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The Dark Triad and aggression among drug abstiners: a moderated mediation model of self-control and physical exercise

Li-Shuang Chen^{1,2}, Ying Yao⁴ and Ming-Sheng Xiong^{1,3*}

Abstract

Background Drug addiction is a significant public health concern, and aggression is common among people with drug addiction. Despite mounting evidence showing that the Dark Triad is a risk factor for aggression, the mediating and moderating mechanisms underlying this relationship are less known. This study tested the mediation effect of self-control in the association between the Dark Triad and aggression and whether this mediation was moderated by physical exercise.

Methods A cross-sectional study was conducted in two compulsory drug rehabilitation centers in Nanning, China. A convenience sample of 564 drug abstiners completed a questionnaire to assess their Dark Triad, self-control, aggression, and physical exercise levels. Mediation and moderation analyses were carried out in SPSS macro-PROCESS.

Results Self-control partially mediated the positive association between the Dark Triad and aggression. Physical exercise moderated the indirect effect of the Dark Triad on aggression via self-control, with the effect decreasing with the increase in physical exercise levels.

Conclusions This study offers fresh insights into the underlying mediating and moderating mechanisms between the Dark Triad and aggression. The findings provide important practical implications for future intervention and prevention programs to address aggression among drug abstiners, which may be realized through strengthening self-control and physical exercise.

Keywords Dark personality, Self-control, Aggression, Physical activity, Drug addiction, Mediator, Moderator

Introduction

Drug addiction is among the most prevalent psychiatric disorders worldwide and represents a major global health concern [1]. According to the World Drug Report 2019, 270 million people were drug users, and 35 million people suffer from drug addiction globally, which caused a death toll of 585,000 people in 2017 [2]. In the US, the lifetime prevalence of drug addiction reached as high as 10%, representing more than 23 million drug addicts [3]. In China, over two million people are reported to be drug users each year, and most of them are admitted to compulsory drug rehabilitation centers for treatment [4].

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Drug addicts represent a dangerous group that poses a severe to social security, with a strong propensity for aggression [5]. In this context, aggression encompasses not only physical and verbal aggression but also aggressive cognitions such as hostility, resentment, and self-blame [6]. An extensive body of research has consistently shown that aggression is common among drug addicts [7, 8], especially those in compulsory drug rehabilitation centers [9]. Aggression not only contributes to an increased risk of mental and behavioral disorders but also presents potential safety risks to compulsory drug rehabilitation centers [9]. It is thus crucial to investigate the influencing factors of aggression among drug abstiners in these facilities to identify the high-risk population and guide targeted prevention and intervention efforts.

Research has shown a significant association between personality disorder and aggression among drug addicts, with the Dark Triad gaining increasing research attention in recent years [10–12]. The Dark Triad, a personality cluster comprising Machiavellianism, psychopathy, and narcissism [13], shares common features such as low likability, low morality, low empathy, and antagonistic personality traits. Individuals with the Dark Triad exhibit aggressive destructiveness, self-righteousness, emotional indifference, and superficial dissonance [14]. In contrast to the traditional “bright personality” characterized by significant personality disorders and adverse behavioral traits [15, 16], the Dark Triad reshapes our understanding of personality traits in drug addicts [17]. Emerging research suggests that the Dark Triad significantly contributes to aggression and aggressive behaviors among drug addicts [11, 12]. For instance, a robust positive correlation has been established between psychopathy, a component of the Dark Triad, and aggression [18]. As such, the Dark Triad may provide a more accurate representation of aggression observed in drug addicts compared to the “bright personality” paradigm [19].

Although abundant evidence has established a positive correlation between the Dark Triad and aggression among drug addicts, the underlying mechanism of such an association remains elusive. One potential mediator linking the Dark Triad to aggression may be self-control. Self-control is a dominant tendency of individuals to regulate their responses and a specific ability to control cognition, emotions, and behavior, with a proximal initiation of positive psychological effects [20]. Self-control may be an inhibitory factor of aggression, with studies showing a robust negative correlation between self-control and aggression theoretically and empirically [21]. Further, self-control may moderate dark traits such as narcissism and antisocial tendencies and decrease their effects on aggression [22]. Therefore, the Dark Triad may be associated with aggression, with self-control acting as a mediating factor in this relationship.

