

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maladaptive use of the Internet has a negative influence on individual mental health (Carli et al., 2013; El Asam et al., 2019), academic performance (Azizi et al., 2019; Sengupta et al., 2018), sleep (Alimoradi et al., 2019), and behavioral adaptation (Carli et al., 2013), which has attracted increasing attention in the scientific community. This phenomenon is known as "problematic Internet use (PIU)" (Caplan, 2002), referring to "use of the Internet that creates psychological, social, school and/or work difficulties in a person's life" (Beard & Wolf, 2001); it is also known as "Internet addiction" (Young, 1998), "pathological internet use" (Davis, 2001), or "compulsive internet use" (Meerkerk et al., 2009). Despite the different terms used, researchers are describing the same phenomenon (Uçur & Dönmez, 2021). It is worth noting that PIU covers all forms of Internet applications, thus reflecting various kinds of excessive Internet use behaviors (Tóth-Király et al. 2021). In view of this, we used PIU to describe the phenomenon wherein problematic and excessive use of the Internet exerts a negative influence on physical and mental health among adolescents.

According to a recent survey, the number of adolescent netizens in China reached 183 million in 2020, with an Internet penetration rate of 94.9% among them (CNNIC is China Internet Network Information Center 2021). Moreover, the prevalence of PIU among adolescents is increasing with the increasing popularity of the Internet among them (Spada, 2014). According to a systematic literature review, the prevalence of generalized Internet addiction in East Asian countries varied from 12.6 to 67.5%, and the majority of samples were adolescents (Kuss Daria et al. 2021). Therefore, considering the negative effect and high prevalence of PIU, exploring the mechanism of adolescent PIU is of great significance for effective intervention.

The Association Between Stressful Life Events and Adolescent PIU

Adolescence, the transition from childhood to adulthood, is a critical period filled with alterations in physiology, psychology, and behavior (Heaven, 2002), during which adolescents experience stress from various aspects (e.g., academic stress, interpersonal interaction, family environment) (Hashmi, 2013; Lürzel et al., 2010; Murray et al., 2011). As Internet use may be characterized by entertainment and convenience, adolescents adopt it to cope with life stressors (Velezmoro et al., 2010) and regulate their negative emotions (Caplan, 2006), further increasing the likelihood of it becoming problematic (Li et al., 2010). Numerous studies have suggested that stressful life events are an important risk factor for adolescent PIU (Li et al., 2016; Yan et al., 2014; Zhao et al., 2017).

Although previous studies have made contributions to the body of research in the areas of stress and adolescent PIU, gaps in the literature remain. First, most previous studies concentrated on the association between specific stressful events (such as academic stress or interparental pressure) and PIU (Jun & Choi, 2015; Tang et al., 2014; Wang et al., 2021), instead of a wide variety of stressful events. However, facing multiple stressors is the norm among adolescents (Hashmi, 2013), which easily leads to problematic behaviors. Moreover, previous studies failed to focus on the underlying mechanism of adolescent PIU and did not identify those who are vulnerable to PIU, especially under the condition of high levels of stressful life events. To fill these gaps, this study aims to explore the underlying mechanism between stressful life events and

PIU to provide a theoretical basis for the prevention of and intervention in PIU among adolescents.

The Mediating Effect of Self-worth

The self-worth orientation theory assumes that humans, a reasonable and socialized animal, are prone to determining the rationality of their actions. They try to construct and interpret a system of explanations, both inside and outside of themselves, making great efforts to find out who they are and the meaning of life. In other words, self-worth is the ultimate goal of human behavior (Jin, 2010; Jin & Shan, 2011). Research indicates that self-worth derives from a self-worth supporting system, which includes, among others, trust and support from significant others, socioeconomic status, and personal achievement (academic performance for students) (Jin, 2010; Jin & Shan, 2011; Li et al., 2020; Yu et al., 2017).

