



# OPEN A chain mediation model of physical exercise and BrainRot behavior among adolescents

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This study aims to explore the impact of physical exercise on BrainRot behavior, as well as the mediating roles of Resilience and Ego depletion in the relationship between Physical exercise and BrainRot behavior. A total of 1091 adolescents from Sichuan and Hunan provinces completed self-report surveys on physical exercise, BrainRot behavior, resilience, and ego depletion. Descriptive analysis, correlation analysis, and mediation effect testing were conducted. After controlling for demographic variables, ego depletion was found to have an independent mediating effect between physical exercise and BrainRot behavior. Physical exercise was found to negatively predict ego depletion, which in turn significantly and positively predicted BrainRot behavior. The hypothesis that resilience played a mediating role between physical exercise and BrainRot behavior was not supported. Physical exercise significantly predicted resilience, but resilience did not significantly predict BrainRot behavior. Resilience and ego depletion exhibited a chained mediating effect between physical exercise and BrainRot behavior. Resilience could negatively predict ego depletion. Physical exercise could significantly predict BrainRot behavior. Moreover, during the analysis of the indirect effect, it was revealed that the negative predictive effect of physical exercise on BrainRot behavior remained significant. This study further investigates the multivariate mechanisms of influence between physical exercise and BrainRot behavior among adolescents.

**Keywords** Adolescents, Physical exercise, BrainRot behavior, Resilience, Ego depletion

With the rapid development of the Internet, people have entered the era of information technology<sup>1</sup>. While it has brought tremendous convenience to people's work and life, it also has some drawbacks<sup>2</sup>. For instance, a considerable number of adolescents find it difficult to control their browsing time on prevalent short-video apps such as "Douyin", "Kuaishou" and "Bilibili"<sup>3</sup>, and become addicted to them<sup>4</sup>, ultimately having a negative impact on their academic performance<sup>5</sup>. Recently, the Oxford English Dictionary has introduced the term "BrainRot", which is employed to depict the deterioration of brain function and cognitive abilities among adolescents as a result of excessive viewing of worthless short videos. Moreover, during the viewing of short videos, the activities in certain regions of the brain, such as the default mode network (DMN) and the midbrain, are remarkably enhanced<sup>6</sup>. This phenomenon has been gradually revealed in recent neuroscience research. Some scholars have utilized functional magnetic resonance imaging (fMRI) techniques to monitor the evolving roles of task - based and resting - state fMRI in different environments<sup>7</sup>. The results indicate that, compared with the resting state, the activation levels of the default mode network (DMN) associated with self - referential thinking, memory retrieval, and mental simulation are significantly enhanced. In recent years, given the escalating global popularity, short video applications have emerged as a crucial research topic. Presently, the number of users in China has surpassed one billion<sup>8</sup>. According to the '5th National Survey Report on Internet Use among Minors' (China Internet Network Information Center, 2023), the Internet penetration rate among minors increased from 93.7% in 2018 to 97.2% in 2022, indicating near-saturation levels. Meanwhile, the proportion of minor netizens who frequently watch short videos rose from 40.5 to 54.1%. Browsing short videos has already become an important avenue for us to obtain external information and culture in daily life. Numerous traditional Chinese cultural elements are also disseminated through short videos, enhancing public engagement<sup>9</sup>. However, it also gives rise to some new issues, among which the BrainRot behavior by adolescents is one<sup>2,10</sup>. Currently, research on the BrainRot behavior has increasingly drawn the attention of a vast number of scholars. The academic community generally holds that the BrainRot behavior means that the ease of use and entertainment features

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of short-video applications strengthen people's propensity for overuse, making it difficult for them to restrain their impulses. This is mainly manifested by young people spending a substantial amount of time on these short-video apps<sup>2</sup>. According to existing research findings, BrainRot behavior brings about numerous negative impacts on adolescents<sup>2,11,12</sup>. For instance, addiction may lead to mental health problems<sup>13</sup>, a decline in academic and work performance, as well as poor interpersonal communication quality and other issues<sup>10</sup>. Many existing studies have explored the relationship between physical exercise, Internet addiction, short-video addiction, and excessive short-video use<sup>14</sup>. However, there are few studies specifically focused on the relatively new concept of "BrainRot". Most studies mainly focus on the behavioral characteristics and direct consequences brought about by Internet addiction, short-video addiction, and excessive smartphone use<sup>15–19</sup>. For example, in a cross-sectional study of Chinese college students ( $n=950$ ), it was found that physical exercise could significantly and negatively predict the Internet addiction of college students<sup>20</sup>. However, if no timely intervention measures are taken<sup>21</sup>, ultimately, Internet addiction will lead to problems such as a decline in their academic performance and low social skills. In contrast, the term "BrainRot" in this study emphasizes more on the degradation of cognitive functions, rather than just staying at the description of the behavioral level. In other words, short-video addiction is the behavioral antecedent of "BrainRot", and "BrainRot" is its cognitive consequence. Therefore, this study aims to establish a chain-mediating model between adolescent physical exercise and "BrainRot" behavior to explore the relationship and influence mechanism between them.

