



The buffer effect of physical activity: Why does parental marital satisfaction affect adolescents' problematic Internet use



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ABSTRACT

Introduction: To explore the moderating effect of physical activity and the mediating effect of depression on the relationship between marital satisfaction and adolescents' problematic internet use (PIU).

Methods: This study adopted a sample of 288 adolescents and their parents, and measured adolescents' depression, PIU, physical activity, and parents' marital satisfaction.

Results: These results showed that parental marital satisfaction negatively predicted adolescents' PIU. Adolescents' depression played a mediating role between parental marital satisfaction and adolescents' PIU. Further mediated moderation effect analysis showed that the interaction between marital satisfaction and adolescents' physical activity affected the PIU through adolescents' depression. Specifically, for individuals with lower physical activity, the marital satisfaction affected the PIU through adolescents' depression. However, for the group with higher physical activity, physical activity weakened the effects of marital satisfaction on adolescents' depression, and the mediating effect of depression did not reach a significant level.

Conclusion: These results are of theoretical and practical significance in understanding and intervening to address adolescents' PIU.

1. Introduction

While the Internet brings efficiency and convenience to human society, it also carries negative effects. Some users use the network immoderately, jeopardizing their physical, social-emotional, and interpersonal health (Cao, Sun, Wan, Hao, & Tao, 2011; Liang, Zhou, Yuan, Shao, & Bian, 2016; Wendi Li, Zhang, Xiao, & Nie, 2016). This phenomenon is known as the "problematic internet use (PIU)", which is defined as "use of the Internet that creates psychological, social, school and/or work difficulties in a person's life" (Beard & Wolf, 2001). With the number of Internet users increases rapidly, the problem of PIU has become more prominent in recent years. Notably, adolescents are

shown to be the subpopulation that are most frequently exposed to the Internet and meanwhile particularly vulnerable to PIU (Ko, Yen, Chen, Yeh, & Yen, 2009). It is important for academics as well as policy makers to examine the mechanism of PIU and to effectively intervene and improve adolescents' PIU.

1.1. The relationship between parental marital satisfaction and adolescents' PIU

Family is essential for adolescents' healthy development and social adaptation (Bowen, 1966; Ko et al., 2015). According to Bowen's Family System Theory, family is a fundamental emotional unit with clear

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boundaries and internal rules and a family system usually contains three subsystems: the parent–child subsystem, the marital subsystem, and the sibling subsystem. Each of these three subsystems may influence and be influenced by the others (Bowen, 1966). Importantly, past research found that parents' negative emotions induced by the marital relationship issues within the family system could "spill over" to the relationship with their children and lead to children's depression or maladjustment (Kouros, Papp, Goetze-Morey, & Cummings, 2014). Thus, we may speculate that some adolescents' indulgent behaviors on Internet could partially derive from the family system, in particular, the marital subsystem. Previous studies found that adolescents from troubled families were more likely to use the Internet to generate intimate social relationships than those from healthy families (Wolak, Mitchell, & Finkelhor, 2003). Also, some recent studies have shown that marital conflict or marital satisfaction can significantly predict adolescents' PIU (De Leo & Wulfert, 2013; Deng, Fang, & Yan, 2013; Li, Garland, & Howard, 2014; Zhang, Spinrad, Eisenberg, Luo, & Wang, 2017). However, it remains unclear "how" (a mediating mechanism) and "under what conditions" (a moderating mechanism) marital satisfaction influences adolescents' PIU. We aim to address this question in the current paper.

1.2. The mediating effect of adolescents' depression

Adolescents are in a sensitive period of being gradually aware of their parents' relationship and the quality of their parental relationship has a direct impact on their mental health (Li, Jiang, Fan, & Zhang, 2018; Zhou & Buehler, 2019). According to the emotional security hypothesis, a destructive parental relationship begets negative emotions and insecurities among children, which may further lead to some emotional expression and regulation issues and even mental illnesses, such as depression and anxiety (Davies & Cummings, 1994; Erel & Burman, 1995). Moreover, a number of studies have shown that marital conflict can positively predict adolescents' depression (Coln, Jordan, & Mercer, 2013; De Los Reyes et al., 2015; Fan, Zhu, Miao, Liu, & Zhang, 2018; Wang & Crane, 2001).

