


Exercise and Adolescent Flourishing: A Gender-Specific Chain Mediation Model Involving Mindfulness and Rumination

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Introduction: This study examined the association between physical exercise and flourishing among adolescents, focusing on the potential mediating roles of mindfulness and rumination.

Methods: A total of 1608 adolescents (mean age = 16.02 ± 1.16 years) were assessed using the Physical Activity Rating Scale-3, the Mindful Attention Awareness Scale, the Rumination Response Scale, and the Flourishing Scale. Chain mediation analyses were conducted using the SPSS PROCESS macro (Model 6).

Results: Physical exercise was positively associated with flourishing in both adolescent boys ($r = 0.254$) and adolescent girls ($r = 0.202$). For adolescent boys, the total association between physical exercise and flourishing was 0.220, with a non-significant direct effect (0.031) and significant indirect effects (0.189). Indirect pathways included mindfulness (effect = 0.086; share = 39.09%), rumination (effect = 0.027; share = 12.27%), and the sequential pathway of mindfulness and rumination (effect = 0.076; share = 34.55%). For adolescent girls, the total association was 0.192, with both direct (0.119) and indirect effects (0.073). Significant indirect pathways were observed through mindfulness (effect = 0.041; share = 21.35%) and the sequential pathway of mindfulness and rumination (effect = 0.043; share = 22.40%), whereas rumination alone was not significantly associated.

Conclusion: Physical exercise was associated with flourishing among adolescents. For boys, the association was primarily observed through independent pathways involving mindfulness and rumination, as well as their sequential chain mediation. For girls, flourishing was associated with both direct and indirect pathways involving mindfulness and the sequential pathway of mindfulness and rumination.

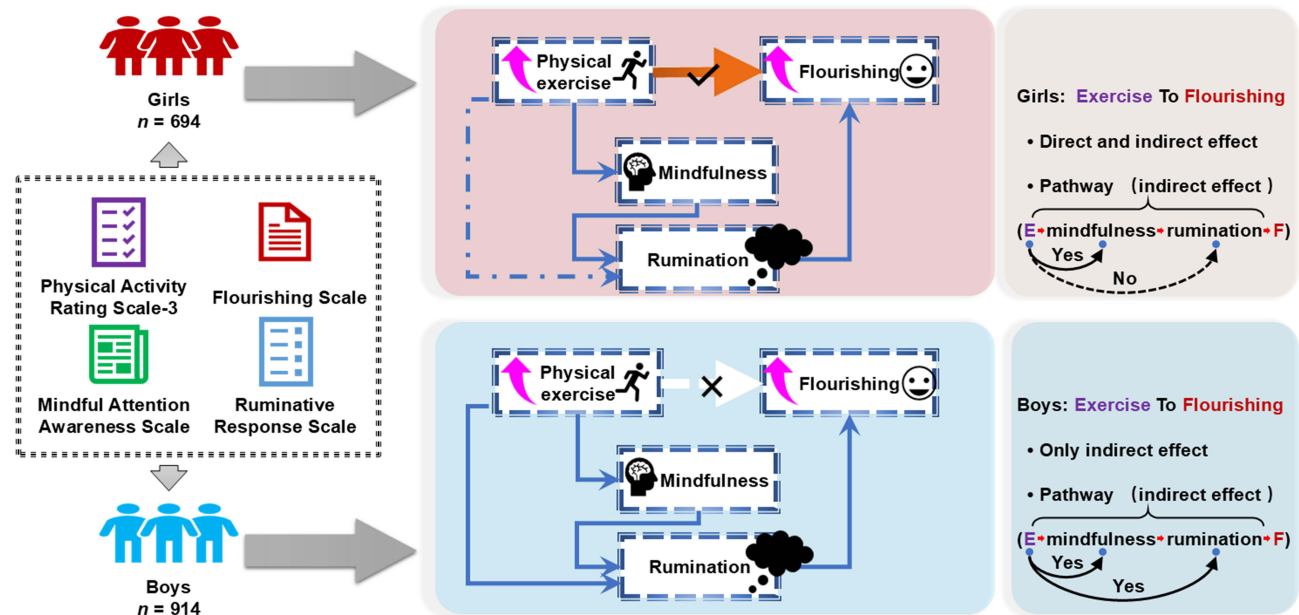
Keywords: adolescents, flourishing, mindfulness, physical exercise, rumination

Introduction

Flourishing is one of the core concepts in the field of positive psychology and is regarded as the highest expression of well-being. Keyes defines flourishing as a highly integrated state of mental health, in which individuals exhibit a strong sense of vitality, frequent experiences of positive emotions, and optimal psychological and social functioning.¹ In the “PERMA” model proposed by Seligman,² flourishing is considered a central indicator of well-being, encompassing five essential elements: Positive Emotion, Engagement, Relationships, Meaning, and Accomplishment. Within this framework, flourishing is not only a holistic manifestation of individual well-being, but also the ultimate goal that positive psychology aims to cultivate and enhance.

In recent years, a growing body of research has shifted its focus from merely exploring the role of physical activity in alleviating negative emotions to examining its potential in promoting positive psychological states, particularly flourishing.³ Studies have shown that individuals with higher levels of flourishing tend to demonstrate stronger emotional regulation, greater psychological resilience, and better social adaptability.⁴ They are more likely to perceive social support, cope effectively with life challenges, and actively construct meaning in life.^{5,6} Well-being is derived from individuals' subjective evaluations of life quality, which are based on personal experiences, interpersonal relationships,

Graphical Abstract



emotional states, and overall functioning.⁷ Building upon this understanding, the theory of flourishing offers a more integrative perspective, emphasizing the multidimensional development of cognitive, emotional, and functional domains. Therefore, exploring the key factors that influence flourishing and uncovering their underlying mechanisms holds significant theoretical and practical value. This is especially important in adolescents, whose psychological development is at a critical and plastic stage, making them particularly responsive to interventions targeting well-being. From a neurodevelopmental perspective, adolescence is characterized by heightened emotional reactivity alongside ongoing maturation of cognitive control systems.⁸ The relative imbalance between a more reactive limbic system and a still-developing prefrontal cortex may increase vulnerability to maladaptive cognitive patterns such as rumination, while also making regulatory capacities such as mindfulness particularly salient during this stage.⁹ Therefore, examining the associations among physical exercise, mindfulness, rumination, and flourishing during adolescence is especially meaningful.¹⁰ Such inquiry not only advances theoretical discourse in positive psychology but also informs practical strategies for enhancing adolescent psychological well-being. Given the current scarcity of systematic research on flourishing in youth populations and the need for further refinement of its measurement tools, the development of a robust theoretical model to elucidate its pathways of influence is both timely and necessary.

