



## Research article

# Effects of physical exercise on adolescent short video addiction: A moderated mediation model

He Jianfeng, Zhuo Xian, Ai Zexiu\*

School of Wushu, Chengdu Sports University, Chengdu, China

## ARTICLE INFO

## Keywords:

Adolescents  
Physical exercise  
Short video addiction  
Self-control  
Cumulative ecological risk

## ABSTRACT

**Objective:** To discuss the effects of physical exercise (PE) on adolescent short video addiction (SVA) and analyze the mediating effects of self-control (SC) and the moderating effects of the cumulative ecological risk (CER), aiming to provide theoretical support for PE relative to adolescent SVA, investigate the underlying mechanisms of the effects of PE.

**Methods:** The Physical Activity Rating Scale-3, Problematic TikTok Use Scale, Self-Control Scale, and Cumulative Ecological Risk Scale were used to survey 756 adolescents in Chongqing and Chengdu, China. SPSS was used to construct a research model by conducting reliability, confirmatory factor, common method bias, and AMOS analyses.

**Results:** PE was significantly and negatively related to adolescent SVA ( $\beta = -0.30, p < 0.01$ ). SC served as a partial mediator between PE and adolescent SVA, the direct and indirect effect values are  $-0.304$  and  $-0.167$  respectively, showing that SC negatively predicted the relationship between the two variables. The CER moderated the effect of PE ( $t = -11.679, p < 0.001$ ) and SC ( $t = -15.069, p < 0.001$ ) on adolescent SVA.

**Conclusion:** PE mitigates and moderates adolescent SVA through the mediating effect of SC and the moderating effect of CER.

## 1. Introduction

In the past COVID-19 pandemic, social isolation and closure have made Short video addiction(SVA) a hot topic of discussion [1]. As a social software that allows users to create and share their own beautiful moments, short videos, with their fragmented model and rich personalized content, have rapidly become a worldwide hit form of entertainment [2]. In December 2022, short video users topped one billion for the first time with a user utilization rate of 94.8 % [3]. The number of users climbed from 648 million in 2018 to 1.012 billion in 2022, with yearly membership growth of more than 60 million members [4]. Currently, short videos have become an essential 'life partner', but excessive use of these videos can lead to addictive behaviours [5]. As the main users of short video software, adolescents aged 15–25 years [6] are immature in terms of self-regulation and self-control(SC) [7,8], deal with sensitive periods of psychological development, and are easily stimulated by external stressors [9], exacerbating mental health risks. SVA is harmful to adolescents, as it may lead to conditions such as reduced attention span, depression, increased loneliness, distraction, sleep disturbance, and social isolation [2,10–13], and addictive behaviours and associated negative effects can persist into adulthood.

SVA belongs to the subconcept of Internet addiction, a specific type of Internet addiction with mostly 1–5 min of video, the subject is clear, the style is clear, the content is concise and clear, fast-paced, and other characteristics to quickly attract the attention of the

\* Corresponding author

E-mail address: [13102326815@163.COM](mailto:13102326815@163.COM) (A. Zexiu).

<https://doi.org/10.1016/j.heliyon.2024.e29466>

Received 26 June 2023; Received in revised form 31 March 2024; Accepted 8 April 2024

Available online 10 April 2024

2405-8440/© 2024 Published by Elsevier Ltd.

This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

user so that the user continues to watch and gradually addictive behavior [14]. Social ecology suggests that ecological subsystems such as social environment, family environment, school environment, peer relationships, and SC are all important factors in the induction of SVA, which seriously affects adolescents' academic performance, emotional adjustment, and physical health [15]. Existing studies have found that physical exercise (PE) has a certain effect on addictive behaviors [16]. From the physiological level, PE can compensate for the decrease in dopamine levels affected by the reduction of addictive behaviors [17], reduce the level of addiction, and enhance physical fitness. At the psychological level, PE can effectively improve social interaction, enhance SC [18], enhancing interpersonal communication and self-identity, and alleviating the positive effects of academic stress [19,20], as well as reducing negative emotions such as anxiety and depression [21]. Cognitive-behavioral group therapy processes have also utilized sport to enhance the effectiveness of addiction interventions [17].

Compared with other types of addictive behaviours, SVA remains under-researched. To date, research on SVA has focused on family and school environments, technology, cognitive-emotional models, rival process theories, and imaging neurology to investigate its causes [5,22–25], as well as on psychological stress, well-being, and behavioural patterns [2,26,27]; however, no studies have yet evaluated the effects of PE on SVA. Furthermore, earlier studies have mainly used qualitative or single statistical approaches, leaving room for further methodological development [28–30]. In the context of the digital age and the development of addictive behaviours, the mental health status of adolescents has gradually deteriorated in relation to the level of addiction. To investigate the impact of PE on adolescent SVA and clarify the mechanism of such addiction to promote adolescent mental health. Therefore, this study will aim to investigate the effect of sports on SVA through a questionnaire survey among adolescents and to explore the mediating role of SC and the moderating influence of cumulative ecological risk (CER).

### 1.1. Physical exercise and adolescent short video addiction

Short video addiction is defined as the excessive or compulsive use of short videos for the purpose of mood alteration or need fulfilment, with excessive or irrational use affecting the lives and habits of young people and producing negative effects [14,31–33]. According to the sleep disruption process theory and compensatory psychoanalysis, SVA predicts sleep disturbance, and high SVA groups may experience poor sleep [34]. At the same time, higher levels of short video addiction can damage moods and relationships and lead to lower academic and work performance [35]. According to the objectification theory, excessive use of short videos is a direct predictor of depression in female university students and affects self-objectification and body satisfaction [36]. During the COVID-19 pandemic, there was linear increase of short video addictive behaviour owing to social closure and isolation, and severe symptoms affect the mental health of the adolescent population, including increased risk of anxiety, depression, and decreased academic performance, and are more pronounced among boys than among girls [37–39].

PE is seen as an activity that benefits mental health. and can significantly alleviate internet addiction or other types of addiction [40]. Getting pleasure from short videos is an important experience for addiction, and Flow Theory suggests that the flow experience of deep concentration and engagement can bring pleasure, and PE is more likely to produce flow experience, satisfy needs, and reduce dependence on short videos when the PE is fully engaged and secretes dopamine [41]. According to Self-Determination Theory, adolescents' growth requires the satisfaction of basic psychological needs (autonomy needs, relational needs, and competence needs), as well as the acquisition of self-acceptance through deterministic regulation [42], and PE is precisely the activity that is chosen autonomously and enhances positive interactions with others, improves one's own competence, and generates a sense of self-achievement as a way to achieve the satisfaction of basic psychological needs and to promote positive behaviors, which reduces the likelihood of SVA [43]. Intervention modality for addiction based on the explanatory principles of the three authoritative models, PE has been inferred to be an effective prevention [44]. A recent empirical study suggests that PE has a long-term positive impact on Internet addiction and mental health [45]. From a neurological perspective, Li et al. concluded that PE can effectively intervene in internet addiction by improving the function of the autonomic nervous system to a certain extent, and increasing the plasma GDNF (glial cell derived neurotrophie factor) and glucocorticoid levels [46]. An empirical and mate analysis showed that PE interventions have benefits on smartphone addiction and are effective in the long term [47]. Based on these previous findings, PE may have a positive effect on adolescent SVA.

Herein, we hypothesized that PE is negatively correlated with adolescent SVA (hypothesis H1).

### 1.2. Mediation of self-control

SC is the behavior by which people modify their ingrained ways of acting and thinking in response to their own needs and desires, and it is the process by which one way of acting and thinking replaces another [48]. It is closely linked to PE [49]. Schöndube et al. argued that SC is positively linked to PE, with high levels of SC resulting in greater PE [50]. According to the power model of SC, SC is like a finite resource, PE can be "exercised" in the form of self-regulation and impulse control, which not only restores but also enhances SC, similar to muscle growth, and thus improves SC [51]. The Executive Function Model suggests that PE can enhance executive control functions in the prefrontal cortex, such as inhibiting impulses, managing emotions, and maintaining conflicting rules, which explains the neuropsychological benefits of PE for SC from a neuropsychological perspective [52]. In a long-term investigation of aerobic exercise, it was found that regular PE behaviors could significantly improve or enhance self-regulation through the assessment of emotional distress, regulatory behaviors, self-efficacy [53]. A good level of SC facilitates PE participation. Research on intention-behavior differences suggests that lower levels of SC may hinder PE habit formation when encountering temptations or difficulties such as interesting things, bad weather [54].