Depressed individuals are more likely to use the Internet for emotional regulation and to develop PIU (Brunet et al., 2014; Gámez-Guadix, 2014; Ko et al., 2009). The mood enhancement hypothesis argues that individuals tend to use media to improve mood when having some negative feelings (Bryant & Zillmann, 1984; Zillmann, 1991). In order to alleviate emotional stress, depressed individuals are also found to be more likely to participate in leisure activities, such as watching TV, surfing the Internet, and playing online games (Liang et al., 2016). The online entertainment can indeed reduce individuals' stress level and relieve depression (Bessière, Kiesler, Kraut, & Boneva, 2004). Besides, Davis (2001) cognitive-behavioral model of PIU suggests that individuals with psychopathological factors (e.g., depression, anxiety) are more likely to develop maladaptive thoughts about themselves as well as the world. The self-related consequences include self-doubt, low self-efficacy, and negative self-appraisal. For worldview consequences, psychopathological individuals tend to hold the belief that the Internet can better satisfy their needs than the real world does. Depressed people tend to seek online support to alleviate negative emotions, which exacerbates their dependence on the Internet (Davis, 2001). A large body of research has shown that depressed adolescents are more susceptible to PIU than healthy others (Caplan, 2003; Spada, 2014; Tokunaga & Rains, 2010).

Based on the literature discussed above, we propose that parents' marital problems may contribute to the adolescents' PIU by increasing adolescents' experience of negative emotions (e.g., depression). Put it formally, this study hypothesized that *adolescents' depression will mediate the effect of parents' marital satisfaction on adolescents' PIU (Hypothesis 1)*.

1.3. The moderating effect of physical activity

Although low marital satisfaction has been found to engender depression (Wang & Crane, 2001; Cui, Donnellan, & Conger, 2007), not all adolescents that come from dysfunctional families would be affected the same way (El-Sheikh & Whitson, 2006; El-Sheikh, Harger, & Whitson, 2001). The Organism-Environment Interaction Model (Lerner, Lerner, Almerigi, & Theokas, 2006) maintains that individual factors often tend to modify the effects of environmental factors and it is the interaction between individuals and the environment that determines individual social development outcomes. Thus, some individual level factors among adolescents might buffer or augment the effects of parental marital relationship on their depression and also PIU.

One individual-level factor of interest here is the physical activity that adolescents engage in since a number of recent studies have linked physical activity to beneficial changes in depression (Eather, Morgan, & Lubans, 2016; Knapen, Vancampfort, Moriën, & Marchal, 2015; Nyström, Neely, Hassmen, & Carlbring, 2015; Roshanaei-Moghaddam, Katon, & Russo, 2009; Stathopoulou, Powers, Berry, Smits, & Otto, 2006). As a behavioral intervention strategy, a large volume of studies have indicated that physical activity could alleviate or directly improve depression even though the relationship between depression and physical activity are bidirectional in nature (Babiss & Gangwisch, 2009; Dinas, Koutedakis, & Flouris, 2011; Kandola, Ashdown-Franks, Hendrikse, Sabiston, & Stubbs, 2019; Łakomski, Pietsch, Chłystek, Abramczyk, Golus, & Żukow, 2017; Meyer, Koltyn, Stegner, Kim, & Cook, 2016; Rosenbaum, Tiedemann, & Ward, 2014; Sanders, Field, Diego, & Kaplan, 2000; Schuch et al., 2018).

From the physiological perspective, the Endorphin Hypothesis (Steinberg & Sykes, 1985) states that physical activity is associated with the release of endogenous opiates that can reduce depression, such as the beta-endorphins. They can improve people's mood and help them maintain a refreshed view of themselves. From the psychological perspective, the Distraction Hypothesis (Bahrke & Morgan, 1978) also suggests that physical activity might weaken the effect of stress on depression. It argues that physical activity can serve as a useful distraction or a 'time out' strategy from stressful stimuli and thereby improve people's psychological wellness (Gleser & Mendelberg, 1990; Johnsgard, 1989; Leith, 1994). When individuals do exercise, they usually focus on training goals or physical changes, such as breathing, heart rate, fatigue, or muscle soreness, instead of the negative emotions caused by other stressful events (e.g., low parental marital satisfaction) (Leith, 1994). Abundant studies have demonstrated that physical activity buffer against the impact of stress on depression (Harris, Cronkite, & Moos, 2006; Sigfusdottir, Asgeirsdottir, Sigurdsson, & Gudjonsson, 2011). Accordingly, physical activity, a buffer against stress, may divert individuals' attention from stressful events or daily worries and protect them from developing associated psychological problems (e.g., depression, anxiety) (Salmon, 2001).

