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ORIGINAL ARTICLE

# The Impact of Physical Activity on College Students' Mobile Phone Dependence: the Mediating Role of Self-Control

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**Abstract**
The mobile phone dependence of college students has gradually become a common and serious problem in society. Physical activity constitutes an important intervention to ameliorate this phenomenon. Previous studies have found that self-control can effectively reduce dependence on mobile phones. Therefore, it is necessary to consider whether physical activity can improve self-control and reduce college students' mobile phone dependence. In total, 418 college students were selected by means of convenience sampling. The Physical Activity Rating Scale (PARS-3), the College Student Phone Dependency Questionnaire, and the College Student Self-Control Scale (SCS) were distributed electronically. The results show that 1) physical activity has a negative effect on college students' mobile phone dependence, 2) physical activity plays a positive role in the self-control of college students and 3) self-control plays a mediating role in the effect of physical activity on mobile phone dependence. Physical activity is an effective intervention for decreasing an individual's mobile phone dependence, and self-control acts as a mediator to reduce mobile phone use.

**Keywords** Physical activity · Self-control · Mobile phone dependence · Mediating effect · College students

Mobile phones have become a significant component of our daily life due to their multifunctionality. The current statistics show that the number of mobile phone users in China has reached 1.59 billion (Ministry of Industry and Information Technology of the People's Republic of China 2019). Mobile phones provide convenient methods for payment, shopping,

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entertainment, and learning that greatly simplify people's lives. However, the increasing negative impacts of mobile phones cannot be ignored. College students are also under the influence of the impact of mobile phones, leading some students to have a lower GPA, suffer from anxiety, and experience lower well-being and life satisfaction (Lepp et al. 2014). Many studies revealed that college students who are mobile phone overusers are more likely to suffer from poor-quality sleep (Sahin et al. 2013; Thomée et al. 2011). After a long period, their situation could worsen due to physical and psychological issues. Furthermore, mobile phone dependence is related to increased impulsiveness in college students (Mei et al. 2018). Mobile phone addiction is a related issue that has also become widespread among college students (Qing et al. 2019), especially long-term addiction and uncontrolled behavior.

## Mobile Phone Dependence among College Students

College students who depend on mobile phones and develop social and emotional disorders (Yen et al. 2009) exhibit a series of behavioral and technological addictions (Billieux 2012). High-frequency mobile phone use occupies college students' time, leading to lower academic performance. Academic performance is an important indicator of students' professional competence, and prior studies have shown that academic anxiety and procrastination among college students are positively correlated with their mobile phone use (Yang et al. 2019). Mobile phone dependence is positively related to depressive symptoms (Sara 2011) and negatively correlated with interpersonal relationships, self-esteem, self-regulation, and life satisfaction among young people (Lepp et al. 2014). Such poor and unsound social relationships could further increase individuals' dependence on their mobile phones, and thus, they reduce their number of social activities to alleviate their anxiety regarding social interactions. This situation presents a vicious circle (Demirci et al. 2015). Studies have shown that overreliance on mobile phones or mobile phone addiction can lead to physical and psychological discomfort that is detrimental to the social functioning of individuals (Walsh et al. 2011). Thus, it is vital to prevent and improve the excessive use of mobile phones among college students.

## Physical Activity

Physical activity is a progressive, nondisposable type of activity that is planned, developed, and repeatedly implemented; it can improve or maintain good physical fitness, including improved cardiopulmonary function, muscle strength, refined body composition, flexibility, etc. (Puetz et al. 2006). A meta-analysis found that there is no threshold of physical activity for health benefits (Warburton and Bredin 2017). Thus, sedentary people can easily gain observable benefits from minimal physical activity. In recent years, people have started to recognize the multifaceted positive effects of physical activity on the body and mind and have become convinced of the benefits of physical activity, even activity involving relatively low exertion.

## Self-Control

Self-control is the ability of an individual to regulate reactions to overcome impulses, which requires individuals to change not only their inherent or spontaneous behavior and their way of

thinking but also their levels of effort and consciousness to help them independently adjust their behavior to match their values and social expectations. Controlling impulses enables people to make better behavioral choices and maintain better long-term behaviors (Tangney et al. 2004). In many fields, self-control is considered a characteristic or the ability to influence behavior, and can be divided into state self-control and trait self-control. State self-control is a short-term, temporary resource-based characteristic, while trait self-control is a long-term and more stable characteristic. A higher level of trait self-control indicates that more self-control resources can be used (Baumeister et al. 2006), which also suggests that while trait self-control is a long-term, stable cognitive ability, it is also a trainable behavior.

The self-control strength model (Baumeister et al. 1998) considers that the resources available for self-control are limited. Once used, an individual's limited mental energy temporarily declines, which is also known as self-loss and has an impact on subsequent behaviors that require self-control (Finne et al. 2019). On the basis of previous studies, Zhang and Zhang (2017) proposed that self-control can be divided into inhibition self-control and persistence self-control. Inhibition self-control mainly refers to refraining from engaging in a behavior, while persistence self-control refers to maintaining a behavior.

## Self-Control and Mobile Phone Dependence

Self-control is among the psychological factors that effectively predict mobile phone addiction (e.g., Bianchi and Phillips 2005; Khang et al. 2012; Jiang and Zhao 2016; Mei et al. 2018). People with weak self-control are less able to resist automated habitual actions, such as the use of mobile phones, and tend to pursue immediate enjoyment, current desires, novel experiences, etc. Poor planning skills, low reaction inhibition, and the tendency to feel lost without their mobile phones and become bored easily are the characteristics of college students who rely on their mobile phones. Self-control can effectively restrain the unhealthy use of mobile phones. Impulse is a dimension of self-control, and many studies have shown that impulse is among the critical dimensions determining mobile phone overuse (Roberts and Pirog 2013). The more impulsive the student is, the more desperate they are to use their phones to satisfy their desires, and the more time they lose that could be used for studying; thus, they cannot control their behavior well and have a greater urge to rely on their phones, suggesting that their overuse of mobile phones is positively related to their impulses (Mei et al. 2018). Self-control involves not only healthy physical and mental behaviors, habits and concentration both at work and while studying, but also impulse control, controlled desire for entertainment, and resistance to temptation (Tan and Guo 2008). These are important qualities that help college students find a balance between their studies and mobile phone usage. Self-control implies that one engages in the appropriate behaviors needed to achieve one's goals.