Based on the S–O–R (stimulus-o-bio-response framework), the OPT (opponent process theory) argues that a sense of perceived

enjoyment strengthens users' dependence on short videos and that stopping usage yields a sense of withdrawal, triggering SVA on the influence of reinforcement mechanisms [25]. The theory of self-regulation of addiction posits that addictive behaviours originated from a loss of SC, unable to control addictive desires, and the inability of those with diminished SC to prevent cravings from intensifying and eventually developing into addiction [55]. A neuroimaging study has found that the addiction levels for problematic short video use are considered to be negatively correlated with SC through fMRI testing, users with a low-level SC are more likely to get addicted to the excitement of their favorite videos [24]. Therefore, based on these reports, it is hypothesized that SC has a positive effect on SVA.

Herein, hypothesis H2 was proposed: SC mediates the relationship between PE and SVA.

1.3. Moderation of the cumulative ecological risk

The CER is thought to be the result of an individual's developmental journey being influenced by more than a single ecological subsystem, but intersecting with interpersonal, social, family, peer, and other ecological subsystems, all of which yield a synergistic influence to the individual [56]. Adolescents who are chronically exposed to high levels of CER are more likely to develop problematic behaviours such as hesitancy, anxiety, aggressive behaviours, addictions. The interaction between individual factors and the environment, according to the Individual-Environment Interaction Theory, influences a person's behavioral problems [57]. A good environmental situation (social environment, family environment, school environment, etc.) contributes to the healthy physical and mental growth of adolescents [58]. At this time, adolescents are in the rebellious period, and their minds are not yet mature. If they receive sufficient warmth and support from various ecological subsystems at this stage and satisfy the basic psychological needs of adolescents, they may choose a more active lifestyle, stimulate their enthusiasm for sports, and form the habit of PE [59]. On the contrary, if they lack the warmth of parental love and care, care from their teachers at school, and companionship of their peers, they may seek solace in short videos [60,61], leading to the phenomenon of excessive short-video use [60]. This suggests that the CER level will affect the effect of PE on adolescent SVA.

Self-determination theory suggests that individuals have three intrinsic psychological needs: autonomy, competence, and relationships. The ability of the subsystems of CER to satisfy basic psychological needs plays a prominent role in the healthy physical and psychological growth of adolescents [43,59,62]. Lower levels of SC fail to satisfy adolescents' sense of belonging to family and school and lack of interpersonal interactions with peers [63]. Good CER can enhance adolescents' sense of belonging, strengthen interpersonal interactions with peers, obtain social support, and develop a healthy lifestyle [64,65]. At the same time, good CER can also restore and replenish SC resources to a certain extent, strengthen ideal beliefs, enhance anti-interference ability, improve adolescents' SC ability, and actively alleviate or avoid SVA. Overall, under constant SC, the higher the level of CER, the more likely adolescents are to develop SVA. Previous studies have demonstrated that good levels of CER are beneficial in reducing addictive and other problematic behaviors.

1.4. 1.4 therefore, research hypothesis 3 was formulated

**Hypothesis 3.** (H3). CER moderates the relationship between PE and adolescent SVA. In addition, hypothesis 4 was proposed:

**Hypothesis 4.** (H4). CER that moderates the relationship between SC and adolescent SVA

1.5. Hypotheses and conceptual model

Based on the above reviewed literature and assumptions, a hypothesized model was built. The model, displayed in Fig. 1, shows the effect of PE on SVA; to examine the mediating role of SC between PE and SVA, and to test whether PE and SC moderated the CER of SVA.

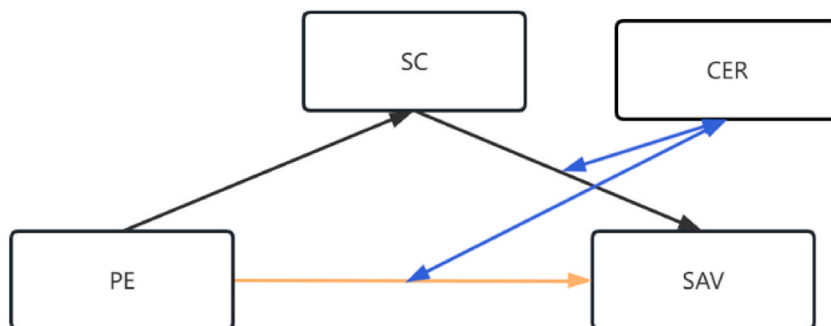


Fig. 1. Hypothetical model.

## 2. Materials and methods

### 2.1. Participants and procedures

The initial questionnaire was formed on the basis of kinesiology experts from Chengdu Sports University and various mature questionnaires. Subsequent to soliciting opinions from these kinesiology experts, a pilot dissemination of the questionnaire was carried out on a small scale within the confines of the Chengdu Sports University. The feedback garnered from this preliminary deployment was instrumental in facilitating targeted refinements to the questionnaire. Consequent modifications encompassed both stylistic enhancements and judicious alterations to the phrasing of specific items. These revisions were predicated on the expert recommendations and were aimed at augmenting the comprehensibility and ease of completion for the adolescents, thereby ensuring the instrument's suitability for the intended cohort.

To investigate the mechanisms of the effect of PE on adolescent SVA, we used the Chinese online questionnaire platform Questionnaire Star (WJX) in this study. Questionnaires were distributed to participants between March and April 2023, and they were distributed to designated groups offline (by two to three researchers visiting schools) and online to participants recruited through random sampling from the western Chinese cities of Chongqing and Chengdu. A total of 800 questionnaires were sent out randomly, of which 756 were effectively returned, giving a valid response rate of 94.5 %. Average age 19.9 years (as shown in Table 1). Following were the inclusion criteria: 1. no serious mental or physical illness, 2. signed informed consent and no cognitive impairment, and 3. age of 15–25 years. The exclusion criteria were as follows: 1. same IP address in completing the questionnaire, 2. questionnaire response time of less than 120 s, 3. apparently consistent responses, and 4. a sample with regular responses. The participants were rewarded with a red packet upon completion of the questionnaire. All study participants gave informed consent and the study design was approved by the Chengdu Sport University Ethics Review Board (code:2023-108).

### 2.2. Control variables

To reduce the risk of statistical bias, this study used sex, age and education as control variables.

### 2.3. Measurements

#### 2.3.1. Short video addiction

The Problematic TikTok Use Scale, revised by Troy Smith based on the Bergen Social Media Addiction Scale, was used to assess SVA [66]. It has six items, including 'spends a great deal of time considering or preparing to use short video software.' and 'feels an urge to use short video software more and more', scored on a 5-point Likert scale, with scores from 1 to 5 indicating *never* to *very often*, respectively. The overall score runs from 6 to 30, with scores above 21 denoting high risks and higher values denoting increased levels of addiction to short videos. The scale's Cronbach coefficient in this study was 0.921.

#### 2.3.2. Physical exercise

Utilizing the Physical Activity Rating Scale (PARS-3) by T.C. Leung, PE was evaluated [67]. The scale examines exercise in terms of intensity, duration, and frequency. There are three items on the scale, including 'How intensely do you do PE?' and 'How often a month do you do the aforementioned PE? at the above intensity?'. The volume of exercise is calculated as follows: intensity  $\times$  time (N–1)  $\times$  frequency, the total score range is 0–100, with a score of 1–5 for intensity and frequency and a score of 0–4 for time. The scale's Cronbach coefficient in this study was 0.845.

**Table 1**  
Demographic characteristics of the sample.

Name	Option	Frequency	Percentage (%)	Cumulative percentage (%)	
Age	15	39	5.159	5.159	
	16	100	13.228	18.386	
	17	73	9.656	28.042	
	18	70	9.259	37.302	
	19	80	10.582	47.884	
	20	63	8.333	56.217	
	21	76	10.053	66.27	
	22	60	7.937	74.206	
	23	75	9.921	84.127	
	24	59	7.804	91.931	
	25	61	8.069	100	
	Sex	Male	396	52.381	52.381
		Female	360	47.619	100
Education Level	Middle school	43	5.688	5.688	
	High school/technical secondary school	348	46.032	51.72	
	Bachelor's degree/college	338	44.709	96.429	
	Postgraduates	27	3.571	100	
Total		756	100	100	

### 2.3.3. Self-control

To evaluate SC, Tan and Guo's updated Self-Control Scale from 2008 was employed [68]. It is widely used in adolescent addiction research [69]. The scale contains the following sample items: 'People say I am impulsive' and avoiding temptation, maintaining healthy routines, avoiding recreation, exercising impulse control and concentrating on work are the next five dimensions. The items are scored as follows: 1 = *not at all*, 2 = *no*, 3 = *not sure*, 4 = *yes*, and 5 = *very much*. Greater levels of SC are indicated by higher scores. The total score ranges from 19 to 95, with items reversed scored as necessary. The scale's Cronbach coefficient in this study was 0.928.

