Effects of Physical Exercise on Internet Addiction among College Students: A Mediated Model with Moderation

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Abstract

OBJECTIVE

To investigate the effects of physical exercise on Internet addiction, as well as the mediating role of stress and the moderating role of self-control.

METHODS

An online questionnaire was used to survey 473 college students and the data collected were statistically analyzed using SPSS 26.0, AMOS 24.0, and PROCESS 3.4.

RESULTS

Physical exercise significantly and negatively predicted Internet addiction ($\beta = -0.568$, $P < 0.01$); stress mediated the relationship between physical exercise and Internet addiction, 95% CI = [-0.260,-0.138]; self-control moderated the effects of physical exercise and stress on Internet addiction, and an increase in the level of self-control increase enhances the negative effect of physical exercise on Internet addiction ($\beta = -0.095$, $P < 0.01$) and decreases the positive prediction of stress on Internet addiction ($\beta = -0.210$, $P < 0.01$).

Conclusion

Regular physical exercise and a higher level of self-control can reduce the probability of Internet addiction.

1. Introduction

With the rapid development of science and technology, the Internet has become an indispensable part of people’s daily life. The 51st statistics of 2022 released by China Internet Network Information Center (CNNIC) shows that the total number of Chinese Internet users reached 1.067 billion by December 2022, and the Internet penetration rate was 75.6% [1], and college students account for most of the huge number of Internet users. While the Internet brings convenience to college students, it may also harm their physical and mental health, leading to a decline in academic performance and easily triggering a series of mental diseases [2–4], among which Internet addiction is the most direct negative impact on college students [5]. The college student population has high acuity and intuition for advanced technology and knowledge, and has great enthusiasm for the Internet. With more free time and weak regulation and restraint from outside [6], especially during the 3 years of COVID-19 pandemic (2019–2022), college students face force majeure such as school closure, class suspension, residential closure and control, and the need to take online classes, making the Internet an integral part of their studies and lives, leading
to a significant increase in the rate of Internet addiction among college students [7]. Young, an American psychologist, considers Internet addiction similar to pathological gambling as an impulse control disorder. Internet addiction is defined as excessive Internet use and uncontrolled behavior [8], with strong psychological and behavioral effects. The negative effects of Internet addiction are severe and associated with many psychological problems, such as depression [9], sleep disorders [10], anxiety [11], loneliness [12], and aggressive behavior [13]. For college students, Internet addiction can reduce their interest in learning, impair physical and mental health, etc. [14]. Therefore, there is an urgent need to explore ways to reduce the prevalence of Internet addiction as a way to reduce its negative effects. This study focuses on whether stress mediates between physical exercise and Internet addiction and whether self-control has a moderating role between physical exercise, stress, and Internet addiction. This study has important implications for further prevention and intervention of Internet addiction and promotion of healthy growth of college students.

1.1 Physical Exercise and Internet Addiction

Physical exercise is an activity with certain intensity, frequency and duration with the purpose of enhancing physical and mental health [15]. Numerous studies have shown that regular physical exercise can reduce people's stress, depression, and enhance their sense of well-being [16–18]. Satisfaction theory suggests that people use the Internet to gain satisfaction based on their psychological needs, such as socialization or entertainment, which may prompt more frequent Internet use and lead to Internet addiction [14]. Regular physical exercise can also satisfy the psychological needs of college students [19], thus reducing the frequency of Internet use. In addition, physical exercise can promote dopamine secretion and reduce addictive behaviors [20, 21]. Previous studies have shown that there are different views on the intervention of physical exercise on Internet addiction, such as: short-term exercise intervention is more effective [22]; exercise intervention is not effective for patients with severe Internet addiction [23]; severe patients need prolonged exercise intervention, and Internet addiction may be replaced by exercise addiction [24]. It is shown that physical exercise can intervene in Internet addiction, and the two are significantly and negatively correlated, and maintaining regular physical exercise can help alleviate the symptoms of Internet addiction in college students [25]. In summary, the following hypotheses were proposed in this study:

Hypothesis 1 (H1): Physical exercise has a negative effect on college students' Internet addiction.