Although the Dark Triad may be related to aggression through self-control, not all drug addicts with the Dark Triad equally experience decreased self-control and develop aggression. Physical exercise is one of the most important and widely studied factors that may moderate the association between the Dark Triad and aggression via self-control. Presently, physical exercise is integrated into therapeutic interventions for drug addiction, underscoring its pivotal role in the recovery and substance withdrawal treatment of those afflicted with drug dependency [23]. In the compulsory drug rehabilitation centers in China, mandatory participation in physical exercise is required for each drug addict under the current policies and practices [24, 25]. Research has demonstrated that physical exercise has a potent mitigating effect on aggression among drug addicts [26]. Specifically, physical exercise can help drug addicts curtail drug cravings and assist them in effectively managing negative emotions, thus curbing aggressive behaviors [26–29]. Moreover, a significant positive correlation exists between physical exercise and self-control [30, 31]; physical exercise substantially enhances self-control [32], and both are associated with decreased levels of aggression [21, 30]. These findings suggest that physical exercise may moderate the mediating role of the Dark Triad on the association between self-control and aggression in drug abstiners.

Although the correlations among the Dark Triad, self-control, aggression, and physical activity have been reported separately in various studies, there is a lack of comprehensive investigation of their interrelationships by examining them in a unified model, especially within the drug rehabilitation cohort. While it has been well-established that the Dark Triad is positively correlated to aggression, less well-known is the indirect effect of the Dark Triad on aggression via self-control and whether this effect was moderated by physical exercise. Thus, we conducted the current study to investigate the relational model among dark personality traits, self-control, aggressiveness, and physical activity in the context of drug rehabilitation, subsequently elucidating direct and indirect relational pathways. We proposed a conceptual model, as shown in Fig. 1, to test a moderated mediation model of physical exercise and self-control on the relationship between the Dark Triad and aggression among drug abstiners. Specifically, we proposed the following hypotheses:

Hypothesis 1 The Dark Triad would be positively associated with drug abstiners’ aggression.

Hypothesis 2 Self-control would mediate the relationship between the Dark Triad and aggression.

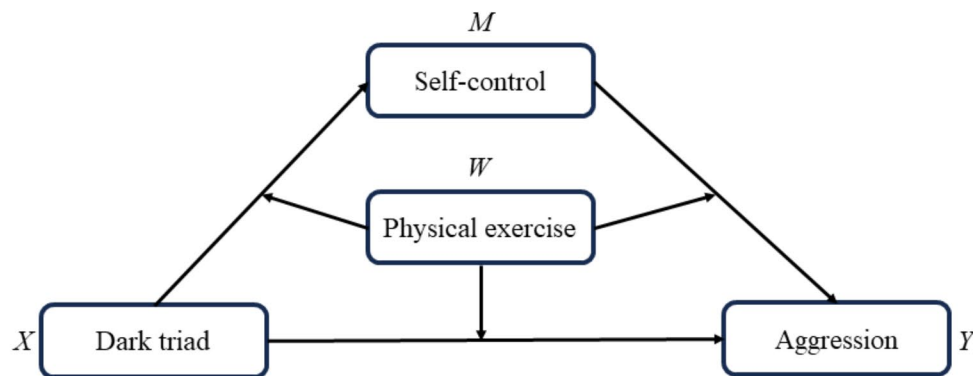


Fig. 1 Hypothetical model

Hypothesis 3 Physical exercise would moderate the direct and indirect relations between the Dark Triad and aggression.

In addition, considering the significant gender differences in the Dark Triad [33], self-control [34], aggression [35], and physical exercise [36], and that compulsory drug rehabilitation centers in China are segregated by gender, we further included gender as a covariate in the mediation model to mitigate potential confounding effects due to gender differences.

Methods

Participants and procedure

This was a cross-sectional study conducted in two local compulsory drug rehabilitation centers in Nanning City, Guangxi Province. A convenience sampling method was used to select 700 drug abstainers at the rehabilitation centers. The inclusion criteria for participants were as follows: (1) Drug abusers who met the DSM-V diagnostic criteria for psychoactive substance abuse or dependence; (2) Had completed physical detoxification with a negative urine test in 1 month; (3) Aged between 18 and 60; (4) Had no serious mental illness and were not taking any medication. Those who were unable to complete the questionnaire survey due to severe physical or mental illness or illiteracy were excluded from the study. The sample size was calculated based on the following formula $n = [Z_{1-\alpha/2}^2 * \pi (1-\pi)] / \delta^2$, where π (the prevalence of aggression) was estimated at 69% based

on the literature [37], $Z_{1-\alpha/2}$ was set as 1.96 with a 95% confidence interval, and the allowable error δ was set as 0.15. Hence, the minimum sample size for this study was calculated to be $n = [1.962 \times 69\% (1-69\%)] / (0.15 \times 69\%)^2 \approx 77$. Considering a rejection or loss-to-follow-up rate of about 20%, the minimum sample size was expanded to $77 + (77 \times 20\%) \approx 93$.