### 2.3.4. Cumulative ecological risk

Based on the Cumulative Ecological Risk Scale by Yaqi et al. [56] and Li et al. [58], which was appropriately modified according to the actual situation and used to assess the CER, four risk factors related to family, peer, school, and other risks relative to SVA were selected comprehensively according to the bioecological theory and relevant literature on the CER. In the Cumulative Ecological Risk Scale, a total of 43 questions are asked, including 'I wish my friends were not my friends now' and 'I am angry with my mother'. These items are scored on a 5-point Likert scale that includes four other dimensions. The overall score is between 43 and 215. As the CER is a negative variable, the scoring for the relevant questions was reversed herein; scores are proportional to the CER. The scale's Cronbach coefficient in this study was 0.977.

### 2.3.5. Statistical analysis

We used SPSS 26.0, AMOS 24.0, and PROCESS 4.0 for the data analysis. There were a total of four variables in this study, and a questionnaire survey was used to gather the data. The data may be at risk of common-method bias. In order to detect a possible common technical bias effect in this study, a Harman one-way test was conducted, which showed fewer than 40 % of the threshold criteria. The linear association between PE, SC and SVA was assessed using Pearson's correlation coefficient. Structural equation modeling was used to determine the significance and identify whether SC played a mediating role between PE and SVA, as well as to illustrate a good model fit through a model goodness-of-fit analysis.

Finally, the potential moderating effect of CER on the association between PE and SVA in adolescents was examined using linear regression. The following is a detailed description (example of the moderating effect of PE on adolescent SVA). SPSS 26.0 was used for the statistical analysis of PE, and a linear regression model was utilized for the divisional analysis: M1 included age, sex and educational level as the control variables and PE as the independent regression variable; M2 added the CER (moderating variable) to M1; and M3 added an interaction term to M2. The impact of the moderating variables was further determined by plotting slopes.

## 3. Results

### 3.1. Reliability and validity tests

It showed that the Cronbach coefficients are 0.921 for SVA, 0.845 for PE, 0.928 for SC, and 0.977 for CER. The AVE values corresponding to each variable ranged from 0.54 to 0.66, all of which were greater than 0.5, while the CR values ranged from 0.845 to 0.921, all of which were higher than 0.7, demonstrating the data's high convergent validity (Table 2). A model fit analysis was also conducted; the model fit indicators are illustrated in Table 3. There was a good model fit, and the following values were obtained:  $\chi^2/$

**Table 2**  
Confirmatory factor analysis.

Dimension	Items	Parameters of significant test				SMC	CR	AVE
		Estimate	S.E.	C.R.	p value			
CER	CER1	0.83	0.02	39.43	***	0.69	0.86	0.60
	CER2	0.71	0.03	22.87	***	0.50		
	CER3	0.72	0.03	24.72	***	0.51		
	CER4	0.83	0.02	43.79	***	0.69		
SC	SC1	0.72	0.03	23.36	***	0.53	0.85	0.54
	SC2	0.75	0.03	23.53	***	0.57		
	SC3	0.71	0.04	20.26	***	0.50		
	SC4	0.75	0.03	24.03	***	0.56		
	SC5	0.74	0.03	23.97	***	0.55		
PE	PE1	0.81	0.02	45.22	***	0.66	0.85	0.65
	PE2	0.80	0.02	41.95	***	0.64		
	PE3	0.80	0.02	42.05	***	0.64		
SVA	SVA1	0.85	0.01	71.00	***	0.73	0.92	0.66
	SVA2	0.79	0.02	52.80	***	0.63		
	SVA3	0.79	0.02	52.47	***	0.62		
	SVA4	0.81	0.01	57.57	***	0.65		
	SVA5	0.85	0.01	60.43	***	0.72		
	SVA6	0.79	0.02	52.60	***	0.62		

**Note(s):** The triangle below is the Pearson correlation coefficient; \*\*\* $p < 0.001$ . CER:cumulative ecological risk; SC: self-control; PE: physical exercise; SVA: short video addiction.

**Table 3**  
Model fit indicators.

	$\chi^2$	df	$\chi^2/df$	P	GFI	SRMR	CFI	NFI	IFI	RMSEA
Model	2914.65	2399.00	1.22	0.00	0.90	1.3	1.99	1.93	0.99	1.2

Note(s):GFI:Goodness of Fit Index; SRMR: Standardized Root Mean Square Residual; CFI: Comparative Fit Index; NFI: Normed Fit Index; IFI: Incremental Fit Index RMSEA: Root Mean Square Error of Approximation.

$df < 3$ ,  $GFI > 0.9$ ,  $SRMR < 0.08$ ,  $CFI > 0.9$ ,  $NFI > 0.9$ ,  $IFI > 0.9$ , and  $RMSEA < 0.05$  [70].

### 3.2. Descriptive statistics and correlation analysis

PE was significantly and negatively linked with addiction to short videos, as indicated in Table 4 ( $r = 0.39$ ,  $p < 0.01$ ). Additionally, there was a strong positive correlation with SC. ( $r = 0.32$ ,  $p < 0.01$ ). This finding indicates that both PE and SC increase in a similar manner. SVA and SC also had a strong and negative relationship. ( $r = -0.48$ ,  $p < 0.01$ ), implying that the risk of SVA decreases as SC increases.

The correlation coefficients for CER were 0.27,  $-0.06$ , and 0.10, respectively, and correlated with PE and SVA, all at 0.01 or below.

### 3.3. Common method bias

In order to find any potential common technique bias effects in this study, Harman’s single-factor test was performed. The SPSS analysis revealed 11 factors with questionnaire items with eigenvalues larger than 1. 31.684 % is the amount of variation explained by the first factor. The results display that the data collection method used yielded no significant common method bias.

### 3.4. Mediation analysis

Based on the model fit indices of the mediating effects of PE, SC, and SVA shown in Table 5, the model of how PE affects SVA fit well with the following values:  $\chi^2/df < 3$ ,  $GFI > 0.9$ ,  $SRMR < 0.05$ ,  $CFI > 0.9$ ,  $RMSEA < 0.05$ ,  $NFI > 0.9$ . According to Fig. 2, the path coefficient for PE → SVA was significant ( $\beta = -0.30$ ), indicating that PE had a direct effect on SC. Therefore, hypothesis H1 was supported. The path coefficients for both PE → SC ( $\beta = 0.38$ ) and SC → SVA ( $\beta = -0.18$ ) were significant, demonstrating that PE and SVA can be mediated by SC. Therefore, hypothesis H2 was supported.

The mediating role of SC was further verified using a bootstrap test, as indicated in Table 6. The direct, indirect, and total effects 95 % confidence interval for the indirect effect of this pathway did not include 0. The indirect effect’s standard error (SE) of PE → SC → SVA was 0.05, with a z value of  $-6.76$ , indicating a strong mediating role for SC. The direct effect’s SE of PE → SVA was 0.03, with a z value of  $-6.42$  and the total effect’s SE of PE → SVA was 0.4, with a z value of  $-12.08$ . These findings imply that SC partially mediates the process of influencing SVA.

### 3.5. Moderation analysis

Without considering the CER, M1’s goal was to investigate how the PE affected the SVA. As shown in Table 7, SVA is significantly impacted by PE ( $t = -11.68$ ,  $p = 0.01 < 0.05$ ), Hypothesis H1 hold. The interaction between PE and the effect of the CER on SVA (M2 → M3) showed a notable shift in the F values from M 2 to M3 [ $F(5,750) = 37.60$   $F(6,749) = 32.78$ ]. Furthermore, the interaction between PE and SVA in M 3 was significant ( $t = -2.67$ ,  $p = 0.01 < 0.05$ ). This finding indicates that the extent of the effect of PE on SVA varies with the level of CER, therefore supporting hypothesis H3.

As shown in Fig. 3, Among adolescents at low CER (below 1 SD, simple  $\beta = -0.07$ ,  $p < 0.001$ ), PE had a strong negative predictive effect on adolescent SVA., but not for those with a high CER (above 1 SD, simple  $\beta = -0.10$ ,  $p < 0.001$ ). The impact of PE on SVA was greater for adolescents with a low CER than for those with a high CER; this finding implies that the impact of PE on adolescents’ SVA increases as CER decreases.

M1 included SC and the three control variables (age, gender, and educational level); M2 added CER to M1; and M3 added the product of the independent variable and moderator variable to M 2.