1.2 Physical Exercise, Stress, and Internet Addiction

For college students, college campus is like a small society, and they have to face competition in many aspects, large and small, while the environment of college is different from that of secondary school, making it difficult for some students to adapt, which brings heavy pressure to them. Foreign researchers found that the main sources of stress among Chinese college students are: study, interpersonal relationships, emotions, sexual distress, and self-esteem [26]. This is consistent with the view of domestic scholars, but there is a difference: domestic scholars consider daily annoyances (unsatisfactory
examination results, interpersonal tensions, health problems, etc.) as the main source of stress among college students, and sudden negative events are not the main source [27]. Some studies have ranked the main sources of stress faced by college students during their school years in the following order: academic problems, employment problems, interpersonal problems, financial problems, and romantic problems [28]. Numerous studies have shown that the stress experienced by college students is closely related to their problem behaviors (e.g., Internet addiction) [29, 30] and that students with higher stress levels exhibit higher rates of Internet addiction [31]. Cognitive-behavioral models show that external environmental stress is an important source of action leading to Internet addiction among college students [32], and a large number of empirical studies have also shown that stress has a significant positive predictive effect on Internet addiction [33]. That is, when college students are more stressed, their probability of Internet addiction will increase.

Reducing the stress of college students has a positive effect on reducing the symptoms of Internet addiction, while physical activity is negatively associated with stress [15]. Numerous studies have shown that physical exercise can have a positive impact on individual psychological stress and improve individuals’ frustration tolerance [34], and regular physical exercise can help promote the formation of a positive mindset and improve mental health [35]. In summary, physical exercise is negatively correlated with stress, and stress is positively correlated with Internet addiction and interacts with physical exercise, and the following hypotheses are proposed in this study:

**Hypothesis 2 (H2):** There is a mediating role of stress between physical exercise and Internet addiction.

### 1.3 Self-control and Internet addiction

Self-control refers to an individual’s ability to control self-behavior, i.e., a self-regulatory process that individuals engage in to suppress inappropriate impulsive behavior with the aim of delaying immediate gratification in order to gain long-term benefits [36, 37]. According to the two-stage model of self-control, the two stages are the first stage of conflict identification process and the second stage of conflict resolution process [38]. College students do not adjust well to the problem of Internet use during the first stage, which leads to deviations in the second stage and prolonged use of the Internet resulting in the development of addiction symptoms. In addition, general maladaptive behavior theory suggests that low self-control is an important psychological indicator for individuals to develop maladaptive behaviors [39]. Individuals with high self-control are better able to regulate impulsive behaviors, emotion, and attention etc., and are less influenced by external factors [40], thus inhibiting addictive symptoms of Internet use, and self-control plays a moderating role in the effect of behavioral deviance on Internet addiction in college students and is an important moderating variable of maladaptive behavior in adolescents [41].

For college students, their self-control is at a fluctuating stage, and when faced with the lure of the online world or the stimulating experience of games, individuals with higher self-control are able to adjust their behavior to meet self-expectations and control impulsive behavior [40], and are less likely to develop Internet addiction. Conversely, individuals with lower self-control are more likely to be attracted to certain
features of the Internet and unable to extricate themselves from it, and have a higher probability of Internet addiction [42]. It has been suggested that self-control may buffer the adverse effects of sensation seeking on Internet addiction [43], and when individuals have higher levels of sensation seeking, those with higher self-control will switch the experience seeking of undesirable behaviors and turn to positive and healthy activities to satisfy their experiences [44]; on the contrary, individuals with lower self-control will focus more on some undesirable behaviors that can satisfy their experiences in the present moment (e.g. online gaming) [45], increasing the risk of Internet addiction. In addition, self-control plays a moderating role in the relationship between anxiety-sensitive personality and online misbehavior, and self-control acts as a self-protective factor during individual development to reduce the probability of risky behaviors [46]. Previous studies have confirmed that self-control moderates Internet addiction in college students, and that Internet addiction is directly influenced by physical activity and stress. In this study, self-control was used as a moderating variable to test whether self-control could moderate the effects of physical exercise and stress on Internet addiction. In summary, the following hypotheses were formulated:

Hypothesis 3 (H3). Self-control has a moderating effect during the influence of physical exercise on Internet addiction.