To sum up, from both the physiological and psychological perspectives, physical activity can attenuate the association between parental marital relationship and adolescents' depression. Thus, this study further hypothesized that *physical activity will moderate the mediating effect of depression on the effect of parental marital satisfaction on adolescents' PIU (Hypothesis 2, see Fig. 1)*.

In order to test the two hypotheses, a matched sample of middle-school students and their parents were recruited in the current research. As shown in previous studies, boys are more likely to overindulge in the Internet than girls are (Li, Zhang, Lu, Zhang, & Wang, 2014; Liang et al., 2016). Emerging adults' PIU is significantly higher than that of adolescents (Akman & Mishra, 2010; Yu et al., 2017). Moreover, parents' sex could affect adolescents' depression (Sheeber et al., 2007). Also, previous studies have shown that the same-sex parent could have stronger impact on adolescents' depression and adjustment (Branje, Hale, Frijns, & Meeus, 2010; Brouillard, Brendgen, Vitaro, Dionne, & Boivin, 2018; Stroud, Meyers, Wilson, & Durbin, 2015). Therefore, we

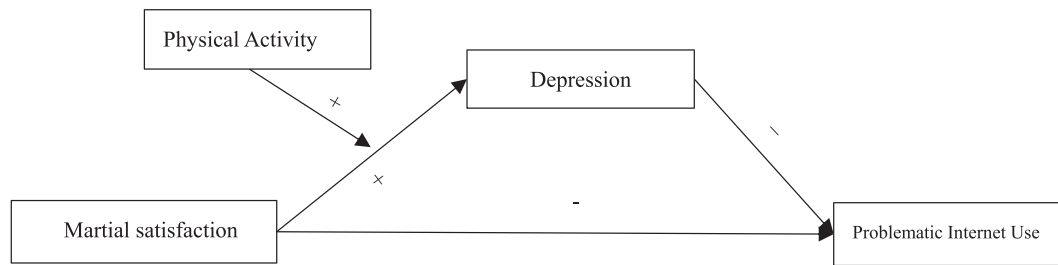


Fig. 1. The mediating effect of depression and the moderating effect of physical activity on the relationship between marital satisfaction and problematic internet use.

included adolescents' sex, age, parents' sex, and the sex composition of the parent-adolescent dyad as control variables in the current research.

2. Method

2.1. Participants

A total of 295 student-parent pairs were recruited from a local middle school in Hubei Province, China. Seven pairs were excluded for their incomplete data, leaving a total of 288 student-parent pairs. For students, 165 were seventh-grade students (88 males), 92 were eighth-grade students (40 males), and 31 were ninth-grade students (14 males). The average age of the students was 13.92 years old ($SD = 0.86$ years old). We coded students' sex (1 = male, 2 = female). In terms of parents, 62 were fathers and 226 were mothers. This study was reviewed and approved by the local Ethics Committee and all methods were performed in accordance with government regulations and laboratory policies.

2.2. Measures

Parental Marital Satisfaction. We adopted the Parental Marriage Satisfaction Scale in Olson Marriage Quality Questionnaire to measure parents' marital satisfaction. It consists of 10 items (e.g., "I am satisfied with how we handle role responsibilities in our marriage", and "I am satisfied with the way we make decisions and resolve conflicts"). Participants were instructed to rate on a 5-point Likert scale, ranging from 1 (*it is not the case*) to 5 (*this is true*). The Cronbach α coefficient and the test-retest reliability of this scale are both 0.86. The past literature also reported reasonable discriminant validity (Fowers & Olson, 1989). This scale was translated and revised by Li and his colleagues, and its reliability and validity have been confirmed in Chinese context (Li et al., 1990). In the present research, the Cronbach α coefficient was 0.79, and the split-half reliability was 0.81.