**Table 4**  
Descriptive statistics and correlation of the variables.

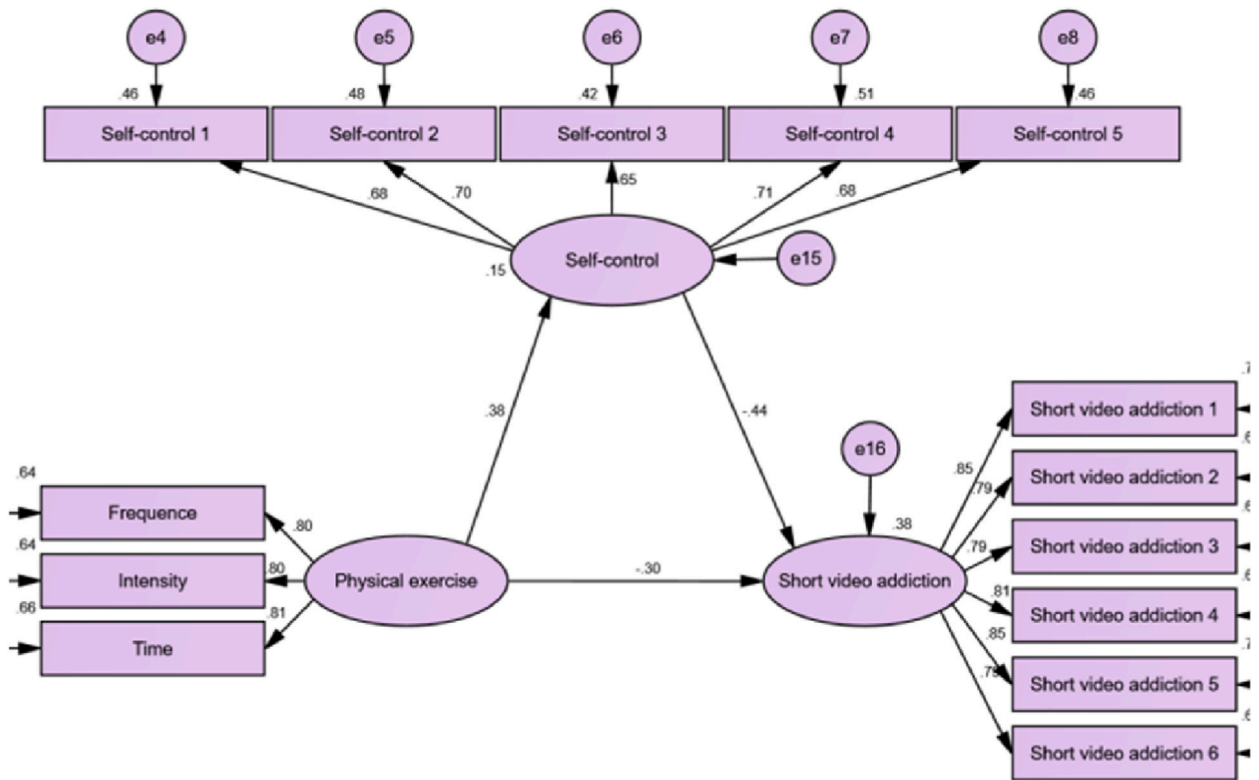
	M	S.D.	PE	SC	SVA	CER
PE	38.25	31.96				
SC	65.41	15.73	0.32 <sup>a</sup>			
SVA	17.55	6.40	-0.40 <sup>a</sup>	-0.48 <sup>a</sup>		
CER	125.32	39.28	0.27 <sup>a</sup>	-0.06	0.10 <sup>a</sup>	

Note(s): The Pearson correlation coefficient is depicted in the triangle below.

<sup>a</sup>  $p < 0.01$ .

**Table 5**  
Mediated-effect model fit indices for PE, SC, and SVA.

	$\chi^2$	df	$\chi^2/df$	P	GFI	SRMR	CFI	NFI	IFI	RMSEA
model	162.06	74.00	2.19	0.00	0.97	0.02	0.98	0.97	0.98	0.04



**Fig. 2.** Visualization intermediary effect.

**Table 6**  
Bootstrap analysis of the mediating effect.

	Path	Estimate	SE	Z	Bias-Corrected Bootstrap 95% CI		Non-Parametric percentile for bias correction Bootstrap 95%CI	
					Lower	Upper	Lower	Upper
Direct effect	PE→SVA	-0.30	0.05	-6.76	-0.39	-0.21	-0.39	-0.21
Indirect effect	PE→SC→SVA	-0.17	0.03	-6.42	-0.22	-0.12	-0.22	-0.12
Total effect	PE→SVA	-0.47	0.04	-12.08	-0.55	-0.39	-0.55	-0.39

When CER was not taken into account, M1 sought to investigate how the SC affected SVA. Table 8 shows that SC has significance ( $t = -15.07, p = 0.01 < 0.05$ ), suggesting that SC has a significant impact on SVA. Table 8 displays the interaction of SC and CER, which showed significance ( $t = -2.32, p = 0.02 < 0.05$ ). The magnitude of CER was significantly different at different levels when SC affected SVA, indicating that the CER moderates SC and SVA, thus supporting hypothesis H4.

Fig. 4 demonstrates that the SC had a significant negative predictive effect on adolescent SVA at high CER (above 1 SD, simple  $\beta = -0.21, p < 0.001$ ); when the CER was low (below 1 SD, simple  $\beta = -0.16, p < 0.001$ ), the negative predictive effect of SC on adolescent SVA was increased. The effect of SC on SVA was more pronounced among the adolescents with a low CER than among those with a high CER. These findings imply that the impact of SC on adolescent SVA increases as the CER decreases.

**Table 7**  
PE and CERs. moderation analysis (n = 756).

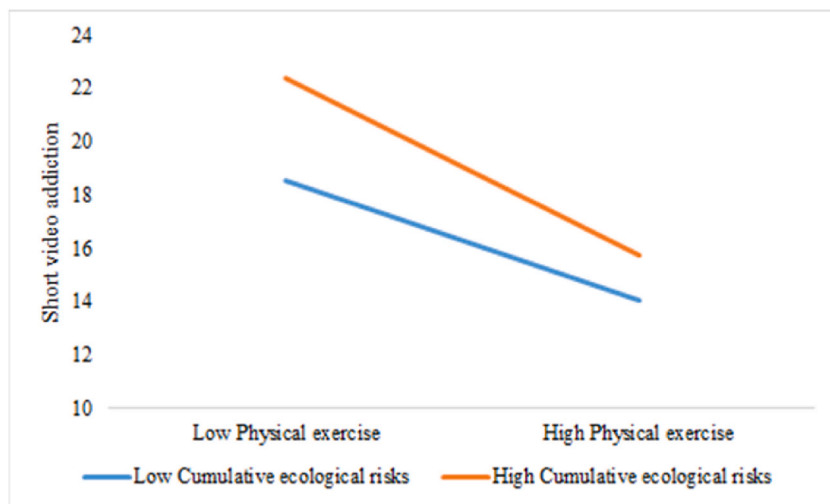
	M1			M2			M3		
	t	p	β	t	p	β	t	p	β
Constants	11.15	0.00 <sup>b</sup>	–	11.67	0.00 <sup>b</sup>	–	11.73	0.000 <sup>b</sup>	–
Age	0.58	0.57	0.03	0.37	0.71	0.02	0.44	0.66	0.02
Gender	–1.11	0.27	–0.04	–1.06	0.29	–0.03	–0.98	0.33	–0.03
Education	–0.27	0.79	–0.01	–0.26	0.8	–0.01	–0.31	0.76	–0.01
PE	–11.68	0.00 <sup>b</sup>	–0.39	–13.28	0.00**	–0.45	–12.83	0.00 <sup>b</sup>	–0.44
CER				6.47	0.00 <sup>b</sup>	0.22	6.41	0.00 <sup>b</sup>	0.22
PE <sup>a</sup> CER							–2.67	0.01 <sup>b</sup>	–0.09
R 2	0.16			0.20			0.21		
Adjusted R 2	0.15			0.20			0.20		
F -value	F (4,751) = 34.64, p = 0.00			F (5,750) = 37.60, p=0.00			F (6,749) = 32.78, p = 0.00		
ΔR 2	0.16			0.05			0.01		
ΔF -value	F (4,751) = 34.64, p=0.00			F (1,750) = 41.90, p=0.00			F (1,749) = 7.13, p=0.01		

\*\*\*p < 0.001.

Note(s):Dependent variable: SVA; The triangle below is the Pearson correlation coefficient.

<sup>a</sup> p < 0.05.

<sup>b</sup> p < 0.01.



**Fig. 3.** Mediation diagram of CER between PE and SVA.

**Table 8**  
SC and CERs moderation analysis (n = 756).

	M1			M2			M3		
	t	p	β	t	p	β	t	p	β
Constants	12.02	0.00 <sup>b</sup>	–	12.11	0.00 <sup>b</sup>	–	12.09	0.00 <sup>b</sup>	–
Age	0.62	0.54	0.03	0.56	0.58	0.02	0.60	0.55	0.03
Gender	–1.43	0.15	–0.05	–1.42	0.16	–0.05	–1.40	0.16	–0.04
Education	–0.59	0.55	–0.03	–0.59	0.55	–0.03	–0.63	0.53	–0.03
SC	–15.07	0.00 <sup>b</sup>	–0.48	–14.94	0.00**	–0.48	–13.89	0.00 <sup>b</sup>	–0.46
CER				2.20	0.03 <sup>a</sup>	0.07	1.85	0.07	0.06
SC <sup>a</sup> CER							–2.32	0.02 <sup>a</sup>	–0.08
R 2	0.23			0.24			0.24		
Adjusted R 2	0.23			0.23			0.24		
F -value	F (4,751) = 57.36, p=0.00			F (5,750) = 47.09, p=0.00			F (6,749) = 40.37, p=0.00		
ΔR 2	0.23			0.01			0.01		
ΔF -value	F (4,751) = 57.36, p=0.00			F (1,750) = 4.84, p=0.03			F (1,749) = 5.39, p=0.02		

\*\*\*p < 0.001.