Hypothesis 4 (H4). Self-control has a moderating effect in the process of the influence of stress on Internet addiction.

According to the above hypotheses, a hybrid model of physical exercise and Internet addiction with mediating and moderating effects was constructed (see Fig. 1).

2. Methods

2.1 Participants

A random sampling method was used to select 500 students from five undergraduate universities in Chengdu, and the questionnaires were sent to the participants between February and April 2023, and a total of 473 valid questionnaires were collected, with an effective rate of 94.6%. Among them, 257 (54.3%) were male students and 216 (45.7%) female; 212 (44.82%) were freshmen, 133 (28.12%) sophomores, and 128 (27.06%) juniors; 322 (68.08%) were from rural areas and 151 (31.92%) from towns; 211 (44.61%) were only children and 262 (55.39%) were not. All participants had experience in using the Internet. All test contents were informed to each participant before the survey started, and consent was obtained from the participants themselves.

2.2 Instruments

2.2.1 Physical Activity Rating Scale

The Physical Activity Rating Scale (PARS-3) revised by Liang Deqing was used [47]. The measurement contains 3 dimensions of time, frequency, and intensity of physical exercise. Both intensity and frequency
were scored from 1 to 5, and time was scored from 0 to 4. The amount of physical activity = intensity score × time score × frequency score. The assessment criteria were: ≤19 as small exercise; 20–42 as moderate exercise; ≥43 as large exercise. The Cronbach alpha coefficient of this scale in this study was 0.876.

### 2.2.2 Internet Addiction Scale

The Chinese Internet Addiction Scale (CIAS-R) developed by Chen Shuhui et al. was used [48]. It contains five dimensions of Internet addiction: compulsive surfing, tolerance, withdrawal reaction, interpersonal and health problems, and time management problems. The higher the score, the more serious the Internet addiction behavior. The specific criteria: below 42 points are for general Internet users, 42–59 points are for mild Internet addiction, and above 59 points are for severe Internet addiction. The Cronbach alpha coefficient of this scale in this study is 0.983.

### 2.2.3 Stress Questionnaire for College Students

The Stress Scale for College Students developed by Li Hong and Mei Jinrong [49] was used. It contains three dimensions: study annoyance, personal annoyance, and negative life events. The scores from "no stress" to "severe stress" correspond to 0 to 3 respectively, and the higher the score, the higher the stress level. The Cronbach alpha coefficient of the scale in this study was 0.990.

### 2.2.4 Self-control Scale

A revised self-control scale by Tan Shuhua and Guo Yongyu was used [50]. It contains five dimensions: impulse control, resisting temptation, healthy habits, abstaining from entertainment, and focusing on work. The scores from "not at all" to "very much" corresponded to 1–5 points, except for questions 1, 5, 11, and 14, which were scored positively, while the rest of the questions were scored negatively. Finally, the total score was calculated and the level of self-control was indicated by the level of the total score. The Cronbach alpha coefficient of the scale in this study was 0.985.

### 2.3 Statistical Methods

Statistical analysis was performed using SPSS 26.0, AMOS 24.0, and the SPSS macro program PROCESS 3.4 developed by Hayes. The test of variance was first performed using independent sample T; secondly, validation factor analysis and model fitting were performed using AMOS to confirm the validity of each variable of the model; next, Pearson correlation was used to analyze the correlation between variables; then Bootstrap sampling test was used to validate the mediation and moderating effects (5000 repetitions of sampling); and finally, slope plots were plotted to determine the the effect of moderating variables.

### 3. Results

#### 3.1 Common Method Bias Test
Harman's one-way test for common method bias was used, and the results showed that there were four common factors with eigenvalues greater than one, and the first factor explained 38.733% (< 40%), so the study did not have significant common method bias and met the statistical requirements [51].