In light of the growing recognition of flourishing as a multidimensional indicator of well-being, recent research has increasingly focused on the role of physical exercise as a potential contributor to this positive psychological state. Empirical studies have demonstrated that regular physical activity not only supports physical health but also enhances flourishing by stimulating endorphin release and improving neurobiological functioning.^{11,12} In addition to its physiological benefits, exercise can boost self-efficacy¹³ and foster a sense of social connectedness,¹⁴ which in turn cultivate positive emotional experiences, a stronger sense of purpose, and interpersonal relationships—key elements of flourishing.¹ Among adolescents, participation in regular physical activity has been associated with higher levels of vitality, optimism, and life satisfaction,¹⁵ suggesting that exercise may serve as an effective means for promoting psychological thriving. Given that adolescence is a period marked by increasing physical capability, identity formation, and sensitivity to peer environments, the existing literature underscores a positive link between physical activity and flourishing, however, the specific mechanisms underlying this association during adolescence remain underexplored.^{9,16} Recent studies have begun to focus on the mediating roles of cognitive and emotional processes—particularly

mindfulness¹⁷ and rumination¹⁸—in explaining how physical activity may promote flourishing.¹⁹ Nevertheless, research examining their joint or interactive effects within a unified model in younger populations remains scarce.

Building upon previous findings in the fields of positive psychology and mental health, mindfulness has garnered significant scholarly attention as a psychological training approach rooted in Eastern contemplative traditions. Mindfulness is commonly defined as a conscious state of awareness characterized by nonjudgmental, open, and accepting attention to present-moment experiences.²⁰ Beyond attentional control, it embodies a quality of awareness and acceptance that enables individuals to engage more adaptively with their internal and external environments.²¹ A growing body of empirical research suggests that adolescents with higher levels of mindfulness exhibit superior emotional regulation, stress management, and psychological adaptability.²² In school settings, mindfulness training has been shown to effectively reduce anxiety, depression, and emotional distress, while enhancing psychological resilience and subjective well-being.²³ Within the theoretical framework of flourishing, mindfulness contributes positively by strengthening awareness of inner experiences, improving the perception of positive emotions, enhancing the construction of life meaning, and facilitating the development of quality interpersonal relationships.²⁴ Emerging evidence also suggests that mindfulness may not only directly predict flourishing, but may serve as a key mediating mechanism in the relationship between physical exercise and flourishing.^{25,26} These insights provide a valuable foundation for further exploring the psychological pathways through which physical activity enhances flourishing during critical developmental stages. While mindfulness promotes adaptive regulation through present-moment awareness, its counterpart—rumination—represents a maladaptive cognitive style that undermines psychological well-being.

Rumination, defined as a maladaptive cognitive processing style characterized by repetitive, passive focus on negative emotions and their causes and consequences,²⁷ is widely recognized as a central factor in the development of various psychological difficulties. Adolescents who habitually engage in rumination often struggle to disengage from negative affective states, which may in turn exacerbate symptoms of anxiety, depression, and perceived stress.²⁸ In contrast to mindfulness—which promotes acceptance and awareness of the present—rumination involves excessive preoccupation with past negative experiences and emotional reactivation, creating a sharp functional opposition between the two. Research has shown that rumination not only impairs emotional regulation but also undermines the quality of social interactions and the capacity for meaning-making, thereby impeding the development of flourishing.²⁹ In youth populations, high levels of rumination have been consistently associated with lower well-being, diminished self-worth, and reduced psychological resilience.³⁰ Recent studies suggest that rumination may act as a negative mediator, such that physical activity enhances flourishing by reducing tendencies to ruminate.¹⁸ This proposed mechanism offers valuable insights into how physical exercise influences psychological well-being through the reduction of maladaptive cognitive patterns during adolescence.

The interaction between mindfulness and rumination reflects two psychologically regulatory pathways that are both independent and interconnected, helping to explain how physical activity promotes flourishing among adolescents. Mindfulness emphasizes present-moment awareness and non-judgmental acceptance, which facilitates adaptive emotion regulation and reduces cognitive reactivity.²⁴ In contrast, rumination manifests as persistent and repetitive negative thinking, which may reinforce maladaptive cognitive patterns and thus undermine mental health.³¹ Existing research indicates that higher levels of mindfulness can help suppress rumination,³² suggesting a potential psychological process whereby strengthened positive regulatory capacities may limit the intrusion of negative cognitions, thereby providing conditions conducive to psychological flourishing.^{33,34} Rumination itself may be negatively associated with flourishing, whereas individuals with higher flourishing typically exhibit more balanced emotional states and reduced tendencies toward rumination.^{35–37} Meanwhile, physical activity is also associated with higher levels of flourishing,³⁸ potentially through mechanisms such as enhanced present-moment attention, reduced negative thinking patterns, and improved adaptive psychological functioning. Overall, these theoretical perspectives suggest that mindfulness and rumination may jointly serve as key psychological mechanisms linking physical activity to psychological flourishing.

Although these theoretical foundations provide conceptual support for the proposed chain mediation framework, the cross-sectional design warrants cautious interpretation. Prospective evidence has shown that increases in physical activity are associated with subsequent levels of mindfulness.³⁹ Rumination is often conceptualized as a cognitive manifestation of negative affect, and mindfulness-based interventions have been found to significantly reduce negative emotions,

particularly among individuals with higher baseline mindfulness,⁴⁰ indirectly suggesting a potential link between mindfulness and reduced ruminative tendencies. In addition, longitudinal studies indicate that rumination prospectively predicts declines in subjective well-being and mental health,^{41,42} which may subsequently influence flourishing. Collectively, these findings lend theoretical plausibility to the proposed associations among physical activity, mindfulness, rumination, and flourishing. Nevertheless, given the cross-sectional nature of the present study, the findings should be interpreted as evidence of statistically consistent relationships rather than definitive causal pathways.