Note(s):Dependent variable: SVA; The triangle below is the Pearson correlation coefficient.

<sup>a</sup> p < 0.05.

<sup>b</sup> p < 0.01.



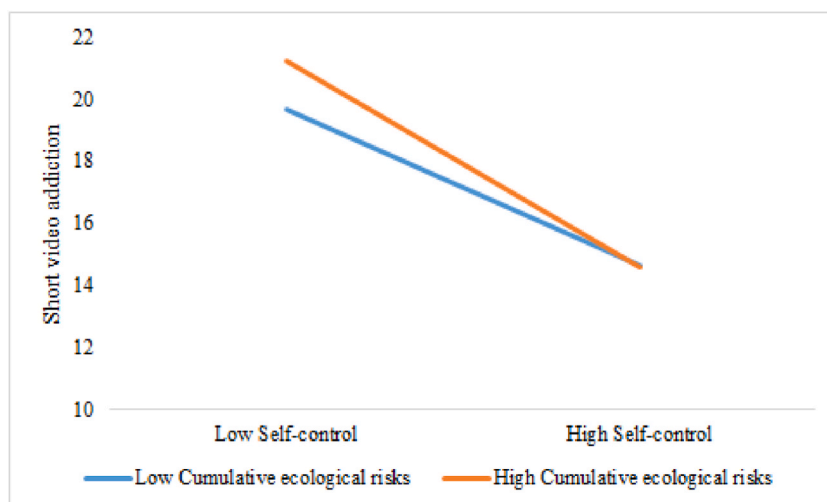


Fig. 4. Mediation diagram of CER between SC and SVA.

## 4. Discussion

### 4.1. Physical exercise and short video addiction

The effect of PE on addiction has been corroborated by numerous empirical studies; however, discussions on SVA are still lacking. The results of this research support hypothesis H1. Expanding on the results of previous studies [58], the results of this study show that increased PE among adolescents can reduce SVA behaviours to a certain extent and promote adolescents' physical and mental health. Self-determination theory states that adolescent development and mental health are influenced by the degree to which one's external environment impacts basic psychological needs, and when basic psychological needs cannot wait to be satisfied, adolescents may choose to get satisfaction from short videos, increasing the risks of SVA [15,71–73]. PE, as a positive source of external stimulation, helps greatly to satisfy basic psychological needs [74]. to improve adolescent physical and mental health, enhance social adjustment [75], and alleviate adolescent SVA [76,77]. Additionally, research have discovered that adolescent SVA is caused by stress and negative emotions, while regular PE can effectively reduce negative moods including stress [78,79] and improve self-efficacy and well-being [80]. Therefore, PE should be given more importance for adolescents in order to improve the fulfilment of their fundamental psychological needs, relieve academic stress, promote peer friendship, and prevent adolescent SVA.

### 4.2. Mediating effect of self-control

The current findings imply that SC partially mediates the link between PE and SVA; PE significantly predicts adolescents' SC; and SC significantly and negatively predicts adolescent SVA, confirming hypothesis H2. These findings are consistent with those on other addictive behaviours, such as internet [81] and gaming addictions [82]. The addiction-based self-regulation theory, a lack of SC may lead to the emergence and development of addictive behaviours [83]. The results of this study show that SC is negatively correlated with adolescent SVA and that low levels of SC may possibly lead to adolescent SVA behaviour. PE can expand control resources, reduce control energy loss, enhance control power in specialized areas, and improve adolescents' SC ability [84,85], so that they have a higher level of SC and regulation ability to better resist SVA [22]. Also, youth who regularly attend PE will have a higher level of SC to access more SC resources [84]. It suggests that SC is an important influence of PE on adolescents' addiction to short videos. Adolescents with greater SC levels have higher levels of self-regulation for better resisting SVA [22], suggesting that SC is an influencing factor of PE relative to adolescent SVA. Further study indicates that adolescent SVA may also be a result of stress and dissatisfaction with basic psychological needs [86–88]. According to the "compensatory loss hypothesis", being confined to their homes during the COVID-19 pandemic further reduces emotional regulation and SC [89], and adolescents may resort to "pathological" forms of addiction such as short videos [75], thereby increasing the likelihood of addiction during this period [90,91].compensation [75], thereby increasing the odds of addiction during this period [90,91]. If adolescents' SC can be improved, it may reduce SVA behaviour [92]. Accordingly, adolescents can counteract and reduce adolescent SVA by engaging in PE and improving their level of SC. The present findings also reveal the mechanism of influence: Adolescents have higher levels of SC with PE, which can reduce the emergence of adolescent SVA.

### 4.3. Moderating effect of the cumulative ecological risk

This research reveals that the impact of PE and SC on adolescent SVA were moderated by the CER, and the impact of PE and SC on adolescent SVA were stronger at low CER than at high CER. These findings are similar to those of previous studies in which low levels of

CER showed a positive correlation with addiction [58], and in addition, the present study builds on this foundation, showing that reducing CER are significant in reducing adolescent SVA.

The present results also suggest that the direct course of the model is moderated by the CER. ( $\beta = -0.088, p < 0.01$ ), supporting hypothesis H3. Specifically, the effect of PE on adolescent SVA was pronounced at low CER, high levels of CER mitigate the impact. Firstly, adolescents with high levels of CER are trapped in situations of family conflict and interpersonal isolation, which leads to a decrease in their participation in PE and an increase in the use of short videos [19,93]. In addition according to social ecology theory, peers, family, school, and other ecological subsystems influence an individual's development, and each ecological subsystem coordinates to act on individual behavior and produce corresponding effects [94]. Accordingly, the school environment, exercise climate, peer relationship, family environment, and parenting style all influence individual PE behaviour, indicating that the CER has a significant impact on youth PE. A previous review of studies has concluded that school is a daily living space and an important place for PE among adolescents [95]. A good school physical environment provides support for PE, while school encouragement of PE and teachers' values for PE influence adolescents' PE. A good school environment and sports climate will help young people to engage in PE, promote a positive and healthy psychological state, and alleviate short video addictive behaviour [19,61]. Further, parents' attitudes and education towards their children have a significant impact on adolescent physical and mental development. Parental support and concern for their children's physical activities will enhance PE behaviour [96]. Based on parental acceptance-rejection theory, parents' warmth, concern and support for their children is beneficial to their wellbeing and lays the foundation for the eradication of SVA [97]. Finally, peers are an important factor influencing the behaviours of adolescents. As adolescents become more independent, they spend more time with their peers, and the importance of peer relationships peaks during adolescence [98], positive peer relationships enhance self-identity and motivation to participate, stimulate youth sport participation behaviors, and moderate addictive behaviors [56]. Thus, a low CER promotes PE, thereby enhancing the effect that PE has on adolescent SVA, whereas a high CER reduces the effect of PE.

The results of this study demonstrated that the CER moderated the association between teenage SC and SVA. ( $\beta = -0.077, p < 0.05$ ), supporting hypothesis H4. SC is a complex psychological construct essential in the pursuit of happiness and success, the lack of control over impulses has been linked to individual social issues including addiction and delinquency [99]. Therefore, with a high SC level, adolescents can effectively use their own regulation and control to counteract the onslaught of short video addictive behaviour [100]. Further research has concluded that there is a low level of CER (favorable school climate, pleasant teacher-student relationships, and the individual through interpersonal interactions with peers and feelings of parental warmth and affection) that can restore and replenish attentional resources, maintain high levels of SC, and provide adolescents with sufficient control to resist SVA [61]. In addition, with the end of COVID-19, the gradual opening of society, the improvement of the external environment (social environment, family environment, peer interactions, etc.), the decline of CER, and the reduction of depletion of SC, the effect of SC on SVA will be more significant [65]. Therefore, SC plays an important role in helping adolescents maintain a positive psychological state in cases of high CERs. It also plays a positive role in alleviating dependence on short videos, and the effect on adolescent short video addictive behaviour is further enhanced in environments with low CER.

Finally, adolescents have low levels of SVA in cases of low CER. According to the social ecological theory, individual behaviour is influenced by the coordinated action of various ecological subsystems [101]. In the context of the media age, ecological risks influence the psychological state of adolescents through three key aspects: family, school, and peers, which consequently affect adolescent short video addictive behaviour [102]. Therefore, the total number of high-risk subsystems in the ecological subsystems of family, school, and peers should be reduced as much as possible to create a highly structured and supportive ecological environment for adolescents to reduce adolescent short video addictive behaviour at its root.

