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Impact of awareness of sports policies, school, family, and community environmental on physical activity and fitness among children and adolescents: a structural equation modeling study

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Abstract

Background Understanding the impact of environmental factors on physical activity (PA) and physical fitness (PF) is crucial for promoting a healthy lifestyle among children and adolescents. This study examines how awareness of sports policies, school, family, and community environments influence PA and PF in Chinese youth.

Methods A cross-sectional study was conducted with 2747 children and adolescents (mean age 12.90 ± 2.49; 48.2% male) from 17 schools across five Chinese cities. Environmental factors were assessed via questionnaires, and PA levels were measured using the International Physical Activity Questionnaire-Short Form (IPAQ-SF). PF metrics, including BMI, waist-to-height ratio, grip strength, vertical jump, and 20-m shuttle run test (20-mSRT), were measured onsite. Structural Equation Modeling (SEM) was used to explore relationships between environmental factors and PA/PF outcomes.

Results The school environment scored highest (78.0 ± 9.5), while the community environment scored lowest (38.7 ± 18.0). Family environment positively influenced low-intensity PA (LPA) (β = 0.102, $P < 0.001$) but negatively affected moderate-to-vigorous PA (MVPA) (β = -0.055, $P = 0.035$). Community environment and awareness of sports policies positively impacted MVPA (β = 0.216, $P < 0.001$; β = 0.072, $P = 0.009$, respectively). Family environment positively influenced BMI reduction (β = -0.103, $P < 0.001$) but negatively affected grip strength (β = -0.063, $P = 0.018$). Community environment improved grip strength and 20-mSRT performance (β = 0.088, $P = 0.002$; β = 0.065, $P = 0.027$).

Conclusions School environments, despite high scores, do not significantly impact PA and PF. Community environments, though scoring lower, positively affect MVPA, grip strength, and 20-mSRT. Awareness of sports policies boosts MVPA, while family environments support LPA and BMI but are inversely related to MVPA and grip strength. Integrated strategies involving community infrastructure, family support, and policy awareness are essential for promoting active lifestyles among children and adolescents.

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Keywords Physical activity, Physical fitness, Children, Adolescent, Environmental factors, Structural equation modeling

Background

Physical fitness (PF) in children and adolescents is intricately linked to their health status and encompasses both health-related and performance-related components [1]. Health-related PF includes measures such as body composition, muscular strength, muscular endurance, and cardiorespiratory function (CRF), which are critical for maintaining overall health and preventing chronic diseases [2, 3]. Performance-related PF, on the other hand, involves attributes like agility, speed, and explosive power, which are essential for optimal athletic performance [4]. During these formative years, PF serves as a positive indicator of current health status and plays a pivotal role in ensuring well-being during adolescence and laying a solid foundation for health in adulthood [5]. An expanding body of evidence underscores the developmental trajectories during childhood and adolescence as being significantly associated with reduced metabolic risk factors later in life, including obesity, hypertension, dyslipidemia, and insulin resistance [6, 7]. This highlights the critical importance of fostering robust PF from an early age as a vital determinant of future health outcomes and as a strong predictor for subsequent morbidity and mortality rates.

Despite the recognized importance of PF, the status among children and adolescents globally, especially in China, is concerning. Recent surveys indicate that only a small percentage of the youth in China meet the recommended PF standards, with less than 30% of those aged 9 to 18 achieving national fitness benchmarks [8]. Moreover, the past decade has witnessed a significant decline in key PF indicators within this demographic, including running performance, jump length, and overall physical strength [9, 10, 11].

The deterioration in PF among children and adolescents can largely be attributed to an increase in sedentary behavior and a reduction in engagement with physical activity (PA) [12]. During childhood and adolescence, particularly throughout school years, PA is positively correlated with PF metrics [13, 14], demonstrating benefits such as reduced cardiometabolic risk, decreased fat accumulation, and enhanced muscular and skeletal health. These health benefits associated with active behaviors extend into adulthood [15]. To encourage higher levels of PA during these crucial years, the World Health Organization (WHO) has established global physical activity guidelines recommending that children and adolescents aged 5 to 17 years should accumulate at least 60 min of moderate-to-vigorous physical activity (MVPA) daily [16]. Additionally, the *Healthy China 2030 Action Plan* emphasizes the importance of engaging school-aged children and adolescents in at least 60 min of school-based physical activities daily, aiming for a 25% excellence rate in achieving PF standards among this demographic [17]. However, this target remains elusive as national surveys in China reveal that school-aged children and adolescents engage in an average of merely 45.4 min of MVPA daily, with only about a third adhering to the recommended MVPA guidelines [18, 19]. This gap underscores the urgency of exploring and implementing targeted interventions that can bridge the discrepancy between current physical activity levels and the WHO's benchmarks, thereby addressing the declining physical fitness trends observed in this demographic.

Identifying the key determinants of PA and PF outcomes is essential for effective enhancement in children and adolescents. Recent studies underscore the profound influence of environmental factors—including those related to awareness of sports policies, school, family, and community settings—on young individuals' participation in PA [20, 21]. These factors play a pivotal role not only in shaping immediate health behaviors but also in forging long-term health habits [22].

