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Family Physical Activity Environment and Adolescent Suicidal Ideation: The Mediating Roles of Parent‑Child Relationship and Resilience and the Moderating Role of School Connectedness

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Abstract: Background: To examine the association between the family physical activity environment and adolescent suicidal ideation. We also examined the serial mediation effect through parent–child relationship and resilience, and the direct and moderating effects of school connectedness. **Methods:** A total of 727 secondary school students completed the Family Physical Activity Environment Scale, Suicidal Behavior Screening Questionnaire, Parent–Child Relationship Scale, Chinese resilience scale, and School Connectedness Scale. **Results:** (1) Family physical activity environment, parent–child relationship, resilience, and school connectedness were positively intercorrelated. All four variables were significantly negatively correlated with suicidal ideation. (2) Both the total and direct associations of family physical activity environment with suicidal ideation were significant. The indirect association through resilience and the serial indirect association through parent–child relationship and resilience were significant. The indirect association through parent–child relationship alone was nonsignificant. (3) School connectedness was significantly negatively associated with suicidal ideation. It also significantly moderated the associations of family physical activity environment and resilience with suicidal ideation. Both negative associations were stronger at higher levels of school connectedness. **Conclusions:** Family physical activity environment was directly and negatively associated with adolescent suicidal ideation. It was also indirectly associated with lower suicidal ideation through resilience and through the sequential pathway from parent–child relationship to resilience. School connectedness was independently and negatively associated with suicidal ideation and strengthened the associations of family and individual protective resources with suicidal ideation.

Keywords: family physical activity environment; suicidal ideation; parent–child relationship; resilience; school connectedness; adolescents

1 Introduction

Suicidal ideation refers to a cognitive state involving an urge to end one's life without having attempted suicide. It is described as a necessary psychological stage preceding suicidal behavior [1, 2]. It is also among the most commonly used and sensitive indicators for predicting suicidal behavior. The World Health Organization reports that more than 720,000 people die by suicide worldwide each year. Suicide is the third leading cause of death among people aged 15–29 years [3]. Suicide-related problems among children and adolescents in China also warrant attention. A meta-analysis included 132 studies involving 1,103,309 children and adolescents younger than 18 years. It reported pooled prevalence estimates of 15.400%, 6.400%, and 3.500% for suicidal ideation, suicide planning, and suicide attempts, respectively, in mainland China [4]. These estimates vary by sex, educational stage, and region. Adolescence involves rapid physical and psychological changes, alongside increasing academic and interpersonal stress. Supportive family and school environments substantially influence adolescents' psychological adjustment [5]. Examining the mechanisms underlying adolescent suicidal ideation through modifiable family and school resources therefore has theoretical and practical value.

Previous research identifies a substantial association between physical activity and suicidal ideation [6]. However, the variables examined in existing reviews suggest that research primarily addresses physical activity levels and individual behaviors. These include individual characteristics, activity types, and populations participating in physical activity [6]. Less attention has been given to the family physical activity environment. This integrated system encompasses material resources for physical activity, parental role modeling, joint participation, encouragement and support, and an educational climate surrounding physical activity [6]. This study therefore examined how family physical activity environment was associated with suicidal ideation among adolescents. A systematic review of family physical activity interventions suggests that joint family participation may increase physical activity. It may also improve family functioning, including cohesion, organization, and communication [7]. Research on Chinese junior and senior secondary school students has associated a more favorable family physical activity environment with better parent–child relationships and mental health [8]. Better family functioning and satisfaction with family relationships can provide psychological support for adolescents. They may reduce loneliness, defeat, and hopelessness, thereby reducing psychological risk factors for suicidal ideation [9].

Accordingly, H1 proposes that family physical activity environment is negatively associated with adolescent suicidal ideation.