Ethical approval Ethical approval was granted by the Medical Ethics Committee of the Wuhan Sports University. Potential participants at drug rehabilitation centers were approached by our research team with assistance from the police, and provided with a detailed explanation of the study's purpose, procedure, benefits, and risks in accordance with the Declaration of Helsinki. Those interested in participating were invited to complete a questionnaire on-site after providing written informed consent. The research team explained how to complete the questionnaire and ensured the survey's anonymity. The participants were informed that participation in the study was voluntary and they could withdraw at any time, which would not affect their rights and obligations in the drug rehabilitation centers. The questionnaire took approximately 20–30 min to complete. After eliminating invalid responses, a total of 564 valid questionnaires were obtained, with an effective response rate of 81%. The participants' average age was 36.78 (SD=8.95) years, with 364 males (64.5%) and 200 females (35.5%).

Measurements

General questionnaire

A self-designed information sheet was used to collect the socio-demographic characteristics of the participants, including age, gender, marital status, and place of residence.

The Dark Triad

The Dark Triad was assessed using the Dark Triad Survey Scale, also known as the Dirty Dozen (DD) [38], developed by Jonason and Webster in 2010. We used the revised Chinese version [39], which includes 12 items equally distributed under three domains: Machiavellianism, narcissism, and psychopathy. Each item is rated on a 7-point Likert scale ranging from 1 to 7 (1=strongly disagree; 2=somewhat disagree; 3=somewhat disagree; 4=not sure; 5=somewhat agree; 6=somewhat agree; 7=strongly agree). The score for each dimension is the average of the corresponding items, and the score for the total scale is the average of all scale items, with higher scores indicating more pronounced dark traits. In the current study, the Cronbach's alpha coefficient of the total scale was 0.80, with subscale coefficients of 0.74 for Machiavellianism, 0.69 for narcissism, and 0.73 for psychopathy.

Self-control

Self-control was assessed using the Dual-Mode of Self-Control Scale (DMSC-S) [40], developed by Dvorak and Simons based on previous scales related to impulsive and control systems. We used the revised Chinese version [41], which includes 21 items under two dimensions: the control system (9 items) and the impulsive system (12 items). The control system comprises problem-solving and future time perspective, while the impulsive system includes impulsivity, distractibility, and low delay gratification. Each item is scored on a 5-point Likert scale ranging from 1 to 5 (1=strongly disagree; 2=disagree; 3=unsure; 4=agree; 5=strongly agree). The score for each dimension is the average of the corresponding items, and the score for the total scale is the average of all scale items. In the current study, the Cronbach's alpha coefficient of the overall scale was 0.90, with subscale coefficients of 0.85 for the control system and 0.87 for the impulsive system.

Aggression

Aggression was assessed using the Reactive-Proactive Aggression Questionnaire (RPAQ) developed by Raine and colleagues [42] to measure the levels of reactive and proactive aggression. We used its revised Chinese version [43], which includes 20 items under two dimensions: reactive aggression and proactive aggression. Each item is rated on a 6-point Likert scale ranging from 1 to

6 (1=never; 2=almost never; 3=sometimes; 4=often; 5=almost always; 6=always). The score for each dimension is the average of the corresponding items, and the score for the total scale is the average of all scale items. In the current study, the Cronbach's alpha coefficient for the total scale was 0.93, with subscale coefficients of 0.90 for reactive aggression and 0.89 for proactive aggression.

Physical exercise

Physical exercise was assessed using the Physical Activity Rating Scale (PARS-3), developed by Kimio Hashimoto and later revised by Liang and colleagues in China [44]. The PARS-3 includes three items to calculate the volume of physical exercise based on the frequency, duration, and intensity of the exercise. Each item is rated on a 5-point Likert scale and is listed as follows: (1) How often do you engage in physical activity? 1=less than once a month; 2=2–3 times a month; 3=1–2 times a week; 4=3–5 times a week; 5=about once a day. (2) How many minutes do you spend on physical exercise per session? 1=less than 10 min; 2=11–20 min; 3=21–30 min; 4=31–59 min; 5=more than 60 min. (3) How intense is your physical exercise? 1=light exercise (e.g., walking, doing calisthenics); 2=low-intensity, less vigorous exercise (e.g., jogging, Tai Chi); 3=moderate-intensity, more vigorous sustained exercise (e.g., cycling, running, playing table tennis); 4=high-intensity, causing rapid breathing and sweating, but not sustained (e.g., basketball, short-duration single fitness activities); 5=high-intensity, causing rapid breathing and sweating, and sustained (e.g., racing, long-duration gym workouts).

The total volume of physical exercise is calculated as frequency \times (duration - 1) \times intensity, which ranges from 0 to 100, with a higher score indicating a higher level of physical exercise. The PARS-3 has been widely used in China as an objective indicator of physical exercise with good reliability and validity [45, 46]. In the current study, the split-half reliability of the scale was 0.76.