Studies conducted in other Asian countries provide valuable insights into the impact of similar environmental factors on PA and PF among youth. For instance, research from Japan has highlighted the importance of school and community environments in promoting physical activity among adolescents [22]. In South Korea, studies have demonstrated the significant role of family support and neighborhood safety in influencing children's physical activity levels [23]. Additionally, a study in Singapore have shown that school-based physical education programs are crucial in enhancing physical fitness among students [24]. These findings underscore the necessity of considering environmental factors based on cultural and social contexts when designing interventions to promote PA and PF among children and adolescents. Notably, analyses within the Chinese context have revealed a disparity in the perceived support from family versus community environments, with the former receiving higher appraisals [25]. Despite recognition of the direct impact these environments have on PA and PF, there remains a significant gap in systematic analysis detailing their specific contributions to PA and PF outcomes. This knowledge gap underscores the necessity of further exploration into how environmental factors collectively influence the PA and fitness levels of youth, establishing a foundation for targeted intervention strategies.

This study hypothesizes that these environmental factors will positively impact PA and PF levels. Therefore, this study utilizes Structural Equation Modeling (SEM) to examine the effects of these environmental factors on PA and PF among a cohort of children and adolescents aged 9 to 18, spanning five diverse cities in China. The findings from this study are expected to contribute to the development of effective interventions that raise awareness of environmental factors, increase PA and fitness levels among children and adolescents, and provide strategic direction for advancing health promotion efforts within this population group.

Methods

Study design and participants

This cross-sectional study was conducted from November 2018 to November 2019 to assess the impact of awareness of sports policies, school, family, and community environmental factors on PA and PF among children and adolescents in China. We employed a stratified cluster random sampling method to ensure a representative sample. Five cities from different regions of China were selected: Shanghai (East), Guangzhou (South), Harbin (Northeast), Yinchuan (Northwest), and Guiyang (Southwest). These cities were chosen to represent diverse geographical, economic, and cultural backgrounds.

Within these cities, we selected ten districts using proportional sampling based on population size. From each district, we randomly selected 3–4 schools encompassing a range of educational levels: primary schools (grade 4), junior middle schools (grade 7), and high schools (grade 10). Ultimately, 17 schools were selected across the ten districts.

The initial sample consisted of 3060 children and adolescents aged 9–18 years. Parents or guardians of each student were also invited to participate in the study to provide information on family environmental factors. Parents were recruited through school notifications and parent-teacher meetings where the study's objectives and procedures were explained. Participation was voluntary and informed consent was obtained from all parents or guardians. After excluding 268 participants due to incomplete or missing parent questionnaires and 45 students who could not participate in the PF tests due to health reasons, the final sample size for both students and parents was 2747 (effective response rate: 89.8%). The final sample included 1665 children aged 9–12 years (60.6%) and 1082 adolescents aged 13–18 years (39.4%) with a gender distribution of 48.2% males and 51.8% females. The sample comprised 1500 students (54.6%) from urban areas and 1247 students (45.4%) from rural areas (Table 1).

Participants and their parents or guardians completed a comprehensive questionnaire survey to evaluate environmental factors and PA levels, while PF metrics were assessed through on-site testing. The study protocol received approval from the Ethics Committee of the Shanghai University of Sport. Participation was voluntary, with informed oral consent obtained from all children and their parents or guardians. Data were collected and analyzed anonymously to ensure privacy and confidentiality.

Procedure

Prior to the commencement of this study, comprehensive training was conducted for all individuals involved in administering the questionnaire survey and conducting the PF tests, with all participating researchers being graduate students specializing in sports science. Before initiating the survey and testing, researchers introduced the study objectives and methods to participants in classroom settings. Under guidance, each student completed a 4-page questionnaire within 20 min, either online or on paper, in a classroom or computer lab setting. This questionnaire primarily assessed awareness of sports policies, school, family, and community environmental factors, PA levels, and demographic information. Additionally, parents or guardians of each student were invited to complete a corresponding 4-page home questionnaire, which included questions about parental support for physical

Table 1 Descriptive statistical analysis of participant characteristics and study variables ($n = 2747$)

Variable	Value
Age	
9–12	1665 (60.6%)
13–18	1082 (39.4%)
Mean (SD)	12.90 (2.49)
Gender	
Boys	1324 (48.2%)
Girls	1423 (51.8%)
Grade	
Primary	1629 (59.3%)
Junior middle	602 (21.9%)
Junior high	516 (18.8%)
Residential area	
Urban	1500 (54.6%)
Rural	1247 (45.4%)

exercise and other family-related characteristics. Following the completion of the questionnaire, students underwent PF testing conducted by trained research assistants during scheduled class times.

To ensure the integrity and accuracy of the data collected, a rigorous double data entry system was employed. Two experienced assistants independently input the collected data into a secure computerized database, which was then meticulously cross-checked to ensure consistency and accuracy. Both questionnaire responses and physical test results were encoded with unique identifiers to maintain participant confidentiality. Access to this database was strictly limited to authorized researchers, ensuring data privacy and security.