Physical Activity. The Physical Activity Rating Scale (PARS-3) was used to assess adolescents' physical activity. This scale was originally established in Japan (Hashimoto, 1990) and has been translated and revised in the Chinese context (Liang, 1994). The test-retest reliability was 0.82 (Liang, 1994). In the scale, physical activity was measured by three items from three aspects. The first item is about physical activity intensity ("During the last four weeks, which of the following physical activities have you mostly participated in?"). Students responded on a 5-point scale, scoring from 1 to 5 points (1 = "mild physical activity, such as walking, broadcast gymnastics and so on", 2 = "low-intensity physical activity, such as volleyball, table tennis and so on", 3 = "moderate-intensity physical activity, such as cycling, running and so on", 4 = "high-intensity but non-persistent physical activity, with shortness of breath, sweating, such as basketball, tennis and so on", and 5 = "high-intensity and persistent physical activity, with shortness of breath, sweating, such as long-distance running, swimming and so on"). The second item relates to the frequency of physical activity ("How often do you perform the above physical activity in terms of a month?") They responded on a 5-point scale, scoring from 1 to 5 points (1 = "less than once a month", 2 = "2-3 times

a month", 3 = "1-2 times a week", 4 = "3-5 times a week", and 5 = "about once a week"). The last item speaks to the duration of physical activity ("During the last four weeks, how long have you participated in the above physical activity every time?"). They responded on a 5-point scale, scoring from 0 to 4 points (0 = "within ten minutes", 1 = "eleven to twenty minutes", 2 = "twenty-one to thirty minutes", 3 = "thirty-one to fifty-nine minutes", and 4 = "over sixty minutes"). The amount of physical activity was evaluated by the multiplication of intensity, frequency, and duration, with the resulting score ranging from 0 to 100.

Depression. The Self-Rating Depression Scale (SDS) was used to measure adolescents' depression level. This scale contains twenty items (e.g., "I feel tired for no reason", "I don't sleep well at night", and "I feel unhappy and depressed"). Students responded on a 4-point Likert scale, ranging from 1 (*never*) to 4 (*always*). The average score would represent the level of depression (Zung, 1965; Wang, Wang, & Ma, 1999). The Chinese version of this scale, translated and revised by Shu, has been demonstrated with good reliability and validity (Shu, 1999). In the current research, the Cronbach's coefficient was 0.84 and the split-half reliability was 0.74.

Problematic Internet Use. Adolescents' PIU was assessed by the Young's Internet Addiction Diagnostic Questionnaire (Young, 1998), which modified the criteria for pathological gambling in the Diagnostic and Statistical Manual of Mental Disorders- Fourth Edition (DSM-IV). This scale contains eight items (e.g., "Do you feel the need to use the Internet with increasing amounts of time in order to achieve satisfaction?", "Have you lied to family members, a therapist, or others to conceal the extent of involvement with the Internet?", and "Have you repeatedly made unsuccessful efforts to control, cut back, or stop Internet use?"). 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 Dependent Internet Users. To better interpret and explore the relationship among variables, following previous studies (Yu et al., 2017), we considered internet addiction as a continuous variable and averaged all items as an indicator of PIU. Higher scores indicate a stronger tendency for internet addiction. Cui and Wang (2003) translated and revised this scale in the Chinese context and demonstrated high reliability and validity (Cui & Wang, 2003; Yu et al., 2017). In the current research, the Cronbach's coefficient was 0.81, and the split-half reliability was 0.78.

Demographic measures. We gathered participants' demographic information, including students' sex (1 = "male", 2 = "female"), age, parents' sex (1 = "male", 2 = "female") and the sex composition of the parent-adolescent dyad (1 = "same sex", 2 = "different sex").

2.3. Procedure

At first, researchers trained the teachers as research assistants and teachers then distributed the student-part questionnaires to students in their classes. The students completed the questionnaire on the Internet. During the next step, teachers invited students' parents to fill in the parent-part questionnaire through social network groups, such as WeChat group or QQ group. Finally, the two parts were paired based on the students' names and dates of birth.

Table 1
The descriptive results of key variables and their correlations ($N = 288$).