Meanwhile, a substantial body of research has revealed that physical exercise confers a multitude of benefits<sup>22–24</sup>. Most scholars concur that physical exercise, which is a form of physical activity aiming to enhance cardiopulmonary function and augment muscle strength, is carried out under planned, regular, and repetitive conditions<sup>25</sup>. According to existing research, active participation in physical exercise can not only strengthen the body but also enhance the self-control ability of adolescents, reducing the probability of BrainRot behavior. This, in turn, promotes and contributes to the mental health of adolescents and guides their healthy growth<sup>26</sup>. In a recent national investigation, 61.8% and 65.1% of junior and senior high school students in China used short videos, and 72.1% and 77.0% used social media, respectively<sup>27</sup>. Evidently, adolescents account for a significant proportion among current short-video users. Physical exercise, as a non-pharmacological and efficacious approach to breaking addictive behaviors, can serve as a crucial means for preventing and treating various forms of addiction<sup>28–32</sup>. Some scholars have also implemented action research to conduct sports intervention experiments on adolescents with Internet addiction. The results demonstrated that employing physical exercise as a means to intervene in adolescents' Internet addiction yields remarkable effects<sup>33,34</sup>. Aken together, this study formulates the first hypothesis (H1): Physical exercise exerts a significant predictive effect on BrainRot behavior among adolescents.

According to relevant research, physical exercise also exerts a positive influence on mental health, enabling a significant enhancement in an individual's resilience<sup>35,36</sup>. Resilience<sup>40</sup> refers to an individual's capacity to maintain or swiftly recover to a healthy mental state when confronted with stress, challenges, or adversities. Regular participation in physical exercise can positively predict the resilience of adolescents<sup>41</sup>, as it facilitates the release of positive chemicals such as endorphins in the brain<sup>42</sup>, augments an individual's self-efficacy<sup>43</sup>, ameliorates and mitigates emotional states like anxiety and depression<sup>15,36,37–39</sup>, thereby assisting individuals in better coping with the stress and challenges in life<sup>44</sup>. Based on existing research, individuals with higher resilience are more capable of managing their emotions and behaviors<sup>45</sup>, resisting temptations, maintaining focus and self-discipline, and thus can effectively control and alleviate the BrainRot behavior<sup>46</sup>. Conversely, individuals with lower resilience lack healthy mechanisms to cope with stress and boredom, making them more prone to relying on short videos to seek immediate gratification and escape from the current situation, resulting in BrainRot behavior<sup>47</sup>. To sum up, this study formulates the second hypothesis (H2), that resilience has a significant mediating role between physical exercise and BrainRot behavior.

Furthermore, relevant research has revealed that physical exercise can also augment an individual's cognitive energy when they are experiencing a lack of personal energy and their cognitive resources are depleted by various life events, thereby reducing Ego depletion. Persisting in a task may temporarily impair one's capacity to persevere in subsequent tasks. This occurrence is termed "ego depletion"<sup>48</sup>. The positive effects of physical exercise on ego depletion include helping individuals to recover their energy and reducing the feeling of ego depletion. According to existing research, it is known that physical exercise can negatively predict ego depletion<sup>39,49</sup>. The theory of ego depletion posits<sup>50</sup>, that after an individual engages in activities requiring self-control, their self-control resources will be temporarily diminished<sup>51</sup>, rendering them more likely to succumb to temptations. The rapid and stimulating content provided by short-video platforms can readily capture users' attention and prompt them to spend copious amounts of time browsing. Thus, when individuals are in a state of ego depletion deficiency, they are more prone to become addicted to short videos, resulting in BrainRot behavior<sup>52</sup>. The instant gratification and addictive nature of short videos may further deplete an individual's self-control resources, creating a vicious cycle. According to the behaviorist theory, individuals who receive rewards for certain behaviors are more likely to respond to those behaviors. For instance, individuals with low social adaptability are more prone to experiencing frustration and failure in reality. In contrast, those with negative emotions and dissatisfaction with life can temporarily escape from their troubles via mobile phones. They achieve a sense of pleasure and relaxation by engaging in online games, online socializing, and accessing videos and music through mobile networks. Precisely due to these reasons, their frequent use of mobile phones leads to mobile phone addiction<sup>53</sup>. Ego depletion, as a psychological state, can be intervened through physical exercise, subsequently reducing the BrainRot behavior. Specifically, when an individual engages in physical exercise, it can diminish and alleviate the state of ego depletion<sup>54</sup>, thereby curtailing the BrainRot behavior. In this context, ego depletion serves as an intermediary variable, linking physical exercise and the BrainRot behavior. Hence, this study formulates the third hypothesis (H3): Ego depletion plays a significant mediating role between physical exercise and the BrainRot behavior.