Measures

In this study, awareness of sports policies, school, family, and community environmental factors and PA levels were based on self-reports from survey questionnaires, and PF test was assessed through on-site testing. The specific methodologies for each measurement area are detailed below:

Environmental factors

In this study, environmental factors, including awareness of sports policies (Qp), school (Qs), family (Qf), and community (Qc) environments, were assessed using the 'Child and Adolescent Sports Fitness Survey Questionnaire' developed by Shanghai University of Sport, which has been extensively utilized nationwide and has demonstrated high reliability and validity [18, 21, 26].

Awareness of Sports Policies (Qp): To assess parents' awareness of sports policies, we measured their knowledge of the National Physical Fitness Standards for Students (NPFS) and the Interim Measures for the Prevention and Control of Risks in School Physical Activity. Parents responded to two questions designed to gauge their familiarity with these policies.

School Environment (Qs): This term refers to the conditions and factors within the school that influence PA and PF among students. It includes the adequacy of sports facilities and equipment, the impact of PE classes, satisfaction with PE teaching, support from other teachers for engaging in physical exercises, the sufficiency of time allocated for extracurricular physical activities, and the overall exercise atmosphere in the school. Students answered six questions related to these aspects.

Family Environment (Qf): This term encompasses various aspects of parental and family support for children's PA and PF. It includes parents' encouragement of their children's participation in sports, attendance at their sports activities, communication regarding the health benefits of sports, active interest in their children's PE learning at school, the importance of parental involvement in sports competitions or performances, joint participation in sports activities, accompaniment to sports events, family participation in sports as leisure activities, financial support for sports activities, and leading by example in sports participation. Parents completed a series of ten questions evaluating these aspects.

Community Environment (Qc): This term refers to the broader community factors that influence PA and PF among children and adolescents. It includes the prevalence and quality of youth sports activities in the community or neighborhood, the organization of sports events, the availability of free sports skill training, the establishment of youth sports organizations, and the accessibility to sports facilities suitable for young people. Students were asked four questions about these aspects.

Each of these questions was scored on a five-point scale where 1 equated to 100 points, 2 to 75 points, 3 to 50 points, 4 to 25 points, and 5 to 0 points (Supplementary file). The total scores for each section of the questionnaire were calculated, and the average score for each environmental factor was determined based on these totals.

PA Level

The modified Chinese-version of the International Physical Activity Questionnaire Short Form (IPAQ-SF) was used to assess the PA levels of the students, which has been used in previous studies [18, 19, 21]. These items facilitated the assessment of activities across three distinct intensity levels: (1) low-intensity activities, such as walking; (2) moderate-intensity activities, such as carrying light loads and cycling at a normal pace; and (3) vigorous-intensity activities, such as running quickly and performing aerobics dance [27]. For each grade level, respondents indicated the frequency (days of engagement in each activity) and duration (minimum of 10 min per session) of these activities over the past seven days. The average daily minutes of low-intensity physical activity (LPA) were calculated by dividing the total minutes of low-intensity activities by seven. Similarly, the average daily minutes of MVPA were obtained by summing the minutes of moderate and vigorous-intensity activities and dividing by seven.

PF test

PF indicators in this research were categorized into health-related and performance-related components:

Health-Related PF BMI: Children's barefoot weight (in kilograms) and height (in centimeters) were measured using a portable device (GMCS-IV, Beijing Jianmin Company, China). BMI was calculated as the weight in kilograms divided by the square of height in meters (kg/m^2).

BMI was categorized based on the "Chinese National Survey on Students' Constitution and Health" standards, which classify BMI into normal weight, overweight, and obese based on age-specific values [28].

WHtR: WHtR was measured with the participant standing naturally and breathing normally. The tape measure was placed 1 cm above the navel, encircling the body horizontally and passing through the midpoint between the lower margin of the 12th rib and the top of the iliac crest on both sides. The measurement was recorded to the nearest 0.1 mm. WHtR cutoff values for central obesity were based on Chinese reference standards, with 0.48 for boys and 0.46 for girls [29].

Grip Strength: A convenient and effective method for assessing upper limb strength and muscle development, grip strength was measured using a portable dynamometer (T.K.K 5401, Japan). Participants stood with their arms hanging naturally, palms facing inwards, and squeezed the dynamometer with maximum force. The highest value from two attempts for each hand was recorded in kilograms to one decimal point.

Performance-related PF Vertical Jump: To evaluate lower limb explosive power and muscle strength, participants performed vertical jumps using a portable device (T.K.K 5406, Japan). The height of the jump was determined by measuring the distance pulled by a connected thread at the peak of the jump. The best of two attempts was recorded in centimeters to one decimal point.

20-mSRT: Used to assess maximal oxygen uptake (VO2max), involved participants running back and forth between two markers 20 m apart with increasing speed every minute starting at 8.5 km/h. The test ended when participants could no longer maintain the pace or elected to stop.