#### 4.4. Contributions

The main contributions of this study are as follows: first, this investigation expanded the research and theoretical knowledge on adolescent PE and SVA, particularly in terms of the effects of PE on SVA after the COVID-19 epidemic; second, this study showed that the CER in PE and SC had a moderating effect on adolescent SVA, expanding the research on the relationship between the CER, PE, and SVA; third, the study examined the mechanism of how PE affects teenage SVA and proved how SC mediates the role between the two and how CER acts as a moderator. finally, the findings can serve as a guiding direction and theoretical basis for reducing adolescent SVA through PE.

#### 4.5. Limitations

Firstly, the context of this study is at the end of COVID-19 when the survey was conducted, resulting in intermittent social closure, which is not common in other time periods, and the results of the study may be slightly different. Secondly, this study is cross-sectional in nature and thus cannot effectively elucidate the causal relationships between variable values. It has not distinguished between gender differences or variations across different age groups. The small sample size of the study somewhat limits its representativeness. Future research could enhance this by providing a larger sample and conducting stratified analyses based on gender and age categories. Furthermore, the study did not analyze the impact of cumulative ecological risks at the subsystem level, which could be addressed through subgroup analyses in subsequent research. There are also limitations at the methodological level, as the PARS-3 used in this paper does not take into account the possible impact of different forms of exercise on the addiction to short videos among adolescents, and further research may use an internationalized PE questionnaire to investigate different forms of exercise. Finally, the present study lacks a specific motivational behavior classification system, enhancing intrinsic motivation for PE. It only considers the mediating role

of SC and the moderating effect of CER. It remains unclear whether there are other mediating or moderating influences between PE and adolescents' engagement with SVA. Future research should delve deeper into this area, exploring factors such as psychological resilience.

## 5. Conclusion

This study investigated the relationships and mediating model between PE and SVA. The findings suggest the following: adolescent SVA is positively affected by PE; SC acts as a mediator in the connection between PE and adolescent SVA; CER plays a moderating role between PE, SC on SVA; and adolescents with low CER have lower levels of SVA than those with high CER. Adolescents should increase PE during adolescence, and society can make use of short video platforms to accurately deliver and guide adolescents to lead a positive and healthy lifestyle and cultivate the value of sports; schools can create a second classroom, carry out rich and interesting PE activities, cultivate sports awareness, satisfy the sense of personal achievement, and get rid of the dependence on short videos; families and parents should give adolescents more care and positive support and set up an Families and parents should give more love and positive support to young people, establish an equal communication mechanism, understand the inner needs of children, and positively guide their upward values. Therefore, the CER is crucial to adolescent short video addictive behaviour. Parents, schools, and peers should then work together to provide a variety of emotional and psychological support to guide the physical and psychological growth of adolescents.

At the same time, the results of this study can not only provide a scientific basis for alleviating the problem of SVA in modern society but also contribute to the development of public health policies to prevent and intervene in SVA behaviours by advocating PE. In addition, it may also provide guidance for the sustainable development of short video platforms, encouraging them to design content and features that are more likely to promote users' physical and mental health. Meanwhile, the impact of CER on SVA reveals a multilevel prevention and intervention framework that emphasises the importance of identifying and mitigating risk factors in different ecosystems. This comprehensive intervention strategy can help build a healthier and more resilient living environment, thereby reducing the occurrence and development of SVA behaviours.

## Data availability statement

The authors do not have permission to share data.

## Institutional review board statement

This study was reviewed and approved by Chengdu Sport University, with the approval number: 2023-108.

## CRediT authorship contribution statement

**He Jianfeng:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Investigation, Formal analysis. **Zhuo Xian:** Writing – review & editing, Validation, Investigation. **Ai Zexiu:** Writing – review & editing, Writing – original draft, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

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

## References

- [1] H. Mu, Q. Jiang, J. Xu, S. Chen, Drivers and consequences of short-form video (SFV) addiction amongst adolescents in China: stress-coping theory perspective, *Int. J. Environ. Res. Publ. Health* 19 (21) (2022).
- [2] Y. Chen, M. Li, F. Guo, X. Wang, The effect of short-form video addiction on users' attention, *Behav. Inf. Technol.* (2022) 1–18.
- [3] K.Y. Kai, Internet audiovisual development is booming, *People's Daily* (PRC newspaper), p. 7..
- [4] C.I.N.I. Center, Expert Interpretation of the 51st <Statistical Report on the Development Status of the Internet in China>, 2023.
- [5] X. Zhang, Y. Wu, S. Liu, Exploring short-form video application addiction: socio-technical and attachment perspectives, *Telematics Inf.* 42 (2019).
- [6] L. Lu, M. Liu, B. Ge, Z. Bai, Z. Liu, Adolescent addiction to short video applications in the mobile internet era, *Front. Psychol.* 13 (2022) 893599.
- [7] T.E. Gladwin, B. Figner, E.A. Crone, R.W. Wiers, Addiction, adolescence, and the integration of control and motivation, *Dev Cogn Neurosci* 1 (4) (2011) 364–376.
- [8] H.X. Wang, L. Lei, The relationship between parental phubbing and short-form videos addiction among Chinese adolescents, *J. Res. Adolesc.* 32 (4) (2022) 1580–1591.
- [9] M. Zheng, J.Y. Zhi, The relationship between adolescent extroverted personality, loneliness and problematic short video use in the context of the new coronary pneumonia epidemic, *Chinese Journal of Health Psychology* 1–9..
- [10] F.-Y. Hong, D.-H. Huang, H.-Y. Lin, S.-L. Chiu, Analysis of the psychological traits, Facebook usage, and Facebook addiction model of Taiwanese university students, *Telematics Inf.* 31 (4) (2014) 597–606.
- [11] S. Ponnusamy, M. Iranmanesh, B. Foroughi, S.S. Hyun, Drivers and outcomes of instagram addiction: psychological well-being as moderator, *Comput. Hum. Behav.* 107 (2020).
- [12] E.A. Crone, E.A. Konijn, Media use and brain development during adolescence, *Nat. Commun.* 9 (1) (2018) 588.