Adolescents experience stress from various aspects, including academic stress and interpersonal problems, which are precisely the resources that influence self-worth (Li et al., 2020; Yu et al., 2017). According to the self-worth orientation theory, once individuals are exposed to stressful situations, their self-worth supporting system will be challenged, which leads individuals to experience low levels of self-worth. When supporting resources are insufficient to satisfy people's self-worth needs, they resort to other compensatory means (Li et al., 2020; Yu et al., 2017). For example, previous studies found that once individuals fail to satisfy their self-worth in real life, they are likely to seek it from alternative sources, such as a preference for online social interaction (Yu et al., 2017). In contrast, when supporting resources are sufficient, alternative sources (e.g., online activities) become less attractive to individuals (Jin, 2010; Jin & Shan, 2011). That is, when some resources that support self-worth are lacking, other resources, such as online activities, can play a compensatory role, which can easily lead to dependence on the Internet. Therefore, according to the self-worth orientation theory, such supporting resources could influence individuals' self-worth, affecting the attractiveness of network activities to them and further predicting their dependence on the Internet.

Based on the above discussion, we proposed that stressful life events may increase the possibility of adolescent PIU by hindering them from constructing self-worth in real life. Thus, we hypothesized that self-worth would mediate the association between stressful life events and adolescent PIU (*H1*).

The Moderating Effect of Physical Activity

Although stressful life events could increase the tendency of PIU indirectly by influencing the construction of self-worth in real life, it seems unlikely that all adolescents suffering from such events would experience a sense of decreased self-worth and develop PIU. The organism-environment interaction model maintains that it is not environmental factors alone, but the interaction between individual and environmental factors that determines individual social development outcomes (Lerner et al., 2006).

Over the past few decades, researchers have found that physical activity in adolescents is linked to a wide array of psychological benefits (Carter et al., 2021; Currier et al., 2020;

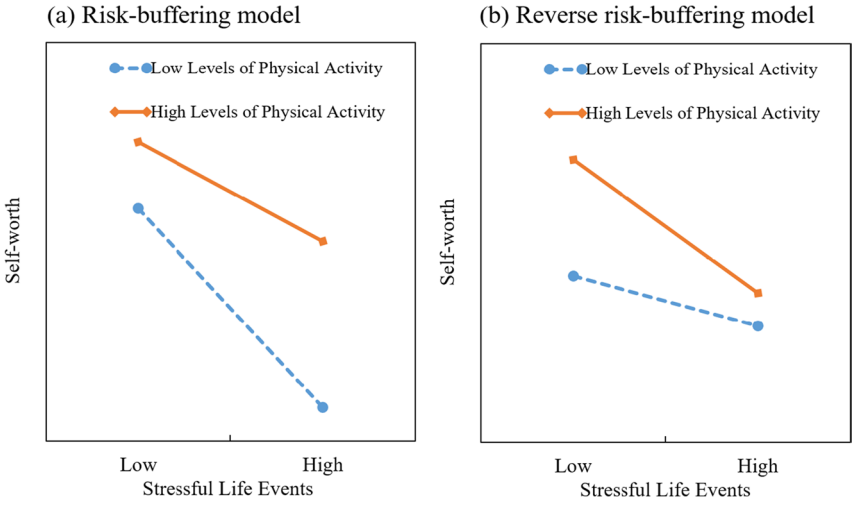

Fig. 1 Two different moderating models of physical activity on the relationship between stressful life events and self-worth

Haugen et al., 2011). Ample evidence suggests that, in particular, physical activity could attenuate the negative influence of environmental factors (e.g., school-related stress, family conflict) on individual emotions as a stress buffer (Haugland et al. 2003; Sigfusdottir et al., 2011) and further reduce the likelihood of PIU among adolescents (Zheng et al., 2020).

Physical activity might moderate the relationship between stressful life events and self-worth as a stress buffer because of the following aspects. First, from a physiological perspective, physical activity, an energetic activity characterized by increased blood flow and oxygen uptake, is associated with the release of hormones, which contributes to a better-regulated physiological response to various stresses (Greenwood & Fleshner, 2011; Klaperski et al, 2013; Sothmann, 2006). Second, from a psychological perspective, physical activity could serve as an effective distraction from stressful stimuli, thereby reducing the negative influence of stress on individual development outcomes (Altshuler & Ruble, 1989; Leith, 1994). Therefore, it is reasonable to assume that engaging in physical activity could enable individuals to "feel better" when faced with stressful life events, attenuating the deteriorating effect of such events on self-worth, further reducing the tendency of PIU among adolescents.