Demographic measures

Throughout the survey, demographic information such as age, gender, grade, and residential area (rural or urban) of the participants was collected.

Statistical analysis

Baseline characteristics and descriptive statistics were calculated to summarize the demographic and main study variables, employing means and standard deviations for continuous data, and frequencies and percentages for categorical data. SEM was employed to investigate the causal relationships among the variables. While SEM allows for the analysis of complex relationships, it is important to note that, due to the cross-sectional design of this study, we cannot establish causal relationships between the independent and outcome variables. Instead, SEM provides insights into the associations and potential pathways between these variables.

The fit of the model to the data was rigorously evaluated using several indices: the chi-square value (χ^2), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI). These indices were employed collectively to assess the adequacy of the model, with a focus on the χ^2 value, RMSEA less than 0.08, and CFI and TLI values exceeding 0.90, indicating a well-fitting model. Statistical analyses of baseline features were carried out using SPSS, and SEM was analysed using Mplus version 7.4. The significance threshold for all hypothesis tests was set at $\alpha = 0.05$, ensuring the statistical validity of the findings.

Results

Environmental factors, PA, and PF scores

Table 2 presents the environmental factors, PA, and PF scores of the study participants. The evaluation of environmental factors revealed varying scores, with the school environment receiving the highest average score (78.0 ± 9.5), followed by the awareness of sports policies (70.1 ± 14.5) and the family environment (70.0 ± 9.5), whereas the community environment scored the lowest (38.7 ± 18.0). Assessments of PA and PF indicated an average daily LPA of 146.49 ± 77.42 min and MVPA of 49.67 ± 24.80 min. The mean BMI was 18.59 ± 2.69 kg/m^2, WHtR was 0.45 ± 0.08, grip strength was 28.89 ± 10.58 kg,

Table 2 Environmental factors, PA, and PF scores ($n = 2747$)

Variable	Value
Environmental Factors (Mean ± SD)	
Awareness of Sports Policies	70.1 ± 14.5
School Environment	78.0 ± 16.4
Family Environment	70.0 ± 9.5
Community Environment	38.7 ± 18.0
Physical Activity (Mean ± SD)	
LPA (minutes/day)	146.49 ± 77.42
MVPA (minutes/day)	49.67 ± 24.80
Physical Fitness (Mean ± SD)	
BMI (kg/m^2)	18.59 ± 2.69
WHtR	0.45 ± 0.08
Grip Strength (kg)	29.89 ± 10.58
Vertical Jump (cm)	32.11 ± 4.64
20-mSRT (laps)	35.98 ± 15.07

LPA Low-Intensity Physical Activity, *MVPA* Moderate to Vigorous Physical Activity, *BMI* Body Mass Index, *WHtR* Waist-to-Height Ratio, *20-mSRT* 20-Meter Shuttle Run Test vertical jump was 32.11 ± 4.64 cm, and the performance in the 20-mSRT was 35.98 ± 15.07 laps.

Structural equation modeling analysis

PA

The SEM analysis for PA impacts revealed adherence to univariate normal distribution across model variables, albeit diverging from multivariate normality prerequisites. Employing the Bollen-Stine Bootstrap approach ($n = 2000$) recalibrated the model's chi-square (χ^2) and refined other fit indices, yielding an optimized fit for the LPA and MVPA models. Specifically, the LPA model exhibited $\chi^2 = 1441.306$, RMSEA = 0.050, CFI = 0.934, and TLI = 0.925, whereas the MVPA model displayed $\chi^2 = 1416.648$, RMSEA = 0.050, CFI = 0.936, and TLI = 0.927, aligning with recommended fit parameters.

The LPA SEM underscored significant influences of family and community environments on LPA levels (Fig. 1), with effect sizes of 0.102 ($P < 0.001$) and -0.074 ($P = 0.010$), respectively. This analysis delineated a positive correlation between family environment and LPA, whereas the community environment inversely affected LPA levels. No significant effects of awareness of sports policies and school environments on LPA were identified ($P > 0.05$).

Conversely, the MVPA SEM illuminated significant contributions of awareness of sports policies, family, and community environments to MVPA levels (Fig. 2), with effect sizes of 0.072 ($P = 0.009$), -0.055 ($P = 0.035$), and 0.216 ($P < 0.001$), respectively, highlighting a negative correlation between family environment and MVPA levels. The school environment did not exhibit a direct impact on MVPA (0.016, $P > 0.05$).