Parent–child relationship comprises patterns of emotional connection, support, communication, and conflict formed through sustained interactions between parents and children. Attachment theory holds that consistent and sensitive caregiver responses provide a secure base for children. Such responses support positive internal working models of self and others, exploration, emotion regulation, and help-seeking during difficulties [10]. Joint physical activity, parental companionship, and encouragement within the family physical activity environment can create low-threat situations with frequent opportunities for parent–child communication. These situations may facilitate reciprocal understanding and support [7, 11, 12]. Parental understanding and communication are associated with lower depression, self-harm, and suicidal ideation [13]. Greater family closeness within parent–child relationship is also an important protective factor associated with lower suicidal ideation [14]. Conversely, excessive control, overprotection, limited care, and relationship conflict may increase defeat, loneliness, and helplessness. They may also weaken adolescents' willingness to seek help [15, 16]. Family physical activity environment may therefore improve parent–child relationship and subsequently reduce suicidal ideation. Accordingly, H2 proposes a mediation effect of parent–child relationship in the association between family physical activity environment and adolescent suicidal ideation.

Resilience refers to the capacity and process of maintaining or restoring adaptive functioning when facing stress, setbacks, or adversity [17]. The broaden-and-build theory holds that positive emotions broaden immediate thought and action repertoires. Their accumulation builds cognitive, social, and psychological resources [18]. The dynamic model of resilience also suggests that positive external developmental resources promote the formation and development of internal psychological resources, including resilience [19]. Family physical activity may thus support psychological resource development through enjoyable experiences, goal achievement, competence, and stress regulation [20]. Empirical research also identifies a positive association between physical activity and adolescent resilience. Self-efficacy and basic psychological needs may contribute to this association [21]. Resilience can help adolescents reappraise stress, regulate negative emotions, mobilize support, and adopt adaptive coping strategies [22, 23]. It may thereby buffer associations between risk factors and suicide-related thoughts and behaviors [24]. Accordingly, H3 proposes a mediation effect of resilience in the association between family physical activity environment and adolescent suicidal ideation.

Ecological systems theory suggests that activities and support within the family environment require sustained proximal interactions to develop into relatively stable individual psychological resources. Parent–child relationship and resilience are therefore not independent in this process. Children first perceive family support through relational experiences. These experiences are then internalized as security, self-efficacy, emotion regulation, and beliefs about problem solving, supporting more stable resilience. Empirical research also suggests that parent–child attachment and trust promote resilience development [25]. The association of parent–child support with resilience is more robust than that of parent–child conflict [26]. Joint activities, role participation, and support within the family physical activity environment may first improve parent–child closeness and communication. Repeated emotional responses, behavioral modeling, and collaborative problem solving may then strengthen adolescents' confidence and capacity to cope with adversity, reducing suicidal ideation. Accordingly, H4 proposes a serial mediation effect through parent–child relationship and resilience in the association between family physical activity environment and adolescent suicidal ideation.

The social support buffering theory suggests that social support can buffer the adverse effects of stressful events on mental health. It can help individuals respond more adaptively to stress and difficulties [27]. School connectedness has received increasing attention as an important relational and protective resource for adolescents [28]. School connectedness refers to students' perceived belonging at school and their sense of acceptance, respect, and support from teachers and peers. It also encompasses perceptions of school fairness and safety [29]. Marraccini and colleagues associate greater school connectedness with less adolescent suicidal ideation and fewer suicide attempts [30, 31, 32]. Greater school connectedness may facilitate more stable experiences of acceptance, support, and belonging. Research also suggests that school connectedness can mitigate internalizing and externalizing responses to adversity [33]. It may thus support the protective role of resilience in its association with suicidal ideation. Conversely, conservation of resources theory suggests that students with lower school connectedness perceive limited relational resources [34]. They may experience greater powerlessness, or learned helplessness [35]. Under stress, they may adopt unconstructive emotion-focused responses or maladaptive behaviors [36, 37]. Their coping resources may consequently become depleted. Reduced belonging may also affect resilience [38], contributing to maladaptive outcomes. Accordingly, H5 proposes that school connectedness is negatively associated with suicidal ideation. H6 proposes that school connectedness moderates the association between family physical activity environment and suicidal ideation. H7 proposes that school connectedness moderates the association between resilience and suicidal ideation.