The discussion above suggests that physical activity might protect individuals' self-worth from stressful life events as an important protective factor, which is consistent with the risk-buffering model (Li et al., 2018; Peng et al., 2019; Wang et al., 2018). This model holds that protective factors may attenuate the adverse effects of risk factors on individual development. Thus, the link between stressful life events and self-worth is weaker for adolescents with higher levels of physical activity (Fig. 1a).

However, according to previous studies (Peng et al., 2019; Rueger et al., 2016; Wang et al., 2018), the moderating effect of physical activity on the relationship between stressful life events and self-worth might also fit the reverse risk-buffering model, which states that protective factors may only play a role in low-risk conditions, and their protective effect is dampened once the risk factors reach a relatively high level (Peng et al., 2019). Following this logic, there is evidence that cumulative stressful life

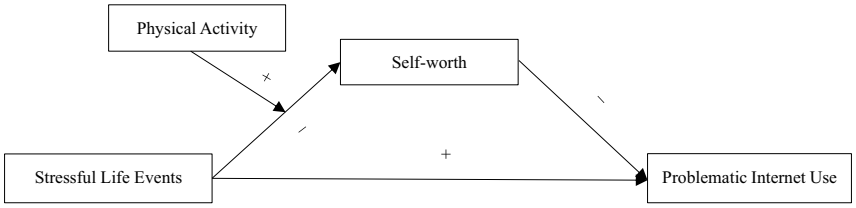

Fig. 2 The mediating effect of self-worth and the moderating effect of physical activity on the relationship between stressful life events and PIU

events overwhelm adolescents, leading them to experience a variety of psychological maladjustments (Monroe, 2008; Wang & Mesman, 2015). In this case, physical activity does not buffer the extremely negative effects of stressful life events on individual adaptation. Specifically, high levels of physical activity could enable adolescents to obtain higher self-worth when exposed to low levels of stressful life events; however, once these events reach a high level, physical activity loses its protective effect, which further leads to low self-worth and PIU. Thus, the moderation model would be consistent with the reverse risk-buffering model (Fig. 1b).

In sum, this study hypothesized that physical activity could moderate the relationship between stressful life events and self-worth (*H2*) (Fig. 2). And this moderation effect of physical activity might manifest in one of two ways (Fig. 1).

The Present Study

To explore the proposed model, this study used a self-report method to measure the stressful life events, self-worth, PIU, and physical activity among adolescents. In addition, given that previous studies found gender (Zhai et al., 2019), age (Okwaraji et al., 2015), health status (Kelley & Gruber, 2013), and family economic situation (Yu et al., 2017) to be associated with adolescent PIU, therefore, these variables were considered as covariates in the subsequent analyses.

Method

Participants

The participants were 2105 middle school students recruited from multiple provinces in China. Considering the representativeness and availability of the sample, we collected data from multiple regions in China as comprehensively as possible. In the present survey, the researchers sampled two provinces (Hubei and Anhui) from the central region, two (Zhejiang and Jiangsu) from the eastern region, and one (Guangdong) from the southern region. After removing incomplete data, 2058 valid participants remained, consisting of 1037 males and 1021 females. Among them, 1104 students were in the seventh grade (572 males, $M_{age} = 13.51$ years, $SD = 0.55$), 744 in the eighth grade (373 males, $M_{age} = 14.44$ years, $SD = 0.55$), and 210 in the ninth grade (92 males, $M_{age} = 15.33$ years, $SD = 0.60$). The mean age of the participants was 14.03 years ($SD = 0.83$).

Measures

Stressful Life Events

The Adolescent Self-Rating Life Events Checklist was adopted to assess individuals' subjective suffering from stressful life events experienced during the past 12 months (Liu et al., 1997). This questionnaire comprises 27 items that are categorized into six types of problems: interpersonal (e.g., "I was misunderstood by others"); academic pressure (e.g., "I failed an examination"); punishment (e.g., "I was criticized or punished"); bereavement (e.g., "A friend or family member died"); health (e.g., "I was seriously ill"); and others. Participants answer the question, "Whether the stressful life events had happened over the past 12 months or not?" If the answer is "no," a score of 0 is given. If the answer is "yes," they continue to assess the influence of stressful life events, resulting in a score ranging from 1 (not at all) to 5 (very much). This questionnaire has demonstrated good reliability and validity in Chinese adolescents (Li et al., 2016; Mo et al., 2019). Higher total scores on the scale represent a greater number of stressful life events experienced in the past 12 months. In the present study, Cronbach's α was 0.95.

