



OPEN The association between family physical activity environment and exercise adherence in adolescents: a chain mediation model

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The family plays an immensely crucial role in the development of adolescents, significantly influencing their behavioral patterns. To explore the impact mechanism of the family physical activity environment on adolescents' exercise adherence, and analyze the chain-mediating role of exercise self-efficacy and exercise satisfaction. A questionnaire was administered to 500 adolescents and their parents using the Family Physical Activity Environment Scale, Exercise Adherence Scale, Exercise Self-Efficacy Scale and Satisfaction Scale. The direct impact value of the family physical activity environment on adolescents' exercise adherence is 0.148, with an effect size of 32.81%. The impact values of exercise self-efficacy and satisfaction between the family physical activity environment and adolescents' exercise adherence are 0.113 and 0.092 respectively, with effect sizes of 25.05% and 20.39%. The chain-mediating effect of exercise self-efficacy and satisfaction is significant, with an effect value of 0.097 and an effect size of 21.50%. Family physical activity environment can directly and positively predict adolescents' exercise adherence, positively predict adolescents' exercise adherence through the independent mediating role of exercise self-efficacy and satisfaction, and also positively predict adolescents' exercise adherence through the chain mediating role of exercise self-efficacy and satisfaction. This provides a theoretical reference for enhancing adolescents' exercise adherence and improving their levels of physical health.

Keywords Family physical activity environment, Exercise self-efficacy, Exercise satisfaction, Adolescents, Exercise adherence

The Physical Activity and Sedentary Behavior Guidelines released by the World Health Organization (WHO) in 2020 provide more specific guidelines for adolescents to be physically active, with an average of at least 60 min of moderate to vigorous physical activity per day, vigorous aerobic exercise at least three days per week, and limiting sedentary time, especially screen time, among other things. The World Health Summit 2022 released a report stating that 80% of adolescents do not get enough exercise in terms of time and intensity. Inadequate physical activity is a major cause of declining physical health among adolescents, and lack of physical activity leads to overweight and obesity and can lead to a range of chronic diseases^{1,2}. Engaging in regular physical activity is a key initiative to reduce morbidity and maintain adolescent physical and mental health³.

Human behaviors are the result of the interaction between the environment and the self-beliefs⁴. The family is considered to be the most important environment for shaping children's physical activity⁵, and has a sustained influence effect⁶. Parents' physical education concepts and exercise habits have a significant impact on adolescents' physical activity behaviors, which helps to develop active exercise habits and lifelong awareness of physical education⁷. The family physical activity environment is able to effectively improve adolescents' self-efficacy and enhance exercise adherence through the improvement of exercise self-efficacy⁸. The family physical activity environment can enhance adolescents' exercise satisfaction⁹. Exercise satisfaction has a positive effect on the improvement of physical activity adherence. Based on this, this study will explore the relationship between family physical activity environment, adolescents' exercise self-efficacy, exercise satisfaction and adolescents' physical activity adherence from a family perspective. In order to reveal the unique advantages of the family physical activity environment in adolescents' exercise adherence, to make targeted suggestions for the improvement of adolescents' exercise adherence level, and to promote adolescents' physical and mental health.

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Theoretical basis and hypothesis

The relationship between family physical activity environment and adolescents' exercise adherence

Adolescents' exercise adherence is the implicit psychological trait and outward behavioral state of an individual who insists on long-term, regular, and long-lasting physical exercise¹⁰. Adolescents' exercise adherence can effectively promote physical health and improve one's psychological quality and regulate psychological state¹¹. Social cognitive theory emphasizes the interaction between the environment, individual characteristics and behavior, and the environment can influence individual behavior and learning process by providing model behaviors, providing feedback, setting incentives and providing social support, etc. Scholars such as McLeroy have proposed the social ecological model to emphasize the influence of the environment on individual behavior¹², and the family factors will affect the development of individual physical activity behavior change direction¹³. It can be seen that the family physical activity environment is an exogenous driving force to enhance adolescents' volitional qualities and improve their behavioral status¹⁴. The family physical activity environment includes the family physical environment, which refers to the availability and accessibility of family physical activity resources, and the family social environment, which refers to the strategies and role modeling of parents in physical activity¹⁵. Self-Determination Theory, proposed by Deci, emphasizes that individuals are capable of optimal self-regulation and performance when their basic psychological needs are satisfied. These needs include autonomy, competence, and relatedness, and the fulfillment of each need generates self-determined motivation¹⁶. The family physical activity environment can satisfy adolescents' needs for autonomy, competence, and relatedness, which can facilitate the transition from external motivation to internal motivation¹⁷. This means that adolescents' motivation for physical exercise can shift from external rewards, punishments, or social expectations to being driven by their intrinsic interest, enjoyment, and perceived value of exercise itself, thereby promoting their exercise adherence. Hypothesis H1: The family physical activity environment positively predicts adolescents' exercise adherence.