2 Participants and Methods

2.1 Participants

Sample size was estimated a priori using G*Power 3.1. Given the moderated serial mediation design, the power analysis targeted the increment in explained variance attributable to the moderation effect, using the "Linear multiple regression: Fixed model, R^2 increase" procedure with a small effect size ($f^2 = 0.02$), $\alpha = 0.05$, power = 0.90, one tested predictor, and eight total predictors. The minimum required sample size was 528. The present study included 727 valid questionnaires, which exceeded this requirement for detecting the interaction effect.

Convenience sampling was used to distribute 789 paper and online questionnaires in Shandong. Of these, 727 valid questionnaires were obtained, yielding a valid response rate of 92.142%. Participants included 358 boys and 369 girls. There were 669 participants from two-parent families and 58 from single-parent families or other family types. This study was reviewed and approved by the Ethics Committee of the Faculty of Basic Medical Sciences, Shandong University (approval No. ECSBMSSDU2024-1-141). All participants and their guardians provided written informed consent and were free to withdraw at any time.

2.2 Measures

2.2.1 Family Physical Activity Environment

The Family Physical Activity Environment Scale developed by Yang [39] was used. Following previous studies [40, 41], dimensions related to parent–child relationship were selected: parental control, parental support, and screen-related climate. These dimensions were adapted into parallel adolescent self-report items. The adapted scale contained 13 items, including reverse-scored items. Responses were rated on a 5-point Likert scale, with higher scores indicating a more favorable family physical activity environment. Cronbach's α was 0.870 in this study. The Kaiser–Meyer–Olkin (KMO) value was 0.891, exceeding 0.700, and Bartlett's test of sphericity was significant ($p < .001$). The cumulative percentage of variance explained by the rotated sums of squared loadings for the three dimensions was 67.364%, exceeding 50%. These results suggested that the selected items provided preliminary support for the three-dimensional structure.

2.2.2 Suicidal Ideation

The Suicidal Behavior Screening Questionnaire (SBSQ), developed by Yang and colleagues [42], was used to measure suicidal ideation. The questionnaire contained 8 items. Items 1–2, which directly assess the frequency and severity of suicidal thoughts, were used as the indicator of suicidal ideation in this study; the ideation dimension was designed as an independent dimension in the original scale and has documented psychometric support in Chinese adolescent samples. Responses were rated on an 8-point Likert scale, with higher scores indicating greater suicidal ideation. Cronbach's α was 0.736 for the two items in this study. A two-item index captures the core cognitive dimension of suicidal ideation but cannot fully represent its multi-dimensional features.

2.2.3 Parent–Child Relationship

The Parent–Child Relationship Scale developed by Buchanan and colleagues [43] was used. The scale contained 9 items rated on a 5-point Likert scale. Father–child and mother–child relationships were assessed separately. Higher scores indicated a better parent–child relationship. Cronbach's α was 0.851 in this study.

2.2.4 Resilience

The Chinese version of the 10-item Connor–Davidson Resilience Scale (CD-RISC-10) was used [44]. Responses were rated on a 5-point Likert scale, with higher scores indicating greater resilience. Cronbach's α was 0.876 in this study.

2.2.5 School Connectedness

The School Connectedness Scale (SCS) was used [29]. The scale contained 5 items rated on a 5-point Likert scale. Higher scores indicated greater school connectedness. Cronbach's α was 0.760 in this study.

2.3 Data Processing and Statistical Analysis

SPSS 27.0 was used to assess common method bias and conduct descriptive and correlation analyses. The PROCESS v5.0 macro developed by Hayes and colleagues was used to test mediation and moderation effects. HC3 heteroscedasticity-consistent standard errors were used. Bootstrapping with 5,000 resamples was used, and 95% confidence intervals were reported.

3 Results

3.1 Common Method Bias

Common method bias was examined using Harman's single-factor test and a single-factor confirmatory factor analysis (CFA). In the Harman test, all 39 items were entered into an exploratory factor analysis; 11 factors had eigenvalues greater than 1, and the first factor accounted for 21.931% of the variance, below the 40% threshold [45]. In the single-factor CFA, all 39 items were loaded on a single factor and the model fit was poor: $\chi^2(702) = 8500.35$, $p < .001$, $\chi^2/df = 12.11$, CFI = 0.377, TLI = 0.343, RMSEA = 0.124, SRMR = 0.119. Together, these results suggest that common method bias was not a serious threat in this study.