Self-worth

Adolescent self-worth was assessed using the Rosenberg Self-Esteem Scale, which represents overall feelings of individual self-worth and self-acceptance (Rosenberg, 1965). This scale consists of 10 items (e.g., "On the whole, I am satisfied with myself"). Participants were instructed to rate on a 5-point Likert scale, ranging from 1 (this is not the case) to 5 (this is true). Its reliability and validity have been confirmed in the Chinese context (Chen & Wei, 2011; Nie et al., 2018). In the present study, Cronbach's α was 0.83.

Physical Activity

The Physical Activity Rating Scale (PARS-3) was used to assess adolescent physical activity. This scale was originally developed in Japan (Hashimoto, 1990) and has been translated and revised in the Chinese context (Liang, 1994). It comprises three items assessing the intensity of physical activity ("During the last four weeks, which of the following physical activities have you mostly participated in?"); its frequency ("How often do you participate in the above physical activity in a month?"); and duration ("During the last four weeks, how long have you participated in the above physical activity every time?"). Responses for the three items were rated on a 5-point scale. The scores of the first and second items ranged from 1 to 5; however, the third item was scored from 0 to 4. The level of physical activity was evaluated by multiplying intensity, frequency, and duration, with the resulting score ranging from 0 to 100. Higher scores indicate higher levels of physical activity.

Problematic Internet Use

Young's Internet Addiction Diagnostic Questionnaire was used to measure adolescent PIU (Young, 1998). This scale was found to have a high level of reliability in Chinese samples (Yu et al., 2017). It contains eight items (for example, "Do you feel the need to use the Internet with increasing amounts of time in order to achieve satisfaction?"; "Do you use the Internet as a way to escape from problems and deal with negative emotions?"). Participants

responded with a dichotomous answer ("yes" or "no") for each item. Those who answered "yes" to five or more of the eight items were classified as "problematic Internet users." To better interpret and explore the relationships among variables, we considered Internet addiction as a continuous variable and averaged all items as an indicator of PIU, based on previous studies (Yu et al., 2017; Zheng et al., 2020). Higher scores indicate a stronger tendency toward PIU. In the current study, Cronbach's α was 0.83.

Demographic Measures

We measured demographic information, including gender, age, health status, and family economic situation, which were regarded as covariates in the statistical analysis. We dummy coded adolescents' gender (1 = "male," 2 = "female"). Health status was rated on a 4-point scale, with higher scores indicative of high levels of health status. In addition, higher scores of family economic situation also indicated better economic situation.

Procedure

Informed consent was obtained from all participants before the assessment. Moreover, teachers and school administrators from each school were recruited and trained as research assistants to standardize the data collection process. Further, the students were invited to complete the questionnaire on the Internet. Finally, we analyzed the data to test the hypotheses.

Data Analysis

SPSS software (version 22.0) was used for the data analysis. First, descriptive statistics (mean and standard deviation) were calculated to reflect the overall characteristics of the sample. Second, we adopted SPSS macro PROCESS (http://www.afhayes.com) to test the moderated mediation model developed by Hayes (2013). This macro can examine more than 70 models, including the mediation model, moderation model, and other models that are more complex. In this study, macro PROCESS model 4 (which represents the mediation model, consistent with *H1* in this study) was used to explore the mediating effect of self-worth on the relationship between stressful life events and PIU. Then, macro PROCESS model 7 (the first half path of the mediation model is moderated by the moderator, consistent with *H2* in this study) was adopted to explore the moderating role of physical activity on the mediation model of self-worth. A bootstrapping procedure was adopted to estimate the indirect effect and confidence intervals (CI; without zero in the confidence interval indicating statistical significance).