The mediating role of exercise self-efficacy

According to Bandura, self-efficacy is an individual's initial judgment of whether he or she can accomplish a behavior and whether he or she can successfully perform the behavior that produces the outcome^{18,19}. Adolescent exercise self-efficacy is the cognitive ability of an individual to strongly believe that he or she can accomplish a given exercise goal or task²⁰. Michael et al., in their study of psychological factors related to exercise adherence, found that self-efficacy can be increased by familiarity with people, environments, and procedures²¹. Self-efficacy theory suggests that an individual's self-efficacy has an impact on individual behavior, and that exercise self-efficacy is the one psychological factor variable most closely related to exercise behavior²². Self-efficacy has a significant impact on exercise duration and intensity, and adolescents with high self-efficacy are more regular in their physical activity²³. The greater the adolescent's exercise self-efficacy, the greater the effort and persistence in exercise behavior²⁴. Based on this, the present study proposed the hypothesis H2: exercise self-efficacy mediates the relationship between family physical activity environment and adolescents' exercise adherence.

The mediating role of exercise satisfaction

According to Bandura, satisfaction is an important measure of an individual's willingness²⁵. Exercise satisfaction is the degree to which adolescents are satisfied with their personal exercise or sports activities. The formation of adolescents' physical activity satisfaction is influenced by external factors such as teachers, parents, and peers, and parental support has a significant impact on adolescents' physical activity satisfaction⁹. Parents' correct exercise beliefs, supportive family physical activity behaviors, and a facilitative family physical activity environment will positively contribute to adolescents' physical activity satisfaction²⁶. Adolescents' satisfaction with their own participation in physical activity status directly affects adolescents' physical activity behavior²⁷. The higher the adolescents' exercise satisfaction, the stronger the level of adolescents' exercise adherence²⁸. Based on this, the study proposes hypothesis 3: exercise satisfaction mediates the relationship between family physical activity environment and adolescents' exercise adherence.

Chain mediation of exercise self-efficacy and satisfaction

The emotional experience of adolescents' exercise is one of the most important factors influencing individual exercise adherence²⁹. Positive emotional experiences, encompassing feelings of joy, fulfillment, and energy during the exercise process, contribute to enhancing exercise adherence³⁰. There is a strong correlation between adolescents' exercise self-efficacy and satisfaction, and individual exercise self-efficacy has a positive effect on exercise satisfaction^{27,31}. That is, enhancing adolescents' confidence in overcoming obstacles to exercise leads to increased satisfaction with their physical activity. It also has the ability to play a sustained mediator role in the intervention of physical activity³². This suggests that positive emotions during physical activity will be enhanced as exercise self-efficacy increases. Based on this, the present study proposed Hypothesis H4: Exercise self-efficacy and exercise satisfaction may mediate between family physical activity environment and adolescents' exercise adherence. Based on previous theories and studies, the hypothesized model shown in Fig. 1 is constructed.

Research participants and methods

Participants and sampling

Referring to Wang Rui yuan's definition of adolescents³³, the group of 12 to 18-year-olds was chosen as the stage to focus on, i.e., adolescents at the secondary school level (junior high school and senior high school) and their parents were surveyed. A stratified random sampling method was employed to conduct a questionnaire survey among students from two junior high schools and two high schools in Shandong Province, China. Prior to the