3.2 Descriptive Statistics and Correlation Analysis

Descriptive statistics and intercorrelations for all study variables are presented in Table 1.

Table 1. Descriptive Statistics and Correlations

Variable	*M*	*SD*	1	2	3	4	5
1 Family physical activity environment	3.220	0.753	—				
2 Parent–child relationship	3.782	0.655	0.314***	—			
3 Resilience	3.550	0.674	0.346***	0.413***	—		
4 School connectedness	3.571	0.797	0.088*	0.121**	0.194***	—	
5 Suicidal ideation	2.546	1.475	-0.342***	-0.192***	-0.315***	-0.335***	—

Note. $n = 727$. *$p < .050$. **$p < .010$. ***$p < .001$.

3.3 Testing the Moderated Serial Mediation Model

First, Model 6 of the PROCESS v5.0 macro for SPSS was used. It tested the serial mediation effect through parent–child relationship and resilience between family physical activity environment and suicidal ideation. Family physical activity environment was significantly negatively associated with suicidal ideation ($\beta = -0.339$, $t = -9.831$, $p < .001$). Parent–child relationship was significantly negatively correlated with suicidal ideation ($r = -0.192$, $p < .001$). Resilience was also significantly negatively correlated with suicidal ideation ($r = -0.315$, $p < .001$). After parent–child relationship and resilience were included, the direct association between family physical activity environment and suicidal ideation remained significant ($\beta = -0.261$, $t = -6.945$, $p < .001$). Family physical activity environment was significantly positively associated with parent–child relationship ($\beta = 0.314$, $t = 9.071$, $p < .001$) and resilience ($\beta = 0.236$, $t = 7.090$, $p < .001$). Parent–child relationship was significantly positively associated with resilience ($\beta = 0.338$, $t = 9.509$, $p < .001$). Resilience was significantly negatively associated with suicidal ideation ($\beta = -0.213$, $t = -5.329$, $p < .001$). However, the direct association between parent–child relationship and suicidal ideation was nonsignificant ($\beta = -0.019$, $t = -0.520$, $p > .05$).

Bootstrapping yielded a completely standardized total indirect effect of -0.079 (*Boot SE* = 0.017, 95% CI [-0.112, -0.047]). The indirect effect through parent–child relationship was -0.006 (*Boot SE* = 0.011, 95% CI [-0.028, 0.016]). Its confidence interval included 0, indicating a nonsignificant effect. The indirect effect through resilience was -0.050 (*Boot SE* = 0.011, 95% CI [-0.074, -0.030]). The serial indirect effect through parent–child relationship and resilience was -0.023 (*Boot SE* = 0.005, 95% CI [-0.034, -0.013]). The latter two effects were significant. Based on the original effects, the total indirect effect accounted for approximately 23.195% of the total effect. The resilience-only pathway accounted for 14.816%, the serial pathway for 6.664%, and the parent–child relationship-only pathway for 1.715% (see Table 2). Thus, H2 was not supported, whereas H3 and H4 were supported.

Table 2. Mediation Effects Through Parent–Child Relationship and Resilience

Model effect	Effect	SE / Boot SE	95% CI		Proportion of total effect
			Lower	Upper	
Total effect	-0.339	0.035	-0.407	-0.272	100.000%
Direct effect	-0.261	0.038	-0.334	-0.187	76.805%
Total indirect effect	-0.079	0.017	-0.112	-0.047	23.195%
Family physical activity environment→Parent–child relationship→Suicidal ideation	-0.006	0.011	-0.028	0.016	1.715%
Family physical activity environment→Resilience→Suicidal ideation	-0.050	0.011	-0.074	-0.030	14.816%
Family physical activity environment→Parent–child relationship→Resilience→Suicidal ideation	-0.023	0.005	-0.034	-0.013	6.664%