Results

Common Method Bias Tests

Because we only used a self-report method to collect data, Harman's single-factor test (Podsakoff, 2003) was adopted to assess the extent to which the data were affected by common method bias. The results showed that the initial eigenvalues of the seven factors were

higher than 1, and a single factor explained 26.55% of the total variance, which was lower than 40%, indicating that it was not necessary to adjust for common method bias. Therefore, we believe that the data did not suffer from a serious common method bias.

Descriptive Analysis

The descriptive results and correlations among the variables are presented in Table 1. The results indicated that stressful life events were significantly negatively and positively correlated with self-worth ($r = -0.28$, $p < 0.001$) and PIU ($r = 0.24$, $p < 0.001$), respectively. Moreover, self-worth was significantly negatively correlated with PIU ($r = -0.31$, $p < 0.001$).

In addition, according to the criterion of Young's Internet Addiction Diagnostic Questionnaire, those who answered "yes" to five or more of the eight items were classified as problematic Internet users. The results suggested that there were 337 problematic Internet users, accounting for 16.38% of the sample. Specifically, there were 184 problematic Internet users (16.67%) in the seventh grade, 109 (14.65%) in the eighth grade, and 44 (20.95%) in the ninth grade, indicating the highest prevalence of PIU among ninth graders in this study.

The Mediating Effect of Self-worth

We used macro PROCESS model 4 (Hayes, 2013) to analyze the data and test the mediating effect of self-worth on the influence of stressful life events on adolescent PIU. We considered stressful life events as the independent variable, self-worth as the mediating variable, and PIU as the dependent variable. The results are presented in Fig. 3. Stressful life events predicted PIU positively ($\beta = 0.23$, $p < 0.001$), indicating a significant total effect. With the addition of self-worth to the regression model, the results showed that stressful life events predicted self-worth negatively ($\beta = -0.27$, $p < 0.001$), which in turn predicted PIU negatively ($\beta = -0.25$, $p < 0.001$). The positive association between stressful life events and PIU was still significant ($\beta = 0.16$, $p < 0.001$). Therefore, the results suggested that self-worth partially mediated the relationship between stressful life events and PIU. Furthermore, the bias-corrected percentile bootstrap procedure showed that the indirect effect of stressful life events on PIU through self-worth was significant ($\beta = 0.07$, 95% CI = [0.05, 0.09]). The ratio of the indirect effect to the total effect was 29.38%. These results indicated that self-worth could partially account for the relationship between stressful life events and adolescent PIU.

The Moderating Effect of Physical Activity

To further examine the moderating effect of physical activity in the mediation model, we used model 7 in PROCESS to analyze the data. Specifically, we considered stressful life events as the independent variable, self-worth as the mediation variable, PIU as the dependent variable, and physical activity as the moderation variable. The results are shown in Table 2, suggesting that the interaction between stressful life events and physical activity predicted adolescent self-worth significantly ($\beta = -0.06$, $p < 0.01$), and self-worth predicted PIU negatively ($\beta = -0.25$, $p < 0.001$), indicating that the moderating effect of

physical activity was significant. To better illustrate the pattern of this moderation effect, the association between stressful life events and self-worth was plotted across different values of the moderator in Fig. 4. The results suggested that the relationship between stressful life events and self-worth was significant ($\beta_{simple} = -0.21$, $p < 0.001$) for adolescents with lower levels of physical activity ($M - SD$); however, for adolescents with higher levels of physical activity ($M + SD$), the effect of stressful life events on self-worth was stronger ($\beta_{simple} = -0.33$, $p < 0.001$).

Furthermore, an indirect effect analysis was performed at different levels of moderation (Fig. 5). The results indicated that, although the conditional indirect effect was always significant, it was stronger for physically active students ($\beta = 0.08$, $SE = 0.01$, 95% CI = [0.06, 0.10]) than those with a lower level of physical activity ($\beta = 0.05$, $SE = 0.01$, 95% CI = [0.04, 0.07]). Therefore, the negative association between stressful life events and self-worth was stronger for adolescents participating in higher levels of physical activity, consistent with the reverse risk-buffering model.