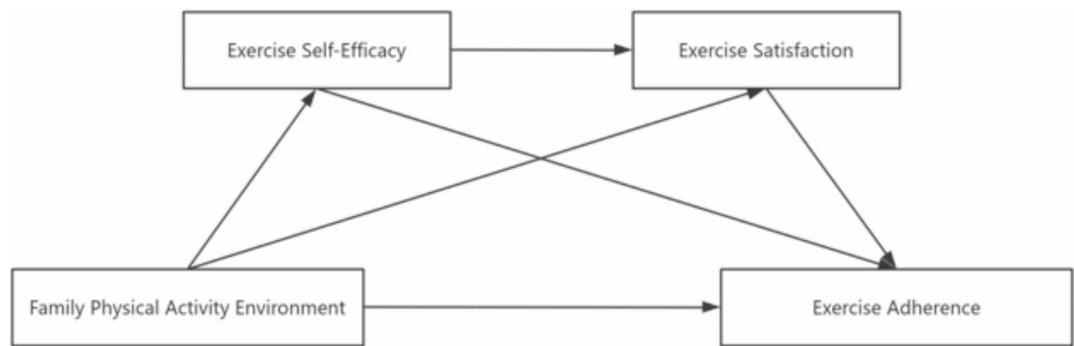


Fig. 1. A hypothetical model of family physical activity environment affecting adolescents' exercise adherence.

testing, consent was obtained from the schools, parents, and the students themselves. The questionnaire adhered to the principles of voluntary participation, data confidentiality, and anonymous completion.

After the questionnaires were collected, invalid questionnaires were excluded for data entry, and 500 valid data were finally retained. In the valid sample, there were 254 male and 246 female participants; 297 were junior high school students, and 203 were high school students. Among the collected questionnaires, those with any of the following issues were considered invalid: (1) inconsistent responses to reverse-scored items; (2) excessively short completion times; (3) clear patterns of repetitive answer choices.

Research methodology

Family physical activity environment scale

The Family Physical Activity Environment Scale compiled by Yang Jiapeng and revised by Zhang Ning (2023) was used, which was divided into three parts: family physical environment, family behavioral environment, and family psychological environment. The scale consists of a total of 36 items. The scale questions were set as declarative sentences, and the first-person interrogation method was used. For example, "I often engage in physical activity in front of my children," "I will let my children choose the sports they like," and "I think it is important to be physically active and stay healthy." The questions in the scale were rated on a 5-point Likert scale from "never" to "often", and the total score of the scale indicated the level of family physical activity environment. The results of the reliability test showed that the Cronbach's coefficient of the scale was 0.95, indicating that the scale had good internal consistency.

Exercise self-efficacy scale

It was measured using the Exercise Self-Efficacy Scale developed by Wu, Roni's, and Pender (2002) based on the Maturity Scale, which consists of 12 items. For example, "I will keep exercising even if I feel tired" "I will continue to work on this skill even if I am not good at it" and "I will keep exercising even if I have to get up early on weekends. The questionnaire items were scored on a 5-point Likert scale ranging from "I can't do it" to "I am sure I can do it", and the total score of the scale was used to indicate the level of adolescents' exercise self-efficacy. The Cronbach's alpha coefficient of the scale was 0.94, indicating that the scale had good internal consistency.

Exercise satisfaction scale

The exercise satisfaction questionnaire developed by Yang Shangjian (2016) was revised based on the Life Satisfaction Scale developed by Diener (1985) and others, which consists of five questions. For example, "My physical activity is in good condition", "The effect of physical activity is close to my ideal state in most aspects", and "I am satisfied during physical activity". These questions were scored on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree". The higher the score, the higher the exercise satisfaction. The results of the reliability test showed that the scale had good internal consistency with a Cronbach's alpha coefficient of 0.89.

Exercise adherence scale

The exercise adherence scale developed by Wang Shen (2016) was used for measurement. The scale includes 3 sub-dimensions, i.e., effort participation dimension, affective experience dimension, and behavioral habit dimension, and there are 14 questions in this scale. For example, "I participate in physical activity at least three times a week," "I am determined to persist in physical activity," and "I will try to eliminate distractions and persist in physical activity." These questions were scored on a five-point Likert scale from "completely disagree" to "completely agree", and the total score of the scale was used to indicate the extent to which the adolescents adhered to physical activity. The Cronbach's alpha coefficient for the scale was 0.94, indicating good internal consistency of the scale.

