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Research Article

Adolescent Depressive Symptoms, Physical Activity, and Core Self-Evaluation in Chinese Adolescents: Evidence from Mediation and Latent Profile Approaches

Chang Hu[1†], Jing Yang[2†*], Wenling Gou[3]

[1]Department of Physical Education, Physical Education College, Jiangxi Normal University, Nanchang, Jiangxi 330022, China

[2]Department of Social Work, School of Psychology and Sociology, Mianyang Normal University, Mianyang, Sichuan 621000, China

[3]SanTESiH Research Unit (UR_UM211), Faculty of Physical and Sports Sciences and Techniques (UFR STAPS), University of Montpellier, Montpellier, Occitanie 34090, France

[†]*These authors contributed equally to this work.*

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Background

Adolescent depressive symptoms are a significant mental health concern. Physical activity and core self-evaluation are potential protective factors against mental health issues. However, their combined associations with depression and subgroup heterogeneity in Chinese adolescents remain insufficiently understood.

Objective

This study examines the relationship between physical activity and core self-evaluation in relation to depressive symptoms, employing both variable-centered and person-centered approaches, and identifies subgroups defined by joint patterns of these variables.

Methods

Participants included 948 junior high school students (mean age: 12.54 ± 1.11 years; 56.2% female) who completed the Physical Activity Rating Scale, the Core Self-Evaluation Scale, and the depression subscale of the Depression, Anxiety, and Stress Scale-21. Controlling for sex, grade, and residence, mediation was tested in SPSS using PROCESS Model 4 with 5,000 bootstrap resamples. Item-level indicators were entered into Mplus 8.3 for latent profile analysis (LPA) of physical activity and core self-evaluation.

Results

Physical activity was inversely associated with depressive symptoms ($\beta = -0.22$, $p<0.001$) and positively associated with core self-evaluation ($\beta = 0.46$, $p<0.001$). Core self-evaluation was negatively associated with depressive symptoms ($\beta = -0.35$, $p<0.001$) and partially accounted for the association between physical activity and depressive symptoms (indirect $\beta = -0.16$, 95% confidence interval = [−0.21, −0.12]), representing about 42% of the total effect. LPA identified three subgroups: low physical activity-low core self-evaluation (18.36%), moderate-moderate (60.55%), and high-high (21.09%), with the low-low group reporting the highest depressive symptoms and the high-high group the lowest.

Conclusion

Physical activity and core self-evaluation show complementary associations with lower depressive symptoms in Chinese adolescents, supporting integrated, stratified programs that foster active lifestyles and positive self-views.

***Corresponding author:**
Jing Yang
Department of Social Work, School of Psychology and Sociology, Mianyang Normal University, Mianyang, Sichuan 621000, China.
E-mail: 101357@mtc.edu.cn

1. INTRODUCTION

Across the globe, depressive symptoms in adolescents have become a critical public health issue in the field of mental health.[1-3] Their high prevalence and often insidious onset pose serious threats to both the physical and psychological development of young people.[4,5] Depressive symptoms are typically characterized by persistent low mood, anhedonia, and feelings of worthlessness,[6] as well as cognitive and behavioral impairments that interfere with everyday functioning.[7] These symptoms not only cause immediate emotional distress but are also linked to long-term adverse outcomes in academic performance, social relationships, and overall health.[8,9] Epidemiological studies indicate that 15–30% of adolescents worldwide experience depressive symptoms.[10] Beyond reflecting individual suffering, adolescent depression can set off a cascade of negative consequences, including smoking, alcohol consumption, social withdrawal, reduced levels of physical activity, irregular sleep patterns, academic decline, and even an elevated risk of self-harm and suicide.[11-14]

1.1. PHYSICAL ACTIVITY AND DEPRESSIVE SYMPTOMS

Physical activity is typically defined as planned and regular participation in exercise and is identified by the World Health Organization as a key behavior for promoting mental health in young people.[15] A growing body of evidence indicates that adolescents who engage in regular physical activity report fewer depressive symptoms than their less active peers.[16-18] Epidemiological and longitudinal studies have shown that insufficient physical activity during adolescence is associated with a higher risk of depressive symptoms and depressive disorders, whereas meeting recommended levels of moderate-to-vigorous activity appears to confer a protective effect.[19-21] Intervention studies further suggest that increasing physical activity can reduce core depressive symptoms, such as persistent low mood, anhedonia, and feelings of worthlessness, indicating that physical activity may play both a preventive and an adjunctive therapeutic role in adolescent depression.[22,23]

1.2. THE MEDIATING ROLE OF CORE SELF-EVALUATION

In the relationship between physical activity and depressive symptoms, core self-evaluations are likely to serve as a key mediating factor. Core self-evaluations refer to individuals' fundamental appraisals of their abilities and worth (i.e., their overall self-view or self-worth),[24,25] encompassing components such as self-esteem, self-efficacy, emotional stability, and the locus of control.[26] According to Bandura's social cognitive theory,[27] individual behavior is shaped by the reciprocal interaction of personal, environmental, and behavioral factors, among which self-efficacy plays a central role in motivating behavior and maintaining mental health. As a foundational psychological resource, core self-evaluations influence how individuals interpret stressful events and what coping strategies they adopt when facing adversity.[28,29]

As a self-enhancing behavior, physical activity can strengthen core self-evaluations through multiple pathways. Regular participation in physical activity provides repeated mastery and achievement experiences, which, in turn, reinforce positive self-judgments and enhance self-efficacy. Improvements in physical condition and fitness further help to increase self-esteem and reduce self-devaluation and feelings of worthlessness.[30] In addition, the planning, persistence, and self-regulation involved in physical activity help to strengthen individuals' sense of personal control and internal locus of control, thereby fostering more positive and stable core self-evaluations.[31,32]

Higher levels of core self-evaluations are closely associated with lower levels of depressive symptoms and can, to some extent, buffer the negative emotional impact of adverse life events.[33,34] Empirical studies have shown that adolescents with higher core self-evaluations tend to display stronger psychological resilience, more adaptive coping strategies, and a lower risk of depression than those with lower self-evaluations.[35-38] Although existing research has preliminarily revealed associations among physical activity, core self-evaluations, and depressive symptoms, the specific mechanisms through which physical activity influences depressive symptoms through core self-evaluations remain unclear and warrant further investigation.