3.2 Demographic Differences

Demographic analysis of variance was performed for the four variables and the results were obtained (Table 1). In terms of physical activity, the mean of male students was higher than that of female students, with significant differences; the mean of freshman year was significantly higher than that of sophomore and junior year, with significant differences; there were no significant differences in either family location or whether they were only children. In terms of Internet addiction, the mean value of male students was higher than that of female students, and the difference was significant; the mean value of only child was significantly higher than that of non-only child, and the difference was significant; there was no significant difference in home location and grade level. In terms of stress, the mean value of only children was significantly higher than that of non-only children, and the difference was significant; there was no significant difference in gender, home location and grade level. In terms of self-control, the mean value of freshman year was higher than that of sophomore and junior year, and the difference was significant; there were no significant differences in gender, whether or not the child was an only child, and home location.
Table 1
Variance Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Physical exercise (Mean ± Standard Deviation)</th>
<th>Internet addiction (Mean ± Standard Deviation)</th>
<th>Stress (Mean ± Standard Deviation)</th>
<th>Self-control (Mean ± Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>49.80 ± 30.63</td>
<td>1.94 ± 0.94</td>
<td>1.32 ± 1.23</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>36.48 ± 26.19</td>
<td>1.64 ± 0.90</td>
<td>1.24 ± 1.17</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.000**</td>
<td>0.000**</td>
<td>0.458</td>
</tr>
<tr>
<td></td>
<td>Family Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rural area</td>
<td>45.17 ± 28.67</td>
<td>1.77 ± 0.92</td>
<td>1.23 ± 1.17</td>
</tr>
<tr>
<td></td>
<td>Urban area</td>
<td>40.62 ± 30.84</td>
<td>1.88 ± 0.95</td>
<td>1.41 ± 1.27</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.117</td>
<td>0.206</td>
<td>0.138</td>
</tr>
<tr>
<td></td>
<td>The Only Child in the Family</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>41.25 ± 29.42</td>
<td>2.01 ± 1.01</td>
<td>1.49 ± 1.32</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>45.71 ± 29.32</td>
<td>1.12 ± 1.08</td>
<td>1.12 ± 1.08</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.101</td>
<td>0.000**</td>
<td>0.001**</td>
</tr>
<tr>
<td></td>
<td>Grade Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Freshman year</td>
<td>53.72 ± 29.72</td>
<td>1.74 ± 0.95</td>
<td>1.28 ± 1.31</td>
</tr>
<tr>
<td></td>
<td>Sophomore</td>
<td>38.11 ± 29.87</td>
<td>1.83 ± 0.93</td>
<td>1.36 ± 1.16</td>
</tr>
<tr>
<td></td>
<td>Junior</td>
<td>32.98 ± 22.50</td>
<td>1.89 ± 0.90</td>
<td>1.22 ± 1.06</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.000**</td>
<td>0.360</td>
<td>0.659</td>
</tr>
</tbody>
</table>

Note: *P 0.05;**P 0.01

3.3 Reliability and Validity Tests

The CR and AVE of the model variables were tested, and as shown in Table 2, the range of CR between variables was 0.875–0.990, and the range of AVE was 0.689–0.777. Based on the existing studies on CR and AVE, the values in this study were better, indicating that the variables have good reliability and validity [52, 53]. In addition, the fit of the model was tested (Table 3) and the GFI, AGFI, CFI, TLI, and IFI were all greater than 0.9 and RMSEA = 0.041, indicating a good model fit.
Table 2
Confirmatory factor analysis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>CR</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical exercise</td>
<td>0.875</td>
<td>0.701</td>
</tr>
<tr>
<td>Internet addiction</td>
<td>0.983</td>
<td>0.689</td>
</tr>
<tr>
<td>Stress</td>
<td>0.990</td>
<td>0.777</td>
</tr>
<tr>
<td>Self-control</td>
<td>0.985</td>
<td>0.771</td>
</tr>
</tbody>
</table>

Note: CR = composite reliability; AVE = average variance extraction.

Table 3
Model fit indices.