Data statistics and analysis

This study used SPSS 27.0 statistical software for data analysis. First, reliability was tested using Cronbach's alpha test and common method bias after data collection was tested using Harman's one-way test. Second, after importing the data into SPSS, demographic analysis was performed using descriptive statistics. Pearson's correlation coefficient was used to analyze the correlation between home physical activity environment, exercise

Dependent variable	Independent variable	N=500	M±SD	t	p
Family physical activity environment	Gender	Male (254)	3.900±0.572	7.721	<0.001
		Female (246)	3.493±0.605		
	Grade	Junior high school (297)	3.716±0.557	0.683	0.495
		Senior high school (203)	3.676±0.708		
Exercise adherence	Gender	Male (254)	4.328±0.572	11.795	<0.001
		Female (246)	3.566±0.841		
	Grade	Junior high school (297)	4.096±0.676	4.577	<0.001
		Senior high school (203)	3.744±0.940		
Exercise self-efficacy	Gender	Male (254)	3.852±0.761	11.409	<0.001
		Female (246)	3.035±0.839		
	Grade	Junior high school (297)	3.549±0.804	2.893	0.004
		Senior high school (203)	3.305±1.004		
Exercise satisfaction	Gender	Male (254)	4.112±0.707	11.039	<0.001
		Female (246)	3.370±0.794		
	Grade	Junior high school (297)	3.825±0.732	2.410	0.016
		Senior high school (203)	3.633±0.960		

Table 1. Sample size demographic information and independent sample *t* test. ***p*<0.01, ****p*<0.001.

	Family physical activity environment	Exercise self-efficacy	Exercise satisfaction	Exercise adherence
Family physical activity environment	1			
Exercise self-efficacy	0.562**	1		
Exercise satisfaction	0.617**	0.775**	1	
Exercise adherence	0.560**	0.691**	0.721**	1

Table 2. Pearson correlation coefficient. ***p*<0.01.

self-efficacy and exercise satisfaction and exercise adherence. Multiple regression analyses were conducted using Model 6 in the SPSS PROCESS macro program developed by Hayes. Bootstrap test was used to assess the significance level of the mediating effect so as to analyze the study.

Research results

Common method bias test

A combination of procedural controls and Harman's one-way tests were used to test for possible common methodological biases. The study emphasized, bolded, labeled, and highlighted "This survey is for research use only" in the lead-in of the questionnaire and included three reverse questions in the family physical activity environment questionnaire. After the questionnaires were returned, invalid questionnaires were excluded and data were entered. A common method bias test was conducted using Harman's one-way test, and the results showed that there were eight factors with eigenvalues greater than 1, and the amount of variation explained by the first factor was 36%, which was less than the critical value of 40%. Therefore, it was concluded that there was no serious common method bias in this study.

Descriptive statistics and correlation analysis of each variable

Independent samples *t*-test was used to analyze the differences in family physical activity environment, physical activity adherence, exercise self-efficacy and satisfaction among adolescents of different genders and grades. The results showed that boys were better than girls in family physical activity environment, physical activity adherence, exercise self-efficacy and satisfaction, showing significant differences. Middle school students were better than high school students in physical exercise adherence, exercise self-efficacy and satisfaction, showing significant differences. Family physical activity environment did not show significant differences between middle school and high school students (Table 1).

As shown in Table 2, Pearson correlation analyses were conducted on home physical activity environment, exercise self-efficacy, exercise satisfaction and exercise adherence. The results showed that there were significant correlations between all the research variables, and they were significantly positive, and the hypothesis 1 was verified. This provides support for further constructing structural equation models.

Test of Intermediate Effect

As shown in Table 3, the chain mediation effect was tested using Model 6 of the SPSS macro program prepared by Hayes. The mediating effects of exercise self-efficacy and satisfaction between family physical activity environment and adolescents' exercise adherence were tested by using gender and grade as control variables.