	1	2	3	4	5
1. age	—				
2.marital satisfaction	-0.050	—			
3.depression	0.093	-0.124*	—		
4.physical activity	0.094	0.091	-0.052	—	
5.problematic internet use	0.029**	-0.215**	0.316**	-0.083	—
<i>M</i>	13.92	3.67	2.39	32.99	1.22
<i>SD</i>	0.86	0.66	0.55	27.14	0.27

Note. *** $p < .001$. ** $p < .01$. * $p < .05$.

3. Results

3.1. Descriptive analysis

The descriptive results of each variable and the correlations among the variables are shown in Table 1. Parental marital satisfaction was significantly negatively correlated with adolescents' depression and PIU. Moreover, adolescents' depression was significantly positively correlated with PIU.

3.2. The mediating effect of depression

In order to test the mediating effect of depression on the influence of parental marital satisfaction on adolescents' PIU, we used model 4 in the process software package to analyze the data (Hayes, 2013). The results are shown in Fig. 2. After controlling for children's age, sex, parents' sex, and the sex composition of the parent-adolescent dyad, parental marital satisfaction significantly predicted depression and PIU. Depression also had a significant effect on PIU. The Sobel test showed that the mediation model was significant ($B = -0.016$, $SE = 0.008$, $z = -2.039$, $p < .05$) and the 95% bootstrap confidence interval was $[-0.034, -0.001]$, not including zero. Furthermore, the ratio of the indirect effect to the total effect was 21.28%. These results indicated that depression could partially account for the relationship between parental marital satisfaction and adolescents' PIU.

3.3. The moderating effect of physical activity

To examine the moderating role of physical activity in the mediation effect of depression on the relationship between parental marital satisfaction and PIU, we used model 8 in the PROCESS macro while controlling for children's age, sex, parents' sex and the sex composition of the parent-adolescent dyad (Hayes, 2013). Results are shown in Fig. 3. The interaction between parental marital satisfaction and physical activity significantly predicted adolescents' depression, and depression mediated the effect of marital satisfaction on adolescents' PIU. Further, a simple slope effect test was conducted (Fig. 4). Results showed that, for students with a smaller amount of physical activity, the 99% bootstrap confidence interval for the mediation effect of depression on the relationship between parental marital satisfaction and

PIU was $[-0.060, -0.014]$, not including zero. In other words, the mediation effect was significant in the low physical activity condition and the mediation effect accounted for 35.45% of the total effect. However, for students with a higher amount of physical activity, the 99% bootstrap confidence interval for the mediation effect of depression on the relationship between parental marital satisfaction and PIU was $[-0.022, 0.019]$, including zero. That is, the mediation effect was not significant in the high physical activity condition.

4. Discussion

The current research found that parents' marital satisfaction negatively predicted adolescents' PIU, which was consistent with previous studies (Yang, Zhu, Chen, Song, & Wang, 2016; Zhang et al., 2017). Moreover, our findings showed that parents' marital satisfaction can indirectly affect adolescents' PIU through the mediation of adolescents' depression and this mediation effect is qualified by physical activity among adolescents. Notably, physical activity could reduce the risk of PIU by ameliorating adolescents' depression resulted from their parents' low marital satisfaction.

Based on the Family System Theory (Bowen, 1966), the current research examined the influence of parental marital satisfaction on adolescents' PIU as well its psychological mechanism and boundary conditions, which has theoretical and practical significance for PIU intervention. Notably, the present findings indicated that physical activity could buffer negative emotions (e.g., depression) triggered by family problems and reduce adolescents' vulnerability to PIU, especially for those under family stress. Following this logic, this research provides a new perspective on preventing and intervening adolescents' PIU and physical activity may be considered as a simple and effective intervention for adolescents' PIU. Thus, in order to protect adolescents who are negatively impacted by parental marital relationship and prevent PIU issues, schools should encourage and promote more physical activity along with adolescents' coursework.

4.1. The mediating effect of depression

Family System Theory proposes that couples with low marital satisfaction can hardly resolve conflicts in a constructive way and their anxiety and tension may "spill over" other subsystems of the family, such as causing depression or maladjustment among their children (Bowen, 1966). Due to the depression induced from parental marital conflict, adolescents might turn to internet for compensatory support, control, and security. In this way, they can escape from the emotional difficulties of the real world and obtain relief in the virtual world (Leung, 2006). Thus, adolescents suffering from depression are more likely to use internet to alleviate their depression and become gradually addicted to it (Ko et al., 2009). Besides, depressed individuals may hold low evaluation of their self-esteem and negatively perceive their social competence (Gable & Shean, 2000). This maladaptive perception might lead to them seeking safer, more effective, and more comfortable computer-mediated communication and gradually developing a stronger preference for online social interactions (POSI) (Caplan, 2003).