Building on the above theoretical foundation, this study constructs a chain mediation model to investigate the potential pathways through which physical activity influences adolescent flourishing, focusing on the mediating roles of mindfulness and rumination. Specifically, it posits that physical activity may enhance mindfulness and reduce ruminative thinking, which in turn contribute to higher levels of flourishing. To deepen the analysis, this study also considers a gender-based perspective, recognizing that adolescent boys and girls may differ in their patterns of physical activity, cognitive-emotional regulation strategies, and psychological outcomes. Prior research has shown that girls are more prone to ruminative thinking, whereas boys often engage in higher levels of physical activity and demonstrate distinct mindfulness patterns.⁴³ Therefore, this study examines whether the mediating mechanisms differ across genders, aiming to provide more nuanced insights for tailored mental health interventions. Based on the theoretical background and empirical evidence, four hypotheses are proposed: H1: Physical activity would directly predict flourishing. H2: Mindfulness would mediate the relationship between physical activity and flourishing. H3: Rumination would mediate the relationship between physical activity and flourishing. H4: Mindfulness and rumination jointly chain-mediated the relationship between physical activity and flourishing. [Figure 1](#) depicts the proposed model for the study.

Materials and Methods

Participants

This study used whole group sampling approach and conducted a cross-sectional survey between April and May 2025. Participants were students from six secondary schools (including junior and senior high schools) located in Hebei, Beijing, and Shaanxi provinces in China. Based on the study objectives, the inclusion criteria were as follows: (1) aged ≤ 18 years; (2) voluntary participation; and (3) adequate cognitive and comprehension abilities. The exclusion criteria were: (1) current participation in other similar studies; (2) serious illnesses or physical conditions that prevented completion of the questionnaire; and (3) inability to understand the questionnaire. The study protocol was reviewed and approved by the Ethics Committee of Hebei North University (Approval No.: 2025G7001). Prior to data collection, detailed information about the study purpose, procedures, data usage, and confidentiality was provided to students and their parents. Written informed consent was obtained from all adolescent participants and their parents or legal guardians. Teachers were also informed and agreed to the study procedures.

With the assistance of homeroom teachers and substitute teachers who received standardized training, researchers distributed the online questionnaire to students and their parents on weekends, as junior and senior high school students are not permitted to bring their mobile phones onto campus. A total of 1,913 questionnaires were collected. Based on stringent quality control criteria—specifically, “response completeness” and “response consistency”—305 invalid

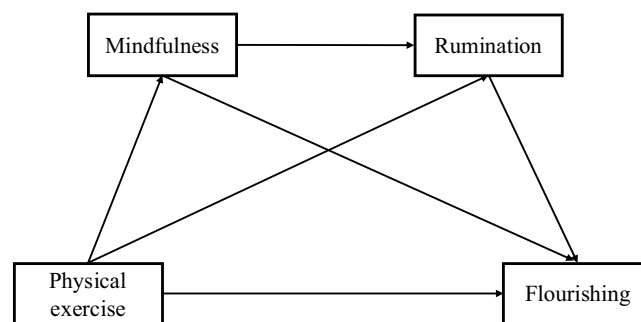


Figure 1 Proposed model.

questionnaires were excluded, resulting in 1,608 valid responses, yielding an effective response rate of 84.05%. The final sample comprised 1,608 adolescents with a mean age of 16.02 ± 1.16 years; 56.8% were boy ($n = 914$) and 43.2% were girl ($n = 694$). Additional demographic information is presented in Table 1.

Measures

Physical Activity Rating Scale-3 (PARS-3)

The Physical Activity Rating Scale-3 (PARS-3), originally developed by Japanese scholar Koo Hashimoto, was revised into a Chinese version by Liang Deqing.⁴⁴ This scale uses a 5-point Likert scoring method and includes three questions, assessing the dimensions of intensity, time, and frequency of physical exercise. The total physical exercise score is calculated using the formula: Physical exercise score = Intensity score \times (Time score - 1) \times Frequency score. A higher score reflects a greater amount of physical exercise, with the total score ranging from 0 to 100 points. According to the theory of sports activity levels, scores are classified into three categories: low (≤ 19 points), moderate (20—42 points), and high (≥ 42 points).

Mindful Attention Awareness Scale (MAAS)

The Mindful Attention Awareness Scale (MAAS) is a unidimensional scale with 15 items developed by Brown and Ryan in 2003 to assess an individual's trait mindfulness.²² The scale was translated into Chinese by Deng et al in 2011.⁴⁵ Participants performed a rating of their responses based on a frequency scale from 1 to 6, where 1 stands for "almost always", 2 is "very often", 3 means "frequently", 4 stands for "Occasionally", 5 is "Rarely", and 6 is "Almost Never". Higher scores indicate higher levels of mindfulness in these moments. The reliability of the Chinese version of the MAAS has been validated and the Cronbach's alpha coefficient in our study was 0.875, indicating good internal consistency.

Rumination Responses Scale (RRS)

Rumination was assessed using the Rumination Responses Scale (RRS),⁴⁶ which measures an individual's tendency to think repetitively and intrusively about negative emotions (eg., "I often think about how sad I am"). The scale was translated into Chinese and validated by Han et al⁴⁷ It consists of 22 items rated on a 4-point Likert scale (1 = never, 4 = always), with a total score ranging from 22 to 88. Higher scores indicate more severe ruminative thinking. In this study, the RRS demonstrated excellent internal consistency, with a Cronbach's alpha coefficient of 0.947.

Flourishing Scale (FS)

This study used The Flourishing Scale (FS) developed by Dienes et al (2010), which consists of 8 questions rated on a scale of 1 (Strongly Disagree) to 7 (Strongly Agree), with higher scores indicating higher levels of Flourishing in an individual. This study used the Chinese version of the FS introduced by Lai (2014),⁴⁸ which has been shown to have high reliability and validity. Specifically, its Cronbach's alpha coefficient was 0.948, and its retest reliability coefficient was 0.819. The results of exploratory factor analysis (EFA) showed that the scale contained a single factor explaining 75.03% of the total variance. In addition, confirmatory factor analysis (CFA) also demonstrated that the fit indicators were all at acceptable levels.