PF

SEM analysis assessing the nexus between environmental factors and PF metrics—BMI, WHtR, grip strength, vertical jump, and the 20-mSRT—demonstrated adherence

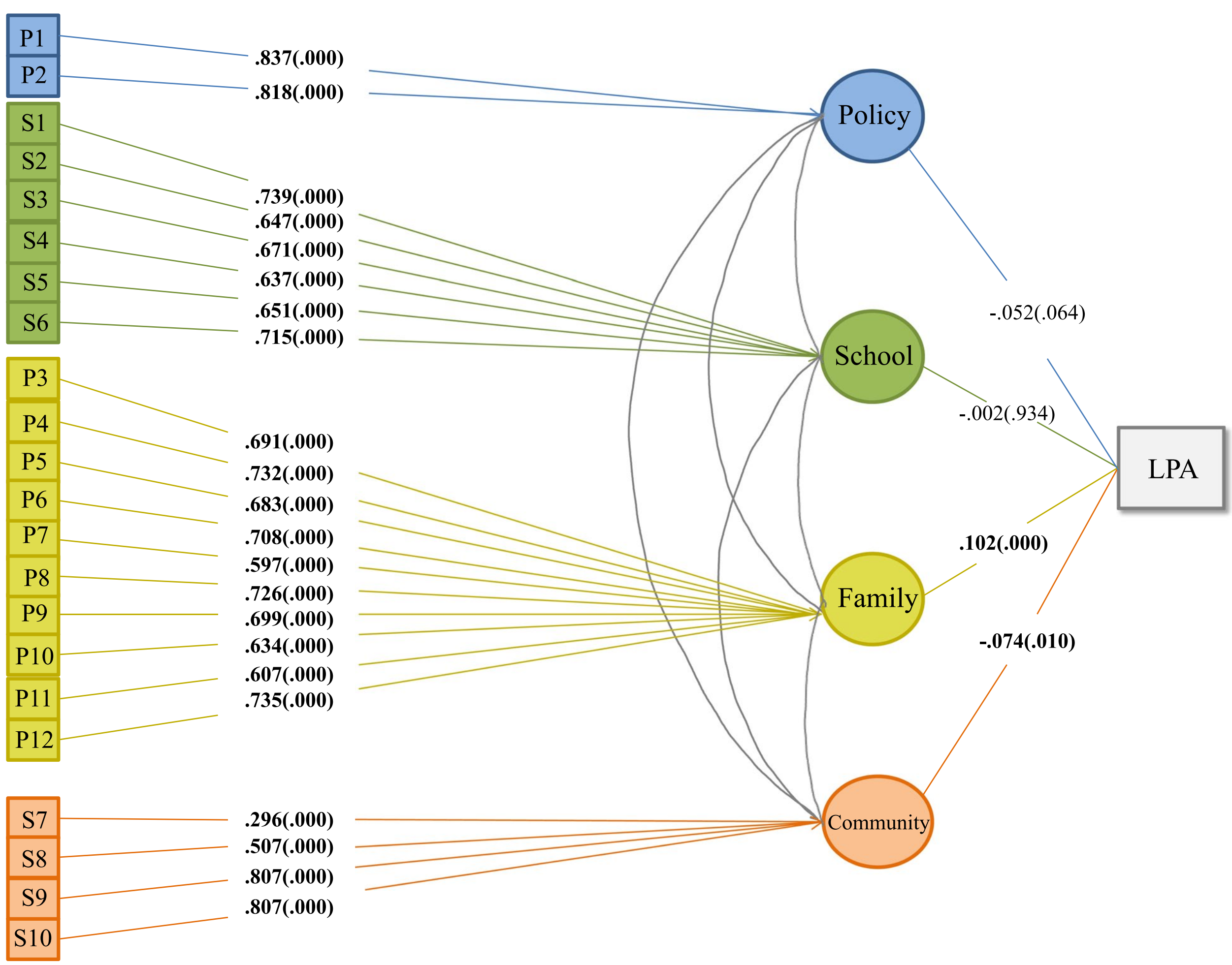

Fig. 1 Environmental factors affect on LPA. The figures presented outside of the brackets correspond to the estimated values, and those enclosed within the brackets signify the *P*-values. Numbers highlighted in bold represent statistically significant findings