Statistical analysis

SPSS 24.0 software was employed for statistical analysis. The data distribution was assessed using skewness and kurtosis values, with the absolute value of skewness $<$ 2 and kurtosis $<$ 7 indicating approximate normal distribution [47]. The skewness of the four key variables ranged from 0.40 to 2.45, and their kurtosis ranged from 0.19 to 7.23, indicating slightly or significantly skewed. The independent sample t-test was used to compare the gender differences in key variables. Pearson correlation was used to analyze the relationships among the Dark Triad, self-control, aggression, and physical exercise. Model 4 of Hayes' PROCESS procedure for SPSS version 3.3 [48] was used to test for mediation analysis, and Model 59 was utilized for conditional process analysis. The indirect

Table 1 Socio-demographic characteristics of the drug abstainers

	Categories	N
Gender	Male	364
	Female	200
Place of residence	Towns	215
	Rural	349
Marital status	Married	307
	Not married	257

Table 2 Correlations analysis among key variables

Variables	$\bar{x} \pm s$	Dark Triad	Self-control	Aggression
Dark triad	2.79±0.85			
Self-control	3.10±0.56	-0.29***		
Aggression	2.29±0.69	0.60***	-0.46***	
Physical exercise	9.60±9.48	0.07	0.13**	-0.22***

Note * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Gender differences in variables

Factors	Male (n = 364)	Female (n = 200)	t
Dark Triad	2.86±0.83	2.68±0.86	2.40*
Self-control	3.02±0.55	3.25±0.55	-4.69***
Aggression	2.35±0.72	2.17±0.61	3.26**
Physical exercise	10.72±11.06	7.55±4.98	4.67***

Note * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

effect of mediation was tested using a bootstrapping method with 5,000 samples, with a 95% confidence interval not including zero indicating a significant effect. All analyses were controlled for participants' socio-demographics, including age, gender, marital status, and place of residence.

Results

Sample characteristics

Table 1 shows the socio-demographic characteristics of the drug abstainers. Among the 564 participants who provided valid questionnaires, most were males (64.5%), rural (61.9%), and married (54.4%), with an average age of 36.78 ± 8.95 .

Descriptive statistics and correlation analysis

Table 2 presents the means and SDs and the Pearson correlations of study variables. The mean and SD of each study variable was 2.79 ± 0.85 for Dark Triad, 3.10 ± 0.56 for self-control, 2.29 ± 0.69 for aggression, and 9.60 ± 9.48 for physical exercise. Pearson correlations analyses showed that Dark Triad was negatively associated with self-control ($r = -0.29$, $p < 0.001$) and positively associated with aggression ($r = 0.60$, $p < 0.001$). Self-control was negatively associated with aggression ($r = -0.46$, $p < 0.001$) and positively associated with physical exercise ($r = 0.13$, $p < 0.01$). Finally, aggression was negatively associated with physical exercise ($r = -0.22$, $p < 0.001$).

Table 4 Self-control as a mediator in the relationship between Dark Triad and aggression

Regression equation (n = 564)		Fitting index			Significance of coefficients
Dependent variables	Independent variables	R^2	F	β	t
Aggression	Age	0.38	67.23	0.01	2.33*
	Gender			-0.11	-1.54
	Marital status			0.19	2.58†
	Place of residence			0.12	1.56
	Dark Triad			0.59	17.65***
Self-control	Age	0.17	23.38	-0.03	-5.73***
	Gender			0.34	4.00**
	Marital status			-0.42	-5.07***
	Place of residence			-0.05	-0.54
	Dark Triad			-0.27	-6.94***
Aggression	Age	0.46	77.69	0.01	0.30
	Gender			-0.01	-0.12
	Marital status			0.06	0.80
	Place of residence			0.10	1.47
	Dark Triad			0.51	15.57***
	Self-control			-0.31	-9.03***

Note The data of the above equations were normalized, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Gender differences in key variables

Before examining the mediating effects, independent sample t-tests were conducted to analyze gender differences in the key variables. As shown in Table 3, significant gender differences were observed in all four variables, with males exhibiting significantly higher levels of Dark Triad, aggression, and physical exercise. In comparison, females showed significantly higher levels of self-control. Therefore, gender was included as a covariate in the subsequent mediation analyses.

Mediation analysis

We first examined the mediating effect of self-control between the Dark Triad and aggression using Model 4 in the PROCESS procedure for SPSS version 3.3, developed by Hayes and Rockwood [48]. As shown in Table 4, the Dark Triad was significantly and positively associated with aggression ($B = 0.59$, $P < 0.001$), and the association decreased but remained significant after including the mediating variable self-control ($B = 0.51$, $P < 0.001$), indicating partial mediation. The Dark Triad was associated with lower self-control, which, in turn, was associated with increased aggression.