Table 1 Demographic Characteristics of Participants $n = 1608$

Variable	Category	n (%) / Mean \pm SD
Gender	Boy	914(56.8%)
	Girl	694(43.2%)
Age (years)	—	16.02 \pm 1.16
Grade (senior high school)	Grade 1	665(40.7%)
	Grade 2	623(38.7%)
	Grade 3	330(20.5%)
Place of residence	Rural	1093(68.0%)
	Urban	515(32.0%)
Only child status	Yes	1170(72.8%)
	no	438(27.2%)

Design and Procedures

This cross-sectional study was conducted using a uniquely linked questionnaire distributed to participants via an online platform. Principles of confidentiality and anonymity were strictly followed throughout the data collection process. All collected data were securely stored and accessible only to authorized personnel. The questionnaire included two control questions designed to detect random or inattentive responses, thereby ensuring data quality. Participants were assured that their responses would be used solely for research purposes and that their anonymity would be preserved in all reports and publications related to this study. After obtaining informed consent, participants were instructed to complete the questionnaire independently. A researcher monitored the process remotely to ensure compliance while remaining available to address any questions. All procedures in this study conformed to the ethical standards of the institutional and national committees responsible for human experimentation and adhered to the principles of the 1975 Declaration of Helsinki, as revised in 2000.

Statistical Analysis

All study variables were assessed using self-report questionnaires. Harman's single-factor test was conducted to examine potential common method bias; however, given the limitations of this approach, the results were interpreted with caution. The Kolmogorov–Smirnov test indicated that the data were not normally distributed. Therefore, descriptive statistics are presented as the median and interquartile range [M (IQR)]. Spearman's rank correlation analyses were conducted to examine the associations among physical exercise, mindfulness, rumination, and flourishing. Mediation analyses were performed using the PROCESS macro for SPSS. Model 6 of the PROCESS macro (Falk et al, 2024) was selected because it is specifically designed to test serial mediation models, allowing for the examination of both independent and sequential indirect effects among multiple mediators. The bootstrap method (5,000 resamples) was used to estimate indirect effects, with 95% confidence intervals (CIs). Effects were considered statistically significant if the CIs did not include zero. These analyses were conducted to examine the indirect associations of mindfulness and rumination in the relationship between physical exercise and flourishing. Given the cross-sectional design, the results should be interpreted as statistical associations rather than evidence of causal or directional relationships.

Results

Common Method Deviation Test

Harman's single-factor test was conducted to assess common method bias. The first factor accounted for 36.0% of the total variance, which is below the recommended threshold of 40%.⁴⁹ This result suggests that common method bias may not be severe; however, this result should be interpreted with caution, as Harman's single-factor test cannot fully rule out common method variance.

Preliminary Analyses

As shown in Table 2, Figures 2 and 3, for both adolescent boys and girls, physical exercise was significantly positively correlated with mindfulness (boys: $r = 0.369$; girls: $r = 0.107$, $p < 0.01$), and significantly negatively correlated with rumination (boys: $r = -0.238$; girls: $r = -0.071$, $p < 0.01$) as well as positively correlated with flourishing (boys: $r = 0.254$; girls: $r = 0.202$, $p < 0.01$). Mindfulness was significantly positively correlated with flourishing (boys: $r = 0.480$; girls: $r = 0.432$, $p < 0.01$) and significantly negatively correlated with rumination (boys: $r = -0.516$; girls: $r = -0.550$, $p < 0.01$). In contrast, rumination was significantly negatively correlated with flourishing (boys: $r = -0.560$; girls: $r = -0.534$, $p < 0.01$). These results provide a basis for subsequent mediation analyses.

Chain Mediation Analysis of the Association Between Physical Exercise and Flourishing

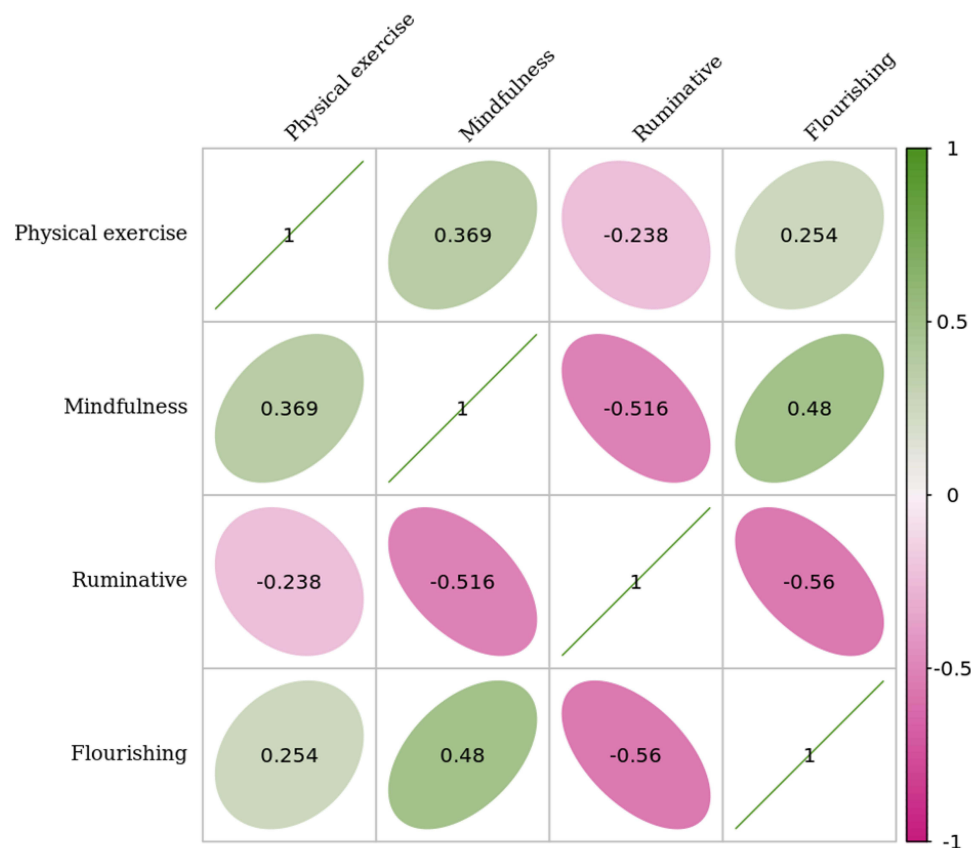
To examine whether mindfulness and rumination mediate the association between physical exercise and flourishing, as well as potential gender differences, regression analyses were conducted separately for adolescent boys and girls. A chain mediation analysis was performed using Hayes' PROCESS macro (Model 6), with age, place of residence, and grade as