1.3. LATENT PROFILE ANALYSIS (LPA)

Prior work has largely relied on variable-centered methods to explore how physical activity and core self-evaluations relate to depressive symptoms. However, such analyses fail to capture heterogeneity within adolescent populations.[39] With marked differences among adolescents in physical activity and core self-evaluations, focusing on averages alone risks obscuring subgroup distinctions. To address this issue, the present study employed LPA, using combinations of physical activity and core self-evaluations as classification indicators to identify potential subgroups, and then comparing subgroup differences in depressive symptoms. This method allows for the exploration of how distinct joint patterns of physical activity and core self-evaluations shape adolescents' risks for depression.

1.4. CURRENT RESEARCH

In summary, drawing on both variable- and person-centered perspectives, this study systematically investigated the relationship between physical activity, core self-evaluations, and depressive symptoms in adolescents. We first employed structural equation modeling to examine the direct relationship between physical activity and depressive symptoms (Hypothesis 1) and investigate whether core self-evaluations mediate this association (Hypothesis 2). We then applied LPA to derive adolescent subgroups from joint patterns of physical activity and core self-evaluations and compared their depressive symptom levels (Hypothesis 3). The results are expected to advance the understanding of mechanisms of adolescent depression and inform targeted interventions across school, family, and community settings.

2. MATERIALS AND METHODS

2.1. PARTICIPANTS AND DATA COLLECTION

Using G*Power 3.1, we conducted an a priori power analysis tailored to a mediation model. Assuming a small-to-moderate effect (f^2 = 0.05), with a power of 0.80

and an alpha level of 0.05, the analysis indicated that a minimum of 160 participants were required.

A cross-sectional design was adopted. Data were collected between March and April 2024 from four middle schools in Jiangxi, China (two in urban areas and two in rural areas). Schools were selected based on administrative feasibility and willingness to participate. Within each school, intact classes were recruited using convenience cluster sampling (intact classes).

All measures were administered electronically through an online survey platform in the schools' computer rooms. The platform automatically recorded each student's start and completion times, which were used to calculate total response duration and apply the 300-s exclusion criterion. Questionnaires were completed collectively during regular class sessions under the supervision of trained research assistants and classroom teachers. Students were assured of anonymity and confidentiality, and the survey took approximately 20–25 min to complete.

No monetary or material compensation was provided to participating students or schools. Participation was entirely voluntary, and students were informed that they could discontinue their participation at any time without incurring any academic or administrative consequences.

All psychological data collected from children and adolescents were stored and managed in de-identified form. Immediately after data collection, raw records were exported from the online platform and stripped of any directly identifying information (e.g., names and student IDs). Each participant was assigned a unique code; the linkage file, which connected codes to specific classes, was stored separately in an encrypted file accessible only to the principal investigator.

In total, 1,180 questionnaires were distributed, and 1,137 were returned (response rate = 96.4%). After data screening, we excluded cases with more than 10% missing items (n = 95), cases with extremely short completion times (<300 s) and/or clear evidence of patterned responding (n = 21), and cases that failed the validity check item (n = 73). The final analytic sample consisted of 948 participants (effective rate = 83.4%). Little's missing completely at random test indicated that the remaining missing data were trivial; therefore, listwise deletion was used in the primary analyses. As shown in Table 1, the final sample (n = 948) had a mean age of 12.54 years, included slightly more girls than boys, and was approximately evenly distributed across grades and residential (urban/rural) settings.

The study was approved by the Ethics Committee of Jiangxi Normal University (IRB-JXNU-PEC-20240103) and conducted in accordance with the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all student participants and their legal guardians before the commencement of data collection. Participants were informed of their right to withdraw at any time without penalty, and all data were de-identified before analysis. An on-site referral protocol to school counseling services was available for any participant who exhibited notable distress during the survey.

Table 1. General characteristics of participants (n=948)

Variable	Values (%)
Sex	
Male	415 (43.8)
Female	533 (56.2)
Grade	
Grade 7	485 (51.2)
Grade 8	463 (48.8)
Residence	
Rural	466 (49.2)
Urban	482 (50.8)
Age (years), mean (standard deviation)	12.54 (1.11)

Note: Data are presented as n (%), unless stated otherwise.

2.2. MEASUREMENTS

This study employed a self-report questionnaire, with all included scales administered in Chinese using validated Chinese versions. To ensure consistency of item comprehension and feasibility, a small pilot test (n = 18) was conducted. To mitigate common method bias, we implemented procedural controls, including counterbalanced presentation order, embedded attention-check items, and the retention of reverse-worded items.

Physical activity was assessed using the Physical Activity Rating Scale 3 developed by Liang.[40] The scale measures individuals' physical activity levels across three dimensions: intensity, duration, and frequency. Intensity is rated on a five-point scale from 1 (light activity) to 5 (vigorous, long-lasting activity accompanied by rapid breathing and heavy sweating); frequency is rated from 1 (less than once per month) to 5 (once every day); and duration is rated from 0 (<10 min) to 4 (more than 60 min). The total physical activity score is calculated by multiplying the scores from the three dimensions, yielding a possible range of 0–100, with higher scores indicating higher levels of physical activity. In the present sample, the Cronbach's α was 0.77.