<table>
<thead>
<tr>
<th></th>
<th>χ²/df</th>
<th>P</th>
<th>GFI</th>
<th>AGFI</th>
<th>CFI</th>
<th>TLI</th>
<th>IFI</th>
<th>RMSEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indices</td>
<td>1.813</td>
<td>0</td>
<td>0.923</td>
<td>0.902</td>
<td>0.949</td>
<td>0.947</td>
<td>0.949</td>
<td>0.041</td>
</tr>
</tbody>
</table>

3.4 Correlation Analysis of Each Variable

Descriptive statistics and correlation analysis were conducted for each study variable, and the results are shown in Table 4. The results showed that physical exercise was significantly negatively correlated with Internet addiction and significantly negatively correlated with stress; stress was significantly positively correlated with Internet addiction; and self-control was significantly correlated with other variables.

Table 4
Correlations and descriptive statistics of the main variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical exercise</td>
<td>43.719</td>
<td>29.422</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Internet addiction</td>
<td>1.804</td>
<td>0.931</td>
<td>-0.579**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Stress</td>
<td>1.286</td>
<td>1.206</td>
<td>-0.439**</td>
<td>0.615**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4. Self-control</td>
<td>2.946</td>
<td>1.320</td>
<td>0.184**</td>
<td>-0.006</td>
<td>0.023</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: *P 0.05; **P 0.01

3.5 Mediated Model Analysis

To test the mediating effect of stress, Bootstrap sampling test was used to verify the mediating effect, and the sample was repeated 5000 times. Table 5 shows that physical exercise negatively predicted Internet addiction (β = -0.383, P < 0.01), so Hypothesis 1 was supported; physical exercise negatively predicted stress (β = -0.439, P < 0.01) and stress positively predicted Internet addiction (β = 0.447, P < 0.01). Table 6 shows that the direct effect of physical activity on Internet addiction was −0.018, 95% CI = [-0.014, -0.010] and the indirect effect of stress was −0.006, 95% CI = [-0.260, -0.138]. Bootstrap 95%
confidence intervals for both direct and indirect effects did not contain 0, indicating that both effects were significant. Thus, stress partially mediates the relationship between physical activity and internet addiction among college students, and hypothesis 2 was supported.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Stress</th>
<th>Internet addiction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>SE</td>
</tr>
<tr>
<td>Physical exercise</td>
<td>-0.439</td>
<td>0.002</td>
</tr>
<tr>
<td>Stress</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.193</td>
<td></td>
</tr>
<tr>
<td>$F$</td>
<td>112.652</td>
<td></td>
</tr>
</tbody>
</table>

Table 6
Bootstrapping analysis of the mediation model.

<table>
<thead>
<tr>
<th>Effect</th>
<th>SE</th>
<th>95% CI</th>
<th>Ratio to Total Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct effect</td>
<td>-0.012</td>
<td>0.001</td>
<td>[-0.014, -0.010]</td>
</tr>
<tr>
<td>Indirect effect</td>
<td>-0.006</td>
<td>0.031</td>
<td>[-0.260, -0.138]</td>
</tr>
<tr>
<td>Total effect</td>
<td>-0.018</td>
<td>0.001</td>
<td>[-0.021, -0.016]</td>
</tr>
</tbody>
</table>

3.6 Moderated Model Analysis

Table 7 shows that physical exercise significantly negatively predicted Internet addiction ($\beta = -0.568$, $t = -14.277$, $P < 0.01$), hypothesis 1 was further supported; physical exercise negatively predicted stress ($\beta = -0.493$, $t = -10.614$, $P < 0.01$) and stress positively predicted Internet addiction ($\beta = 0.568$, $t = 16.520$, $P < 0.01$), and hypothesis 2 was further supported. The interaction term of physical exercise and self-control significantly predicted Internet addiction ($\beta = -0.095$, $t = -2.418$, $P < 0.01$), indicating that self-control moderated the relationship between physical exercise and Internet addiction; the interaction term of stress and self-control significantly predicted Internet addiction ($\beta = -0.210$, $t = -5.903$, $P < 0.01$), indicating that self-control also moderated the relationship between stress and Internet addiction. Therefore, hypotheses 3 and 4 were supported.
Table 7
Regression analysis of the moderating model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stress</th>
<th>Internet addiction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\beta)</td>
<td>(SE)</td>
</tr>
<tr>
<td>Physical exercise</td>
<td>-0.493</td>
<td>0.002</td>
</tr>
<tr>
<td>Stress</td>
<td>0.568</td>
<td>0.027</td>
</tr>
<tr>
<td>Self-control</td>
<td>0.108</td>
<td>0.027</td>
</tr>
<tr>
<td>Physical exercise × Self-control</td>
<td>-0.095</td>
<td>0.001</td>
</tr>
<tr>
<td>Self-control × Stress</td>
<td>-0.210</td>
<td>0.021</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.193</td>
<td></td>
</tr>
<tr>
<td>(F)</td>
<td>112.652</td>
<td></td>
</tr>
</tbody>
</table>