## Physical Activity and Self-Control

An increasing number of studies have confirmed that physical activity not only shapes the body, improves weight loss, and strengthens the musculature but also has psychological benefits in terms of emotions, thinking, etc., and studies have shown that people with low self-control can benefit from physical activity (Schöndube et al. 2017). To date, limited research has investigated whether physical activity can improve self-control. Zou et al.

(2016) found that five weeks of aerobic exercise could be a potentially effective intervention to improve self-control in college students. The authors assert that through low-intensity but regular exercise, individuals can train and enhance their self-control. Other studies have demonstrated that moderate-intensity physical activity can effectively promote self-control among exercise participants (Kamijo et al. 2007).

## Hypothesis and Aims

As mobile phone dependence shares characteristics with Internet addiction, physical activity could improve behaviors that are similar to those observed with Internet addiction (Gao et al. 2012). On the one hand, physical activity objectively occupies a certain amount of time. On the other hand, physical activity can improve individuals' capacity for self-control and ameliorate their mobile phone dependence. Physical activity and the use of mobile phones are considered dual tasks performed within a short period, warranting the introduction of the self-control strength model (Baumeister et al. 1998). Based on this model, it is easier for people to lose their restraint regarding unconscious behaviors at night (such as playing on their mobile phones for a long time before going to bed), possibly due to depletion of their self-control resources after completing their daytime activities (Baumeister 2002). When self-control is regarded as a long-term stable state, accomplishing various tasks that consume one's self-control resources can actually improve one's level of self-control (Muraven 2010). Thus, a more stable level of self-control ability ensures that an individual has greater capacity to refrain from mobile phone use.

A meta-analysis (de Ridder et al. 2012) indicated that trait self-control has a small to moderate effect on behavior in many areas of life; i.e., self-control is positively correlated with adaptive, idealized behaviors (e.g., habitual, automated behavior) and negatively correlated with nonadaptive, nonidealized behaviors. The comprehensive model proposed by Hagger (2013) regarding trait self-control and its diverse influence on behaviors is similar: Hagger argued that self-control exhibits individual differences, reflecting the ability and availability of one's resources to resist impulses and habitual responses to participate in goal-oriented activities. Is there a mediation effect on the influence of self-control on mobile phone dependence?

The purpose of this study is to explore how physical activity can decrease an individual's dependence on mobile phones and how self-control plays a mediating role, i.e., how it decreases mobile phone dependency. According to prior research, self-control has a limiting effect on mobile phone dependence. Thus, it is proposed that if physical activity has a positive effect on self-control, then it is reasonable to speculate that self-control can affect the relationship between physical activity and mobile phone dependence as a mediating variable. Therefore, this paper establishes a structural equation model with physical activity as the independent variable, mobile phone dependence as the dependent variable, and self-control as the mediating variable, and the stability of the model is verified.

## Methods

### Participants

In total, 418 undergraduate students were recruited via convenience sampling from a university in Beijing (151 freshmen; 42 sophomores; 64 juniors; and 137 seniors). The

sample consisted of 115 males (29.2%) and 279 females (70.8%). In total, 220 (55.8%) participants were from rural areas, while 174 (44.2%) participants were from urban areas. Additionally, 137 (34.8%) participants were from a one-child family, while 256 (65.2%) participants were not.

## Measures

**Physical Activity Rating Scale (PARS-3: Liang 1994)** The PARS-3 is used to measure the amount of physical activity that participants engaged in during the previous month. In total, there are 3 items measuring exercise intensity, time and frequency (e.g., What is the intensity of your physical activity? If the frequency of several activities is similar, please select the activity with the maximum exercise intensity.). Each dimension is divided into 5 levels. Levels 1–5 of the exercise intensity correspond to 0–4 points. The exercise time and exercise frequency correspond to 1–5 points. The following formula is used: amount of physical activity = exercise intensity × exercise time × exercise frequency; thus, the minimum score of physical activity is 0 points, and the highest possible score is 100 points. The evaluation standard for the amount of physical activity is as follows: a small exercise amount is ≤19 points, a medium exercise amount is 20 to 42 points, and a large exercise amount is ≥43 points. The scale test-retest reliability is 0.82, and the internal consistency coefficient is 0.75.

**College Students' Mobile Phone Dependence Questionnaire (CSMDQ: Wang 2013)** The CSMDQ was developed by Wang (2013). In total, there are 20 items, and the items are rated on a 5-point Likert scale. The items cover withdrawal, i.e., the negative emotions that occur when an individual is involuntarily separated from his/her phone or is unable to use the applications normally; conflict, i.e., the negative influence on an individual's work or study; prominence, i.e., the meaning of mobile phones to the individual; continuousness, i.e., the number of uninterrupted hours of phone use; and technicality, i.e., an individual's habits during the operation of mobile media functions. The following is a sample item: "Cell phones are more important than clothes and food." "Complete disagreement" is scored as 1 point, "basic disagreement" is scored as 2 points, "uncertain" is scored as 3 points, "basic agreement" is scored as 4 points, and "complete agreement" is scored as 5 points. Thus, the higher the score is, the stronger the dependency trend of that individual. The consistency coefficient of the scale is 0.832, and the internal consistency coefficient of each factor ranges from 0.517 to 0.717. The correlation between each factor of the questionnaire ranges between 0.133 and 0.521, and the correlation between each factor and the total questionnaire ranges between 0.523 and 0.833.