Table 2 Median, Interquartile Range and Biased Correlation Analysis of Each Variable

		Median (IQR)	1	2	3
Boy	1. Physical exercise	0.05(1.46)	1		
	2. Mindfulness	-0.06(1.36)	0.369**	1	
	3. Rumination	0.09(1.62)	-0.238**	-0.516**	1
	4. Flourishing	0.09(2.13)	0.254**	0.480**	-0.560**
Girl	1. Physical exercise	-0.55(0.70)	1		
	2. Mindfulness	-0.13(1.21)	0.107**	1	
	3. Rumination	0.03(1.49)	-0.071**	-0.550**	1
	4. Flourishing	0.27(1.60)	0.202**	0.432**	-0.534**

Notes: ** indicates $p < 0.01$; IQR, interquartile range.

control variables. In this model, physical exercise was specified as the independent variable, flourishing as the dependent variable, and mindfulness and rumination as sequential mediators. The Bootstrap method with 5000 resamples was employed, and a 95% confidence interval (CI) that did not include zero was considered indicative of a significant indirect association. For adolescent boys, the chain mediation model is shown in Figure 4. As presented in Table 3, physical exercise was significantly positively associated with mindfulness ($\beta = 0.421, p < 0.01$); When physical exercise and mindfulness were entered simultaneously into the model predicting rumination, both variables were significantly negatively associated with rumination ($\beta = -0.068, p < 0.05$; $\beta = -0.453, p < 0.01$). When physical exercise, mindfulness

**Figure 2** Correlation matrix of study variables among adolescent boys.

Notes: Values represent Spearman correlation coefficients. All reported correlations were statistically significant at $p < 0.01$. Diagonal values represent self-correlations and are equal to 1.0. Green ellipses indicate positive correlations, and pink ellipses indicate negative correlations. Darker colors and more elongated ellipses indicate stronger correlations.

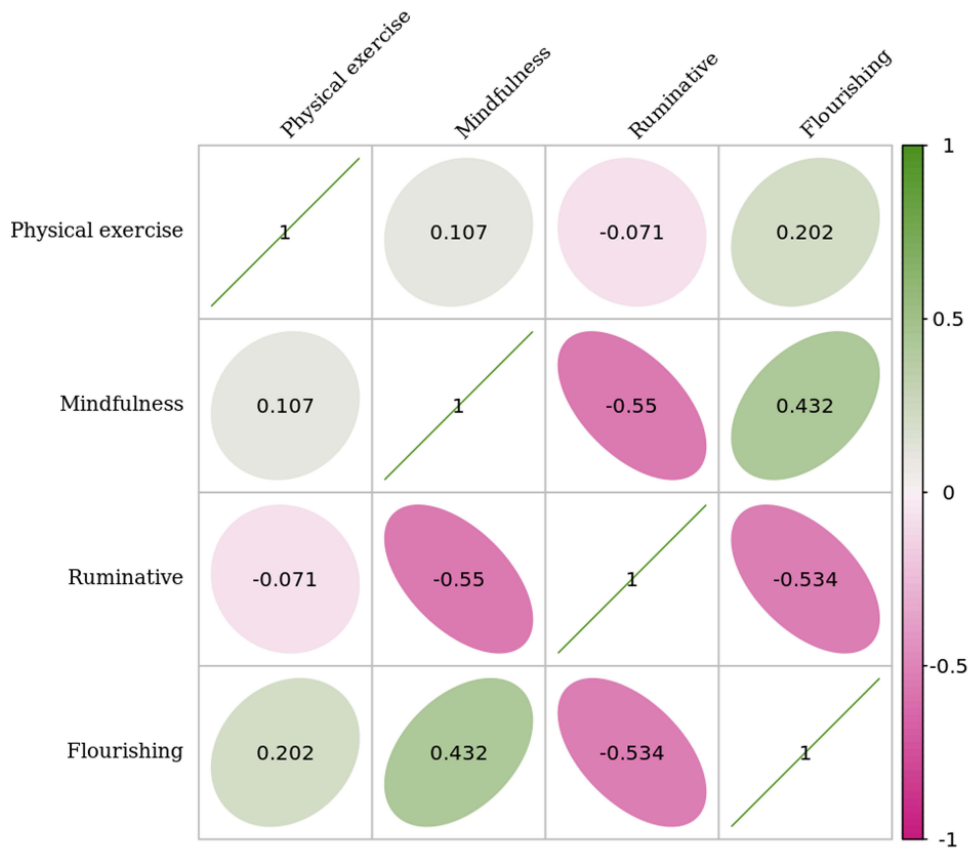


Figure 3 Correlation matrix of study variables among adolescent girls.
Notes: Values represent Spearman correlation coefficients. All reported correlations were statistically significant at $p < 0.01$. Diagonal values represent self-correlations and are equal to 1.0. Green ellipses indicate positive correlations, and pink ellipses indicate negative correlations. Darker colors and more elongated ellipses indicate stronger correlations.