Table 5 shows the bootstrapping results. The total effect of the Dark Triad on aggression was 0.59 (95%CI: 0.53, 0.66), with a direct effect of 0.51 (95%CI: 0.45, 0.58) and an indirect effect of 0.08 (95% CI: 0.05, 0.12) through

Table 5 The bootstrap analysis of effects

	Effect Value	BootSE	BootLLCI	BootULCI
Total effect	0.59	0.03	0.53	0.66
Direct effect	0.51	0.03	0.45	0.58
Indirect effect	0.08	0.02	0.05	0.12

Table 6 Conditional process analysis on the moderated mediation effect of physical exercise on the relationship between Dark Triad and aggression via self-control

Regression equation (n = 564)		Fitting index			Significance of coefficients
Dependent variables	Independent variables	R ²	F	β	t
Aggression	Age	0.53	68.53	-0.01	-0.97
	Gender			-0.12	-1.78 ^a
	Marital status			0.05	0.71
	Place of residence			0.02	0.25
	Dark Triad			0.52	16.67 ^{***}
	Physical exercise			-0.18	-5.34 ^{***}
	Self-control			-0.27	-8.14 ^{***}
	Dark Triad × Physical exercise			-0.13	-4.60 ^{***}
	Self-control × Physical exercise			0.05	1.95 ^a
	Self-control			Age	0.20
Gender		0.40	4.70 ^{***}		
Marital status		-0.40	-4.88 ^{***}		
Place of residence		0.01	0.09		
Dark Triad		-0.27	-7.09 ^{***}		
Physical exercise		0.11	2.64 ^{**}		
Dark Triad × Physical exercise		0.07	1.93 ^a		

Note "a" indicates borderline significant $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

self-control. All these intervals didn't include zero, indicating that self-control partially mediated the relationship between the Dark Triad and aggression, with an indirect effect accounting for 15% of the total effect.

Moderated mediation analysis

To test whether physical exercise moderated the mediation process of the Dark Triad on aggression through self-control, we utilized a conditional process analysis model (Model 59) developed by Hayes and Rockwood [48] for the moderated mediation analysis. Table 6; Fig. 2 show that the product of the Dark Triad and physical exercise was significant for aggression and self-control. This finding indicated that physical exercise moderated

the direct effect of the Dark Triad on aggression and the indirect effect via self-control ($p < 0.10$).

Finally, we conducted further simple slope analyses to visualize the moderated mediation effect of physical exercise. As shown in Fig. 3, for participants with low physical exercise levels ($M - 1SD$), the Dark Triad was positively associated with aggression (*simple slope* = 0.63, $t = 16.05$, $p < 0.001$). As their physical exercise increased to high levels ($M + 1SD$), Dark Triad also exhibited a positive association with aggression, but with a smaller effect (*simple slope* = 0.40, $t = 9.45$, $p < 0.001$). This finding suggested that the positive effect of the Dark Triad on aggression tended to decrease gradually as the level of physical exercise among drug abstiners increased (Table 7).

As illustrated in Fig. 4, for participants with low physical exercise levels ($M - 1SD$), self-control was negatively associated with aggression (*simple slope* = -0.31, $t = -7.46$, $p < 0.001$). As their physical exercise increased to high levels ($M + 1SD$), self-control also had a negative association with aggression but with a smaller effect (*simple slope* = -0.22, $t = -5.59$, $p < 0.001$). This finding suggested that the effect of self-control on aggression tended to decrease gradually as the level of physical exercise among drug abstiners increased. Additionally, the mediating effect of self-control on the association between the Dark Triad and aggression tended to decrease with increasing levels of physical exercise (Table 7).

As illustrated in Fig. 5, for participants with low physical exercise levels ($M - 1SD$), the Dark Triad was negatively associated with self-control (*simple slope* = -0.33, $t = -6.84$, $p < 0.001$). As their physical exercise increased to high levels ($M + 1SD$), the Dark Triad also had a negative association with self-control but with a smaller effect (*simple slope* = -0.20, $t = -3.83$, $p < 0.01$). This suggested that the effect of the Dark Triad on self-control tended to decrease gradually as the level of physical exercise among drug abstiners increased (Table 7).

Discussion

Summary of the findings

To our knowledge, this was the first study to comprehensively investigate the interrelationships of the Dark Triad, self-control, aggression, and physical exercise using a moderated mediation model among drug abstiners in compulsory drug rehabilitation centers. Specifically, we tested the mediation effect of self-control in the association between the Dark Triad and aggression and whether this mediation was moderated by physical exercise. Our findings showed that self-control mediated the relationship between the Dark Triad and aggression, supporting our hypotheses 1 & 2. Additionally, physical exercise moderated both the direct and indirect effects of the Dark Triad on aggression, supporting our hypothesis 3.