**College Student Self-Control Scale (SCS: Tan and Guo 2008)** This scale consists of 19 items, and the Chinese version of the SCS has 5 dimensions (Tangney et al. 2004). The five dimensions are impulse control, resisting temptation, focusing on work or study, healthy habits and moderation. Statements such as "I am good at resisting temptation" are rated on a 5-point Likert scale. "Completely disagree" is scored as 1 point, "basically disagree" is scored as 2 points, "unsure" is scored as 3 points, "basically agree" is scored as 4 points, and "completely agree" is scored as 5 points. The scale includes 15 reverse-scored items. Thus, the higher the score is, the stronger the student's self-control ability. The internal consistency coefficient of the scale is 0.86.

### Procedures

We published the electronic questionnaire online for 5 days, and each participant completed the three scales. The questionnaire included the instructions, requirements and precautions and was completed anonymously. In total, 418 questionnaires were collected; 24 questionnaires were removed because the completion time was too short, and 394 valid questionnaires were obtained, yielding an effective recovery rate of 94.26%.

### Data Analysis

The results of the study were discussed and analyzed using SSPS20.0. A hierarchical linear regression analysis was used to investigate the effects of physical activity on self-control and mobile phone dependence after controlling for the demographic variables. An independent samples t-test was utilized to compare the high-level and low-level physical activity study participants in terms of their self-control and mobile phone dependence. AMOS 17.0 was used to establish a structural equation model and test whether the mediating effect of self-control was significant via the bootstrap method.

## Results

### Common Method Deviation Test

The Harman single factor test was used to conduct a common method deviation test using exploratory factor analysis. Without rotation, nine factors with a trait root greater than 1 were obtained. The first common factor interpretation percentage was 23.905%, which was less than 40%, suggesting that there was no serious common method bias.

### Regression Analysis and Difference Tests of Mobile Phone Dependence

After controlling for gender, place of origin and only-child status, the impact of physical activity on college students' mobile phone dependence was analyzed. Table 1 shows that model 1 was statistically significant before including physical activity in the model ($R^2 = 0.03$, $F$ (2, 391) = 5.78, $p < .01$). Notably, gender had a predictive effect on mobile phone dependence, as females reported more dependence on their mobile phones than males. Additionally, the student's place of origin could predict mobile phone dependence, as the college students from cities relied on their mobile phones more than the college students from rural areas. After including the amount of physical activity, model 2 was found to be statistically significant ($R^2 = 0.06$, $F$ (2, 391) = 8.00 ($p < .01$), $\Delta R^2 = 0.03$), and physical activity was significantly associated with mobile phone dependence ($\Delta F = 12.10$, $p < .01$). The amount of physical activity was negatively associated with mobile phone dependence, whereas the place of origin remained significantly associated with mobile phone dependence.

Because the numbers of college students who performed moderate and high amounts of exercise were not large enough, the two groups were combined, and the subjects were divided into the high- and low-exercise groups as follows: those receiving ≤19 points were assigned to the low-exercise group, and those receiving ≥20 points were assigned to the high-exercise group. The results of the independent samples $t$-test showed (Table 2) that the persistence of

**Table 1** The effect of college students' physical activity on mobile phone dependence using different demographic characteristics

| Variable | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | *B* | *β* | *B* | *B* |
| Gender | 3.18* | 0.12 | 1.30 | 0.05 |
| Place of origin | 3.15* | 0.13 | 3.44** | 0.14 |
| One-child family | / | / | / | / |
| P.A. | | | −0.13** | −0.19 |
| $R^2$ | 0.03 | | 0.06 | |
| *F* | 5.78** | | 8.00** | |
| $\Delta R^2$ | 0.01 | | 0.03 | |
| $\Delta F$ | 5.38* | | 12.10** | |

Note: Model 1 included only gender, place of origin and only-child status; physical activity was added to Model 2. Only-child status was not entered in the model. *$p < .05$; **$p < .01$ (the same below)

mobile phone dependence significantly differed between the two physical activity groups ($t = 2.88$, $p < .01$), as the low-exercise group used their mobile phones for longer periods. Technicality also significantly differed between the physical activity groups ($t = 2.13$, $p < .05$), as the high-exercise group used their mobile phones to pursue technical learning more frequently than the low-exercise group. The difference in the level of withdrawal between the genders according to the amount of physical activity was also significant ($t = 3.08$, $p < .01$); the low-exercise students were more inseparable from their mobile phones. Overall, the results revealed that mobile phone dependence is significantly different between the low- and high-exercise groups ($t = 3.34$, $p < .01$); i.e., college students with high exercise levels are less dependent on their mobile phones.

## Regression Analysis and Difference Tests of Self-Control

We analyzed the impact of physical activity on the self-control of college students after controlling for their gender, place of origin and only-child status (Table 3). Model 1′ is statistically significant ($R^2 = 0.04$, $F$ (2, 391) = 7.07, $p < .01$) before physical activity is entered into the model. The students' place of origin influences their self-control as