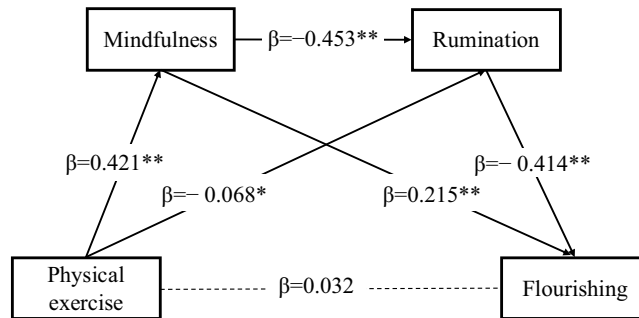


Figure 4 Chain mediation model of the relationship between physical exercise, mindfulness, rumination, and flourishing in adolescent boys.
Notes: Solid lines are paths with significant effects; dashed lines represent non-significant paths. * indicates $p < 0.05$; ** indicates $p < 0.01$.

and rumination were entered simultaneously in this model predicting flourishing, mindfulness was significantly positively associated with flourishing ($\beta = 0.215, p < 0.01$), whereas rumination was significantly negatively associated with flourishing ($\beta = -0.414, p < 0.01$). The association between physical exercise and flourishing was not statistically significant ($\beta = 0.032, p > 0.05$). For adolescent girls, the chain mediation model is shown in Figure 5. As presented in Table 3, physical exercise was significantly positively associated with mindfulness ($\beta = 0.146, p < 0.01$). When physical exercise and mindfulness were entered simultaneously in the model predicting rumination, mindfulness was significantly negatively associated with rumination ($\beta = -0.525, p < 0.01$), whereas physical exercise was not significantly associated with rumination ($\beta = 0.021, p > 0.05$). When physical exercise, mindfulness and rumination were entered simultaneously

Table 3 Regression Analysis of the Effects of Physical Exercise on Mindfulness, Rumination, and Flourishing

	Regression Equation							Confidence Interval	
	Dependent Variable	Independent Variable	R	R ²	F	β	t	LLCI	ULCI
Boy	Mindfulness	Physical exercise	0.424	0.180	66.433**	0.421**	13.955	0.335	0.445
	Rumination	Physical exercise	0.485	0.235	70.015**	-0.068*	-2.116	-0.119	0.005
		Mindfulness				-0.453**	-14.149	-0.509	-0.385
	Flourishing	Physical exercise	0.564	0.318	84.682**	0.032	1.065	-0.026	0.088
		Mindfulness				0.215**	6.423	0.154	0.289
		Rumination				-0.414**	-17.103	-0.498	-0.369
Girl	Mindfulness	Physical exercise	0.174	0.030	7.204**	0.146**	3.862	0.105	0.323
	Rumination	Physical exercise	0.521	0.272	64.208**	0.021	-0.619	-0.067	0.128
		Mindfulness				-0.525**	-15.908	-0.602	-0.469
	Flourishing	Physical exercise	0.566	0.320	64.725**	0.086**	2.688	0.032	0.207
		Mindfulness				0.204**	5.453	0.123	0.262
		Rumination				-0.403**	-10.928	-0.441	-0.306

Notes: * indicates $p < 0.05$; ** indicates $p < 0.01$.

in the model predicting flourishing, both physical exercise and mindfulness were significantly positively associated with flourishing ($\beta = 0.086$, $\beta = 0.204$, $p < 0.01$), whereas rumination was significantly negatively associated with flourishing ($\beta = -0.403$, $p < 0.01$).

Table 4 presents the standardized indirect effects for the mediation pathways linking physical exercise to flourishing. For adolescent boys, the bootstrap 95% confidence interval for the total indirect effect did not contain zero, indicating statistically significant indirect effects. Three significant indirect pathways were identified: (1) the pathway “physical exercise \rightarrow mindfulness \rightarrow flourishing” (standardized effect value = 0.086, accounting for 39.09% of the total effect). (2) the pathway “physical exercise \rightarrow rumination \rightarrow flourishing” (standardized effect value = 0.027, accounting for 12.27% of the total effect), and (3) the sequential pathway “physical exercise \rightarrow mindfulness \rightarrow rumination \rightarrow flourishing” (standardized effect value = 0.076, accounting for 34.55% of the total effect). The direct effect was not statistically significant (effect = 0.031), indicating a pattern consistent with full mediation at the statistical level. For adolescent girls, the bootstrap 95% confidence interval for the total indirect effect did not contain zero, indicating that the indirect effects were statistically significant. Two significant indirect pathways were identified: (1) the pathway “physical exercise \rightarrow mindfulness \rightarrow flourishing” (standardized effect value = 0.041, accounting for 21.35% of the total effect). (2) the sequential pathway “physical exercise \rightarrow mindfulness \rightarrow rumination \rightarrow flourishing” (standardized effect value = 0.043, accounting for 22.40% of the total effect). The pathway “physical exercise \rightarrow rumination \rightarrow flourishing” was not statistically significant (standardized effect value = -0.014). The direct effect of physical exercise on flourishing was statistically significant, indicating a pattern consistent with partial mediation at the statistical level.

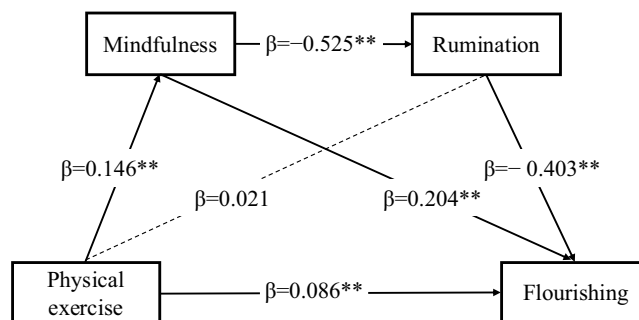


Figure 5 Chain mediation model of the relationship between physical exercise, mindfulness, rumination, and flourishing in adolescent girls.

Notes: Solid lines are paths with significant effects; dashed lines represent non-significant paths. ** indicates $p < 0.01$.