Equation of regression		Overall fit index			Significance of regression coefficient		
Result variable	Variable of prediction	R	R2	F	β	t	p
Exercise self-efficacy	Gender	0.640	0.409	114.674	-0.300	-8.219	0.000***
	Grade				-0.106	-3.087	0.002**
	Family physical activity environment				0.460	12.603	0.000***
Exercise satisfaction	Gender	0.809	0.655	235.389	-0.091	-3.084	0.002**
	Grade				-0.022	-0.836	0.403
	Family physical activity environment				0.256	7.996	0.000***
	Exercise self-efficacy				0.585	17.064	0.000***
Exercise adherence	Gender	0.779	0.607	153.187	-0.143	-4.477	0.000***
	Grade				-0.128	-4.509	0.000***
	Family physical activity environment				0.148	4.064	0.000***
	Exercise self-efficacy				0.245	5.315	0.000***
	Exercise satisfaction				0.361	7.527	0.000***

Table 3. Regression analysis between variables. ** $p < 0.01$, *** $p < 0.001$.

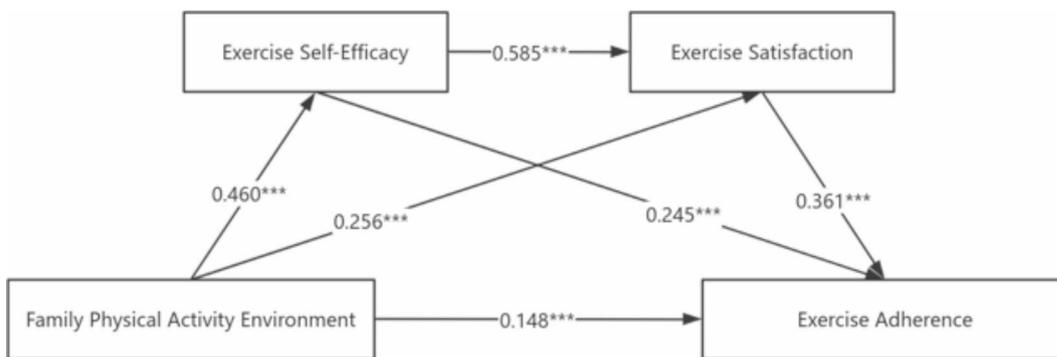


Fig. 2. A mediating model of family physical activity environment affecting adolescents’ exercise adherence (*** $p < 0.001$).

Influence path	Effect size	Boot SE	95% confidence interval		Proportion
			BootLLCI	BootULCI	
Total effect	0.451	0.046	0.496	0.679	100%
Direct effect	0.148	0.047	0.099	0.286	32.81%
Ind1	0.113	0.029	0.056	0.173	25.05%
Ind2	0.092	0.023	0.050	0.140	20.39%
Ind3	0.097	0.020	0.057	0.138	21.50%
Total indirect effect	0.303	0.035	0.234	0.370	67.18%

Table 4. Proportion of the mediating effect.

The results showed that family physical activity environment had a significant positive predictive effect on exercise self-efficacy ($\beta = 0.460, p < 0.001$), exercise satisfaction ($\beta = 0.256, p < 0.001$), and exercise self-efficacy had a significant positive predictive effect on exercise satisfaction ($\beta = 0.585, p < 0.001$), and adolescents’ exercise adherence ($\beta = 0.245, p < 0.001$), had a significant positive predictive effect, and exercise satisfaction had a significant positive predictive effect on adolescents’ exercise adherence ($\beta = 0.361, p < 0.001$). When exercise self-efficacy and satisfaction were jointly included in the structural equation, family physical activity environment was a significant positive predictor of adolescent exercise adherence ($\beta = 0.148, p < 0.001$).

Chain mediation model test

The results of the path coefficients are shown in Fig. 2. The bias-corrected percentile Bootstrap method was used to test the mediating effect (Table 4). The total mediation effect value of exercise self-efficacy and satisfaction between family physical activity environment and adolescents’ exercise adherence was 0.303, and the ratio of the