**Table 2** Analysis of the difference in physical activity amounts, mobile phone dependence dimensions and total scores

| Independent variance | | Dependent variance | *n* | *M* | *SD* | *t* | *p* |
|---|---|---|---|---|---|---|---|
| Amount of P.A. | Low | Continuousness | 237 | 22.58 | 0.30 | 2.88 | 0.00 |
| | High | | 157 | 21.15 | 0.40 | | |
| Amount of P.A. | Low | Technicality | 237 | 9.11 | 0.22 | 2.13 | 0.03 |
| | High | | 157 | 8.38 | 0.26 | | |
| Amount of P.A. | Low | Withdrawal | 237 | 11.44 | 0.23 | 3.08 | 0.00 |
| | High | | 157 | 10.32 | 0.28 | | |
| Amount of P.A. | Low | Conflict | 237 | 9.82 | 0.17 | 1.62 | 0.11 |
| | High | | 157 | 9.35 | 0.24 | | |
| Amount of P.A. | Low | Prominence | 237 | 8.47 | 0.19 | 1.75 | 0.08 |
| | High | | 157 | 7.96 | 0.22 | | |
| Amount of P.A. | Low | Mobile phone dependence | 237 | 61.41 | 0.79 | 3.34 | 0.00 |
| | High | | 157 | 57.17 | 1.00 | | |

**Table 3** The effect of physical education on the self-control of college students with different demographic characteristics

| Variance | Model 1' | | Model 2' | |
|---|---|---|---|---|
| | *B* | *β* | *B* | *β* |
| Gender | −2.81* | −0.11 | −1.82 | −0.07 |
| Place of origin | −3.37** | −0.15 | −3.52** | −0.16 |
| One-child family | / | / | / | / |
| P.A. | | | 0.07* | 0.11 |
| $R^2$ | 0.04 | | 0.05 | |
| *F* | 7.07** | | 6.12** | |
| $\Delta R^2$ | 0.01 | | 0.01 | |
| $\Delta F$ | 5.26* | | 4.11* | |

Note: Model 1′ included only gender, student's place of origin and only-child status; Model 2′ included physical activity. Only-child status was not included in the model

students from urban areas were found to have a higher self-control capacity. Gender also exerted an influence on students' self-control capacity, as females showed worse self-control than males. After adding physical activity to the model, model 2′ was statistically significant ($R^2 = 0.05$, $F$ (2, 391) = 6.12, $p < .01$), and the effect of physical activity was significant ($\Delta F = 4.11$, $p < .05$). Students with higher levels of physical activity had stronger self-control. Moreover, the effect of place of origin on students' self-control remained significant.

The independent samples *t*-tests (Table 4) revealed a significant difference in impulse control between the groups of different levels of physical activity ($t = -2.39$, $p < .05$). Healthy habits were positively associated with physical activity ($t = -3.31$, $p < .01$), and students with low exercise levels were found to have poor health habits. Additionally, the temptation dimension significantly differed between the low-exercise and high-exercise groups ($t = -3.15$, $p < .01$); compared with the high-exercise group, the low-exercise group had less capacity to resist temptation. Focus on work also significantly differed based on the level of physical activity ($t = -2.37$, $p < .05$), as students with high activity levels were more likely to concentrate on their work or studies than those with low levels. Overall, the results revealed that self-control is significantly different between the low- and high-exercise groups ($t = -3.31$, $p < .01$); i.e., a higher level of physical activity leads to greater self-control.

**Table 4** Analysis of the differences in physical activity amount and self-control dimensions

| Independent variance | | Dependent variance | *n* | *M* | *SD* | *t* | *p* |
|---|---|---|---|---|---|---|---|
| Amount of P.A. | Low | Impulse control | 237 | 19.36 | 0.31 | −2.39 | 0.02 |
| | High | | 157 | 20.57 | 0.41 | | |
| Amount of P.A. | Low | Healthy habits | 237 | 8.55 | 0.16 | −3.31 | 0.00 |
| | High | | 157 | 9.47 | 0.23 | | |
| Amount of P.A. | Low | Resisting temptation | 237 | 11.62 | 0.16 | −3.15 | 0.00 |
| | High | | 157 | 12.47 | 0.23 | | |
| Amount of P.A. | Low | Focus on work | 237 | 8.94 | 0.13 | −2.37 | 0.02 |
| | High | | 157 | 9.45 | 0.18 | | |
| Amount of P.A. | Low | Entertainment moderation | 237 | 9.05 | 0.18 | −1.97 | 0.05 |
| | High | | 157 | 9.61 | 0.23 | | |
| Amount of P.A. | Low | Self-control | 237 | 58.32 | 0.66 | −3.31 | 0.00 |
| | High | | 157 | 62.10 | 0.98 | | |

## Mediation Effect Test of the Hypothesized Model

### Mediating Effect Test of the Overall Model

According to the results above, physical activity has an impact on college students' mobile phone dependence, and there is a relationship between physical activity and self-control. We sought to establish the mechanism linking physical activity, self-control and mobile phone dependence. A structural equation model of physical activity and mobile phone dependence with self-control as a mediating variable was established. The model was verified as follows.

First, the mediating effect model (see Fig. 1) was established, including the self-control dimensions (impulse control, healthy habits, resisting temptation, and focus on work), physical activity, and the dimensions of mobile phone dependence (persistence, technicality and withdrawal). Self-control was used as a mediator. The results indicate that the model fit is not ideal ($x^2/df = 3.55$, $GFI = 0.96$, $AGFI = 0.93$, $RMSEA = 0.08$).

Based on the modification index and the practical significance of the research, the two pairs of error terms (resisting temptation and healthy living) are covariates that can reduce the chi-square values by 9.24 and 10.35, respectively. The fit of the modified final structural equation model is good ($x^2 = 38.58$, $df = 16$, $x^2/df = 2.41$, $GFI = 0.98$, $AGFI = 0.95$, $CFI = 0.97$, $RMSEA = 0.06$, $SRMR = 0.04$).