Table 4 Bootstrap Analysis of Indirect Associations Involving Mindfulness and Rumination in the Relationship Between Physical Exercise and Flourishing

	Effects Pathway	Indirect Effect Value	Bootstrap Standard Error	Boot LLCI	Boot ULCI	Relative Effect %
Boy	Total effect	0.220	0.031	0.159	0.281	—
	Direct effect	0.031	0.029	-0.026	0.088	14.09%
	Total indirect effect	0.189	0.019	0.151	0.225	85.91%
	Physical exercise → mindfulness → flourishing	0.086	0.015	0.058	0.118	39.09%
	Physical exercise → rumination → flourishing	0.027	0.013	0.002	0.052	12.27%
	Physical exercise → mindfulness → rumination → flourishing	0.076	0.008	0.058	0.093	34.55%
Girl	Total effect	0.192	0.052	0.089	0.295	—
	Direct effect	0.119	0.045	0.032	0.207	61.98%
	Total indirect effect	0.073	0.030	0.014	0.135	38.02%
	Physical exercise → mindfulness → flourishing	0.041	0.014	0.016	0.072	21.35%
	Physical exercise → rumination → flourishing	-0.014	0.022	-0.051	0.032	-7.29%
	Physical exercise → mindfulness → rumination → flourishing	0.043	0.013	0.018	0.068	22.40%

Discussion

This study explored the indirect pathways linking physical exercise to flourishing among adolescent by introducing mindfulness and rumination as potential mediators. A chain mediation model was proposed and tested to examine the relationships among physical exercise, mindfulness, rumination, and flourishing. For adolescent boys, the results showed that mindfulness, rumination, and their sequential combination were significantly associated with flourishing in relation to physical exercise, whereas the direct association between physical exercise and flourishing was not statistically significant. The findings suggest that the hypothesized chain mediation model was supported among adolescent boys, supporting hypotheses H2, H3, and H4, whereas H1 was not supported. For adolescent girls, the results showed that physical exercise was significantly associated with flourishing at the direct level. Mindfulness showed a significant indirect association in the relationship between physical exercise and flourishing, and a sequential pathway involving mindfulness and rumination was also observed. These findings suggest that the hypothesized chain mediation model was supported among adolescent girls, supporting hypotheses H1, H2, and H4, whereas H3 was not supported.

The Direct Role of Physical Exercise on Flourishing

The present study found a gender-specific pattern in the direct association between physical exercise and flourishing. Physical exercise was directly associated with higher levels of flourishing among adolescent girls, whereas this direct association was not significant among boys. This suggests that girls may experience more immediate well-being-related benefits from physical activity, while boys' flourishing may depend more strongly on underlying psychological factors such as mindfulness and rumination. This interpretation is consistent with prior evidence showing that physical activity is associated with life satisfaction, positive affect, and meaning in life.⁵⁰

A possible explanation is that physical activity may be linked to different psychological experiences across genders. For adolescent girls, engaging in physical exercise is often associated with higher body satisfaction, stronger social connectedness, and more positive affective experiences, which may be related to greater hedonic and eudaimonic well-being. From a positive psychology perspective, flourishing reflects both emotional and functional aspects of well-being, and physical activity may be associated with these components through its links with self-esteem, emotion regulation, and intrinsic vitality.⁵¹ Empirical work further suggests that physical activity is associated with experiences of mastery, purpose, and social engagement, all of which are related to psychological growth.⁵² For adolescent girls, these proximal associations may correspond to higher levels of flourishing, even without deeper psychological mediation, highlighting physical activity as a practical and accessible behavioral context.⁵³ Although our study is cross-sectional and cannot establish causality, longitudinal and meta-analytic evidence supports the plausibility of pathways whereby physical activity is linked to psychological functioning through mindfulness, rumination, and related constructs. For instance,

a three-wave prospective study of adolescents found that higher dispositional mindfulness predicted subsequent reductions in rumination, which were associated with lower negative affect over time.⁵⁴ Therefore, girls' flourishing may be more closely associated with regular physical activity, aligning with evidence that exercise is a practical and accessible approach for promoting adolescent well-being.⁵³ In contrast, the non-significant direct association among boys suggests that the relationship between exercise and flourishing may be more strongly reflected in indirect associations. Boys may place greater emphasis on competence, challenge, and performance during physical activity. Under this pattern, the well-being-related associations of exercise may emerge more clearly when physical activity is linked to psychological processes—such as mindfulness and reduced rumination—which are in turn associated with flourishing. This aligns with longitudinal findings showing that mindfulness predicts subsequent reductions in rumination and later improvements in emotional functioning.^{54,55} At a broader level, meta-analytic evidence demonstrates that physical activity is associated with mental health through variables such as resilience and self-esteem,⁵⁶ while systematic reviews also identify multiple pathways—including affect, resilience, and social support—linking exercise to psychological well-being.⁵⁷ Taken together, these findings support a theoretically plausible pattern in which physical activity is associated with flourishing indirectly through psychological factors, particularly among boys. For girls, physical activity itself appears to be more directly associated with well-being, whereas for boys, psychological factors such as mindfulness and rumination may play a more central role.

The Mediating Role of Mindfulness on Flourishing

The present study indicated that mindfulness showed a significant indirect association in the relationship between physical exercise and flourishing among both adolescent boys and girls. Consistent with our results, higher levels of physical exercise were associated with greater mindfulness, which was in turn associated with higher flourishing. This pattern suggests that physical activity may be linked to more mindful state that is associated with better emotional balance and psychological well-being. Mindfulness enables adolescents to maintain present-moment awareness, regulate attention, and adopt a nonjudgmental attitude toward internal experiences, thereby helping them manage stress and emotional fluctuations more effectively.⁵⁸ In our findings, this pattern was observed for both genders. However, the magnitude of the indirect association differed: for boys, mindfulness accounted for a larger proportion of the indirect pathway, whereas for girls, mindfulness formed one component of a broader chain process involving rumination. These gender-specific patterns suggest that mindfulness may function as a more central psychological factor for boys, while for girls, it operates alongside other cognitive-emotional processes. The indirect role of mindfulness observed in this study consistent with previous literature indicating that mindful awareness is associated with better emotional regulation, self-awareness, and psychological resilience.^{59,60} Physical exercise often involves focused attention on breathing and bodily sensations, which may be to greater mindful engagement and help adolescents anchor themselves in the present moment.⁶¹ Recent findings also support the idea that exercise is associated with mindfulness, which in turn is linked to flourishing among young people.⁶² The theoretical foundations of this pattern are reflected in the Mindfulness-to-Meaning Theory, which posits that mindfulness is associated with well-being through processes such as decentering—the capacity to observe internal states without overidentifying with them.⁶³ As adolescents develop stronger decentering abilities, they may be better able to disengage from automatic negative thoughts and adopt more adaptive cognitive strategies when facing stress. This is consistent with our finding that mindfulness was associated with flourishing and was also related to lower rumination was associated with flourishing and was also related to lower rumination within the sequential pathway.