Further explaining the moderating effect by slope analysis: Fig. 2 shows that the negative predictive effect of physical exercise on college students’ Internet addiction was significant for those with high self-control (1 SD above the mean, \(\beta = -0.021, P < 0.01\)), but not for those with low self-control (1 SD below the mean, \(\beta = -0.015, P < 0.01\)). That is, as the level of self-control increases, the effect of physical exercise on college students’ Internet addiction is enhanced.

Figure 3 shows that the positive predictive effect of stress on college students’ Internet addiction is not significant among those with high self-control (1 SD below the mean, \(\beta = 0.292, P < 0.01\)) but significant for those with low self-control (1 SD above the mean, \(\beta = 0.612, P < 0.01\)). That is, the effect of stress on college students’ Internet addiction decreases as the level of self-control increases.

4. Discussion

4.1 Direct Effect of Physical Exercise

The results of the study showed that physical exercise had a significant negative predictive effect on college students’ Internet addiction symptoms (\(\beta = -0.568, P < 0.01\)), and regular physical exercise helped to alleviate Internet addiction symptoms, which is consistent with the results of previous studies [54–56]. Under the influence of almost full coverage of 5G signals, the renewal of smartphones, the popularity of short video applications and online games, and the smooth access to campus networks, Internet use has become more and more convenient [57], which may lead to serious Internet addiction among college students. According to addiction replacement theory, physical exercise has the same instinctive activation function as the Internet, and exercise addiction can replace Internet addiction and achieve the effect of alleviating Internet addiction [24]. Most college students use the Internet for the purpose of getting pleasure in the virtual world, and participating in physical exercise can promote the secretion and release of \(\beta\)-endorphins, from which they can get pleasure and thus reduce the frequency of Internet use [58].
Active participation in physical exercise helps to reduce the time of Internet use and sedentary behavior [59], and after exercise interventions for college students with different levels of Internet addiction, it was found that not only did physical fitness indicators improve significantly, but the level of addiction was also greatly reduced [60]. It has been pointed out that Internet addicts are often accompanied by poorer interpersonal relationships [61] and life satisfaction [62], and even depressive tendencies [63], and physical exercise can improve college students' self-esteem [64] and self-satisfaction [65], promote interpersonal interactions [66], reduce depression levels [67], and gain more social support [68], which can effectively resist the temptation of the Internet. Therefore, physical exercise makes a positive contribution to alleviating the symptoms of Internet addiction among college students.

4.2 Mediating role of Stress

The results of this study showed that stress mediated the relationship between physical exercise and college students' Internet addiction, with physical exercise significantly and negatively predicting college students' stress ($\beta = -0.493, P < 0.01$) and stress significantly and positively predicting college students' Internet addiction ($\beta = 0.568, P < 0.01$). Physical exercise can reduce the stress (including psychological stress and academic stress) [69, 70], and college students with lower stress can maintain a good mindset and lifestyle habits, and negative emotions are well controlled, which can reduce the probability of Internet addiction [71, 72]. Studies have shown that regular physical exercise helps to reduce the stress level of individuals [15], and for college students, they have to face pressure from various aspects such as family, school, and society [43], and appropriate physical exercise can be one of the important ways to relieve stress. Long-term physical exercise can induce positive thinking and emotions [25], improve the individual's nervous system [73], and promote his/ her cognitive reserve of stress, which can serve as his/ her psychological capital to resist the negative effects of stress when facing various stressors, and cope with stress in a positive way so that stress can be released instead of being addicted to the Internet.