The bootstrap test was used to repeat the sampling 2000 times (Table 5), and the deviation-corrected nonparametric percentile bootstrap method was used as the test basis (Hayes and Scharkow 2013). The indirect effect value is −0.15, and the 90% deviation correction confidence interval is [−0.22, −0.08], suggesting the presence of a mediating effect. The direct effect value is −0.09, and the 90% confidence interval is [−0.17, 0.01] and contains 0, indicating that the direct impact of physical activity on mobile phone dependence in the

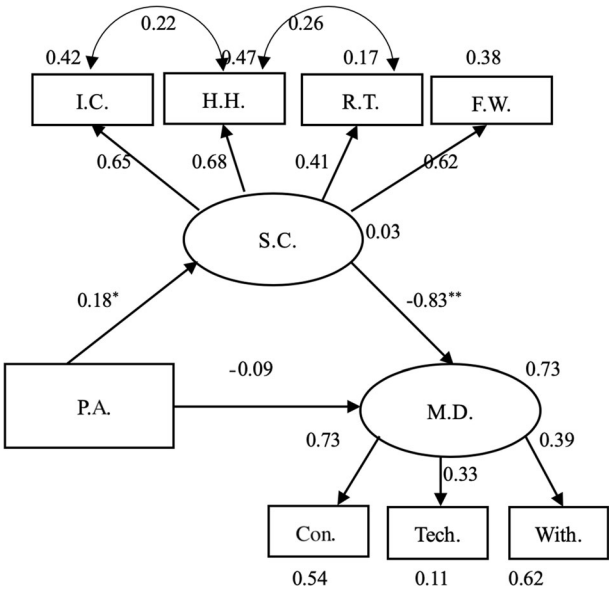


**Fig. 1** The impact of physical activity on mobile phone dependence: a mediation model of self-control

**Table 5** Mediation effect test

| | Effect value | S.E. | 95% C.I. |
|---|---|---|---|
| Total effect | −0.24 | 0.06 | [−0.33, −0.15] |
| Direct effect | −0.09 | 0.05 | [−0.17, 0.01] |
| Indirect effect | −0.15 | 0.04 | [−0.22, −0.08] |

mediation model is not significant (Zhao et al. 2010). In practical research, cases of complete intermediation are rare (Iacobucci 2008). If self-control fully intervenes in the relationship between physical activity and mobile phone dependence, the possibility of other intermediaries is excluded (Pituch et al. 2005); thus, complete mediation should not be considered (Preacher and Hayes 2008). After adding self-control, the direct effect of physical activity on mobile phone dependence is not significant. Bootstrapping verifies that in this model, self-control has a mediating effect on the relationship between physical activity and mobile phone dependence.

## Cross-Group Model Stability Test

To verify whether the mediation model has universal applicability, this study conducted a cross-group analysis of the model based on gender and place of origin (see Table 6). The model fit degree is good ($x^2 = 87.55$, $RMSEA = 0.04$, $GFI = 0.95$). The measurement weight model showed that there is no significant difference in the factor loads; i.e., the loads of the male and female models are equivalent ($p > .05$). The measurement weight model and the structural covariance model were compared and analyzed, and $\triangle x^2$ reaches the critical value of $x^2$ (0.05, $\triangle df$). This finding indicates that there are significant differences in the covariates of the mediation models among college students of different genders. Thus, there are gender differences within the model. Further analysis shows that gender affects only the path from physical activity to self-control. The path coefficients of the male and female students are 0.12 and 0.16, respectively. The critical ratio of the differences between the parameters is $1.05 < 2.13$ (Wu 2010). Thus, gender has a moderating effect on the path from physical activity to self-control. Physical activity is more effective in improving self-control in females than males.

The model fit results ($x^2 = 58.06$, $RMSEA = 0.04$, $GFI = 0.97$) revealed no difference with respect to the students' place of origin. Thus, the model is widely applicable to different groups from rural and urban areas. The model nested comparison table shows the results of the comparison and analysis of the measurement weight model and the structural covariance model. $\triangle x^2$ does not reach the critical value of $x^2$ (0.05, $\triangle df$); thus, there are no significant differences in the factor load values in the mediation models of college students from different places of origin. Additionally, while comparing the measurement residual model with the

**Table 6** Model nested comparison table of the gender and place of origin cross-group analysis

| Model | Gender | | | Place of origin | | |
|---|---|---|---|---|---|---|
| | *df* | $x^2/df$ | *p* | *df* | $x^2/df$ | *p* |
| Measurement weight | 5 | 2.98 | 0.70 | 5 | 10.04 | 0.07 |
| Structural covariance | 9 | 23.42 | 0.01 | 9 | 11.23 | 0.26 |
| Measurement residual | 20 | 36.54 | 0.01 | 20 | 24.75 | 0.21 |

structural covariance model, $\triangle x^2$ does not reach the critical value of $x^2$ (0.05, $\triangle df$), indicating that the residuals are also equivalent. Therefore, this model is equivalent for students from different places of origin.

## Discussion

### The Influence of Demographic Variables and Physical Activity on Mobile Phone Dependence

Physical activity can help decrease college students' mobile phone dependence. Gender affects college students' mobile phone dependence, and females' mobile phone dependence tends to be greater than that of males. This result is consistent with previous findings. Females spend more time and energy on mobile social networking and online shopping than males (Li et al. 2017). In addition, a student's place of origin has an impact on mobile phone dependence, as college students from cities are more dependent on mobile phones than those from rural areas. After controlling for the demographic variables, physical activity still has an overt negative effect on mobile phone dependence, indicating that physical activity can reduce college students' mobile phone dependence; moreover, the gender differences in mobile phone dependence are mainly a consequence of different levels of exercise. Physical activity can effectively reduce the dependence of college students on mobile phones, especially the persistence, technicality and withdrawal aspects of mobile phone dependence. Here, persistence includes both the duration of the use of mobile phones and the continuing psychological impact of the overuse of mobile phones (Wang 2013). Technicality is reflected in the various applications of mobile phones, including ringtones, wallpaper, and camera functions, which are attractive to college students. When overusers are involuntarily separated from or unable to use their mobile phones, they exhibit negative emotions, low self-efficacy, low self-esteem and other withdrawal reactions; physical activity can decrease these symptoms.