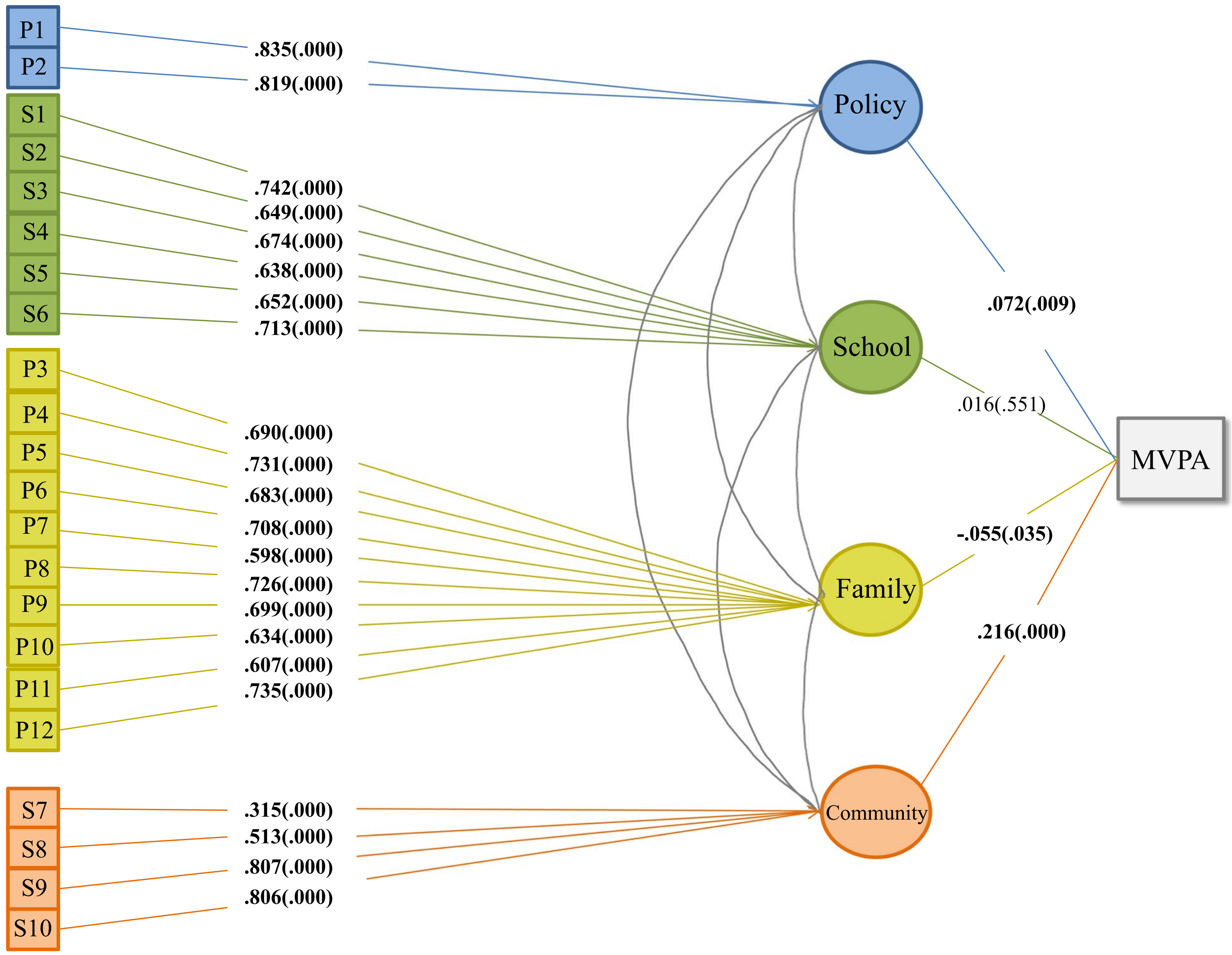

Fig. 2 Environmental factors affect on MVPA. The figures presented outside of the brackets correspond to the estimated values, and those enclosed within the brackets signify the *P*-values. Numbers highlighted in bold represent statistically significant findings

to univariate normal distribution, necessitating recalibration for multivariate normality. Post-adjustment, models reported exemplary fit, substantiating the SEM's efficacy in elucidating complex interrelations between environmental variables and fitness outcomes.

Intriguingly, family environment exhibited a significant inverse correlation with BMI levels (-0.103, $P<0.001$), implying that supportive family settings correlate with healthier BMI indices among youth (Fig. 3). No direct effects of awareness of sports policies, school, and community environments on BMI were observed ($P>0.05$). Similar patterns emerged for WHtR (Fig. 4), with no significant environmental impacts detected ($P>0.05$).

Grip strength analyses revealed significant influences from both family and community environments (Fig. 5), with effect sizes of -0.063 ($P=0.018$) and 0.088 ($P=0.002$), respectively. This suggests that these environmental contexts play pivotal roles in modulating grip strength among youth, while awareness of sports policies and school environments did not exhibit noticeable effects ($P>0.05$). Conversely, in Fig. 6, vertical jump outcomes did not demonstrate direct impacts from awareness of sports policies, school, family, or community environments ($P>0.05$), underscoring the nuanced relationship between environmental factors and specific PF components.

Analysis of the 20-mSRT showed that the community environment significantly improved performance (Fig. 7), as evidenced by an effect size of 0.065 ($P=0.027$). This finding underscores the critical role of community settings in enhancing aerobic fitness levels among children and adolescents, a contrast to the non-significant impacts observed from awareness of sports policies, school, and family environments ($P>0.05$).