Core self-evaluation was assessed using the 10-item Core Self-Evaluation Scale developed by Judge *et al*.[41] The items are rated on a five-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree). After averaging the item scores, higher mean scores reflect more positive core self-evaluations. The scale has been widely used in Chinese populations.[42,43] In the present sample, the Cronbach's α was 0.88, indicating a good internal consistency.

Depressive symptoms were measured using the depression subscale of the Depression Anxiety Stress Scales-21 (DASS-21), originally developed by Lovibond and Lovibond[44] and culturally adapted for Chinese populations. The subscale consists of seven items rated on a four-point Likert scale ranging from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). Scores are summed and then averaged, with higher mean scores indicating more severe depressive symptoms. DASS-21 has demonstrated stable factor structure, excellent reliability, and validity among Chinese adolescents.[45,46] In the present study, the Cronbach's α for the depression subscale was 0.85, indicating a good internal consistency.

2.3. DATA ANALYSIS

Data were analyzed using SPSS Statistics 26.0 (IBM, United States [US]) and Mplus 8.3 (Muthen and Muthen, US). Descriptive statistics and bivariate correlations were computed in SPSS. Before modeling, all continuous variables were standardized (z-scores), and residence, grade, and sex were included as covariates in subsequent analyses. The indirect effect of physical activity on depressive symptoms through core self-evaluation was tested using

Table 2. Descriptive statistics and correlations among study variables

Variable	Mean (SD)	Median	Min/max	Physical activity	Core self-evaluation	Depressive symptoms
Physical activity	29.18 (29.98)	20.00	0/100	1	-	-
Core self-evaluation	3.12 (0.97)	3.20	1.20/4.90	0.47***	1	-
Depressive symptoms	3.33 (3.23)	3.00	0/16	−0.39***	0.47***	1

Note: ***p<0.001.
Abbreviation: SD: Standard deviation.

PROCESS macro (v3.5; Model 4) with 5,000 bootstrap resamples and bias-corrected 95% confidence intervals (CIs).[47] Subsequently, an LPA based on item-level indicators of physical activity and core self-evaluation was conducted in Mplus. The criteria for model selection were as follows: each class had to contain at least 5% of the sample;[48] lower values of the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and sample-size-adjusted BIC (aBIC) indicated a better model fit;[49] significant p-values for the Lo-Mendell-Rubin likelihood ratio test (LMR-LRT) and bootstrap likelihood ratio test (BLRT) (p<0.05) supported the k-class model over the k−1 class model;[50] and entropy values ranged from 0 to 1, with higher values indicating greater classification accuracy. Finally, one-way analysis of variance was used to examine differences in depressive symptoms across the derived LPA classes and across categories of physical activity and core self-evaluation.

3. RESULTS

3.1. DESCRIPTIVE STATISTICS FOR THE OBSERVED VARIABLES

Table 2 presents descriptive statistics and bivariate correlations among the study variables. Physical activity was positively associated with core self-evaluation, whereas both physical activity and core self-evaluation were negatively associated with depressive symptoms (p<0.001). All correlations were analyzed using Pearson's r.

3.2. VARIABLE-CENTERED ANALYSIS

We examined the associations among physical activity, core self-evaluation, and depressive symptoms from a variable-centered perspective, with core self-evaluation specified as a mediator. All variables were standardized (z-scores); depressive symptoms served as the dependent variable, physical activity as the independent variable, and core self-evaluation as the mediator. Sex, grade, and residence were entered as covariates. Analyses were conducted using the PROCESS macro (v3.5; Model 4) with bias-corrected bootstrapping (5,000 resamples).

As shown in Table 3 and Figure 1, physical activity was positively associated with core self-evaluation (β = 0.46, t = 16.06, p<0.001) and negatively associated with depressive symptoms (β = −0.22, t = −7.00, p<0.001). Core self-evaluation also showed a significant negative association with depressive symptoms (β = −0.35, t = −11.43, p<0.001). Model fit indices indicated adequate explanatory power (R^2 = 0.22 for the mediator model; R^2 = 0.29 for the outcome model; both F-statistics p<0.001).

The mediating role of core self-evaluation was further tested using a bias-corrected bootstrap method with 5,000 resamples. The indirect effect was significant (β = −0.16), and the 95% CI [−0.21, −0.12] did not include zero, accounting for approximately 42% of the total effect.[51] These results provide robust evidence that core self-evaluation mediates the relationship between physical activity and depressive symptoms.

Table 3. Multiple regression analyses predicting core self-evaluation and depressive symptoms

Variable	Core self-evaluation		Depressive symptoms	
	β	t	β	t
Sex	−0.13	−2.20*	0.16	2.87**
Grade	−0.06	−1.10	0.25	4.52***
Residence	−0.07	−1.27	0.24	4.35***
Physical activity	0.46	16.06***	−0.22	−7.00***
Core self-evaluation	-	-	−0.35	−11.43***
R^2	0.22		0.29	
F	67.67***		78.77***	

Notes: Standardized regression coefficients (β) are reported.
*p<0.05, **p<0.01, ***p<0.001.