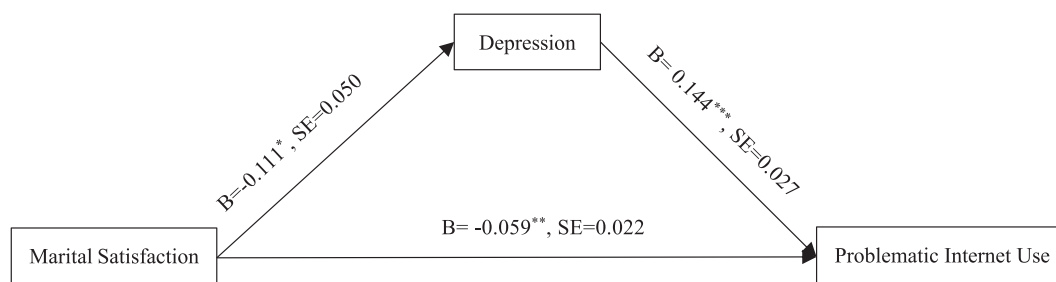


Fig. 2. The mediating effect of depression on the link between marital satisfaction and PIU in whole sample.

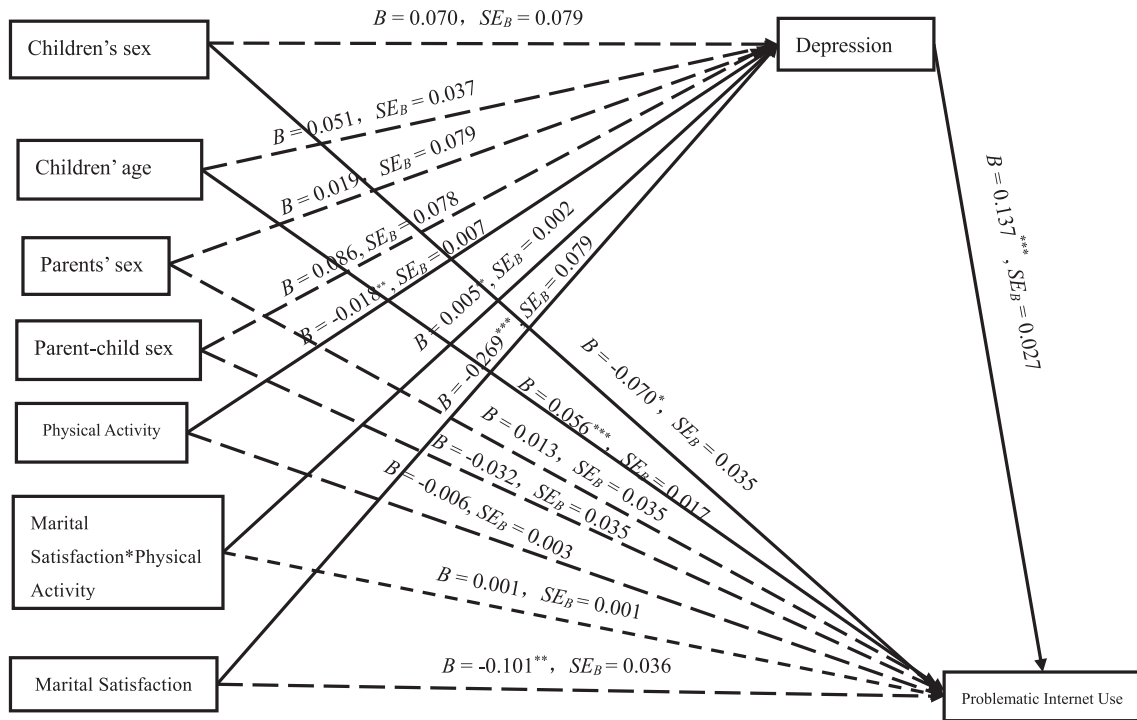


Fig. 3. The moderating effect of physical activity and the mediating effect of depression on the relationship between marital satisfaction and PIU.