Academic stress is the most important source of stress for college students [28]. Academic performance is highly correlated with brain structure, function and cognitive ability [73], exercise can change brain structure and increase the activation level of learning-related brain areas [74], the higher the level of physical exercise, the higher the level of cognitive ability [75], and the positive effect of long-term exercise habits on cognitive ability is also long lasting [76]. The positive effect of physical exercise on the academic performance of college students plays an important role in relieving the academic stress and reducing the stress level.

The results indicated that the higher the stress level, the higher the level of Internet addiction among college students. The ACE theory model suggests that the Internet has the characteristics of escapism and college students will use the Internet to get rid of the stress in the real world [77]; the cognitive model states that external environmental stress is one of the important causes of Internet addiction among college students [32]; and the satisfaction theory indicates that individuals use the Internet to satisfy their psychological needs to obtain satisfaction [14]. College students are in their adolescence and their mental development is not mature enough, so when they need to deal with some life events alone, they will show anxiety and thus produce psychological pressure. At this time, the virtual world of the Internet
gives them a place to release their stress: they can watch movies and TV shows, play games, and chat with video and voice on the Internet, which briefly relieves their stress, but over time this way of relieving stress becomes a habit and even addiction. The more stressful college students are, the more likely they are to use the Internet uncontrollably in order to escape from reality and get a kind of maladaptive psychological satisfaction from it in order to reduce their stress. The conclusion of this study is that college students can reduce their stress and get satisfaction from physical exercise, which is not only good for their physical health but also reduces the probability of Internet addiction.

4.3 Moderating Role of Self-Control

This study found that self-control played a moderating role in the effects of physical activity and stress on Internet addiction among college students. The negative prediction of physical exercise on Internet addiction was more pronounced in individuals with high levels of self-control; the positive prediction of stress on Internet addiction was more pronounced in individuals with low levels of self-control. This indicates that high levels of self-control are more significant in alleviating the symptoms of Internet addiction, which is consistent with previous research findings [42–44].

Self-control moderated the relationship between physical activity and college students' Internet addiction ($\beta = -0.095$, $p < 0.01$), meaning that the negative effect of physical activity on college students' Internet addiction was stronger in individuals with high levels of self-control, but low levels of self-control weakened this effect. Lower self-control is one of the important moderating variables of adolescent delinquent behavior [41], and college students with lower levels of self-control are more likely to be addicted to the Internet, which takes up a lot of their time and leads to less time for exercise. Self-control is the ability of individuals to discipline and manage their behavior and emotions according to social standards or their own will [40], and physical exercise can effectively regulate individuals' self-control level, which is the best way to release individuals' repressiveness and impulsiveness and liberate physical and mental stress [78]. Individuals with low levels of self-control are more likely to be impulsive and produce undesirable behaviors, and coupled with the fact that college students themselves do not have as high an external constraint as secondary school students, this can have negative effects on their lives and psychology, such as a decrease in self-efficacy or psychological capital, which have been shown to significantly reduce their physical activity levels [79, 80]. Therefore, low levels of self-control may reduce college students' physical activity levels, which also weakens the negative effect of physical activity on their Internet addiction. Together with healthy habits as a sub-dimension of self-control, which positively contributes to physical activity, high levels of self-control can significantly contribute to the negative effect of physical activity on college students' Internet addiction.