Supplementary Analysis

Furthermore, to test the robustness of the results, we divided the whole sample into male and female samples to examine whether gender differences exist in the moderated mediation model. The results of the male sample indicated that $\chi^2 = 101.36$, $df = 11$, RMSEA = 0.09, CFI = 0.950, and GFI = 0.977, and the results of female sample suggested that $\chi^2 = 107.62$, $df = 11$, RMSEA = 0.09, CFI = 0.950, and GFI = 0.975. These results showed that this moderated mediation model fits both male and female groups. Further, we set the baseline model and the constraint model to check whether there is a difference between the two samples. As suggested by Little (2013), we considered $\Delta\chi^2$, Δdf, ΔCFI, and critical ratios for differences between parameters as indicators for model comparison. The results showed that the indexes of the baseline model were $\chi^2 = 208.98$, $df = 22$, and

Table 1 s Descriptive statistics and correlations for all study variables ($N = 2058$)

Variables	1	2	3	4	5	6	7	8
1. Gender	–							
2. Age	0.01	–						
3. Health status	−0.04	0.01	–					
4. Family economic situation	−0.04	−0.05*	0.13***	–				
5. Stressful life events	−0.05*	0.01	−0.11***	−0.05*	–			
6. Self-worth	−0.09***	−0.01	0.24***	0.19***	−0.28***	–		
7. Physical activity	−0.21***	−0.03	0.09***	0.08***	0.01	0.10***	–	
8. Problematic Internet use	−0.05*	0.08***	−0.18***	−0.08***	0.24***	−0.31***	−0.06**	–
M	1.50	14.03	3.74	4.22	1.47	3.29	20.74	1.26
SD	0.50	0.83	0.52	1.35	1.01	0.50	20.90	0.29

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

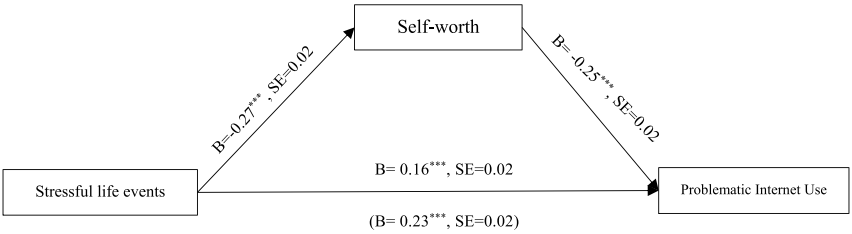

Fig. 3 The mediating effect of self-worth between stressful life events and problematic Internet use. Note: Figures in brackets denote the total effect of stressful life events on problematic Internet use

CFI = 0.950, whereas the indexes of the constraint model were $\chi^2 = 218.78$, $df = 27$, and CFI = 0.948. Thus, $\Delta\chi^2 = 9.80$, $\Delta df = 5$ ($p = 0.08 > 0.05$), and ΔCFI = −0.002, and the critical ratios for differences between parameters are all less than 1.96, indicating that there is no significant difference between the two models. Therefore, these results suggested that the current theoretical model was robust in both male and female groups.

Discussion

In line with previous studies, this study found that stressful life events predicted adolescent PIU significantly (Leung, 2006; Li et al., 2016). Adolescents experience substantial biological and psychological changes, with diverse sources of stress during adolescence (Baum et al., 2013). The Internet, characterized by entertainment and accessibility, could provide a setting for them to escape from stress and relieve negative emotions temporarily (Armstrong et al., 2000). Furthermore, the results also suggested that stressful life events can affect adolescent PIU indirectly through the mediation of self-worth, and physical activity moderated this mediation effect, supporting the hypotheses of this study. In addition, the results indicated that the moderating effect of physical activity was in line with the reverse risk-buffering model. These findings could be of great value to practitioners working with adolescents who experience PIU.