### The Influence of Demographic Variables and Physical Activity on Self-Control

Physical activity has a positive effect on self-control. College students of different genders and places of origin have different self-control capacities. Females have weaker self-control than males, and college students from rural areas have stronger self-control than those from urban areas. Daily city life is colorful, convenient and fast-paced but also full of all types of temptations, including overeating, crime, violence and addictive behavior, which tend to occur later in the day. This finding may be attributable to a depletion of self-control resources after the completion of an individual's daytime activities (Baumeister 2002). For curious youths, resisting the temptation of the mobile phone world is challenging. A student's place of origin has a greater influence than gender.

Physical activity positively influences the self-control dimensions of impulse control, healthy habits, resistance to temptation and the ability to focus on work. Engaging in physical activity can deplete an individual's self-control resources. This physical activity could lead to some discomfort due to the accumulation of the exercise load, thereby motivating the impulse to cease the activity. At this time, an individual's self-control system can activate and force the person to persist in training; in this way, an individual's self-control can actually be improved (Baumeister and Tice 2007). According to the multidimensional self-control perspective

proposed by Berkman et al. (2012), self-control can be divided into three parts, namely, emotional control, behavioral control and cognitive control, and a certain amount of exercise can alleviate negative emotions, restrain unhealthy/bad behaviors, and improve memory. Studies have shown that the mechanisms underlying the benefits of physical activity may be related to specific changes in the brain. For example, an increase in aerobic fitness in childhood is linked to a larger dorsal striatum region, which is the region of the brain that promotes cognitive control (Chaddock et al. 2010).

## The Impact of Physical Activity on Mobile Phone Dependence: The Mediating Effect of Self-Control

The process by which physical activity decreases mobile phone dependence through self-control can be explained by the self-control resource model. The self-control strength model (e.g., Baumeister et al. 1998; Baumeister and Vohs 2016) argues that individuals who undertake tasks that require self-control resources temporarily consume some limited resources that are not immediately recovered (Baumeister et al. 1998). Trainable self-control is divided into two forms, namely, strength (baseline ability) and endurance (ability to endure exhaustion), and self-control can only improve self-control (Muraven 2010). When both physical activity and mobile phone dependence are regarded as long-term and stable behaviors, after the limited resources are consumed, self-control recovery can break through the ceiling of the original self-control resources. This process leads to continuous improvement in an individual's trait self-control capacity. Due to the improvement in the self-control capacity, an individual's dependence on mobile phones decreases.

Self-control can help regulate one's behavior to meet specific criteria, such as ideals, values, ethics, and social expectations, and support the pursuit of long-term goals. The effects of physical activity and self-control are mutual. Many studies have explored the role of self-control in healthy behaviors, especially physical activity (Kinnunen et al. 2012; Galla and Duckworth 2015; Gerdtham et al. 2019; Finne et al. 2019). When engaging in exercise of a certain frequency, duration and intensity, it is necessary to use self-control resources. Lower self-control can lead the individual to fail to create an exercise plan or even meet low-level exercise intentions (Englert and Rummel 2016). Sport psychologists have divided self-control into inhibition and persistence self-control (Zhang and Zhang 2017), and physical activity is a long-term behavior that is not stable. As a dynamic process, physical activity can be divided into the following five stages: the pre-expected phase, the expected phase, the preparation phase, the action phase and the maintenance phase (Zong 2019). People with lower exercise levels are more likely to be in a stage prior to the difficult action phase, while individuals with higher exercise levels tend to be in the maintenance stage. Individuals with lower exercise levels need to use self-control resources more than individuals who have a higher exercise capacity when performing a certain amount of physical activity (Schöndube et al. 2017). Dependence on mobile phones has become a habitual and spontaneous behavior for some people. Individuals need to use cognitive inhibition, i.e., inhibitive self-control, to reduce their use of mobile phones (Zhang and Zhang 2017). In the short term after exercise, individuals with a low exercise level have fewer self-control resources than individuals with a high exercise capacity, reflecting a lower self-control capacity to restrain from using mobile phones. However, in the long term, the more self-control resources are used in the exercise process, the more beneficial exercise is in restoring the original self-control resources; i.e., people with low self-control have more room for improvement. Individuals with higher exercise levels also

consume self-control resources but to a lesser extent. This finding indicates that even if the exercise level is high, the individual has formed a habit with respect to exercise intensity, duration and form, and then, self-control is used. Less exercise is not conducive to improvement in self-control. High exercise levels are the result of long-term adherence to physical activity, and improvement in self-control ability can plateau. Therefore, people who have reached a certain level of physical activity should not continue to exercise in the same way. Researchers recommend more diverse physical activities, including different types, more diverse forms of participation, different rules, and different environments.

The multigroup path analysis indicated that gender has a moderating effect only in terms of the impact of physical activity on self-control. Women can improve their self-control through physical activity more easily than men. Generally, women undertake less physical activity than men; the results of this work and others have shown that females are more apt to benefit from physical activity (Jun and Park 2019) and improve their self-control. To improve the mental health of college students, increasing the amount of their exercise is a suitable method for cultivating self-control ability in the early stage of exercise. After a certain level of exercise has been reached and certain habits have been formed, it is recommended that exercise activities be diversified. The key is to use certain self-control resources in the exercise process, thereby improving one's self-control ability and decreasing one's dependence on mobile phones. Eliminate a series of physical and mental problems caused by the tendency of addiction in the long term.