In addition, self-control moderated the relationship between stress and Internet addiction among college students ($\beta = -0.210$, $p < 0.01$). Modern college students face pressure from various aspects such as academics and interpersonal relationships, which has a serious negative impact on their mental health [27], and compared to less stressed college students, stressed are more likely to be addicted to the Internet and gradually become addicted [31]. At this time, college students with higher levels of self-control are able to think and plan independently when dealing with stress and are hopeful for the future,
while college students with lower levels of self-control have difficulty in attenuating the negative effects of stress because of their limited resources and are prone to impulsive behaviors or gain instant gratification through undesirable behaviors [41]. Therefore, college students with a high level of self-control can better regulate their behaviors, resist the temptation of the Internet, and reduce stress with healthy behavioral habits, so that they are less likely to develop Internet addiction. The university environment and management norms are different from those of secondary schools, and the university environment is relatively more open, and college students are less restrained by teachers and parents, which can easily lead to the decline of college students' self-control level, uncontrolled entertainment, regression of academic performance, and thus academic stress. On the contrary, college students with higher self-control can focus on their own work, that is, study, which has a positive impact on relieving academic stress; at the same time, they also have a good degree of control in recreational activities and maintain healthy habits, which have a catalytic effect on reducing their own stress level. Therefore, a high level of self-control can significantly reduce the positive influence of stress on college students' Internet addiction.

In conclusion, when college students have a high level of self-control, their probability of Internet addiction is lower. According to the strength model of self-control, self-control can be enhanced by exercise [81]. Self-control is the same as muscles, which can be enhanced by exercise, and so is self-control. After two to four months of self-control training for college students, results showed that those who completed a particular training program (e.g., fitness) also had significantly higher levels of self-control in other areas (e.g., learning, stress coping, and emotion regulation) compared to the control group [82, 83]. This suggests that self-control can be improved by physical activity, and college students with higher levels of self-control are in turn able to moderate the effects of physical activity and stress on Internet addiction. Therefore, healthy exercise behaviors should be increased to promote the moderating effect of self-control on Internet addiction and reduce the probability of Internet addiction among college students.

4.4 Research Limitations and Outlook

This study clarifies the relationship between physical exercise and Internet addiction and its inner mechanism, which has theoretical and practical significance, but there are still some limitations, and further improvement is needed in the future. Firstly, the physical exercise studied in this paper refers to all sports, and its dimension needs to be extended, and future research can be conducted for specific sports items. Second, this study only considers the mediating role of stress and the moderating role of self-control, and it is not clear whether there are other effects (such as self-esteem, social support, peer relationships, etc.) between physical exercise and Internet addiction among college students, which can be further studied and analyzed in the future. Third, the data in this study comes from subjective questionnaire tests of the subjects and lacks objective tests, which could be added to the study in the future. Fourth, the sample size of this study is small, which limited the generalizability of the findings, and more samples could be added in the future.
5. Conclusions

This study analyzed and verified the relationship between physical exercise, stress, self-control, and Internet addiction among college students. Physical exercise has a significant negative effect on college students’ Internet addiction and plays an important role in reducing the probability of their Internet addiction. Stress plays a mediating role in the effect of physical exercise on Internet addiction, and participation in physical exercise can relieve the stress of college students, thus reducing the probability of Internet addiction. Self-control plays a moderating role in the effects of physical exercise and stress on college students’ Internet addiction. Compared with college students with low levels of self-control, those with high levels of self-control significantly contribute to the negative effects of physical exercise on Internet addiction and can reduce the positive effects of stress on their Internet addiction, showing a lower probability of Internet addiction.

Therefore, college students should participate in more physical exercise to promote healthy physical and mental development; at the same time, they should learn to resist bad temptations, restrain their impulsive behaviors, maintain moderate entertainment activities, and promote the improvement of self-control ability; secondly, school clubs can hold various activities to encourage college students to participate and enrich their after-school life; finally, schools should strengthen the publicity on the hazards and prevention of Internet addiction, so that college students can understand Internet addiction scientifically and use the Internet reasonably.

Declarations

Funding: No external funding was received for this study.

Institutional Review Board Statement: This study was conducted in accordance with The Declaration of Helsinki and was approved by the Ethics Committee of the Chengdu Sport University.

Informed Consent Statement: Consent was obtained from all participants with the assurance of anonymity.

Data Availability Statement: The original data for this study are available from the corresponding author upon reasonable request.

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References


53. Fornell, C. A Second Generation of Multivariate Analysis : Classification of Methods and Implications for Marketing Research; 1985;


Figures
Figure 1
Conceptual framework.

Figure 2
Interaction between physical exercise and Self-control.
Figure 3

Interaction between physical exercise and Stress.