The Mediating Effect of Self-worth

In line with previous studies (Li et al., 2020; Yu et al., 2017), this study proved the important role of self-worth in human behavior, especially in PIU among adolescents. From the perspective of self-worth orientation theory, some online activities, such as acquiring support from online friends in online communities, could provide an alternative avenue to satisfy adolescents' need for self-worth that is unsatisfied in the real world. Consequently, once adolescents are accustomed to obtaining self-worth through online activities, they easily indulge in the Internet, leading to PIU. That is, those who experience low self-worth in the real world tend to engage in network activities to satisfy their need for self-worth. The self-worth orientation theory holds that self-worth supporting resources include various aspects, such as support from significant others, personal achievement, and socioeconomic status, among others. When adolescents are exposed to stressful life events (e.g., failure in examination, misunderstood by others), their self-worth is severely dampened, resulting in an increased need and heightened likelihood of indulging in the virtual

world. In other words, adolescents who experience stressful life events might fail to satisfy their self-worth in the real world; however, online activities offer resources that support self-worth. Once adolescents' self-worth is associated with Internet use behaviors, they would show an increasing dependence on the Internet, eventually causing PIU. In addition to the partial mediation of self-worth, the results also indicated that stressful life events could predict adolescent PIU directly. A possible explanation might be that the stressful life events measured in this study were what adolescents have experienced during the past 12 months, including various aspects of life events and cumulative life stress. Cumulative stressful life events have an extremely negative influence on adolescent emotions (Monroe, 2008; Wang & Mesman, 2015); therefore, they may seek Internet usage directly to relieve stress and regulate these negative emotions (Jun & Choi, 2015; Lavoie & Pychyl, 2001; Leung, 2006).

The Moderating Effect of Physical Activity

This study found that physical activity could moderate the effect of stressful life events on adolescent PIU through the indirect effect of self-worth. The moderating effect of physical activity was consistent with the reverse risk-buffering model. More specifically, physical activity, as an important protective factor, could buffer the deteriorating effect of stressful life events on adolescent self-worth when experiencing low levels of stressful life events. However, physical activity gradually loses its protective effect under high levels of stressful life events. One possible explanation is that when exposed to extremely stressful situations, adolescents cannot satisfy their self-worth by participating in physical activity alone. Although people tend to experience a general "feel-better" effect after engaging in physical activity (Biddle & Ekkekakis, 2005), those unsolved stressful life events would still damage their self-worth, which increases the compensatory need for online activities. Another possibility is that it might be challenging for adolescents to cope with cumulative stressful life events, especially at a high level. Cumulative stress from various aspects have negative impacts on adolescents' emotions and adaptation (Monroe, 2008; Ye et al., 2016), which makes it difficult for them to have enough energy to cope with stress. Therefore, physical activity is a beneficial factor, but its protective effect is limited and cannot attenuate the adverse effects of high levels of stressful life events on individual self-worth effectively, especially under the circumstance of high levels of stressful life events.

Theoretical and Practical Implications

Our findings not only help us build a better understanding of how and when stressful life events influence adolescent PIU, but also have important implications for clinical and educational researchers and practitioners. Theoretically, to the best of our knowledge, this is the first study to examine the relationship between stressful life events and adolescent PIU based on the self-worth orientation theory. The results show that stressful life events could predict adolescent PIU by undermining their self-worth. The results also indicate that physical activity serves as a reverse risk-buffering function. This study proves the negative influence of stressful life events on adolescent self-worth and externalizing behaviors, which not only supports but extends the self-worth orientation theory. Practically, our findings are of great value to practitioners working with adolescents who experience PIU. Self-worth is an important mechanism linking stressful life events with adolescent PIU, indicating that such events overwhelm

Table 2 Testing the moderated mediation model ($N = 2058$)

Predictors	Problematic Internet use			Self-worth		
	β	SE	t	β	SE	t
Gender	−0.14	0.04	−3.47***	−0.15	0.04	−3.71***
Age	0.07	0.02	3.69***	0.01	0.02	0.37
Health status	−0.10	0.02	−4.95***	0.19	0.02	9.04***
Family economic situation	−0.01	0.02	−0.61	0.15	0.02	7.07***
Stressful life events	0.16	0.02	7.09***	−0.27	0.02	−12.23***
Physical activity				0.07	0.02	3.13**
Stressful life events × physical activity				−0.06	0.02	−2.74**
Self-worth	−0.25	0.02	−11.22***			
R^2	0.14			0.16		
F	57.02***			55.59***		

All variables in the model were put into the regression equation after standardized treatment