Second, Model 90 of the PROCESS v5.0 macro for SPSS was used to test the moderating role of school connectedness. School connectedness was significantly negatively associated with suicidal ideation ($\beta = -0.287$, $t = -8.220$, $p < .001$). The interaction between family physical activity environment and school connectedness was significantly associated with

suicidal ideation (β = -0.131, t = -3.562, p < .001, ΔR^2 = 0.014). The interaction between resilience and school connectedness was also significantly associated with suicidal ideation (β = -0.168, t = -4.844, p < .001, ΔR^2 = 0.027). School connectedness therefore moderated both the direct pathway from family physical activity environment to suicidal ideation and the second-stage pathway from resilience to suicidal ideation. Parent–child relationship was not significantly directly associated with suicidal ideation (β = -0.010, t = -0.304, p > .05). However, it was significantly positively associated with resilience (β = 0.338, t = 9.509, p < .001). This suggested that parent–child relationship contributed to the serial indirect effect primarily through resilience. In the resilience equation, boys had slightly higher resilience than girls (β = 0.085, t = 2.594, p < .01). The coefficient for family type was negative (β = -0.082, t = -2.298, p < .05). In the suicidal ideation equation, adolescents from non-two-parent families had significantly higher suicidal ideation than those from two-parent families (β = 0.070, t = 2.059, p < .05). The coefficient for sex was nonsignificant (p > .05) (see Table 3).

Table 3. Results for the Moderated Serial Mediation Model

Predictor	Equation 1 Parent–child relationship				Equation 2 Resilience				Equation 3 Suicidal ideation			
	r	*β*	*t*	*95%CI*	*r*	*β*	*t*	*95%CI*	*r*	*β*	*t*	*95%CI*
Sex	-0.025	-0.029	-0.806	[-0.098，0.041]	0.078	0.085	2.594**	[0.021，0.149]	0.016	0.012	0.383	[-0.050，0.075]
Family type	-0.033	-0.023	-0.650	[-0.093，0.047]	-0.099	-0.082	-2.298*	[-0.152，-0.012]	0.098	0.070	2.059*	[0.003，0.137]
Family physical activity environment	0.314	0.314	9.071***	[0.246，0.382]	0.346	0.236	7.090***	[0.171，0.301]	-0.342	-0.244	-6.975***	[-0.312，-0.175]
Parent–child relationship					0.413	0.338	9.509***	[0.269，0.408]	-0.192	-0.010	-0.304	[-0.075，0.055]
Resilience									-0.315	-0.171	-4.408***	[-0.247，-0.095]
School connectedness									-0.335	-0.287	-8.220***	[-0.355，-0.218]
Family physical activity environment×School connectedness									-0.193	-0.131	-3.562***	[-0.203，-0.059]
Resilience×School connectedness									-0.186	-0.168	-4.844***	[-0.236，-0.100]
R^2			0.100				0.236				0.298	
F(HC3)			27.958***				52.865***				43.900***	

Finally, simple slope tests were conducted at one standard deviation below and above the mean of school connectedness. (1) At low levels of school connectedness, the negative association between family physical activity environment and suicidal ideation remained significant, although it was markedly weaker (βsimple = -0.113, t = -2.073, p < .05). At high levels of school connectedness, this negative association was stronger (βsimple = -0.374, t = -8.062, p < .001; Fig. 1). (2) At low levels of school connectedness, resilience was not significantly associated with suicidal ideation (βsimple = −0.003, t = −0.052, p > 0.05). At high levels of school connectedness, resilience was significantly and negatively associated with suicidal ideation (βsimple = −0.339, t = −6.747, p < 0.001), as shown in Fig. 2. The final moderated serial mediation model is presented in Fig. 3.