Individuals who engage in regular physical exercise typically possess higher levels of resilience<sup>41,55,56,,</sup>. Consequently, when they encounter ego depletion, those with stronger resilience are more capable of effectively managing their psychological resources. Even when confronted with consecutive tasks, they are likely to experience less ego depletion<sup>57</sup>, enabling them to recover from adversity more swiftly. This implies that, even if individuals undergo ego depletion, they have a greater propensity to rebound from such a state in a shorter period<sup>46</sup>. Furthermore, individuals with high resilience are likely to possess a greater variety of coping strategies. For instance, they can mitigate anxiety and depression<sup>45</sup>, modulate their emotions<sup>58</sup>, and seek social support. These strategies can assist them in recovering more rapidly after experiencing ego depletion, consequently reducing the BrainRot behavior. Integrating the above viewpoints, this study formulates the fourth hypothesis (H4): Resilience and ego depletion have a chain mediating effect between physical exercise and the BrainRot behavior.

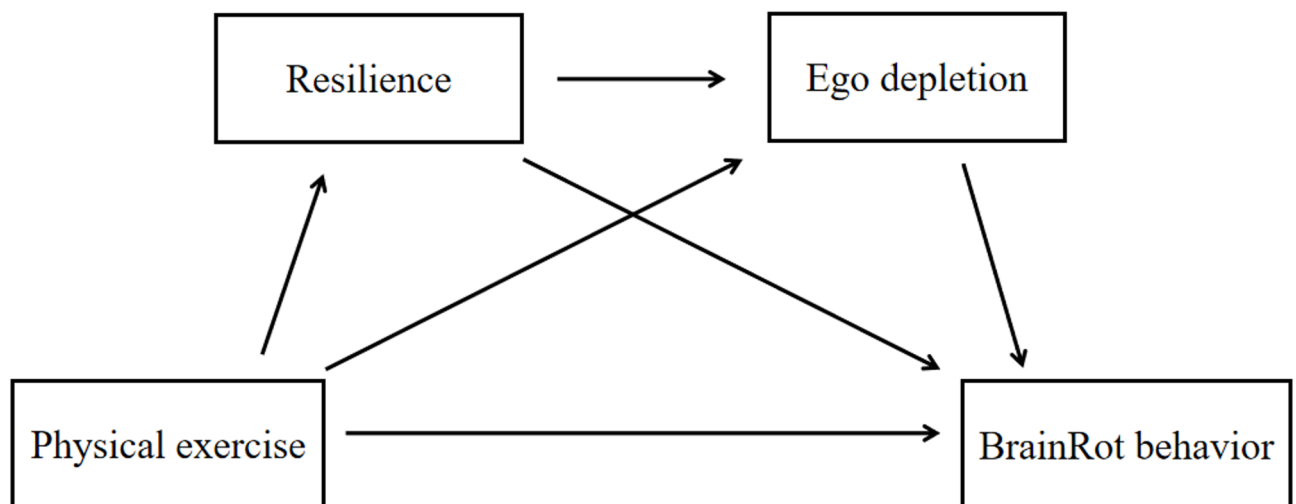
Scholars have investigated the impact of physical exercise on adolescents' short-form video addiction, incorporating self-control and cumulative ecological risk as mediating moderators. The results revealed that physical exercise significantly negatively predicts short-form video addiction<sup>26</sup>. Furthermore, a cross-sectional study on college students' short-form video usage behaviors demonstrated that physical exercise showed direct correlation with reduced nighttime video consumption, while exhibiting no significant effect on daytime usage<sup>59</sup>. Current research consistently identifies substantial associations between short-form video addiction and psychological factors, with physical exercise demonstrating capacity to enhance psychological resilience. In light of the preceding research, this study constructs an explanatory model regarding the impact of physical exercise on BrainRot behavior, employing resilience and ego depletion as significant mediating variables to offer an explanatory theory for the behavior of adolescents' BrainRot behavior. This study can not only augment the relevant theories associated with BrainRot behavior but also uncover the influence mechanism of adolescents' physical exercise on such excessive use, thereby providing theoretical support for resolving issues like BrainRot behavior among adolescents (see Fig. 1).

## Methods

### Participants

This study was conducted in November 2024. A total of 1,098 students were selected from 6 middle schools in Sichuan Province and 2 middle schools in Hunan Province, China, using the convenience sampling method. Through potential cooperative institutions, communication was conducted with the class teachers in advance, and 854 students from Chengdu, Sichuan Province and 237 students from Changsha, Hunan Province were selected respectively.