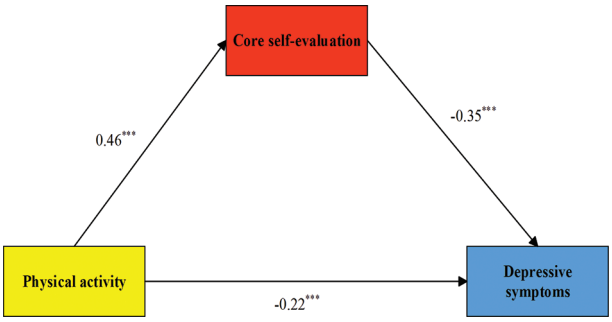

Figure 1. Mediation model of the association between physical activity and depressive symptoms through core self-evaluation
Note: ***p<0.001

3.3. PERSON-CENTERED ANALYSIS

We also investigated the link between physical activity and core self-evaluation using a person-centered approach. Using 13 item-level indicators (X1–X3 for physical activity; M1–M10 for core self-evaluation), we ran LPAs in Mplus 8.3, estimating 1- to 5-profile solutions. As summarized in Table 4, the model fit improved with the addition of profiles, as reflected by declining AIC, BIC, and aBIC values. The 2-profile solution demonstrated good classification quality (entropy = 0.874) and significant LMR-LRT and BLRT (both p<0.001), with class sizes of 31.01% and 68.99%. The 3-profile solution showed further improvement in fit, with higher entropy (0.922), significant LMR-LRT and BLRT (p<0.001), and acceptable class proportions (60.55%, 18.36%, and 21.09%). Although the 4- and 5-profile models also showed a reasonable fit, they yielded relatively small

classes (e.g., 7.17% in the 5-profile solution), which limited their practical interpretability. Considering statistical indices, class size adequacy (⩾5%), and theoretical interpretability, the 3-profile model was retained as the optimal solution.

Figure 2 presents the characteristics of the three identified profiles. Profile 1 (labeled as moderate physical activity-moderate core self-evaluation, n = 574, 60.55%) showed moderate mean scores across the 13 items, maintaining a relatively stable mid-level pattern. Profile 2 (labeled as low physical activity-low core self-evaluation, n = 174, 18.36%) was characterized by consistently low mean scores. Profile 3 (labeled as high physical activity-high core self-evaluation, n = 200, 21.09%) demonstrated the highest mean scores, all above 4, clearly distinguishing it from the other two profiles.

Table 5 shows the differences in depressive symptoms across the three identified profiles. Significant group differences emerged (F = 150.77, p<0.001). *Post hoc* comparisons (Tukey's honestly significant difference) indicated that the low physical activity-low core self-evaluation group reported the highest depressive symptoms, followed by the moderate physical activity-moderate core self-evaluation group, and the high physical activity-high core self-evaluation group reported the lowest (2 > 1 > 3).

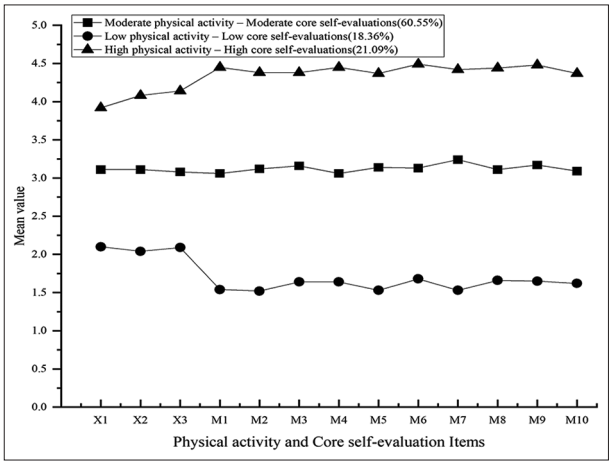

Figure 2. Mean item profiles and class proportions for the three latent profiles

4. DISCUSSION

This study adopted a dual analytic framework, integrating both variable-centered and person-centered approaches, to systematically examine the mechanisms and group differences underlying the relationships among physical activity, core self-evaluations, and depressive symptoms in adolescents. From a variable-centered perspective, the study tested the predictive effect of physical activity on depressive symptoms and further verified the mediating role of core self-evaluations in this association. From a person-centered perspective, item-level indicators of physical activity and core self-evaluations were used to identify latent subgroups, and differences in depressive symptoms across these subgroups were compared. These complementary approaches not only illuminate the key mechanisms shaping adolescent depressive symptoms but also reveal population heterogeneity, offering theoretical and practical guidance for developing stratified and targeted prevention and intervention strategies.

Hypothesis 1 proposed that physical activity would be negatively associated with depressive symptoms, and the present findings provide clear support for this assumption. Consistent with previous research,[52,53] the regression analyses, after adjusting for relevant covariates, showed that higher levels of physical activity significantly predicted lower levels of depressive symptoms. From the perspective of emotion regulation theory, engaging in regular physical activity promotes the release of endorphins and other mood-enhancing neurochemicals that function as natural regulators of stress and negative affect.[54-56] Such physiological benefits enable adolescents to manage emotional challenges more effectively. Conversely, insufficient physical activity deprives adolescents of this protective mechanism, making them more vulnerable when confronted with academic pressures or interpersonal difficulties, as they lack adequate physiological resources to regulate negative emotions.[57,58] Consequently, strengthening adolescents' engagement in physical activity may serve as an important pathway to reducing depressive symptoms and supporting emotional well-being.

Hypothesis 2 tested whether core self-evaluations would mediate the relationship between physical activity and

Table 4. Model fit indices and class distribution for latent profile solutions

Profiles	AIC	BIC	aBIC	LMR-LRT (p)	BLRT (p)	Entropy	Percentage by category
1	43,303.79	43,430.01	43,347.43	-	-	-	-
2	40,527.66	40,721.83	40,594.79	<0.001	<0.001	0.874	31.01/68.99
3	39,305.03	39,567.16	39,395.66	<0.001	<0.001	0.922	60.55/18.36/21.09
4	39,023.50	39,353.60	39,137.63	0.019	<0.001	0.893	16.46/24.05/41.14/18.35
5	38,674.04	39,072.10	38,811.67	0.075	<0.001	0.904	14.13/7.17/25.32/35.87/17.51

Abbreviations: aBIC: Sample-size-adjusted Bayesian Information Criterion; AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion; BLRT: Bootstrap likelihood ratio test; LMR-LRT: Lo-Mendell-Rubin likelihood ratio test.