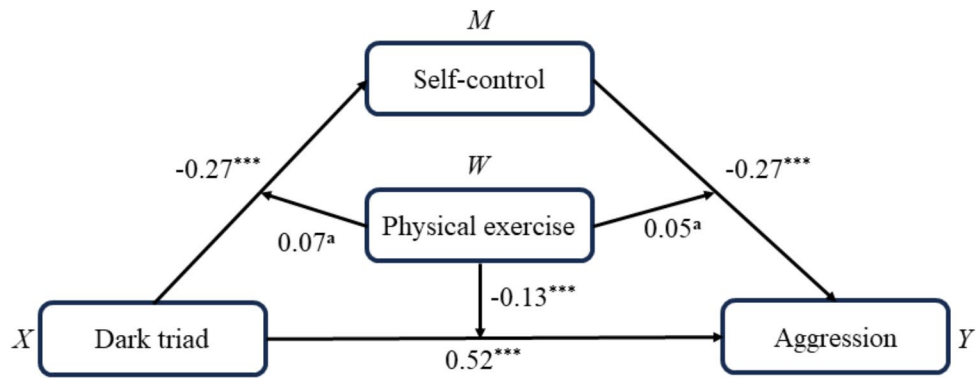


Fig. 2 Conditional process analysis model

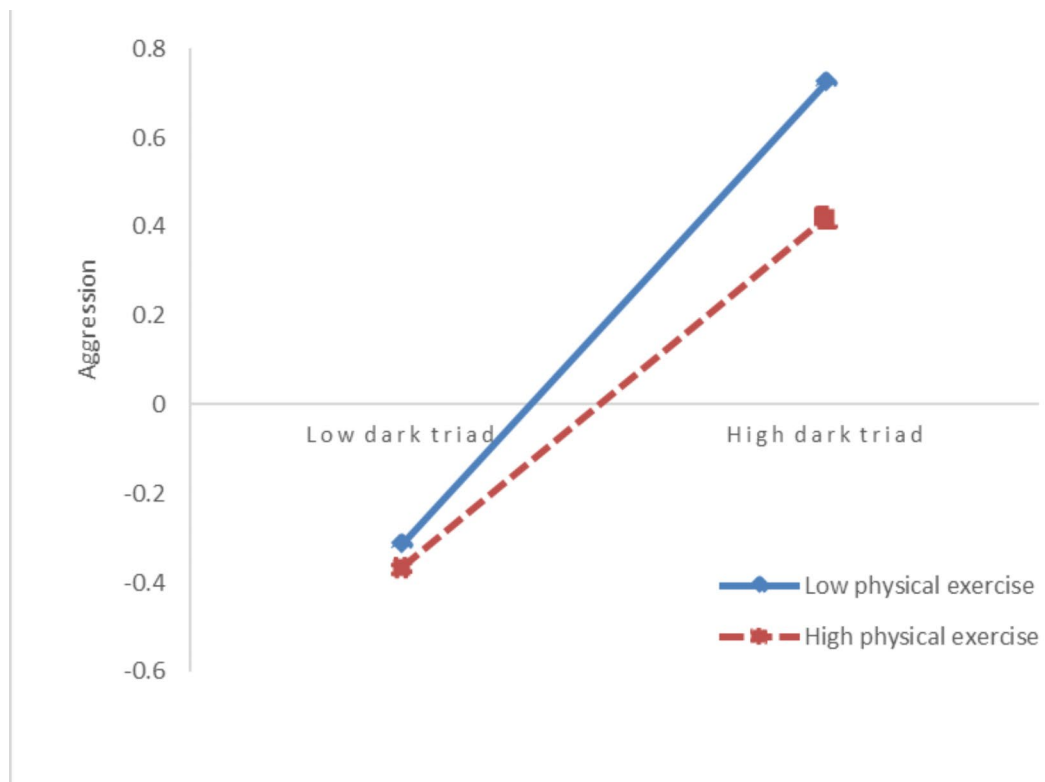
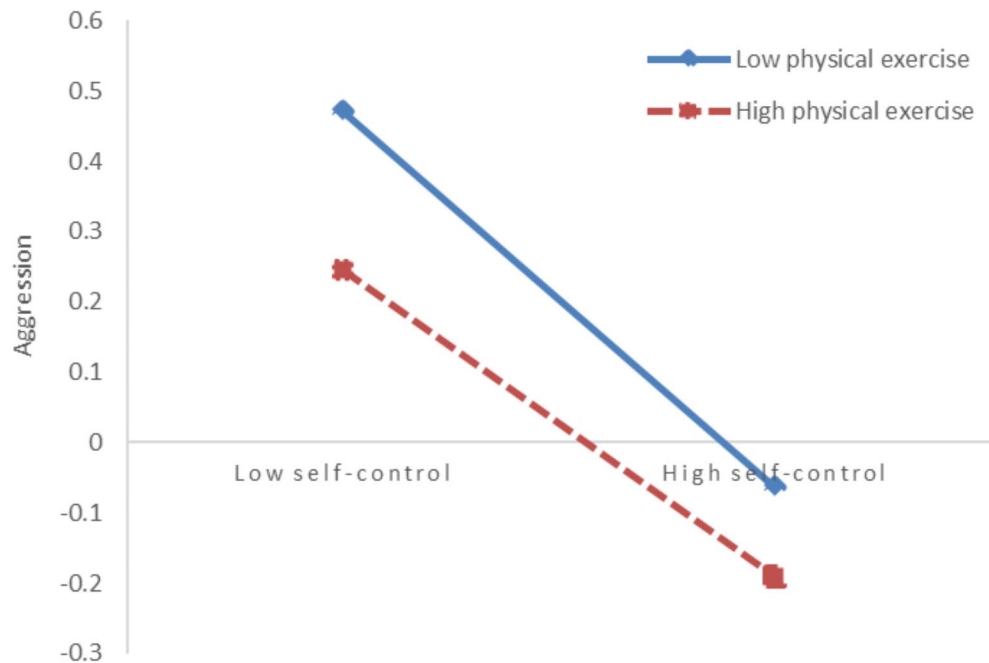