This dual role of mindfulness—being associated with both positive psychological resources and reduced cognitive vulnerabilities—aligns with the two-component model of mindfulness proposed by Bishop et al,⁶⁴ which emphasizing attentional regulation and nonreactive acceptance. Through regular physical activity, adolescents may develop both components, which are in turn associated with more adaptive coping and higher levels of flourishing.

Although the present study is cross-sectional and cannot establish causality, longitudinal research supports the temporal sequence implied by our model. Prospective studies with adolescents have shown that mindfulness predicts later reductions in rumination and internalizing symptoms,^{54,55} suggesting that mindfulness may represent an important pathway linking physical exercise influences psychological functioning over time.

The Chain Mediation Role of Mindfulness and Rumination in the Association Between Physical Exercise on Flourishing

The present study identified a significant chain mediating pattern involving mindfulness and rumination in the association between physical exercise and flourishing among adolescent boys and girls. Physical exercise was associated with flourishing both directly and, more importantly, indirectly through a sequential pathway involving higher mindfulness and reducing rumination. Notably, these psychological patterns varied by gender, offering a nuanced interpretation of the observed results. Consistent with the hypothesized model, mindfulness and rumination were both associated with physical activity and flourishing; however, their mediating patterns differed across genders. Among boys, rumination served as a significant independent mediator, indicating that physical exercise was associated with lower levels of rumination, which in turn was associated with higher flourishing.⁶⁵ This pattern aligns with evidence suggesting that boys typically exhibit lower levels of ruminative tendencies and may be responsive to the self-regulatory aspects of physical activity. In contrast, among girls, rumination did not function as an independent mediator but was involved only in the sequential pathway through mindfulness. This suggests that higher levels of mindfulness were associated with lower levels of rumination occur.⁶⁶ This finding is consistent with developmental literature indicating that adolescent girls often exhibit higher emotional sensitivity and rumination,⁶⁷ suggesting that mindfulness may be associated with cognitive vulnerability among adolescent girls, although the effect size is modest and should be interpreted with caution.

These gender-specific patterns reflect the empirical findings of the present study and are broadly consistent with the Mindfulness-to-Meaning Theory, which posits that mindfulness is associated with adaptive cognitive reappraisal and disengagement from maladaptive thought processes.⁶³ The findings are also in line with the dual-component model of mindfulness,⁶⁴ underscoring the complementary roles of attentional regulation and non-reactivity in relation to rumination and flourishing. From a practical perspective, the gender-specific pathways observed in this study highlight the importance of tailoring physical activity interventions to adolescents' cognitive profiles. For boys, approaches that simultaneously target mindfulness and rumination may be beneficial. For girls, mindfulness-based physical activities emphasizing present-moment awareness and emotional acceptance may be particularly relevant, as mindfulness was closely associated with lower levels of rumination and higher levels of flourishing.

Limitations and Future Directions

This study provides insights into the associations among physical exercise, mindfulness, rumination and flourishing among adolescents. However, several limitations should be acknowledged. First, the cross-sectional design limits the ability to draw causal inferences. Although significant associations were observed, the temporal and directional relationships among physical exercise, mindfulness, rumination, and flourishing cannot be established. Future research should employ longitudinal or experimental designs to further examine the proposed mediation model and strengthen causal interpretations. Second, the study focused exclusively on adolescents from junior high schools in selected regions of China, which may limit the generalizability of the findings to other regions, cultural contexts, or age groups. Future studies should include more diverse samples—such as younger children, older adolescents, or individuals from different cultural backgrounds—to assess the broader applicability of these findings. Third, although gender differences were examined as, other potentially relevant individual differences were not assessed. Factors such as parenting style, baseline mental health, or personality traits may be associated with both physical activity and psychological outcomes. These variables may act as confounders and should be considered in future research to provide a more comprehensive understanding of observed association. Fourth, all variables were assessed using self-report measures, which may be subject to social desirability bias and response inaccuracies. Although Harman's single-factor test was conducted, it cannot fully rule out common method bias. Future studies are encouraged to incorporate multi-method approaches, such as behavioral or physiological assessments, to enhance measurement validity. Despite these limitations, this present study contributes to the literature by identifying gender-specific patterns in the associations among physical exercise, mindfulness, rumination, and flourishing. Future research should further examine these relationships using longitudinal or intervention-based designs to clarify their temporal dynamics and potential underlying mechanisms, while incorporating additional affective components (eg., positive and negative emotional experiences) to provide a more comprehensive understanding of these associations.⁶⁸

Conclusions

This study suggests gender-specific patterns in the associations among physical exercise, mindfulness, rumination, and flourishing in adolescent boys and girls. For adolescent boys, physical exercise was not significantly associated with flourishing at the direct level; instead, the association was primarily observed through three indirect pathways: (1) an independent pathway involving mindfulness, whereby higher levels of physical exercise were associated with higher levels of mindfulness. (2) an independent pathway involving rumination, whereby higher levels of physical exercise were associated with lower levels of rumination; and (3) a sequential pathway involving mindfulness and rumination, whereby higher mindfulness was associated with lower rumination, which in turn was associated with higher flourishing. For adolescent girls, physical exercise was associated with flourishing through both direct and indirect pathways: (1) a direct positive association between physical exercise on flourishing. (2) an independent pathway involving mindfulness; and (3) a sequential pathway involving mindfulness and rumination. Rumination alone was not significantly associated with flourishing in girls. These findings highlight gender differences in the patterns of associations linking physical exercise to flourishing. Mindfulness showed consistent associations across both genders, whereas the indirect association involving rumination was more evident among boys. This study provides preliminary evidence that may inform future research and the development of gender-sensitive approaches to promoting well-being among adolescents.

Data Sharing Statement

The data presented in this study are available on request from the corresponding author, Dr. Qing Xia, due to privacy and ethical reasons.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Declaration of Helsinki. All procedures involving human participants were reviewed and approved by the Ethics Review Committee of Hebei North University (IRB No. 2025GT001). Prior to data collection, written informed consent was obtained from all adolescent participants as well as their parents or legal guardians. Teachers were also informed and agreed to the study procedures.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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