Table 5. Differences in depressive symptoms across latent profiles

Profile	n	Mean	SD	F	Post hoc tests
Moderate physical activity-moderate core self-evaluation	574	2.90	1.68	150.77***	2>1>3
Low physical activity-low core self-evaluation	174	6.55	4.30		
High physical activity-high core self-evaluation	200	1.78	3.68		

Note: ***p<0.001.
Abbreviation: SD: Standard deviation.

depressive symptoms. The results supported this hypothesis, confirming a significant mediating effect. Adolescents who engaged in higher levels of physical activity reported more positive core self-evaluations, which, in turn, reduced depressive symptoms. Drawing on core self-evaluation theory, it can be argued that participation in physical activity helps adolescents strengthen self-efficacy, self-esteem, and perceived control through overcoming challenges and achieving goals.[59,60] Enhanced core self-evaluations enable adolescents to adopt adaptive coping strategies and mobilize social resources when facing stressful situations, thereby lowering the likelihood of depressive symptoms.[61,62] Physical activity provides adolescents with repeated opportunities to experience mastery, overcome challenges, and achieve goals, thereby strengthening self-efficacy, self-esteem, and perceived control. These enhanced core self-evaluations help adolescents interpret stressors in a more adaptive manner, mobilize support, and employ constructive coping strategies, ultimately reducing the likelihood of depressive symptoms.[63] In contrast, low levels of core self-evaluations may magnify negative self-attributions and foster a sense of helplessness, which increases vulnerability to depression. From this perspective, core self-evaluations function not only as a cognitive-emotional resource but also as a key mechanism through which physical activity exerts its protective effect on mental health.[64] These findings underscore the importance of fostering both behavioral engagement and positive self-beliefs in adolescence. Interventions that combine structured physical activity with programs aimed at strengthening self-efficacy, self-esteem, and perceived personal control may be particularly effective in buffering against depressive symptoms and promoting healthy psychological development.

Hypothesis 3 examined whether meaningful subgroup heterogeneity would emerge when considering physical activity and core self-evaluations jointly. Consistent with this hypothesis, the LPA identified three distinct patterns among adolescents: low physical activity-low core self-evaluations (18.37%), moderate physical activity-moderate core self-evaluations (60.54%), and high physical activity-high core self-evaluations (21.09%). These profiles reflected a clear correspondence between behavioral engagement and cognitive-emotional appraisal. Moreover, depressive symptoms showed significant graded differences across the three profiles, with the low-low group displaying the highest level of depressive symptoms, followed by the moderate-moderate group, and the high-high group showing the lowest symptom levels. This pattern reinforces the variable-centered findings by demonstrating that adolescents with lower physical activity tend to exhibit lower core self-evaluations, which, in turn, place them at greater risk for depressive symptoms.

Beyond confirming the mediation results, the person-centered analysis provides deeper insight into the developmental status of adolescents' physical activity and core self-evaluations. Across the latent profiles, both constructs were generally at a moderate or slightly below-average level, a pattern consistent with prior research.[39] Developmental theories suggest that self-evaluative processes and self-regulatory capacities continue to mature throughout adolescence, typically progressing from less differentiated to more coherent and stable forms as cognitive and neural systems develop.[65] Given that the majority of participants in the present study were in early to middle adolescence, it is reasonable that core self-evaluations have not yet reached adult-like levels of stability and sophistication. Overall, these person-centered findings deepen our understanding of how behavioral and cognitive-emotional resources coalesce within different subgroups of adolescents. They underscore the need for differentiated intervention strategies that target the unique profiles of risk and resilience observed across these groups.

One of the strengths of this study is the integration of both variable-centered and person-centered approaches, allowing for the identification of overall associations and individual heterogeneity. Another strength is the demonstration of a dual protective pathway against depression, incorporating the roles of physical activity and core self-evaluations. Methodologically, the use of item-level indicators in LPA and bootstrap-based mediation enhances measurement sensitivity and inferential robustness.

Nevertheless, several limitations warrant mention. First, the sample consisted of junior high school students from a single province, constraining the generalizability of the results; future research should recruit adolescents across multiple regions and educational stages. Second, the cross-sectional design precludes causal inference; prospective cohort or multi-wave, cross-lagged panel designs are needed to test temporal ordering and reciprocal influences. Third, reliance on self-reports may have introduced recall and social desirability biases; future work should incorporate accelerometer-based activity metrics, ecological momentary assessment of mood, and clinician-rated depressive symptoms to strengthen validity. Fourth, core self-evaluations were modeled as a global construct; dismantling analyses (e.g., bifactor or higher-order models) could reveal dimension-specific pathways (self-esteem, self-efficacy, locus of control, and emotional stability). Finally, unmeasured confounding (e.g., sleep duration/quality, body mass index, chronic stress, and socioeconomic status) may bias estimates; sensitivity analyses or inclusion of these covariates are recommended.