### Limitations

In this study, physical activity level was assessed via a questionnaire. Thus, the level of physical activity subjectively reported by the participating respondents may be imprecise. In the future, the amount of physical activity could be tracked to achieve more accurate measurements. Most respondents who participated in the study were women, and most participants did not have a high level of physical activity; thus, the sample was unevenly distributed and lacked universality. Currently, mobile phones are rapidly developing, and the functions of mobile phones are not limited to simply making calls and sending text messages; mobile phones have become multifunctional. The environment on which the mobile phone dependence questionnaire relied was mostly based on the era of non-smartphones. Given the development of mobile phones, the sociological valence needs to be improved. In the future, a more scientific and effective questionnaire should be developed to address this issue. The advent of the era of Big Data helps researchers collect much larger sample sizes for analysis, thereby increasing universality and reducing bias in various factors.

## Conclusion

Physical activity has a predictive effect on college students' mobile phone dependence, and the tendency is lower among students with higher exercise levels. Physical activity also has an influence on the self-control of college students, and those with high levels of physical activity have stronger self-control. Self-control plays a mediating role in the relationship between the physical activity level and mobile phone dependence. Gender influences how physical activity affects self-control, as women can more easily enhance their self-control through physical

activity than men. This study suggests that people should engage in physical activity to improve their self-control to achieve the ultimate goal of decreasing mobile phone dependence.

**Authors' Contribution** All authors designed the study. Wang Yaxin conducted data collection. Zhong Weitan performed data analysis and carried out the bulk of the literature review and manuscript writing. Zhang Guoli participated in checking methods, results and guiding Zhong Weitan during the data analysis. Zhang Guoli played an editorial role when it came to writing up the research study. All authors read and approved the final manuscript.

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## Compliance with Ethical Standards

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Ethics** This study has been approved by the Ethics Committee of the School of Psychology at the Beijing Sport University. All participants agreed to give their information for scientific research and to provide anonymous responses. The research met the required ethical standards and was approved by the research team's university ethics committee.

## References

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*(5), 1252–1265.

Baumeister, R. F. (2002). Yielding to temptation: Self-control failure, impulsive purchasing, and consumer behavior. *Journal of Consumer Research, 28*(4), 670–676.

Baumeister, R. F., Gailliot, M., Dewall, C. N., & Oaten, M. (2006). Self-regulation and personality: How interventions increase regulatory success, and how depletion moderates the effects of traits on behavior. *Journal of Personality, 74*(6), 1773–1802.

Baumeister, R. F., & Tice, V. D. M. (2007). The strength model of self-control. *Current Directions in Psychological Science, 16*(6), 351–355.

Baumeister, R. F., & Vohs, K. D. (2016). Misguided effort with elusive implications. *Perspectives on Psychological Science, A Journal of the Association for Psychological Science, 11*(4), 574.

Berkman, E. T., Graham, A. M., & Fisher, P. A. (2012). Training self-control: a domain-general translational neuroscience approach. *Child Development Perspectives, 6*(4), 374–384.

Bianchi, A., & Phillips, J. G. (2005). Psychological predictors of problem mobile phone use. *Cyberpsychology & Behavior, 8*(1), 39–51.

Billieux, J. (2012). Problematic use of the mobile phone: A literature review and a pathways model. *Current Psychiatry Reviews, 8*, 299–307.

Chaddock, L., Erickson, K. I., Prakash, R. S., Kim, J. S., Voss, M. W., Vanpatter, M., Pontifex, M. B., Raine, L. B., Konkel, A., Hillman, C. H., Cohen, N. J., & Kramer, A. F. (2010). A neuroimaging investigation of the association between aerobic fitness, hippocampal amount, and memory performance in preadolescent children. *Brain Research, 1358*, 172–183.

Demirci, K., Akgönül, M., & Akpinar, A. (2015). Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. *Journal of Behavioral Addictions, 4*(2), 85–92.

De Ridder, D. T., Lensveltmulders, G., Finkenauer, C., Stok, F. M., & Baumeister, R. F. (2012). Taking stock of self-control: A meta-analysis of how trait self-control relates to a wide range of behaviors. *Personality & Social Psychology Review an Official Journal of the Society for Personality & Social Psychology Inc, 16*(1), 76.

Englert, C., & Rummel, J. (2016). I want to keep on exercising but I don't: The negative impact of momentary lacks of self-control on exercise adherence. *Psychology of Sport and Exercise, 26*, 24–31.

Finne, E., Englert, C., & Jekauc, D. (2019). On the importance of self-control strength for regular physical activity. *Psychology of Sport and Exercise, 43*, 165–171.

Galla, B. M., & Duckworth, A. L. (2015). More than resisting temptation: Beneficial habits mediate the relationship between self-control and positive life outcomes. *Journal of Personality and Social Psychology, 109*(3), 508–525.

Gao, J., Sun, J., & Xiao, K. (2012). Influence of sport interference on university students' network addiction. *Journal of Shenyang Sport University, 31*(4), 55–59.

Gerdtham, U. G., Wengström, E., & Östervall, L. W. (2019). Trait self-control, exercise and exercise ambition: Evidence from a healthy, adult population. *Psychology, Health & Medicine, 4*, 1–10.

Hagger, M. S. (2013). The multiple pathways by which self-control predicts behavior. *Frontiers in Psychology, 4*, 849.

Hayes, A. F., & Scharkow, M. (2013). The relative trustworthiness of inferential tests of the indirect effect in statistical mediation analysis: Does method really matter? *Psychological Science, 24*(10), 1918–1927.

Iacobucci, D. (2008). *Mediation analysis*. Thousand Oaks, CA: Sage.

Jiang, Z., & Zhao, X. (2016). Self-control and problematic mobile phone use in chinese college students: The mediating role of mobile phone use patterns. *BMC Psychiatry, 16*(1).

Jun, H. J., & Park, S. (2019). The effect of cross-level interaction between community factors and social capital among individuals on physical activity: Considering gender difference. *International Journal of Environmental Research and Public Health, 16*(3), 495.