- [13] Y. Farchakh, C. Haddad, H. Sacre, S. Obeid, P. Salameh, S. Hallit, Video gaming addiction and its association with memory, attention and learning skills in Lebanese children, *Child Adolesc. Psychiatr. Ment. Health* 14 (1) (2020) 1–11.
- [14] J.H. Ye, Y.T. Wu, Y.F. Wu, M.Y. Chen, J.N. Ye, Effects of short video addiction on the motivation and well-being of Chinese vocational college students, *Front. Public Health* 10 (2022) 847672.
- [15] L. Dongping, Z.Y. Yue, Z. Liyan, W. Yanhui, S. Wenqiang, Cumulative ecological risk and adolescent Internet addiction: the mediating role of psychological need fulfillment and positive outcome expectations, *Psychological Journal* 48 (12) (2016) 1519–1537.
- [16] G. Yang, Y. Li, S. Liu, C. Liu, C. Jia, S. Wang, Physical activity influences the mobile phone addiction among Chinese undergraduates: the moderating effect of exercise type, *Journal of Behavioral Addictions* 10 (3) (2021) 799–810.
- [17] H. Cash, C. D. Rae, A. H. Steel, A. Winkler, Internet addiction: a brief summary of research and practice, *Curr. Psychiatr. Rev.* 8 (4) (2012) 292–298.
- [18] L. Verburgh, M. Königs, E.J. Scherder, J. Oosterlaan, Physical exercise and executive functions in preadolescent children, adolescents and young adults: a meta-analysis, *Br. J. Sports Med.* 48 (12) (2014) 973–979.
- [19] D. Yaqi, G.Y. Yuan, D. Fei, Z. Jianwei, L. Xiaochun, The effects of cumulative ecological risk on college students' physical exercise: mediating effects of exercise climate and exercise self-efficacy, *Chinese Journal of Health Psychology* 30 (8) (2022) 1244–1249.
- [20] M. Monserrat-Hernández, J.C. Checa-Olmos, Á. Arjona-Garrido, R. López-Liria, P. Rocamora-Pérez, Academic Stress in University Students: the Role of Physical Exercise and Nutrition, *Healthcare, MDPI*, 2023, p. 2401.
- [21] M.H. De Moor, A. Beem, J.H. Stubbe, D.I. Boomsma, E.J. De Geus, Regular exercise, anxiety, depression and personality: a population-based study, *Prev. Med.* 42 (4) (2006) 273–279.
- [22] Q.-Q. Liu, W. Tu, Y.-F. Shang, X.-P. Xu, Unique and interactive effects of parental neglect, school connectedness, and trait self-control on mobile short-form video dependence among Chinese left-behind adolescents, *Child Abuse Neglect* 134 (2022) 105939.
- [23] Y. Feng, L. Li, A. Zhao, A cognitive-emotional model from mobile short-form video addiction to intermittent discontinuance: the moderating role of neutralization, *Int. J. Hum. Comput. Interact.* (2022) 1–13.
- [24] C. Su, H. Zhou, L. Gong, B. Teng, F. Geng, Y. Hu, Viewing personalized video clips recommended by TikTok activates default mode network and ventral tegmental area, *Neuroimage* 237 (2021) 118136.
- [25] X.X. Tian, X.H. Bi, H. Chen, How short-form video features influence addiction behavior? Empirical research from the opponent process theory perspective, *Inf. Technol. People* 36 (1) (2023) 387–408.
- [26] Y. Liu, X. Ni, G. Niu, Perceived stress and short-form video application addiction: a moderated mediation model, *Front. Psychol.* 12 (2021) 747656.
- [27] C. Peng, J.-Y. Lee, S. Liu, Psychological phenomenon analysis of short video users' anxiety, Addiction and Subjective well-being, *International Journal of Contents* 18 (1) (2022) 27–39.
- [28] X. Tian, X. Bi, H. Chen, How short-form video features influence addiction behavior? Empirical research from the opponent process theory perspective, *Inf. Technol. People* 36 (1) (2023) 387–408.
- [29] A.S. Hatcher, From one addiction to another: life after alcohol and drug abuse, *Nurse Pract. Am. J. Prim Health Care* 14 (11) (1989) 13–20.
- [30] Z. Yang, M.D. Griffiths, Z. Yan, W. Xu, Can watching online videos be addictive? A qualitative exploration of online video watching among Chinese young adults, *Int. J. Environ. Res. Publ. Health* 18 (14) (2021) 7247.
- [31] Y. Hou, D. Xiong, T. Jiang, L. Song, Q. Wang, Social media addiction: its impact, mediation, and intervention, *Cyberpsychology* 13 (1) (2019).
- [32] A. Chung, D. Vieira, T. Donley, N. Tan, G. Jean-Louis, K. Kiely Gouley, A. Seixas, Adolescent peer influence on eating behaviors via social media: scoping review, *J. Med. Internet Res.* 23 (6) (2021) e19697.
- [33] A. Hossain, Factors influencing facebook addiction among Varendra University students in the lockdown during the COVID-19 outbreak, *Computers in Human Behavior Reports* 6 (2022) 100181.
- [34] H. Wei, J. Yihe, J. Wang, W. Nan, The relationship between short-form social media dependence and sleep disturbance among university students: the mediating role of nighttime social media use and gender differences, *Chin. J. Clin. Psychol.* 29 (1) (2021) 46–50.
- [35] Z. Shuhan, A study on the influencing factors of mobile short video addiction among adolescent groups, *intelligence science* 40 (8) (2022) 85–91.
- [36] L. Xiaoyan, K.H. Wing, Z. Tong, The effect of short video use on depression among female university students: the chain mediating role of self-objectification and body satisfaction, *Psychol. Sci.* 43 (5) (2020) 1220–1226.
- [37] H. Parlak Sert, H. Baskale, Students' increased time spent on social media, and their level of coronavirus anxiety during the pandemic predict increased social media addiction, *Health Inf. Libr. J.* (2022) 1–13.
- [38] M.F. Zahra, T.A. Qazi, A.S. Ali, N. Hayat, T. ul Hassan, How tiktok addiction leads to mental health illness? Examining the mediating role of academic performance using structural equation modeling, *Journal of Positive School Psychology* 6 (10) (2022) 1490–1502.
- [39] I. Sabir, I. Nasim, M.B. Majid, M. Sadad, N. Sabir, TikTok addictions and its disorders among youth of Pakistan, *Scholedge Int. J. Multidiscip. Allied Stud.* 7 (6) (2020) 140–146.
- [40] L. Lin, J. Liu, X. Cao, S. Wen, J. Xu, Z. Xue, J. Lu, Internet addiction mediates the association between cyber victimization and psychological and physical symptoms: moderation by physical exercise, *BMC Psychiatr.* 20 (2020) 1–8.
- [41] J. Nakamura, M. Csikszentmihalyi, Flow theory and research, *Handbook of positive psychology* 195 (2009) 206.
- [42] H. Kalajas-Tilga, A. Koka, V. Hein, H. Tilga, L. Raudsepp, Motivational processes in physical education and objectively measured physical activity among adolescents, *Journal of sport and health science* 9 (5) (2020) 462–471.
- [43] E.L. Deci, R.M. Ryan, Self-determination theory, *Handbook of theories of social psychology* 1 (20) (2012) 416–436.
- [44] L. Yinghai, D. Yujin, A study on psychological attribution and intervention of Internet addiction from the perspective of exercise psychology, *Journal of Beijing University of Sports* 32 (8) (2009) 57–61.
- [45] K. Wang, Y. Li, Y. Yang, T. Zhang, J. Luo, The role of loneliness and learning burnout in the regulation of physical exercise on internet addiction in Chinese college students, *BMC Publ. Health* 23 (1) (2023) 1994.
- [46] S. Li, Q. Wu, C. Tang, Z. Chen, L. Liu, Exercise-based interventions for internet addiction: neurobiological and neuropsychological evidence, *Front. Psychol.* 11 (2020) 1296.
- [47] S. Liu, T. Xiao, L. Yang, P.D. Loprinzi, Exercise as an alternative approach for treating smartphone addiction: a systematic review and meta-analysis of random controlled trials, *Int. J. Environ. Res. Publ. Health* 16 (20) (2019).
- [48] H. Chan, X. Mian, J.G. Rong, W. Hua, Self-esteem and online game addiction - the mediating role of self-control, *Chin. J. Clin. Psychol.* 20 (1) (2012) 58–60.
- [49] C. Englert, The strength model of self-control in sport and exercise psychology, *Front. Psychol.* 7 (2016) 314.
- [50] J.-A. Park, M.-H. Park, J.-H. Shin, B. Li, D.T. Rolfe, J.-Y. Yoo, S.W. Dittmore, Effect of sports participation on internet addiction mediated by self-control: a case of Korean adolescents, *Kasetsart Journal of Social Sciences* 37 (3) (2016) 164–169.
- [51] A.J. Finley, B.J. Schmeichel, Afters of self-control on positive emotional reactivity, *Pers. Soc. Psychol. Bull.* 45 (7) (2019) 1011–1027.
- [52] M.B. Denckla, A Theory and Model of Executive Function: A Neuropsychological Perspective, 1996.
- [53] M. Oaten, K. Cheng, Longitudinal gains in self-regulation from regular physical exercise, *Br. J. Health Psychol.* 11 (4) (2006) 717–733.
- [54] A. Schöndube, A. Bertrams, G. Sudeck, R. Fuchs, Self-control strength and physical exercise: an ecological momentary assessment study, *Psychol. Sport Exerc.* 29 (2017) 19–26.
- [55] C.E. Köpeltz, C.W. Lejuez, R.W. Wiers, A.W. Kruglanski, Motivation and self-regulation in addiction: a call for convergence, *Perspect. Psychol. Sci.* 8 (1) (2013) 3–24.
- [56] D. Yaqi, G.Y. Yuan, D. Fei, C.K. Wai, L. Xiaochun, The effect of cumulative ecological risk on physical activity among university students: mediating effects of exercise climate and exercise self-efficacy, *Chinese Journal of Health Psychology* 30 (8) (2022) 1244–1249.
- [57] R.M. Lerner, J.V. Lerner, J. Almerigi, C. Theokas, Dynamics of Individual↔ Context Relations in Human Development: A Developmental Systems Perspective, 2006.