5. CONCLUSION

This study combined variable-centered and person-centered approaches and found that higher physical activity was associated with fewer depressive symptoms among adolescents. Core self-evaluation was not only significantly negatively related to depressive symptoms but also partially mediated the association between physical activity and depressive symptoms. LPA further identified three groups—low physical activity-low core self-evaluation, moderate-moderate, and high-high—with a clear gradient in depressive symptoms (highest in the low-low group and lowest in the high-high group). These findings suggest that stratified interventions for adolescents should simultaneously promote regular physical activity and strengthen core self-evaluation, with particular priority given to the high-risk "double-low" group.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS

Conceptualization: All authors
Data curation: All authors
Formal analysis: Jing Yang
Methodology: Chang Hu
Writing – original draft: Chang Hu, Jing Yang
Writing – review & editing: All authors

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the School of Physical Education of Jiangxi Normal University (Protocol Code: IRB-JXNU-PEC-20240103; approval date: January 3, 2024). Informed consent was obtained from all participants and their legal guardians involved in the study.

CONSENT FOR PUBLICATION

Consent for publication was obtained from the participants' legal guardians.

DATA AVAILABILITY STATEMENT

Data are available on request from the corresponding author.

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REFERENCES

1. Lu B, Lin L, Su X. Global burden of depression or depressive symptoms in children and adolescents: A systematic review and meta-analysis. *J Affect Disord*. 2024;354:553-562. doi: 10.1016/j.jad.2024.03.074

2. Mullarkey MC, Marchetti I, Beevers CG. Using network analysis to identify central symptoms of adolescent depression. *J Clin Child Adolesc Psychol*. 2019;48(4):656-668. doi: 10.1080/15374416.2018.1437735

3. Zhou SJ, Zhang LG, Wang LL, *et al*. Prevalence and socio-demographic correlates of psychological health problems in Chinese adolescents during the outbreak of COVID-19. *Eur Child Adolesc Psychiatry*. 2020;29(6):749-758. doi: 10.1007/s00787-020-01541-4

4. Clayborne ZM, Varin M, Colman I. Systematic review and meta-analysis: Adolescent depression and long-term psychosocial outcomes. *J Am Acad Child Adolesc Psychiatry*. 2019;58(1):72-79. doi: 10.1016/j.jaac.2018.07.896

5. LoParo D, Matos AP, Arnarson EÖ, Craighead WE. Enhancing prediction of major depressive disorder onset in adolescents: A machine learning approach. *J Psychiatr Res*. 2025;182:235-242. doi: 10.1016/j.jpsychires.2025.01.007

6. Yuan Y, Huang W, Hu C, Zhang W. The interaction of physical activity and sleep quality with depression and anxiety in older adults. *Front Public Health*. 2025;13:1674459. doi: 10.3389/fpubh.2025.1674459

7. Simic V, Vukomanovic IS, Radevic S, *et al*. Association between sociodemographic factors and depressive symptoms among adult population in Serbia. *Iran J Public Health*. 2024;53(4):867-877. doi: 10.18502/ijph.v53i4.15563

8. Oberle E, Ji XR, Molyneux TM. Pathways from prosocial behaviour to emotional health and academic achievement in early adolescence. *J Early Adolesc*. 2023;43(5):632-653. doi: 10.1177/02724316221113349

9. Grossberg A, Rice T. Depression and suicidal behavior in adolescents. *Med Clin North Am*. 2023;107(1):169-182. doi: 10.1016/j.mcna.2022.04.005

10. Shorey S, Ng ED, Wong CHJ. Global prevalence of depression and elevated depressive symptoms among adolescents: A systematic review and meta-analysis. *Br J Clin Psychol*. 2022;61(2):287-305. doi: 10.1111/bjc.12333

11. Thapar A, Eyre O, Patel V, Brent D. Depression in young people. *Lancet*. 2022;400(10352):617-631. doi: 10.1016/S0140-6736(22)01012-1

12. Zhang W, Huang W, Hu C, Yuan Y, Chen X. The impact of physical activity and dietary behavior on depression in college students: A study on mediation effects and network analysis. *Front Public Health*. 2025;13:1683468. doi: 10.3389/fpubh.2025.1683468

13. Keyes KM, Kreski NT, Patrick ME. Depressive symptoms in adolescence and young adulthood. *JAMA Netw Open*. 2024;7(8):e2427748. doi: 10.1001/jamanetworkopen.2024.27748

14. Li JY, Li J, Liang JH, *et al*. Depressive symptoms among children and adolescents in China: A systematic review and meta-analysis. *Med Sci Monit*. 2019;25:7459-7470. doi: 10.12659/msm.916774

15. Ciacchella C, Collacchi B, Fiorillo A, Sampogna G, Cirulli F. Impact of structured physical activity on youth's mental health: A review of umbrella reviews. *Int J Soc Psychiatry*. 2025;71(7):1219-1234. doi: 10.1177/00207640251342425

16. Velki T. Can physical activities suppress negative impact of stress on the mental health of adolescents? *Int J Ment Health Promot*. 2024;26(3):211-219. doi: 10.32604/ijmhp.2024.047950

17. Liu L, Yisongwake A, Hao Y, *et al*. The association between physical activity and positive affect in adolescents: The chain mediating role of psychological resilience and regulatory emotional self-efficacy. *Psychol Health Med*. 2024;29(10):1807-1819. doi: 10.1080/13548506.2024.2411635

18. Liu Y, Xiao T, Zhang W, Xu L, Zhang T. The relationship between physical activity and Internet addiction among adolescents in western China: A chain mediating model of anxiety and inhibitory control. *Psychol Health Med*. 2024;29(9):1602-1618. doi: 10.1080/13548506.2024.2357694

19. Andretta JR, McKay MT. Self-efficacy and well-being in adolescents: A comparative study using variable- and person-centered analyses. *Child Youth Serv Rev*. 2020;118:105374. doi: 10.1016/j.childyouth.2020.105374

20. Fan T, Li G, Liu C. Exercise types for efficacy and adherence in adolescents and young adults with depression: A systematic review with network meta-analysis. *Ment Health Phys Act*.