mediation effect to the total effect was 37.18%. The 95% confidence interval did not contain zero, which indicated that the total mediation effect between family physical activity environment and adolescents' exercise adherence was significant. The total mediation effect consisted of three paths: Ind1: The mediation effect of exercise self-efficacy in the relationship between family physical activity environment and adolescents' exercise adherence, the mediation effect value was 0.113, and the mediation effect accounted for 25.05% of the total effect. The 95% confidence interval did not contain zero, which indicated that the mediation effect of exercise self-efficacy was significant. Ind2: The mediation effect of exercise satisfaction in the relationship between family physical activity environment and adolescents' exercise adherence, the mediation effect value was 0.113, and the mediation effect accounted for 25.05% of the total effect. 95% confidence interval did not contain zero, which indicated that the mediation effect of exercise self-efficacy was significant. The mediating effect of exercise satisfaction between family sports environment and adolescents' exercise adherence, the mediating effect value is 0.092, and the ratio of the mediating effect to the total effect is 20.39%. 95% confidence interval does not contain zero, indicating that the mediating effect of exercise satisfaction is significant. Thirdly, the chain mediation of exercise self-efficacy and satisfaction between family physical activity environment and adolescents' exercise adherence, the mediation effect value was 0.097, and the ratio of the mediation effect to the total effect was 21.50%. 95% confidence interval did not contain zero, which indicated that the chain mediation effect was significant. The above results indicate that the three indirect effects have reached a significant level, and hypothesis 2, hypothesis 3 and hypothesis 4 are valid.

Discussion

To explore the underlying mechanisms through which the family physical activity environment influences adolescents' exercise adherence, our study constructed a chain-mediated model. This model analyzed the chain-mediated role of exercise self-efficacy and exercise satisfaction on adolescents' exercise adherence. This not only helps to uncover the effects of the family physical activity environment on exercise adherence and the mechanisms involved but also provides empirical evidence and recommendations for enhancing adolescents' exercise adherence.

Relationship between family physical activity environment and adolescents' exercise adherence

The results of this study confirmed that the family physical activity environment was significantly and positively associated with adolescents' exercise adherence³⁴. This suggests that the family physical activity environment is a positive factor influencing adolescents' exercise adherence, and that a supportive family physical activity environment as perceived by adolescents has a significant positive and direct effect on both exercise participation and exercise adherence³⁵. The family physical environment both factors, along with the physical activity behaviors of family members, jointly influence an individual's physical activity participation³⁶. On the one hand, the family physical activity environment, including the accessibility of sports resources and facilities in and around the family, directly affects the convenience and possibility of physical activity for adolescents. On the other hand, the attitudes of family members towards physical exercise, their degree of participation and their sports interaction with adolescents have a direct impact on the formation of the family sports atmosphere. Through family members' behavioral modeling, support and encouragement, and the provision of relevant sports facilities and resources, families can promote adolescents' physical activity and help adolescents develop healthy lifestyle habits⁹.

Mediating role of exercise self-efficacy and satisfaction

The results of this study found that exercise self-efficacy mediated the relationship between family physical activity environment and adolescents' exercise adherence, and that self-efficacy served as a bridge between the family physical activity environment and adolescents' exercise³⁷. Exercise self-efficacy is an assessment of adolescents' confidence and competence in accomplishing a specific physical activity task, and a satisfactory external environment and interpersonal support can help to increase an individual's confidence in participating in physical activity³⁸. The ability of the family physical activity environment to influence adolescents' exercise adherence is related to its ability to increase adolescents' sense of competence, effort, and control. The ability of the family physical activity environment to influence adolescents' exercise adherence is inextricably linked to the sense of competence, effort, and control that enhance adolescents' exercise adherence. Self-efficacy is often considered the most common mediating variable influencing physical activity³⁹. Exercise self-efficacy is an important factor influencing adolescents' exercise adherence, and adolescents with high exercise self-efficacy have a more positive attitude toward exercise and a stronger sense of competence in exercise^{40,41}. Adolescents' exercise adherence and motivation can be enhanced.

Exercise satisfaction can directly respond to the extent to which adolescents' expectations of exercise goals are met during physical activity, the comfort of the exercise environment, and their post-exercise condition, etc. Adolescents' satisfaction with physical activity is affected by parental support and encouragement^{42,43}. A good family physical activity environment and exercise practices will promote adolescents' psychological state of positive exercise, and the likelihood of adolescents' sustained physical activity will increase accordingly⁴⁴. By creating a positive family sports atmosphere, providing material support, and emphasizing the importance of physical activity, families can help adolescents establish good physical activity habits and increase the level of adolescent exercise satisfaction. Satisfaction of psychological needs can modulate the relationship between perceived exercise and exercise behavior⁴⁵. Satisfying adolescents' exercise experience can improve individual exercise adherence^{46,47}.