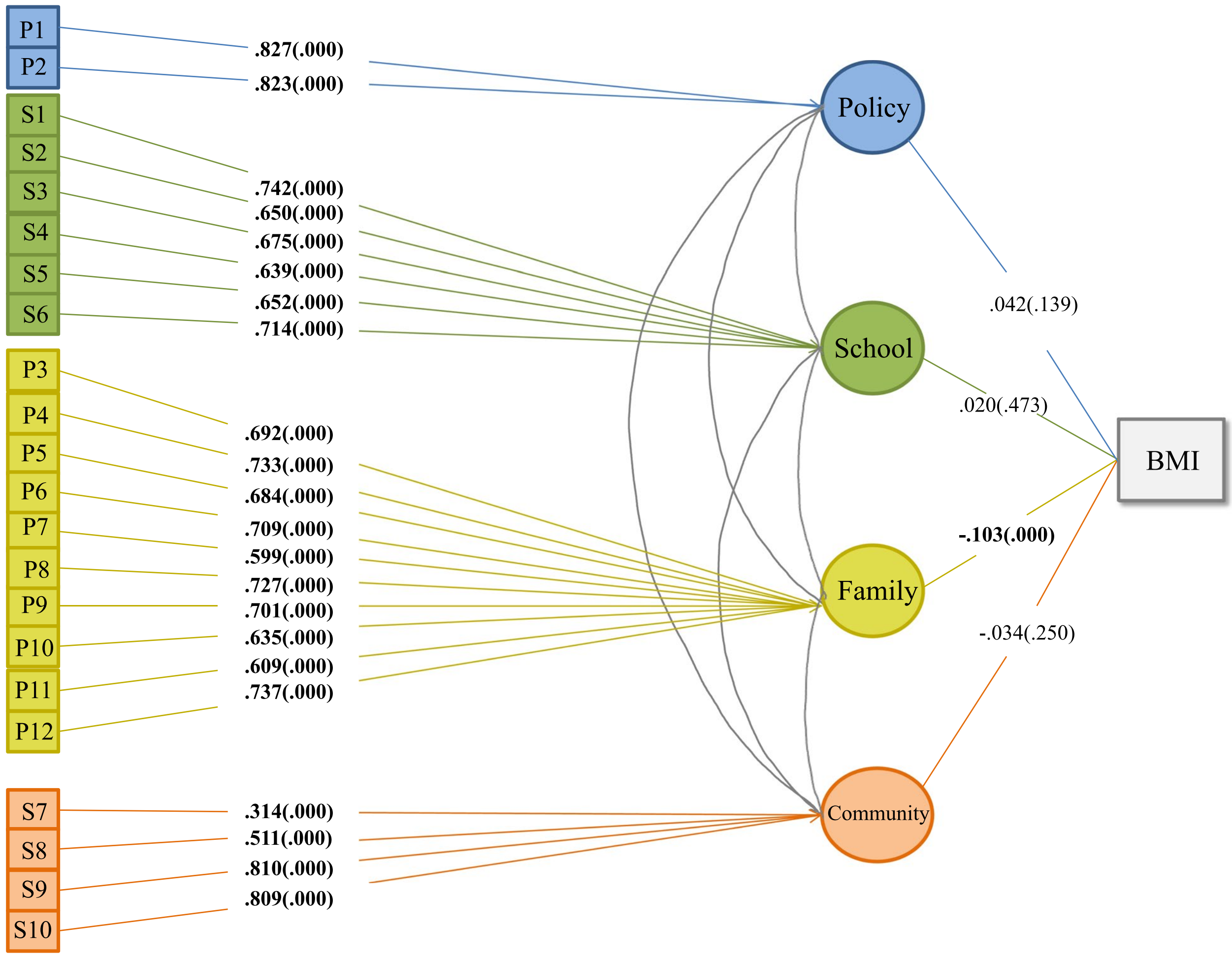

Fig. 3 Environmental factors affect on BMI. The figures presented outside of the brackets correspond to the estimated values, and those enclosed within the brackets signify the *P*-values. Numbers highlighted in bold represent statistically significant findings

Discussion

This involving 2747 children and adolescents from five distinct urban areas across China systematically examines the influence of awareness of sports policies, school, family, and community environmental factors on physical activity PA and PF. The main findings reveal several critical insights: the school environment received the highest average score among the environmental factors, while the community environment scored the lowest. SEM analysis indicated distinct impacts of these environmental factors on various PA and PF metrics. Specifically, the family environment was significantly associated with LPA and BMI reduction but negatively correlated with MVPA and grip strength. Conversely, awareness of sports policies and the community environment positively influenced MVPA, grip strength, and 20-mSRT performance. These results underscore the complex interplay between different environmental contexts and their collective impact on the PA and PF of Chinese youth.

The study reveals a significant disparity in environmental factor scores, with the school environment receiving the highest ratings and the community environment scoring the lowest. This finding aligns with previous reports [25, 30], such as the "Children and Youth Physical Activity Report Card" in China, which also highlights lower scores for community environments. This disparity underscores the imbalance in the development of school and community environments in China, with more substantial investments being directed towards school facilities while the crucial role of community environments in the physical development of children and adolescents is overlooked [31]. The challenges faced by community environments, both in terms of construction and operational management, are more pronounced, leading to slower development compared to school environments. Addressing this imbalance requires not only equal attention to the development of both environments but also a coordinated effort to ensure the comprehensive and