When their failed demands are satisfied by virtual world, individuals may become more dependent on and then addicted to it (Yu et al, 2019). These findings further attest to Davis's cognitive-behavioral model (Davis, 2001) stating that depressed individuals are more likely to engage in PIU.

4.2. The moderating effect of physical activity

Based on the family system theory, we speculated that physical activity could moderate the mediation effect of adolescents' depression on the relationship between parental marital satisfaction and adolescents' PIU. In keeping with the prior studies (Brown & Siegel, 1988; Roth & Holmes, 1985; Sigfusdottir, Asgeirsdottir, Sigurdsson, & Gudjonsson, 2011; Uebelacker et al., 2013), we found that physical activity can buffer stressful events and negative emotions, such as depression. The Endorphin Hypothesis (Steinberg & Sykes, 1985) stated that physical activity and the increased blood flow and oxygen uptake during the activity could stimulate the central nervous system and produce positive anti-depressive effects on human emotions (Daley, 2002).

Moreover, engaging with physical activity could distract people's attention and be temporarily off the stressful events, such as parents' conflicts and other family issues. Thus, physical activity could buffer the depression resulted from parents' marital problems and subsequent risk to PIU.

A seemingly contradictory line of studies showed that physical activity could not buffer stress and psychological distress (Gerber & Pühse, 2008, 2009; Moksnes, Moljord, Espnes, & Byrne, 2010). Our argument is that current focus was specifically the stress caused by parents' marital problems while those studies that failed to find the buffer effect spoke to the overall stress. Stress is a multifaceted construct (Byrne, Davenport, & Mazanov, 2007). It is reasonable to speculate that the buffer effect of physical activity may be effective to certain aspects rather than every aspect of stress. In addition, studies that failed to show the buffer effect of physical activity tended to assess physical activity with single item, which might lose some other important information (e.g., intensity, duration). As suggested by Sallis and Saelens (2000), the ideal measure of physical activity should include items of frequency, intensity, and duration, which were all

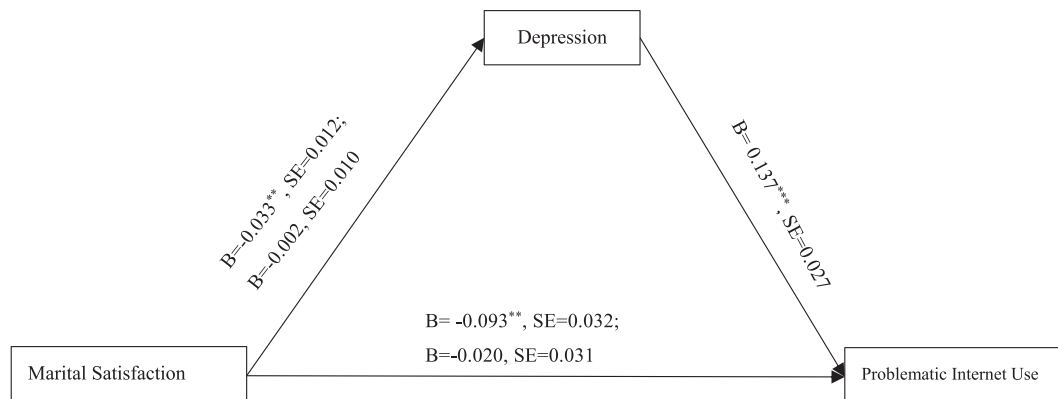


Fig. 4. The mediating effect of depression on the relationship between marital satisfaction and PIU in two physical activity conditions. Notes: The upper part of coefficients were results for the low physical activity condition; the lower part of the coefficients were results for the high physical activity condition.

included in the present research.

4.3. Effects of socio-demographics on PIU

The present research demonstrated that boys' PIU scores were significantly higher than those of girls, which was in line with the existing literature (Li et al., 2014; Tsitsika et al., 2014; Yu et al., 2017). This sex difference might be interpreted by the impulsive and curious nature of adolescent boys and sex differences in physiological transmitter (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006). Besides, being more rebellious to parental supervision, boys may spend more time using internet and then become more vulnerable to the risk of PIU (Asiri et al., 2013; Bahrainian et al., 2014).