2025;29:100696. doi: 10.1016/j.mhpa.2025.100696

21. Che X, Lu Z, Jin Y. Social media addiction as the central mediating variable to explore the mechanism between physical exercise and sleep quality. *Sci Rep*. 2025;15(1):26800. doi: 10.1038/s41598-025-11225-1

22. Recchia F, Bernal JDK, Fong DY, *et al*. Physical activity interventions to alleviate depressive symptoms in children and adolescents: A systematic review and meta-analysis. *JAMA Pediatr*. 2023;177(2):132. doi: 10.1001/jamapediatrics.2022.5090

23. Chen L, Liu Q, Xu F, *et al*. Effect of physical activity on anxiety, depression and obesity index in children and adolescents with obesity: A meta-analysis. *J Affect Disord*. 2024;354:275-285. doi: 10.1016/j.jad.2024.02.092

24. Judge TA, Bono JE. Relationship of core self-evaluations traits with job satisfaction and job performance: A meta-analysis. *J Appl Psychol*. 2001;86(1):80-92. doi: 10.1037/0021-9010.86.1.80

25. Yudes C, Chamizo-Nieto MT, Peláez-Fernández MA, Extremera N. Core self-evaluations and perceived classmate support: Independent predictors of psychological adjustment. *Scand J Psychol*. 2025;66(1):150-157. doi: 10.1111/sjop.13072

26. Lee K, Rathi N. Core self-evaluations, worry, life satisfaction, and psychological well-being: An investigation in the Asian context. *Int J Learn Change*. 2018;10(1):1-20. doi: 10.1504/ijlc.2018.10008838

27. Bandura A. Social cognitive theory: An agentic perspective. *Annu Rev Psychol*. 2001;52(1):1-26. doi: 10.1146/annurev.psych.52.1.1

28. Kammeyer-Mueller JD, Judge TA, Scott BA. The role of core self-evaluations in the coping process. *J Appl Psychol*. 2009;94(1):177-195. doi: 10.1037/a0013214

29. Gnambs T, Schroeders U. Reliability and factorial validity of the core self-evaluations scale. *Eur J Psychol Assess*. 2024;40(5):343-359. doi: 10.1027/1015-5759/a000783

30. White RL, Vella S, Biddle S, *et al*. Physical activity and mental health: A systematic review and best-evidence synthesis of mediation and moderation studies. *Int J Behav Nutr Phys Act*. 2024;21(1):134. doi: 10.1186/s12966-024-01676-6

31. Yue X, Cao H, Wang X, Zhu D, Hu C. More active, less aggressive! Understanding how physical activity reduces aggressive behavior among Chinese adolescents: A three-wave mediation model. *Front Psychol*. 2025;16:1663439. doi: 10.3389/fpsyg.2025.1663439

32. Garn AC, Simonton KL. Young adults' short-term trajectories of moderate physical activity: Relations with self-evaluation processes. *Front Psychol*. 2020;11:2079. doi: 10.3389/fpsyg.2020.02079

33. Xiao Q, Song X, Zou S, Wang Y, Waqi T, Yin L. An ethnic minority perspective: Association between negative life events and depressive symptoms in Yi adolescents in China. *Psychiatry Investig*. 2025;22(4):405-411. doi: 10.30773/pi.2024.0303

34. Zou S, Song X, Tan W, *et al*. Core self-evaluation as a mediator between depressive symptoms and suicidal ideation in adolescents. *J Affect Disord*. 2022;302:361-366. doi: 10.1016/j.jad.2022.01.093

35. Wright LJ, Veldhuijzen Van Zanten JJCS, Williams SE. Examining the associations between physical activity, self-esteem, perceived stress, and internalizing symptoms among older adolescents. *J Adolesc*. 2023;95(6):1274-1287. doi: 10.1002/jad.12201

36. Zeng Q, Yang Z, Xiao T, Luo H, Chen P. Different parental rearing behaviors and depressive symptoms of adolescents: Roles of psychological insecurity and core self-evaluations. *School Psychol Int*. 2025;46(2):172-196. doi: 10.1177/01430343241308554

37. Wan H, Huang W, Zhang W, Hu C. Exploring adolescents' social anxiety, physical activity, and core self-evaluation: A latent profile and mediation approach. *Int J Ment Health Promot*. 2025;27:1611-1626. doi: 10.32604/ijmhp.2025.070457

38. Laurier C, Pascuzzo K, Jubinville V, Lemieux A. Physical activity and its benefits on adolescents' mental health through self-esteem. *Front Child Adolesc Psychiatry*. 2024;3:1503920. doi: 10.3389/frcha.2024.1503920

39. Huang W, Chen B, Hu C. The latent profile structure of negative emotion in female college students and its impact on eating behavior: The mediating role of physical exercise. *Front Public Health*. 2025;13:1663474. doi: 10.3389/fpubh.2025.1663474

40. Liang DQ. Gao xiao xue sheng ying ji shui ping ji qi yu ti yu duan lian de guan xi[Stress levels among college students and their relationship with physical exercise]. *Chin Ment Health J*. 1994;8(1):2. doi: CNKI: SUN:ZXWS.0.1994-01-001

41. Judge TA, Erez A, Bono JE, Thoresen CJ.

The core self-evaluations scale: Development of a measure. *Pers Psychol*. 2003;56(2):303-331. doi: 10.1111/j.1744-6570.2003.tb00152.x

42. Liu F, Zhu Z, Jiang B. The influence of Chinese college students' physical exercise on life satisfaction: The chain mediation effect of core self-evaluation and positive emotion. *Front Psychol*. 2021;12:763046. doi: 10.3389/fpsyg.2021.763046