Kamijo, K., Nishihira, Y., Higashiura, T., & Kuroiwa, K. (2007). The interactive effect of exercise intensity and task difficulty on human cognitive processing. *International Journal of Psychophysiology, 65*(2), 114–121.

Kinnunen, M. I., Suihko, J., Hankonen, N., Absetz, P., & Jallinoja, P. (2012). Self-control is associated with physical activity and fitness among young males. *Behavioral Medicine, 38*(3), 83–89.

Khang, H., Woo, H. J., & Kim, J. K. (2012). Self as an antecedent of mobile phone addiction. *International Journal of Mobile Communications, 10*(1), 65.

Lepp, A., Barkley, J. E., & Karpinski, A. C. (2014). The relationship between cell phone use, academic performance, anxiety, and satisfaction with life in college students. *Computers in Human Behavior, 31*, 343–350.

Li, Z. B., Liang, Y., & Wang, T. T. (2017). The impact of college students' mobile phone dependence and self-control on procrastination. *Psychological Research, 10*(2), 90–96.

Liang, D. Q. (1994). The stress level of college students and its relationship with physical activity. *Chinese Journal of Mental Health, 1*, 5–6.

Mei, S. L., Chai, J. X., Wang, S. B., Ng, C. H., Ungvari, G. S., & Xiang, Y. T. (2018). Mobile phone dependence, social support and impulsivity in chinese university students. *International Journal of Environmental Research & Public Health, 15*(3), 504–510.

Ministry of Industry and Information Technology of China. Telephone users in July 2019 by province. http://www.miit.gov.cn/n1146312/n1146904/n1648372/c7277606/content.html, 2019-9-12.

Muraven, M. (2010). Building self-control strength: Practicing self-control leads to improved self-control performance. *Journal of Experimental Social Psychology, 46*(2), 0–468.

Pituch, K. A., Whittaker, T. A., & Stapleton, L. M. (2005). A comparison of methods to test for mediation in multisite experiments. *Multivariate Behavioral Research, 40*(1), 1–23.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*(3), 879–891.

Puetz, T. W., O'Connor, P. J., & Dishman, R. K. (2006). Effects of chronic exercise on feelings of energy and fatigue: A quantitative synthesis. *Psychological Bulletin., 132*(6), 866–876.

Qing Z. H., Cao J.P., Wu C.H., & Liu X.Q. (2019). Investigation on the status quo and influencing factors of college students' mobile phone addiction from the perspective of ecology. *Modern Preventive Medicine* (5), 865–869+874.

Roberts, J. A., & Pirog, S. F. (2013). A preliminary investigation of materialism and impulsiveness as predictors of technological addictions among young adults. *Journal of Behavioral Addictions, 2*(1), 56–62.

Sahin, S., Ozdemir, K., Unsal, A., & Temiz, N. (2013). Evaluation of mobile phone addiction level and sleep quality in university students. *Pakistan Journal of Medical Sciences, 29*, 913–918.

Sara, A. (2011). Mobile phone use and stress, sleep disturbances and symptoms of depression among young adults – a prospective cohort study. *BMC Public Health, 11*(66), 2–11.

Schöndube, A., Bertrams, A., Sudeck, G., & Fuchs, R. (2017). Self-control strength and physical activity: An ecological momentary assessment study. *Psychology of Sport and Exercise, 29*, 19–26.

Tan, S. H., & Guo, Y. Y. (2008). Revision of the university self-control scale. *Chinese Journal of Clinical Psychology, 16*(5), 468–470.

Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality, 72*(2), 271–324.

Thomée, S., Härenstam, A., & Hagberg, M. (2011). Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults – a prospective cohort study. *BMC Public Health, 11*, 185–188.

Walsh, S. P., White, K. M., Cox, S., & Young, R. M. (2011). Keeping in constant touch: The predictors of young Australians' mobile phone involvement. *Computers in Human Behavior, 27*(1), 333–342.

Wang Z. X. (2013). *Research on the relationship between college students' mobile phone dependence and impulsiveness.* (Doctoral dissertation, Suzhou University).

Warburton, D. E. R., & Bredin, S. S. D. (2017). Health benefits of physical activity: A systematic review of current systematic reviews. *Current Opinion in Cardiology, 32*(5), 541–556.

Wu, M. L. (2010). *Structural equation model – the operation and application of AMOS*. CQ: Chongqing University Press.

Yang, Z., Asbury, K., & Griffiths, M. D. (2019). An exploration of problematic smartphone use among Chinese University students: Associations with academic anxiety, academic procrastination, self-regulation and subjective wellbeing. *International Journal of Meantal Health and Addiction, 7*, 596–614.

Yen, C. F., Tang, T. C., Yen, J. Y., Lin, H. C., Huang, C. F., Liu, S. C., & Ko, C. H. (2009). Symptoms of problematic cellular phone use, functional impairment and its association with depression among adolescents in southern Taiwan. *Journal of Adolescence, 32*, 863–873.

Zhang, Y., & Zhang, L. W. (2017). Progress in the classification of athletes' self-control training. *Chinese Journal of Sports Medicine, 10*, 72–76.

Zhao, X., Lynch, J. G., & Chen, Q. (2010). Reconsidering baron and kenny: Myths and truths about mediation analysis. *Journal of Consumer Research, 37*(2), 197–206.

Zong, H. L. (2019). Research on the relationship between college students' sports spiritual culture needs and exercise behavior. *Zhejiang Sports Science, 41*(5), 98–104.

Zou, Z., Liu, Y., Xie, J., & Huang, X. (2016). Aerobic exercise as a potential way to improve self-control after ego-depletion in healthy female college students. *Frontiers in Psychology, 7*, 501–509.