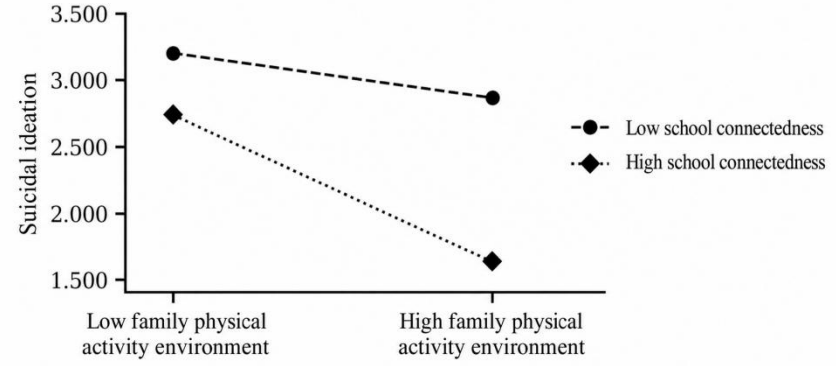


Fig. 1. Moderation by School Connectedness of the Association Between Family Physical Activity Environment and Suicidal Ideation

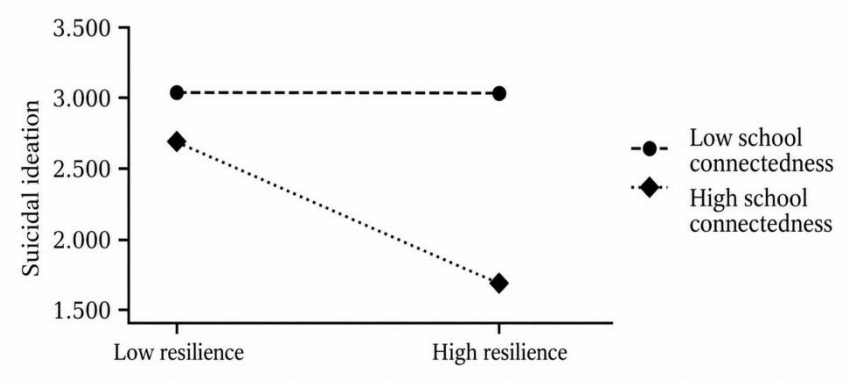


Fig. 2. Moderation by School Connectedness of the Association Between Resilience and Suicidal Ideation

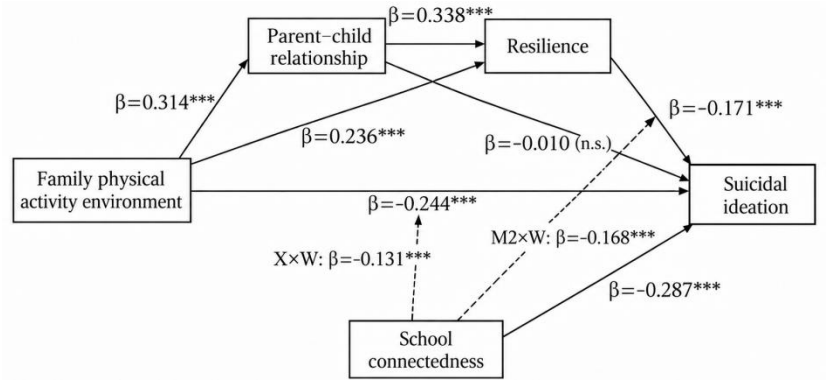


Fig. 3. Moderated Serial Mediation Model Linking Family Physical Activity Environment to Adolescent Suicidal Ideation

3 Discussion

Family physical activity environment was significantly negatively associated with adolescent suicidal ideation, supporting H1. This finding is consistent with previous evidence associating greater physical activity with lower suicide-related risk [6]. Parental support, behavioral modeling, and appropriate behavioral expectations can facilitate sustained adolescent participation in physical activity [46, 47], which may contribute to lower suicidal ideation. Compared with physical activity alone, family physical activity environment is more embedded in daily life, carries greater relational significance, and offers more sustained influence. Its protective association may arise from physical activity itself and the repeated accumulation of parental support, behavioral modeling, and positive feedback during daily interactions. Research identifies physical self-perception and self-esteem as important pathways linking physical activity to mental health [48, 49]. Goal achievement and competence feedback during family physical activity can improve adolescents' physical self-perception and sense of competence. Parental affirmation may help transform short-term success into more stable self-worth. The interpersonal theory of suicide identifies thwarted belongingness and perceived burdensomeness as important sources of suicidal desire [50]. Parental attention and acceptance during physical activity support and rule negotiation may repeatedly communicate two messages: "I can do this" and "I am valued." These messages may reduce subjective experiences of being overlooked or burdening others. A favorable family physical activity environment may therefore be associated with a weaker psychological basis for suicidal ideation by strengthening self-worth and meeting belonging needs.