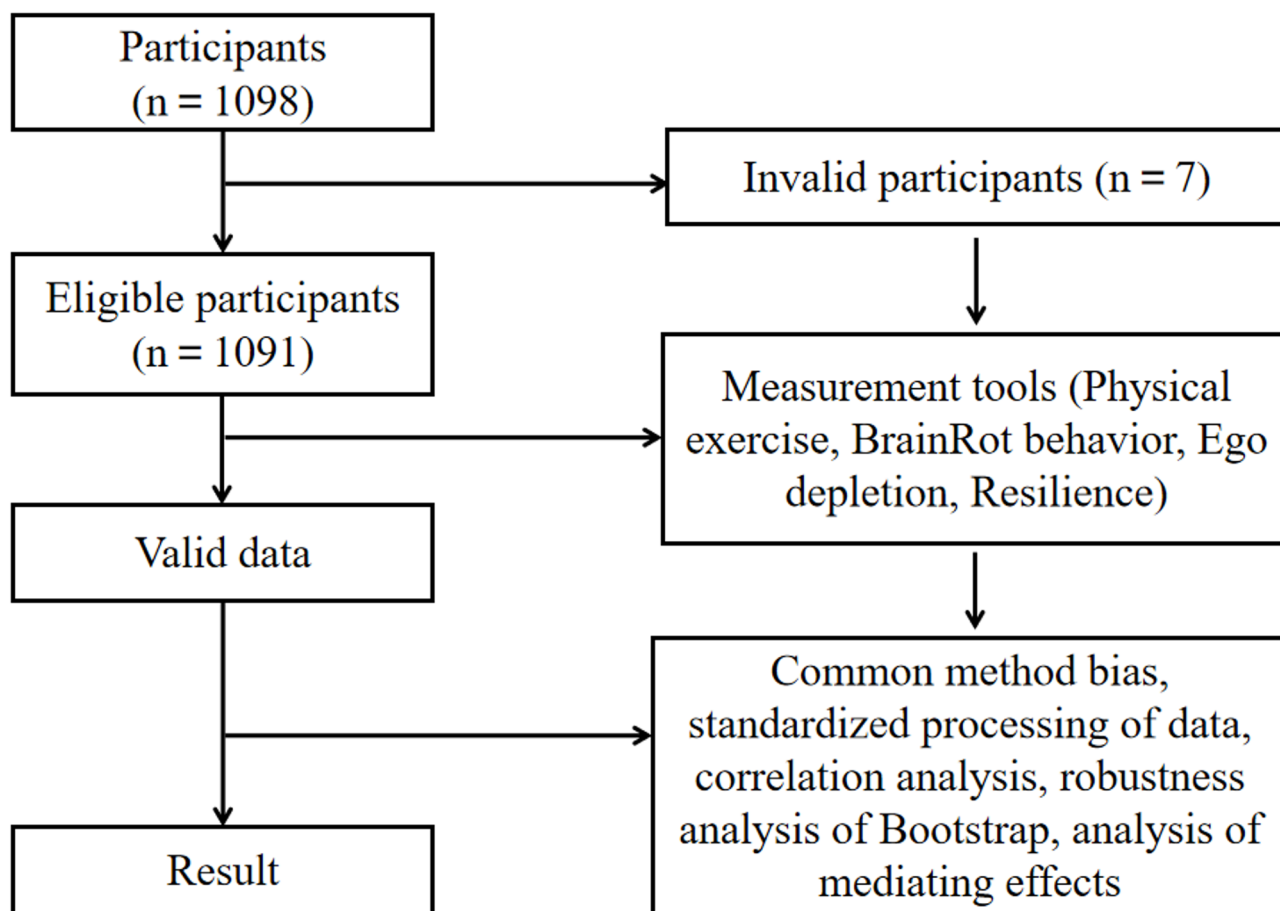
The study adopted the form of offline questionnaires, which were distributed through class groups. Before distributing the questionnaires, the survey content, data anonymization, confidentiality, and usage instructions of this study were clearly explained. Informed consent forms have been obtained from all participants and their guardians. During data collection, access to raw data was restricted to research team members directly involved in the study. These team members are bound by strict confidentiality agreements and are not allowed to disclose any information related to the participants. After the data collection is completed, the questionnaires are sealed and stored. Participants could generally complete the paper questionnaires within about 15 min. The collected data were screened. If two consecutive scales in a questionnaire selected the same answer, or the answers were incomplete, or the answers of the entire questionnaire showed regular patterns such as a wavy shape, the questionnaire would be regarded as invalid and removed. The final analysis sample of this study included 1,091 participants (gender: 533 boys and 558 girls; grade: 40 primary school students, 433 junior high school students, and 618 senior high school students; place of residence: 772 urban residents and 319 rural residents; only child or not: 238 only children and 853 non-only children; boarding or not: 355 boarders and 736 day students), with



**Fig. 1.** Mediation hypothesis model.

Items		N	Percent
Gender	Boys	533	48.9%
	Girls	558	51.1%
Grade	Primary school	40	3.7%
	Junior high school	433	39.7%
	Senior high school	618	56.6%
Place of Residence	Towns	772	70.8%
	Village	319	29.2%
Only child status	Yes	238	21.8%
	No	853	78.2%
Live on campus or not	Yes	355	32.5%
	No	736	67.5%

**Table 1.** Descriptive statistics of population variables.



**Fig. 2.** Study the flowchart.

an average age of 14.77 years ( $SD = 1.58$ ). The descriptive statistical results of the demographic variables are shown in detail in Table 1. The general process of this study is shown in Fig. 2.

### Measurement tools

#### *Physical exercise*

In this study, the Physical Activity Rating Scale (PARS-3) developed by the psychologist Hashimoto Kimitake<sup>60</sup>, was adopted for the measurement of physical exercise. Subsequently, the Chinese version revised by Chinese scholars such as Liang Deqing et al., was utilized, which reflects the physical activity status of the subjects over the past month<sup>61</sup>. The questionnaire employed in this research consists of three items, aiming to evaluate the level of physical activity, encompassing exercise intensity, duration, and frequency. Each item was rated using a 5-point Likert scale. Specifically, the ratings for exercise intensity and exercise frequency ranged from 1 to 5,

while the rating for duration ranged from 0 to 4. The total score of physical activity was calculated as the product of exercise intensity, duration, and exercise frequency. A higher score indicates a greater level of participation in physical activities among adolescents. In the current study, the Cronbach's  $\alpha$  value was 0.601.