43. Ma G, Han Z, Ma X. Core self-evaluation and innovative behavior: Mediating effect of error orientation and self-efficacy of nurses. *Front Psychol*. 2023;14:1298986. doi: 10.3389/fpsyg.2023.1298986

44. Lovibond PF, Lovibond SH. The structure of negative emotional states: Comparison of the depression anxiety stress scales (DASS) with the beck depression and anxiety inventories. *Behav Res Ther*. 1995;33(3):335-343. doi: 10.1016/0005-7967(94)00075-U

45. Dong T, Wang Y, Lin Y. Prevalence and determinants of depression, anxiety, and stress among secondary school students. *PLOS One*. 2025;20:e0328785. doi: 10.1371/journal.pone.0328785

46. Shen Q, Wang S, Liu Y, Wang Z, Bai C, Zhang T. The chain mediating effect of psychological inflexibility and stress between physical exercise and adolescent insomnia. *Sci Rep*. 2024;14(1):24348. doi: 10.1038/s41598-024-75919-8

47. Hayes AF, Montoya AK, Rockwood NJ. The analysis of mechanisms and their contingencies: PROCESS versus structural equation modeling. *Australas Mark J*. 2017;25(1):76-81. doi: 10.1016/j.ausmj.2017.02.001

48. Coelho SG, Keough MT, Hodgins DC, Shead NW, Parmar PK, Kim HS. Latent profile analyses of addiction and mental health problems in two large samples. *Int J Ment Health Addict*. 2025;23(1):70-92. doi: 10.1007/s11469-022-01003-9

49. Vrieze SI. Model selection and psychological theory: A discussion of the differences between the Akaike information criterion and the Bayesian information criterion. *Psychol Methods*. 2012;17(2):228-243. doi: 10.1037/a0027127

50. Vermunt JK. The Vuong-Lo-Mendell-Rubin test for latent class and latent profile analysis: A note on the different implementations in Mplus and LatentGOLD. *Methodology*. 2024;20(1):72-83. doi: 10.5964/meth.12467

51. Preacher KJ, Hayes AF. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behav Res Methods*. 2008;40(3):879-891. doi: 10.3758/brm.40.3.879

52. Kandola A, Ashdown-Franks G, Hendrikse J, Sabiston CM, Stubbs B. Physical activity and depression: Towards understanding the antidepressant mechanisms of physical activity. *Neurosci Biobehav Rev*. 2019;107:525-539. doi: 10.1016/j.neubiorev.2019.09.040

53. Dishman RK, McDowell CP, Herring MP. Customary physical activity and odds of depression: A systematic review and meta-analysis of 111 prospective cohort studies. *Br J Sports Med*. 2021;55(16):926-934. doi: 10.1136/bjsports-2020-103140

54. Mikkelsen K, Stojanovska L, Polenakovic M, Bosevski M, Apostolopoulos V. Exercise and mental health. *Maturitas*. 2017;106:48-56. doi: 10.1016/j.maturitas.2017.09.003

55. Wang X, Liu T, Jin X, Zhou C. Aerobic exercise promotes emotion regulation: A narrative review. *Exp Brain Res*. 2024;242(4):783-796. doi: 10.1007/s00221-024-06791-1

56. Puterman E, Weiss J, Beauchamp MR, Mogle J, Almeida DM. Physical activity and negative affective reactivity in daily life. *Health Psychol*. 2017;36(12):1186-1194. doi: 10.1037/hea0000532

57. Biddle SJH, Ciaccioni S, Thomas G, Vergeer I. Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychol Sport Exerc*. 2019;42:146-155. doi: 10.1016/j.psychsport.2018.08.011

58. Nogg KA, Vaughn AA, Levy SS, Blashill AJ. Motivation for physical activity among U.S. adolescents: A self-determination theory perspective. *Ann Behav Med*. 2021;55(2):133-143. doi: 10.1093/abm/kaaa037

59. Hu C, Zhang W, Huang W, Jin C. How grit enhances physical exercise in college students: Mediating roles of personal growth initiative and self-efficacy. *Front Psychol*. 2025;16:1652984. doi: 10.3389/fpsyg.2025.1652984

60. Yu H, Zhu T, Tian J, *et al*. Physical activity and self-efficacy in college students: The mediating role of grit and the moderating role of gender. *PeerJ*. 2024;12:e17422. doi: 10.7717/peerj.17422

61. Vucenovic D, Sipek G, Jelic K. The role of emotional skills (competence) and coping strategies in adolescent depression. *Eur J Investig Health Psychol Educ*. 2023;13(3):540-552. doi: 10.3390/ejihpe13030041

62. Olivier E, Morin AJS, Tardif-Grenier K, Archambault I, Dupéré V, Hébert C. Profiles of anxious and depressive symptoms among adolescent boys and girls: Associations with coping strategies. *J Youth Adolesc*. 2022;51(3):570-584. doi: 10.1007/s10964-022-01572-x

63. Ma S, Zhang P. Interpersonal adjustment and depression in college students: The mediating effect of core self-evaluation and moderating effect of gender. *J Psychol Afr*. 2025;35(1):135-141. doi: 10.32604/jpa.2025.065759

64. George MG, Collard JJ. The influence of core self-evaluation, mindfulness, and rumination on emotional distress. *J Ration Emot Cogn Behav Ther*. 2024;42(4):681-698.doi:10.1007/s10942-023-00536-9

65. Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, *et al*. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: A systematic review and meta-analysis. *Sports Med*. 2019;49(9):1383-1410. doi: 10.1007/s40279-019-01099-5