Family physical activity environment was also indirectly associated with adolescent suicidal ideation through resilience and through the serial pathway from parent–child relationship to resilience. The indirect association through parent–child relationship alone was nonsignificant. Thus, H2 was not supported, whereas H3 and H4 were supported. The zero-order correlation between parent–child relationship and suicidal ideation remained significantly negative ($r = -0.192$, $p < .001$). However, its direct pathway became nonsignificant after family physical activity environment and resilience were included ($\beta = -0.019$, $p > 0.05$). This distinction suggests that a correlation does not imply an independent direct effect. Parent–child relationship may function as a relatively distal external relational resource. It may support resilience by promoting security, self-efficacy, emotion regulation, and problem-solving abilities. Resilience occupies a more proximal position between stress responses and suicidal cognitions. It may directly influence appraisals of setbacks, emotional recovery, and coping, making it the main indirect pathway. The risk–protection framework suggests that protection rarely depends on a single resource acting alone. Instead, protection develops by interrupting negative chain reactions, maintaining self-esteem and efficacy, and creating new opportunities for adaptation [51]. During joint physical activity, adolescents may experience parental reliability,

support after failure, and opportunities to express opinions as evidence of a reliable and secure parent–child relationship [52]. Stable parental support can reduce the impact of negative experiences, such as failure and conflict. It may prevent these experiences from developing into helplessness, self-rejection, and social alienation. Adolescents can also gain mastery experiences and constructive feedback while breaking down goals, adjusting strategies, and resolving difficulties with parents. Self-efficacy theory identifies mastery experiences and verbal persuasion as important sources of efficacy judgments [53]. These experiences may become beliefs that "difficulties can be managed," "effort can change outcomes," and "help is available when needed." Such beliefs may support the development of resilience resources. As an internal protective system, resilience can help adolescents maintain self-esteem and efficacy and mobilize cognitive regulation and problem-solving abilities [54]. It may thereby reduce the likelihood that difficulties develop into hopelessness and suicidal ideation.

School connectedness was significantly negatively associated with suicidal ideation and significantly moderated the associations of family physical activity environment and resilience with suicidal ideation. These findings supported H5, H6, and H7. The developmental contextual perspective posits that adolescent development is the result of ongoing interactions between the individual and multiple contexts, such as the family, school and peer group; protective resources within different developmental contexts may interact to jointly influence the individual's adaptation [55, 56]. Simple slope tests indicated a substantially weaker negative association of family physical activity environment at low school connectedness. The conditional effect of resilience was nonsignificant at this level. At high school connectedness, both negative conditional effects were significant. The weaker protective association of family physical activity environment at low school connectedness suggests that family resources may partly compensate for limited school relationships. Its stronger association at high school connectedness suggests reinforcement through peer acceptance, responsive teachers, and opportunities for participation. These resources may strengthen competence and perceived support developed through family physical activity. Positive self-evaluations may thus be less vulnerable to subsequent exclusion or rejection. Positive peer relationships at school are important protective factors in adolescent development [57]. They are also longitudinally associated with emotion regulation strategies [57]. Multiple protective factors may produce cumulative protective effects [58, 59], supporting potential synergy between family and school resources. The moderating role of school connectedness was particularly evident in the resilience pathway. Resilience was not significantly associated with suicidal ideation at low school connectedness, but its protective effect was substantially stronger at high school connectedness. The interaction framework of resilience suggests that its protective effects depend on whether external support activates and enables the use of internal adaptive capacities [60, 61]. Without trusted confidants, accessible help, and positive feedback, emotion regulation, goal persistence, and help-seeking abilities may be difficult to translate into action. Higher school connectedness provides specific people and feedback through which these abilities can be used. These theories and previous research suggest three mechanisms through which school connectedness may reduce suicidal ideation. (1) Belonging and acceptance at school may strengthen psychological regulation and reduce exclusion and isolation. (2) Daily school interactions may promote joint action and responsibility, creating additional opportunities to identify risk. (3) Positive norms and expectations may encourage help-seeking and help identify individuals at risk of suicide [62].