*BrainRot behavior*

Regarding the measurement of BrainRot behavior, it was carried out by using a scale with short videos. Specifically, the short video use scale edited by Mao Zheng and Jiang Yongzhi et al., was mainly adopted, which can be utilized to evaluate the level of adolescents' short video addiction<sup>62</sup>. This scale encompasses three dimensions and a total of 13 questions. The score range for each question is from 1 (strongly disagree) to 5 (strongly agree), and the total score ranges from 13 to 65. A higher total score indicates a greater degree of BrainRot behavior. In this study, the Cronbach's  $\alpha$  coefficient of this scale was 0.879.

*Ego depletion*

Ego depletion was gauged by means of a scale devised by Lin and Johnson<sup>63</sup>, which was grounded in the research conducted by Twenge et al.<sup>64</sup>. This particular scale consists of 5 items and utilizes a 5-point Likert scale, with scores ranging from 1 (strong disagreement) to 5 (strong agreement). The total score spans from 5 to 25. A higher score implies a more profound degree of ego depletion. In this sample, the Cronbach's  $\alpha$  was 0.901.

*Resilience*

The Connor-Davidson Resilience Scales (CD-RISC) was adopted to evaluate resilience<sup>65</sup>. It has been ascertained in prior investigations that the first and fifth items within the CD-RISC were also capable of effectively gauging resilience<sup>66,67</sup>. Additionally, in the research carried out by Waddimba et al., it was determined that the second and ninth items exhibited enhanced reliability in assessing resilience<sup>68</sup>. Hence, in line with the recommendation of Waddimba et al., this study utilized these two specific items to appraise the resilience of the sample under consideration. This scale consists of a total of 2 items and employs a 5-point scoring system, with scores ranging from 1 (never) to 5 (always), and the total score spanning from 2 to 10. A higher score signifies stronger resilience. In this sample, the Cronbach's  $\alpha$  was 0.610.

**Data processing and analysis**

After the data is retrieved, the invalid data should be eliminated first, then the valid data should be entered into an excel table, and subsequently imported into SPSS 26.0 for analysis. Common method bias tests and correlation analyses were conducted for these data. Then, the data were standardized and mediated model tests were carried out. Finally, Bootstrap robustness analysis was performed. In the process of conducting the mediating effect test analysis in this study, gender and age were controlled, and  $\alpha < 0.05$  was taken as the significance test level.

**Results**

**Common method bias**

To evaluate the impact of common method bias, we employed Harman's single-factor test. The analysis results revealed that, without performing principal component factor rotation, there were three factors with eigenvalues greater than 1. The variance explained by the first factor (25.06%) fell below the 40% threshold. Consequently, this study did not exhibit significant common method bias.

**Correlation analysis**

As presented in Table 2, the results indicate that there exist significant negative correlations between physical exercise and both BrainRot behavior ( $r = -0.247, p < 0.001$ ) and ego depletion ( $r = -0.204, p < 0.001$ ), while a significant positive correlation is observed between physical exercise and resilience ( $r = 0.146, p < 0.001$ ). BrainRot behavior demonstrates a significant negative correlation with resilience ( $r = -0.144, p < 0.001$ ) and a significant positive correlation with ego depletion ( $r = 0.507, p < 0.001$ ). Moreover, a significant negative correlation is also found between resilience and ego depletion ( $r = -0.198, p < 0.001$ ).

**Mediating model test**

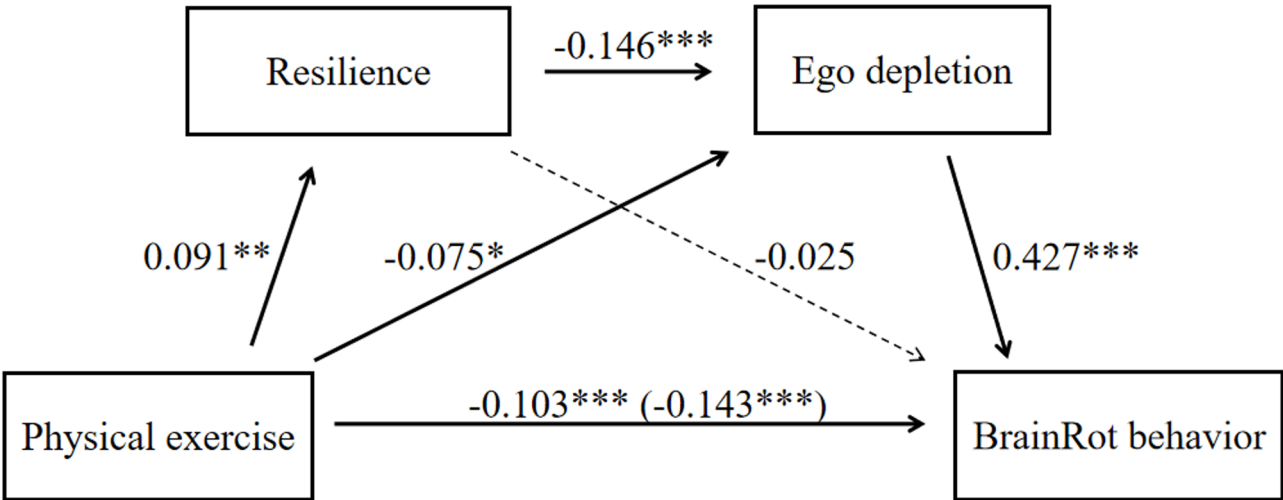
After controlling for demographic variables such as gender and age, physical exercise was found to significantly and negatively predict BrainRot behavior ( $\beta = -0.143, SE = 0.030, p < 0.001$ ). Furthermore, during the indirect effect analysis, it was revealed that the negative predictive effect of physical exercise on BrainRot behavior remained significant ( $\beta = -0.103, SE = 0.028, p < 0.001$ ). Meanwhile, physical exercise could positively predict resilience ( $\beta = 0.091, SE = 0.032, p < 0.01$ ) and negatively predict ego depletion ( $\beta = -0.075, SE = 0.030, p < 0.05$ ). In addition, resilience could also significantly and negatively predict ego depletion ( $\beta = -0.146, SE = 0.028, p < 0.001$ ).