Fig. 3 Interactive effect of physical exercise and Dark Triad on aggression

Table 7 Mediated effects with moderation across varying levels of physical exercise

	Physical exercise	Effect Value	BootSE	BootLLCI	BootULCI
Direct effect	-0.91(<i>M-1SD</i>)	0.63	0.04	0.56	0.71
	0(<i>M</i>)	0.52	0.03	0.46	0.58
	1(<i>M+1SD</i>)	0.40	0.04	0.31	0.48
The mediating effect of self-control	-0.91(<i>M-1SD</i>)	0.10	0.03	0.06	0.16
	0(<i>M</i>)	0.07	0.02	0.04	0.11
	1(<i>M+1SD</i>)	0.04	0.02	0.02	0.08

**Fig. 4** Interactive effect of physical exercise and self-control on aggression

Our findings offer fresh insights into the interrelationships of the Dark Triad, self-control, aggression, and physical exercise. These results also provide helpful guidance for developing targeted and effective physical and psychological prevention and intervention programs to address the aggression of drug abusers at compulsory drug rehabilitation centers.

The mediating role of self-control on the association between the Dark Triad and aggression

Confirming hypothesis 1, our study showed that the Dark Triad was positively associated with aggression, with or without controlling for self-control. This result was consistent with previous studies showing the Dark Triad as a significant contributor to aggression among drug addicts [11, 12]. Confirming hypothesis 2, self-control mediated the relationship between the Dark Triad and aggression, which was also in accordance with the large body

of literature showing that self-control was negatively associated with both the Dark Triad and aggression [21, 22]. These findings suggest that the Dark Triad, a distal factor, constitutes a paradoxically unified cluster of personality traits that contribute to increased impulsivity and decreased self-control, which may further intensify drug abusers' aggression [19]. On the other hand, self-control may serve as a proximal factor and exert an inhibitory effect on aggression in drug abusers, thus alleviating the positive effect of the Dark Triad on aggression. Our findings suggest that strategies focusing on improving drug abusers' self-control may help effectively reduce the negative effects of the Dark Triad and further reduce and prevent aggression.

The moderating role of physical exercise

Corroborating hypothesis 3, our study confirmed that physical exercise moderated the mediating effect of