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

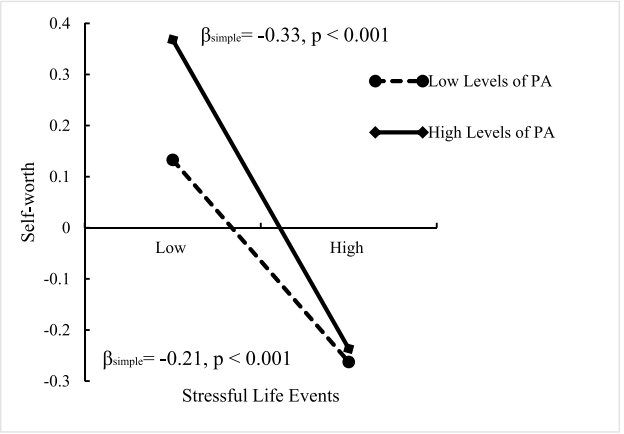

Fig. 4 The moderating effect of physical activity in the relationship between stressful life events and self-worth

adolescents and damage their self-worth. Therefore, online activities that create self-worth are attractive. Following this, practitioners should guide adolescents, especially those exposed to high levels of stressful life events, to seek self-worth in positive ways, instead of indulging in the Internet. Moreover, physical activity only plays a role in low levels of stressful life events, suggesting that the benefits of physical activity may be limited. Therefore, practitioners should encourage adolescents to participate in physical activity but should not overlook the adverse effects of stressful life events on them.

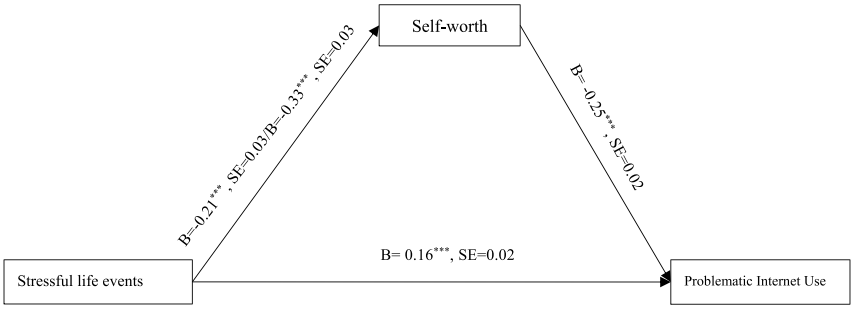

Fig. 5 The mediating effect of self-worth between stressful life events and problematic Internet use. Notes: The left side of the forward slash indicates low levels of physical activity

Limitations and Future Research Directions

Although the hypotheses in this study are supported, several limitations merit future attention. First, because of the cross-sectional nature of the study design, causal relations between the variables could not be revealed. Therefore, future studies should apply a longitudinal research paradigm to improve internal validity. Second, we used adolescent self-report measures to collect data, and PIU measures may be susceptible to social desirability bias (Wang & Qi, 2017); for example, participants may conceal the time spent on the Internet. Future studies could collect information from different informants (e.g., parents, teachers, and peers) to strengthen the reliability of the findings. Finally, cultural differences may exist in the influence of stressful life events on self-worth. For example, Chinese educational contexts are exam-oriented; therefore, Chinese adolescents pay more attention to academic performance than their Western counterparts (Chen & Wong, 2015). A collectivistic culture focuses more on closer connections with others than an individualistic culture (Kim, 2008). Therefore, although adolescents from different cultural environments experience the same stressful life events (e.g., academic failure, misunderstood by others), the negative influence of stressful life events on self-worth and PIU might be different. Thus, the results of this study should be examined in different cultural environments.

Conclusion

In conclusion, this study explored the underlying mechanism of "how" and "under which conditions" stressful life events influence adolescent PIU. The results suggest that adolescent self-worth plays an important role in the link between stressful life events and externalizing behaviors, such as PIU. The protective effect of physical activity is limited, suggesting that stress from various aspects among adolescents should be equally valued when we encourage adolescents to participate in physical activity. These results not only support and further extend the self-worth orientation theory, but also shed light on effective prevention and intervention strategies to reduce adolescent PIU.

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

Declarations

Ethics Approval and Consent to Participate All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all participants for being included in the study.

Conflict of Interest The authors declare no competing interests.

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