- [58] D. Li, Y. Zhou, L. Zhao, Y. Wang, W. Sun, Cumulative ecological risk and adolescent internet addiction: the mediating role of basic psychological need satisfaction and positive outcome expectancy, *Acta Psychol. Sin.* 48 (12) (2016) 1519.
- [59] R.M. Ryan, E.L. Deci, *Self-determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*, Guilford publications, 2017.
- [60] H. Wang, L. Lei, The Relationship between parental phubbing and short-form videos addiction among Chinese adolescents, *J. Res. Adolesc.* 32 (4) (2022) 1580–1591.
- [61] D. Yaqi, C. Ailing, T.C. De, M. Xiao, L. Jianjun, Y.H. Xia, The effect of cumulative ecological risk on college students' sporting lifestyles: mediating effects of sporting climate and self-control, *Chinese Journal of Health Psychology* 1-10..
- [62] R.M. Ryan, E.L. Deci, Intrinsic and extrinsic motivation from a self-determination theory perspective: definitions, theory, practices, and future directions, *Contemp. Educ. Psychol.* 61 (2020) 101860.
- [63] Y. Chen, Y. Gao, Q. Deng, M. Peng, F. Gao, The relationship between shyness and mobile phone dependence in middle school students: a moderated mediation model, *Psychol. Dev. Educ* 1 (2021) 46–53.
- [64] K. Xu, X. Sicheng, Z. Bin, H. Yin, Longitudinal associations between cumulative ecological risk and mobile phone dependence in adolescents: the moderating role of emotionally regulated self-efficacy and gender differences, *Chinese Journal of Health Psychology* 31 (5) (2023) 689–694.
- [65] Yaqi Dong, Ailing Che, Tang Chuande, Xiao Ma, Jianjun Li, Yu Huxia, The impact of cumulative ecological risk on university students' sporting lifestyles: mediating effects of sporting climate and self-control, *Chin. J. Health Psychol.* 31 (2023) 914–919.
- [66] T. Smith, A. Short, Needs affordance as a key factor in likelihood of problematic social media use: Validation, latent Profile analysis and comparison of TikTok and Facebook problematic use measures, *Addict. Behav.* 129 (2022) 107259.
- [67] D. Liang, Stress level of college students and its relationship with physical exercise, *Chin. Ment. Health J.* 8 (2) (1994).
- [68] Shuhua Tan, Yongyu Guo, Revision of the Self-Control Scale for College Students, *Chin. J. Clin. Psychol.* (2008) 468–470.
- [69] L. Han, J. Geng, M. Jou, F. Gao, H. Yang, Relationship between shyness and mobile phone addiction in Chinese young adults: mediating roles of self-control and attachment anxiety, *Comput. Hum. Behav.* 76 (2017) 363–371.
- [70] W. Minglong, *Structural Equation Modelling AMOS Operations and Applications*, 1 ed., Chongqing University Press..
- [71] E.L. Deci, R.M. Ryan, The "what" and "why" of goal pursuits: human needs and the self-determination of behavior, *Psychol. Inq.* 11 (4) (2000) 227–268.
- [72] C. Jianwen, L. Yan, T. Qianbao, Cumulative ecological risk and academic burnout in higher education students: the mediating role of negative self-schemas and internet addiction, *Psychol. Dev. Educ.* 38 (4) (2022) 576–583.
- [73] J. Yang, Y. Ti, Y. Ye, Offline and online social support and short-form video addiction among Chinese adolescents: the mediating role of emotion suppression and relatedness needs, *Cyberpsychol., Behav. Soc. Netw.* 25 (5) (2022) 316–322.
- [74] B. Behzadnia, S. FatahModares, Basic psychological need-satisfying activities during the COVID-19 outbreak, *Appl. Psychol.: Health and Well-Being* 12 (4) (2020) 1115–1139.
- [75] K.-I. Guo, Q.-s. Ma, S.-j. Yao, C. Liu, Z. Hui, J. Jiang, X. Lin, The relationship between physical exercise and mobile phone addiction tendency of university students in China: a moderated mediation model, *Front. Psychol.* 13 (2022) 730886.
- [76] W. Xiao, J. Wu, J. Yip, Q. Shi, L. Peng, Q.E. Lei, Z. Ren, The Relationship between physical activity and mobile phone addiction among adolescents and young adults: systematic review and meta-analysis of observational studies, *JMIR public health and surveillance* 8 (12) (2022) e41606.
- [77] K.-I. Guo, Q.-s. Ma, S.-j. Yao, C. Liu, The relationship between physical exercise and Mobile phone addiction tendency of university students in China: a moderated mediation model, *Front. Psychol.* 13 (2022) 730886.
- [78] A. Strohle, Physical activity, exercise, depression and anxiety disorders, *J. Neural. Transm.* 116 (6) (2009) 777–784.
- [79] Y. Liu, X. Ni, G. Niu, Perceived stress and short-form video application addiction: a moderated mediation model, *Front. Psychol.* 12 (2021) 5691.
- [80] T.J. van Woudenberg, K.E. Bevelander, W.J. Burk, M. Buijzen, The reciprocal effects of physical activity and happiness in adolescents, *Int. J. Behav. Nutr. Phys. Activ.* 17 (2020) 1–10.
- [81] Y. Özdemir, Y. Kuzucu, Ş. Ak, Depression, loneliness and Internet addiction: how important is low self-control? *Comput. Hum. Behav.* 34 (2014) 284–290.
- [82] M. Mehroof, M.D. Griffiths, Online gaming addiction: the role of sensation seeking, self-control, neuroticism, aggression, state anxiety, and trait anxiety, *Cyberpsychol., Behav. Soc. Netw.* 13 (3) (2010) 313–316.
- [83] J.M. Brown, *Self-regulation and the Addictive Behaviors*, 1998.
- [84] R. Boat, S.B. Cooper, Self-control and exercise: a review of the bi-directional relationship, *Brain Plast.* 5 (1) (2019) 97–104.
- [85] R.F. Baumeister, K.D. Vohs, D.M. Tice, The strength model of self-control, *Curr. Dir. Psychol. Sci.* 16 (6) (2007) 351–355.
- [86] Y.B. Liu, X.L. Ni, G.F. Niu, Perceived stress and short-form video application addiction: a moderated mediation model, *Front. Psychol.* 12 (2021).
- [87] P. Salmon, Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory, *Clin. Psychol. Rev.* 21 (1) (2001) 33–61.
- [88] C. Yu, W. Zhang, Y. Zeng, T. Ye, J. Hu, D. Li, Gratitude, basic psychological needs, and problematic Internet use in adolescence, *Psychol. Dev. Educ.* 28 (1) (2012) 83–90.
- [89] M. Zong, D. Dong, Z. Yang, Y. Feng, Z. Qiao, Role of time perspectives and self-control on well-being and ill-being during the COVID-19 pandemic: a multiple mediation model, *BMC psychology* 10 (1) (2022) 238.
- [90] Z. Alimoradi, A. Lotfi, C.-Y. Lin, M.D. Griffiths, A.H. Pakpour, Estimation of behavioral addiction prevalence during COVID-19 pandemic: a systematic review and meta-analysis, *Current addiction reports* 9 (4) (2022) 486–517.
- [91] G. Ballarotto, E. Marzilli, L. Cerniglia, S. Cimino, R. Tambelli, How does psychological distress due to the COVID-19 pandemic impact on internet addiction and Instagram addiction in emerging adults? *Int. J. Environ. Res. Publ. Health* 18 (21) (2021) 11382.
- [92] A. Cudo, M. Toró, M. Demczuk, P. Francuz, Dysfunction of self-control in Facebook addiction: impulsivity is the key, *Psychiatr. Q.* 91 (2020) 91–101.
- [93] J. Wang, Y. Xie, Y. Zhang, H. Xu, X. Zhang, Y. Wan, F. Tao, The relationship between cumulative ecological risk and health risk behaviors among Chinese adolescents, *BMC Publ. Health* 24 (1) (2024) 603.
- [94] D. Hu, S. Zhou, Z.J. Crowley-McHattan, Z. Liu, Factors that influence participation in physical activity in school-aged children and adolescents: a systematic review from the social ecological model perspective, *Int. J. Environ. Res. Publ. Health* 18 (6) (2021) 3147.
- [95] K.L. Morton, A. Atkin, K. Corder, M. Suhrcke, E. Van Sluijs, The school environment and adolescent physical activity and sedentary behaviour: a mixed-studies systematic review, *Obes. Rev.* 17 (2) (2016) 142–158.
- [96] C.A. Yao, R.E. Rhodes, Parental correlates in child and adolescent physical activity: a meta-analysis, *Int. J. Behav. Nutr. Phys. Activ.* 12 (2015) 1–38.
- [97] R.P. Rohner, J.E. Lansford, Deep structure of the human affectional system: introduction to interpersonal acceptance–rejection theory, *Journal of Family Theory & Review* 9 (4) (2017) 426–440.
- [98] S.J. Chung, A.L. Ersig, A.M. McCarthy, The influence of peers on diet and exercise among adolescents: a systematic review, *J. Pediatr. Nurs.* 36 (2017) 44–56.
- [99] H. Chan, X. Mian, J. Guangrong, W. Hua, Self-esteem and online game addiction - the mediating role of self-control, *Chin. J. Clin. Psychol.* 20 (1) (2012) 58–60.
- [100] Y. Zhang, R. Bu, J. Zhao, X. Li, Social Exclusion and Short Video Addiction in Chinese College Students: the Mediating Role of Boredom and Self-Control, 2023.
- [101] D. Stokols, Translating social ecological theory into guidelines for community health promotion, *Am. J. Health Promot.* 10 (4) (1996) 282–298.
- [102] K. Xu, X. Sicheng, Z. Bin, H. Yi, Longitudinal associations between cumulative ecological risk and mobile phone dependence in adolescents: the moderating role of emotionally regulated self-efficacy and gender differences, *Chinese Journal of Health Psychology* 31 (5) (2023) 689–694.