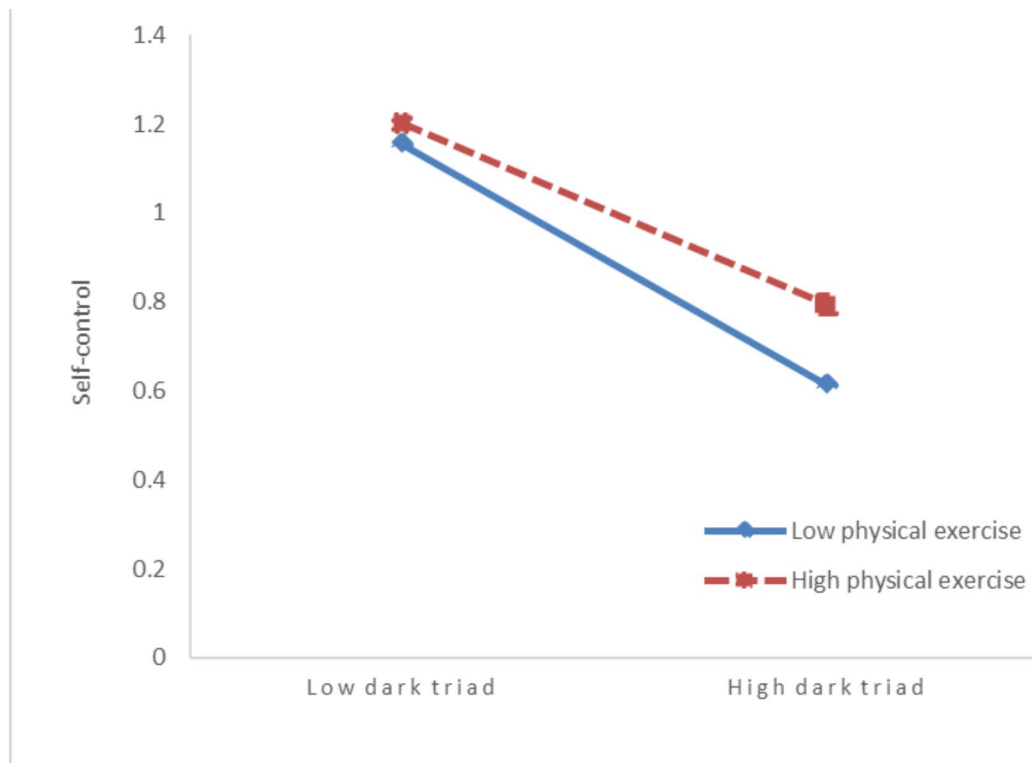


Fig. 5 Interactive effect of physical exercise and Dark Triad on self-control

self-control between the Dark Triad and aggression, establishing a moderated mediation model. The results revealed that the impact of the Dark Triad on aggression varied with the level of physical exercise. Specifically, the association between the Dark Triad and aggression decreased with increased physical exercise. Importantly, this moderating effect was observed across all three levels of physical activity. This suggests that increased physical activity may act as a buffer, making it more difficult for the Dark Triad to induce aggression by impacting self-control.

Noteworthy, although physical exercise moderated the mediation effect of the Dark Triad on aggression via self-control, it only explained a small proportion of variance in aggression. This finding suggests that the nexus between physical exercise and aggression is influenced by a multitude of factors, such as personality traits, which make individuals more prone to problematic behaviors and aggression [49–51]. Despite the modest effect of physical exercise on aggression, it still serves as a potentially mitigatory factor to address aggression in individuals undergoing drug rehabilitation. The therapeutic benefits of physical exercise, such as the increasingly popular “rehabilitation qigong” [52], are being recognized in drug rehabilitation centers. Similar exercise interventions have been shown to alleviate negative emotions that can trigger aggression [53]. Our findings suggest that strengthening physical exercise could be an effective

means of reducing aggression among drug abstiners at compulsory drug rehabilitation centers.

Limitations

While the present study has contributed novel findings, it is imperative to consider its inherent limitations. First, our study incorporated a cross-sectional, self-reported design, which precludes causal deductions concerning the relationships among the Dark Triad, self-control, aggression, and physical exercise. Future research should employ a longitudinal design to elucidate these potential causalities. Second, our participants were recruited from two compulsory drug rehabilitation centers in China using a convenience sampling method and may not represent drug addicts in other locations. Future multi-center studies including individuals from various cultural backgrounds and regions are needed to increase the external validity of our findings. Finally, this study did not extensively explore the role of physical exercise. Future studies should discern the impacts of diverse types and intensities of physical exercise on aggression in individuals abstaining from drug use. Such exploration can further illuminate the underlying physical and psychological mechanisms contributing to mitigating aggression.

Conclusion

In short, this study provides a comprehensive understanding of the complex relationships between the Dark Triad, self-control, physical exercise, and aggression among drug abstainers. Confirming a moderated mediation model, our findings showed that the Dark Triad was associated with aggression both directly and indirectly through self-control, and the mediation effect was further moderated by physical exercise. It highlights the importance of considering both distal and proximal factors in understanding and intervening in aggressive behavior in this population. Furthermore, it underscores the potential benefits of physical exercise as a valuable tool in drug rehabilitation programs. The findings provide important practical implications for future intervention and prevention programs to address aggression among drug abstainers, which may be realized through strengthening self-control and physical exercise.

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Author contributions

LS and MS conceptualized and designed the study. MS gave directions to the study. LS and YY analyzed and interpreted the data and wrote the manuscript. All authors reviewed the manuscript and given final approval of the version to be published.

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Data availability

The datasets used during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The studies involving human participants were reviewed and approved by Ethical Committee of Wuhan Sport University and in compliance with the Helsinki declaration and its later amendments or comparable ethical standards. The participants provided their written informed consent to participate in this study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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