The covariate results further indicated slightly lower resilience among female adolescents than male adolescents. This may reflect differences in interpersonal stress exposure and rumination during adolescence [63]. Greater rumination may sustain attention to relationship conflict and negative evaluations, delay emotional recovery, and weaken positive reappraisal and problem-solving abilities. Adolescents from non-two-parent families had higher suicidal ideation than those from two-parent families. However, this does not imply that non-two-parent family structure necessarily constitutes a risk. The difference may reflect accumulated stress associated with discontinuous caregiving, increased economic pressure, family conflict, and life changes. These stressors may increase suicidal ideation if they persistently deplete belonging, perceived control, and expectations of available help. Future research should use longitudinal data to distinguish family structure, family functioning, and their interaction.

Limitations

This study has several limitations. First, the cross-sectional design does not permit causal inference. Although the proposed sequence from family physical activity environment to parent–child relationship, resilience, and suicidal ideation is theoretically grounded, temporal order and reverse pathways cannot be excluded, and longitudinal or quasi-experimental designs are needed to test the ordering of these associations. Second, suicidal ideation was assessed with two items from the Suicidal Behavior Screening Questionnaire. Although these items directly capture the frequency and severity of suicidal thoughts and showed acceptable internal consistency ($\alpha = .736$), a two-item index cannot represent the multi-dimensional nature of suicidal ideation, and replication with a more comprehensive instrument is warranted. Third, participants were recruited through convenience sampling in one province of China. The sample was drawn from secondary schools in Shandong and may not represent adolescents in other regions, school types, or cultural contexts, which limits the generalizability of the findings. Fourth, the moderation effects were small in magnitude ($\Delta R^2 = .014$ for the family environment × school connectedness interaction and .027 for the resilience × school connectedness interaction), indicating that other individual and contextual factors also contribute to suicidal ideation.

Conclusion

Using a cross-sectional sample of 727 Chinese secondary school students, this study found that a more favorable family physical activity environment was associated with lower suicidal ideation, both directly and indirectly through resilience and through the sequential pathway from parent–child relationship to resilience, whereas the standalone indirect association through parent–child relationship was not supported. School connectedness was independently and negatively associated with suicidal ideation and moderated the associations of family physical activity environment and resilience with suicidal ideation, with stronger associations at higher levels of school connectedness. Although the cross-sectional design precludes causal conclusions, these findings suggest that family-based physical activity programs and school-based efforts to strengthen connectedness may be complementary entry points for adolescent suicide prevention, and they highlight the need for longitudinal studies that examine how family and school resources interact over time.

List of abbreviations

FPAE, family physical activity environment; PCR, parent–child relationship; CD-RISC-10, 10-item Connor–Davidson Resilience Scale; SCS, School Connectedness Scale; SBSQ, Suicidal Behavior Screening Questionnaire; SI, suicidal ideation; CMV, common method bias; CFA, confirmatory factor analysis; CFI, comparative fit index; TLI, Tucker–Lewis index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Faculty of Basic Medical Sciences, Shandong University (approval No. ECSBMSSDU2024-1-141). Written informed consent was obtained from all participants and their legal guardians. All procedures were performed in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analysed during the current study are not publicly available owing to the confidentiality of adolescent participants' responses, but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

H.W. designed the study, conducted the statistical analyses, and drafted the manuscript. Y.D. and X.W. contributed to the study design and data collection. Yan G. and Ying G. contributed to data collection and data curation. J.G. and X.Z. contributed to the literature review and critical revision of the manuscript. All authors read and approved the final manuscript.

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