The mediating chain effect of family physical activity environment and adolescents' exercise adherence

The results of the chain mediation test showed that exercise self-efficacy and exercise satisfaction had a chain mediating effect between family physical activity environment and adolescents' exercise adherence. Self-efficacy is an important factor influencing adolescents' physical exercise satisfaction, and the stronger the adolescents' exercise self-efficacy, the higher the exercise satisfaction^{31,48}. According to the theory of planned behavior, an individual's attitudes, subjective norms, and perceptual-behavioral control can have a significant impact on his or her behavioral decisions⁴⁹. Perceived behavioral control can be understood as self-efficacy as proposed by Bandura⁵⁰. Adolescents with high exercise self-efficacy can measure their abilities and can be confident in overcoming difficulties encountered during exercise. Individual attitudes are expressed as physical exercise satisfaction, and adolescents with high exercise satisfaction acquire motor skills and health knowledge through physical exercise, understand the meaning of physical exercise and physical health, and develop a good sense of and interest in physical exercise^{51,52}. The ecological model of exercise suggests that human exercise behavior is influenced by environmental and individual factors. A good family physical activity environment helps adolescents to better utilize their potential, overcome various challenges in the process of physical activity, and increase their confidence in adhering to exercise. This results in a positive emotional experience of physical exercise and inspires stronger perseverance and action.

From the perspective of the interaction between external environment and adolescents' intrinsic, the comprehensive effects of family physical activity environment, exercise self-efficacy and exercise satisfaction on adolescents' exercise adherence are explored. Admadi et al. drawing from Self-Determination Theory, proposed a classification system for motivational behaviors. This system detailed how educators' specific actions can support the three needs of autonomy, competence, and relatedness, thereby fostering individuals' intrinsic motivation and autonomy⁵³. This provides significant theoretical guidance for designing interventions aimed at enhancing adolescents' motivation for physical activity, which can effectively promote their participation in sports and healthy behaviors. A supportive atmosphere in the family physical activity environment, such as the provision of ample sports equipment by the family, parental support and encouragement, can meet adolescents' needs for autonomous choice in exercise programs, improve their ability to engage in physical activity, and strengthen their connections with family members and peers. This can facilitate the internalization of motivation for adolescents, deepening their interest and love for physical activity itself, thereby cultivating a more enduring and profound motivation for regular exercise.

In order to enhance adolescents' exercise adherence and maximize their physical and mental health, families are encouraged to create a positive and enjoyable physical exercise environment and give adolescents more exercise support. By providing a comprehensive supportive family physical activity environment, the external conditions for adolescents' physical activity are met, thereby overcoming their self-efficacy barriers to exercise, which involves addressing underestimations of their own exercise capabilities, fears of failure, and enhancing their confidence in exercise. This subsequently enhances adolescents' satisfaction with the outcomes of participating in physical activity, thereby increasing their willingness to persist in exercising regularly. In the future, we should develop adolescents' exercise self-efficacy and exercise satisfaction from the perspective of guiding and enriching adolescents' exercise cognition in order to enhance their exercise adherence level.

Conclusions

Family physical activity environment, which promotes adolescents' exercise adherence, serves as an external factor, while exercise self-efficacy and satisfaction performs as an internal factor that exerts influence on adolescents' exercise adherence. At the same time, family physical activity environment cannot only impose influence on adolescents in a direct manner, but also affects their exercise satisfaction state through self-efficacy, thus indirectly affecting their exercise adherence. Exercise self-efficacy and satisfaction play a mediating role in the interpersonal effect on exercise adherence.

Data availability

The original contributions presented in the study and included in the article and its supplementary information files. Further inquiries can be directed to the corresponding authors.

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Author contributions

XYH was responsible for the data analysis and writing of the original draft preparation. JY was responsible for data analysis and methodology. XYH was responsible for the conceptualization, writing, reviewing and editing

the draft. JY was responsible for the conceptualization, writing, reviewing and editing the draft, and funding acquisition. All authors have read and approved the final manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

The design of this study followed the guidelines and regulations of the Declaration of Helsinki and approved by Ethics Committee of Liaoning Normal University (LL2024078), and all participants signed an informed consent form and were paid for their participation.

Informed consent

Written informed consent was obtained from all the participants and their parents (or legal guardian) prior to this study.

Additional information

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