Consistent with previous research (Okwaraji, Aguwa, Onyebueke, Arinze-Onyia, & Shiweobi-Eze, 2015; Yu et al., 2017), the current findings also showed that adolescents' PIU scores tended to increase with their age. One possible account is that older adolescents may feel more autonomous and become more rebellious than younger ones (Okwaraji et al., 2015). In this case, they may care less about their parents' supervision and be more vulnerable to PIU. An alternative account is that senior students face higher stress from graduation or high school entrance exam in comparison with junior middle school students, and may seek the Internet as a safe substitute to relieve the stress (Yu et al., 2017).

In terms of parents' sex, the current study failed to show any significant differences on depression and PIU, which were inconsistent with previous studies (Branje et al., 2010; Brouillard et al., 2018; Sheeber et al., 2007). One possible explanation might be that, Chinese family, in a patriarchal culture, emphasized paternal influence and authority on offspring (Abbott, Ming, & Meredith, 1992). Although fathers are not the typical person responsible for caring children, they might still have the same impact on children as mothers do.

Regarding the parent-child sex, our results did not support our expectation that links between marital satisfaction and adolescents' PIU would generally be varied according to different sex-composition of the parent-child dyad. The possible explanation might be Chinese culture, typical patriarchal culture as mentioned above (Abbott et al., 1992). Fathers might still have the same impact on children as mothers do.

4.4. Limitations and future research

Although the current research showed empirical support for our hypotheses, there are several limitations that merit future attention.

First of all, the sample sizes of fathers ($N = 62$) and mothers ($N = 226$) were unbalanced in the current research ($\chi^2 = 93.39$, $p < .001$). This might have to do with the dominant caring role of mothers rather than fathers in the Chinese society (Branje et al., 2010; Brouillard et al., 2018; Fishman & Meyers, 2000). The process macro model 1 was conducted to exam the moderating effect of parental sex on the relationship between marital satisfaction and adolescents' depression. And results revealed that the moderating effect of parental sex was not significant ($B = 0.047$, $SE = 0.084$, $t = 0.55$, $p = .58$). The possible explanation may be due to Chinese patriarchal culture which emphasized paternal influence on offspring (Abbott et al., 1992). Although we intentionally controlled for parents' gender during our analyses, it still deserves some caution when we are trying to make generalizations of the current findings. Future research that speaks to the dependent relationship between parent and student (e.g., the effect of parental marital relationship on students' PIU) can make greater impact by having a more representative and balanced parent sample.

Secondly, this research adopted a cross-sectional paradigm, which could not infer causal relationship between parental marital satisfaction and children's PIU. Thus, future study may employ a longitudinal approach to improve the internal validity.

Third, this study did not explore whether the moderating effect of physical activity works through physiological mechanism,

psychological mechanism, or even two mechanisms, thus, future study should further explore the moderating mechanism of physical activity.

Lastly, past literature has linked PIU to a host of personality factors, such as vulnerable narcissism (Casale & Fioravanti, 2018; Casale, Fioravanti, & Rugai, 2016), extraversion, conscientiousness, and agreeableness (Stead & Bibby, 2017). It might be interesting for future research to see if parents' personality, such as narcissism and extraversion, might impact adolescents' online social behavior. Besides, previous research has shown that adolescents' metacognitions could fully account for the relationship between negative emotion (e.g., depression, stress, and boredom) and PIU (Spada, Langston, Nikčević, & Moneta, 2008; Casale, Rugai, & Fioravanti, 2018; Marino et al., 2019). It is an interesting direction to test the potential mediating effect of metacognitions in the link between negative emotions related to family crisis and adolescents' PIU.

5. Conclusion

Parental marital satisfaction is negatively related to adolescents' problematic internet use (PIU). The current research showed that depression can partially account for the link between marital satisfaction and PIU, and this mediation effect is moderated by physical activity. Specifically, for adolescents with low levels of physical activity, marital satisfaction affects PIU through adolescents' depression. However, for those with high levels of physical activity, the mediation effect of depression was not significant. This buffer effect of physical activity offers some insight on the intervention of PIU among adolescents.

Declaration of Competing Interest

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

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Appendix A. Supplementary data

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