	Physical exercise	Resilience	Ego depletion	BrainRot behavior
Physical exercise	-			
Resilience	0.146***	-		
Ego depletion	-0.204***	-0.198***	-	
BrainRot behavior	-0.247***	-0.144***	0.507***	-
***: $p < 0.001$				

**Table 2.** Correlation analysis.

Result variable	Predictor	$\beta$	SE	t	R <sup>2</sup>	F
BrainRot Behavior	Physical exercise	-0.143	0.030	-4.680***	0.140	25.167***
Resilience	Physical exercise	0.091	0.032	2.846**	0.052	8.424***
Ego Depletion	Physical exercise	-0.075	0.030	-2.482*	0.167	27.133***
	Resilience	-0.146	0.028	-5.124***		
BrainRot Behavior	Physical exercise	-0.103	0.028	-3.707***	0.299	51.245***
	Resilience	-0.025	0.026	-0.935		
	Ego Depletion	0.427	0.028	15.308***		

**Table 3.** Chain mediation model test. \*:  $p<0.05$ ; \*\*:  $p<0.01$ ; \*\*\*:  $p<0.001$ .



**Fig. 3.** Chain mediation model.

Paths	Effect size	SE	Bootstrap 95% CI	Proportion of mediating effect
Total effect	-0.143	0.030	-0.202, -0.083	
Direct effect	-0.103	0.028	-0.157, -0.048	
Total indirect effect	-0.040	0.015	-0.070, -0.011	27.972%
Physical exercise → Resilience → BrainRot behavior	-0.002	0.003	-0.009, 0.004	1.398%
Physical exercise → Ego depletion → BrainRot behavior	-0.032	0.015	-0.061, -0.003	22.377%
Physical exercise → Resilience → Ego depletion → BrainRot behavior	-0.006	0.003	-0.011, -0.001	4.195%

**Table 4.** Path analysis of the chain mediation model.

yet its prediction on BrainRot behavior was not significant ( $\beta = -0.025$ ,  $SE = 0.026$ ,  $p > 0.05$ ). Ego depletion could significantly and positively predict BrainRot behavior ( $\beta = 0.427$ ,  $SE = 0.028$ ,  $p < 0.001$ ). For detailed information regarding the mediating effect analysis between physical exercise and BrainRot behavior, please refer to Table 3; Fig. 2.

**Analysis of mediating effects**

This study employed path - analysis to test a chain - mediation model, and here we mainly interpret the following three paths. Among the specific mediating paths, the path “Physical exercise → Resilience → BrainRot behavior” (Effect size =  $-0.002$ ,  $SE = 0.003$ , Bootstrap 95% CI =  $[-0.009, 0.004]$ ) had a non - significant mediating effect, while the paths “Physical exercise → Ego depletion → BrainRot behavior” (Effect size =  $-0.032$ ,  $SE = 0.015$ , Bootstrap 95% CI =  $[-0.061, -0.003]$ , mediating effect proportion = 22.377%) and “Physical exercise → Resilience → Ego depletion → BrainRot behavior” (Effect size =  $-0.006$ ,  $SE = 0.003$ , Bootstrap 95% CI =  $[-0.011, -0.001]$ , mediating effect proportion = 4.195%) had significant mediating effects. For detailed information, please refer to Table 4.



## Discussion

This study uncovers the influence mechanism of physical exercise on BrainRot behavior and further explores the mediating roles of resilience and ego depletion therein. The results indicate that physical exercise significantly and negatively predicts BrainRot behavior, suggesting that increasing physical exercise can mitigate an individual's excessive reliance on short videos. Meanwhile, physical exercise positively predicts resilience and negatively predicts ego depletion. Moreover, resilience and ego depletion respectively exert different predictive effects on BrainRot behavior. Specifically, resilience negatively predicts ego depletion, yet its predictive effect on BrainRot behavior is not significant, in contrast, ego depletion significantly and positively predicts BrainRot behavior. These findings provide novel insights and empirical evidence that physical exercise mitigates BrainRot behavior through its impact on psychological states.

## Interpretation of research results

This study has revealed that physical exercise demonstrates a significant negative predictive effect on BrainRot behavior, and this finding has been validated in previous research<sup>69</sup>. The root cause lies in the positive influences that physical exercise imposes on individuals' mental health and self-control capabilities<sup>29</sup>. It is capable of enhancing individuals' cognitive functions and emotion regulation abilities<sup>70</sup>, consequently bolstering their self-control regarding short-video content and diminishing the probability of overuse<sup>71–73</sup>. Furthermore, physical exercise, as an active behavioral activity, can serve as an alternative pastime to short videos. It enables individuals to attain a sense of satisfaction and achievement during the exercise process<sup>74</sup>, thereby diminishing their reliance on short videos. Additionally, physical exercise is capable of strengthening individuals' social interactions, alleviating feelings of loneliness and boredom<sup>75</sup>, which are psychological triggers for BrainRot behavior<sup>76</sup>. Consequently, regular participation in physical exercise, as a healthy lifestyle habit, can reduce BrainRot behavior through multiple channels. Based on the above evidence, it is demonstrated that physical exercise can negatively predict BrainRot behavior among adolescents, confirming the research hypothesis (H1).

The mediating role of resilience between physical exercise and BrainRot behavior elucidates the mechanism through which physical exercise impacts the BrainRot behavior. Abundant research in the academic field has already demonstrated the positive predictive effect of physical exercise on resilience<sup>77–79</sup>. As an ability to cope with stress and challenges, resilience enables individuals to maintain better self-control when confronted with the allure of short videos. Individuals with higher resilience are more proficient in managing their emotions and behaviors<sup>80</sup>, thereby curtailing their BrainRot behavior. Nevertheless, this study has found that the direct predictive effect of resilience on BrainRot behavior is not significant. One potential explanation is that the resilience scale, comprising limited items, may lack specificity to addictive behaviors or tendencies. In this study, resilience was able to significantly and negatively predict ego depletion, which indicates that resilience mainly exerts its influence through other mediating variables such as ego depletion. It also suggests that resilience may play a more prominent role in an individual's internal psychological processes<sup>81</sup>, rather than directly controlling behavior. Based on this, the research hypothesis (H2) in this study, which posited that resilience has a significant mediating role between physical exercise and BrainRot behavior, was not validated.

Furthermore, this study also discovered that ego depletion could be negatively predicted by physical exercise. The underlying reason is that through physical exercise, adolescents can better maintain concentration and enhance their self-management abilities, reducing the feeling of self-fatigue<sup>82</sup>. As a mediating variable between physical exercise and BrainRot behavior, the significant positive predictive effect of ego depletion on BrainRot behavior indicates that as ego depletion increases, an individual's tendency to overuse short videos also rises<sup>83</sup>. It is because ego depletion occurs when an individual's self-control resources are temporarily depleted after exerting self-control, leading to a decline in self-control ability when facing temptations<sup>51</sup>, and consequently resulting in BrainRot behavior. Individuals can reduce ego depletion through physical exercise<sup>84,85</sup>, thereby decreasing the BrainRot behavior. This is consistent with the view of limited self-control in the ego depletion theory<sup>50</sup>, as individuals with sufficient self-control resources can more effectively resist the allure of short videos. To sum up, the research hypothesis (H3) in this study, which posited that ego depletion serves as a mediating variable between physical exercise and BrainRot behavior, has been verified.

Resilience and ego depletion exhibited significant negative predictive effects in this study. Their interplay between physical exercise and BrainRot behavior uncovers how individuals manage self-control resources through resilience. As a positive psychological resource, resilience can assist individuals in strengthening their self-control<sup>86</sup>. Among them, the Resilience Factor (RF) represents a psychological resource that buffers the potential negative impacts of stress on mental health and enables rapid recovery during stressor exposure<sup>87</sup>. Therefore, when individuals maintain a positive attitude in the face of challenges, the occurrence of ego depletion can be reduced, consequently diminishing the BrainRot behavior. Conversely, ego depletion, as a negative psychological resource, its reduction further mitigates the risk of BrainRot behavior. This interaction reveals that physical exercise not only directly impacts individuals' resilience<sup>41</sup>, but also influences their BrainRot behavior by decreasing ego depletion. Therefore, the fourth research hypothesis (H4) in this study, which posited that resilience and ego depletion have a chain mediating effect between physical exercise and BrainRot behavior, has been validated.

## Significance and implications of the research

The results of this study hold certain warning implications for families, schools and even society at large. Physical exercise, as a widely recommended positive lifestyle<sup>88</sup>, exhibits intervention effects on BrainRot behavior that are applicable to a broad range of populations. Resilience and ego depletion, as psychological factors influencing BrainRot behavior, are prevalent across different cultural and age groups. These findings are of great significance for devising intervention measures against BrainRot behavior, particularly among adolescent and adult populations. Moreover, the research results also emphasize the potential value of physical exercise in promoting

mental health<sup>41,89,90</sup>, and reducing ego depletion. Physical exercise not only promotes adolescents' learning in terms of interpersonal relationships and skills<sup>91,92</sup>, but also contributes to the development of the brain, including its organic structure and the default mode network<sup>93–97</sup>, and subsequently ameliorates the so-called “BrainRot behavior” among adolescents.

These research results hold special significance for Chinese adolescents. They emphasize the necessity of integrating physical exercise into daily life<sup>98,99</sup>. The reasons are two - fold: the increasing use of short - form videos and the limited time for physical activities due to academic pressure. Understanding the roles of resilience and ego - depletion can help reduce the likelihood of them developing BrainRot behavior. Compared with the data of Westerners using their leisure time for physical activities<sup>100</sup>, our sample shows that only a small number of people exercise regularly. This indicates that there are cultural barriers in translating health awareness into behavior. Such differences highlight the urgency of formulating intervention programs that are adaptable to the cultural background. Overall, the negative prediction of physical exercise on BrainRot behavior and the mediating roles of resilience and ego - depletion provide multi - faceted perspectives. Therefore, the discoveries of this study can offer guidance to subsequent researchers and relevant educators, assisting them in designing and implementing effective intervention measures to mitigate the phenomenon of BrainRot behavior.

Although this study examined the relationship between physical exercise and adolescents' BrainRot behavior through the lens of resilience and ego depletion, several additional factors warrant attention. First, external environmental influences—including family and school climate, social support systems, interpersonal relationships, and developmental experiences—play a critical role in adolescents' mental health<sup>17,101–109</sup>. A nurturing environment fosters psychological well-being, whereas adverse conditions (e.g., emotional distress) may increase vulnerability to technology addiction<sup>110–112</sup>, including BrainRot behavior. Second, intrinsic factors and behavioral tendencies, such as emotion-regulation strategies, personality traits, and engagement in positive physical activities, significantly modulate these relationships<sup>113,114</sup>. Effective self-regulation and proactive lifestyles can mitigate the impact of negative experiences, while poor regulatory capacity may exacerbate the link between psychological distress and maladaptive behaviors. To address these issues, schools and families should implement targeted interventions for at-risk adolescents, fostering supportive relationships, promoting physical activity, and strengthening adaptive coping skills. Such efforts could create a protective environment to reduce adolescents' susceptibility to BrainRot behavior.

### Limitations of the research

This study comprehensively considered the relationships among physical exercise, resilience, ego depletion, and BrainRot behavior, and employed the method of controlling demographic variables for exploration, reflecting the rigor of this research. However, there are also some limitations in this study. Firstly, the sample size was not extensive enough, which restricted the universal applicability of the results. Secondly, the resilience scale contained relatively few items, indirectly leading to an insignificant correlation between it and BrainRot behavior. Finally, this study mainly relied on cross-sectional data, presenting certain limitations in explaining the causal relationships among variables.

### Conclusion

This study has revealed a significant negative predictive relationship between physical exercise and BrainRot behavior among adolescents, with resilience and ego depletion acting as mediating factors in this relationship. The implications of these findings are multifaceted.

### Theoretical significance

From a theoretical perspective, this research enriches the existing literature on the relationship between physical activity, psychological factors and BrainRot behavior in adolescents. It provides a more in - depth understanding of the underlying mechanisms through the chain mediation model, and enriches the development of theories related to physical exercise and BrainRot behavior.

### Practical significance

In practical terms, the results offer valuable guidance for families, schools, and society. For families, they can be more aware of the importance of encouraging their adolescent children to engage in regular physical exercise. This can not only promote physical health but also reduce the occurrence of BrainRot behavior. Schools should focus on cultivating students' regular exercise habits. This can not only alleviate problems such as anxiety and inattentiveness caused by the “BrainRot” behavior resulting from adolescents' short-video addiction but also create a favorable growth environment and promote the comprehensive and healthy development of adolescents.

### Future research directions

Regarding the limitations of this study, in future studies, a longitudinal design can be adopted to further explore the causal relationships among these variables. Additionally, we should fully consider the practicality of measurement tools and conduct research on a broader sample.

### Data availability

The datasets generated and/or analysed during the current study are not publicly available due [our experimental team's policy] but are available from the corresponding author on reasonable request.

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Sometimes the second corresponding author is also at a loss. Because the first author kept this opinions about "One man's trash is another man's treasure" at least at this stage.

## Author contributions

Yan Gan12345, Ziling He12345, Mengfen Liu356, Jian Ran1235, Pingfan Liu1235, Yang Liu123456, Liping Deng1235.1 Conceptualization; 2 Methodology; 3 Data curation; 4 Writing - Original Draft; 5 Writing - Review & Editing; 6 Funding acquisition.

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## Declarations

### Ethics approval and consent to participate

The study was approved by the Biomedicine Ethics Committee of Jishou University before the initiation of the project (Grant number: JSDX-2024-0086). Informed consent was obtained from the participants and their guardians before the start of the program. We confirm that all the experiment is in accordance with the relevant guidelines and regulations such as the declaration of Helsinki.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

### Additional information

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