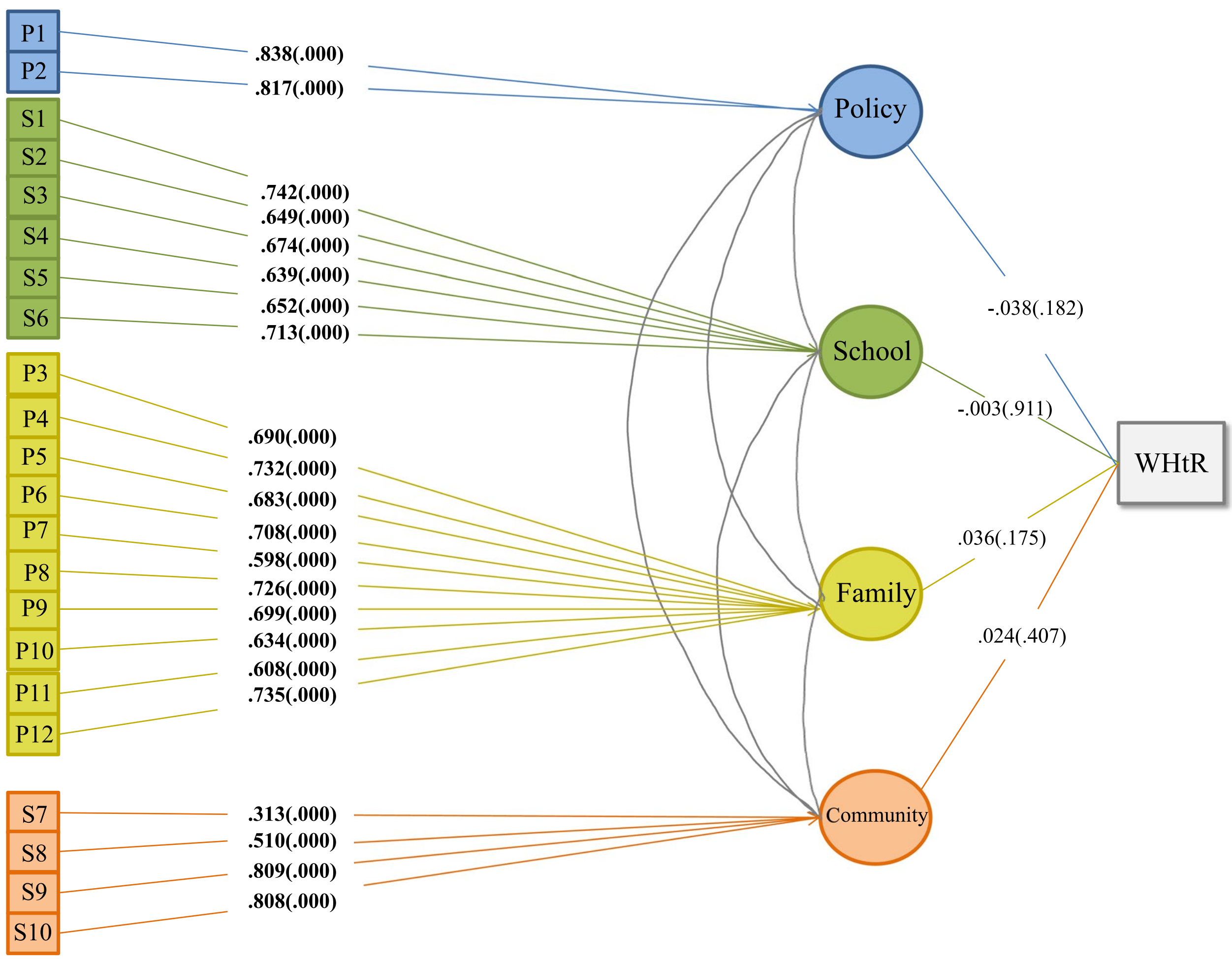

Fig. 4 Environmental factors affect on WHtR. The figures presented outside of the brackets correspond to the estimated values, and those enclosed within the brackets signify the *P*-values. Numbers highlighted in bold represent statistically significant findings

balanced progress of all environmental factors. Such a holistic approach is essential to foster an equitable and supportive setting for the physical development of children and adolescents.

Interestingly, our study found that despite the highest scores for the school environment, there was no significant association between this environment and the PA or PF of children and adolescents. This could be attributed to government regulations or standards that mandate all schools to provide basic sports facilities, such as gyms and basketball courts, resulting in a standardized infrastructure across schools [32, 33]. Additionally, the homogeneity of PE curricula in China suggests that most students' physical activity is derived from these uniform PE classes, diminishing the unique impact of individual school environments on PA and PF. Existing research underscores that while the culture of physical activity within schools is significantly related to students' PA, the number of facilities and PE classes has minimal impact [34, 35]. If schools do not actively promote and support student participation in PA, the potential benefits of these resources remain untapped. Thus, the focus should shift from material resources to fostering a positive and inclusive culture of physical activity. To maximize the potential of school environments in promoting PA and PF among children and adolescents, it is crucial to consider the structure, intensity, and variety of PE classes, as well as the individual differences among students [36]. Schools should encourage broader participation in extracurricular sports activities and cultivate a supportive and inclusive physical activity culture. This approach not only enhances the physical fitness of children and adolescents but also contributes to their overall physical and mental well-being.

Contrary to the school environment, the community environment, despite its lowest scores, was significantly associated with higher levels of MVPA and improved PF indicators such as grip strength and 20-mSRT

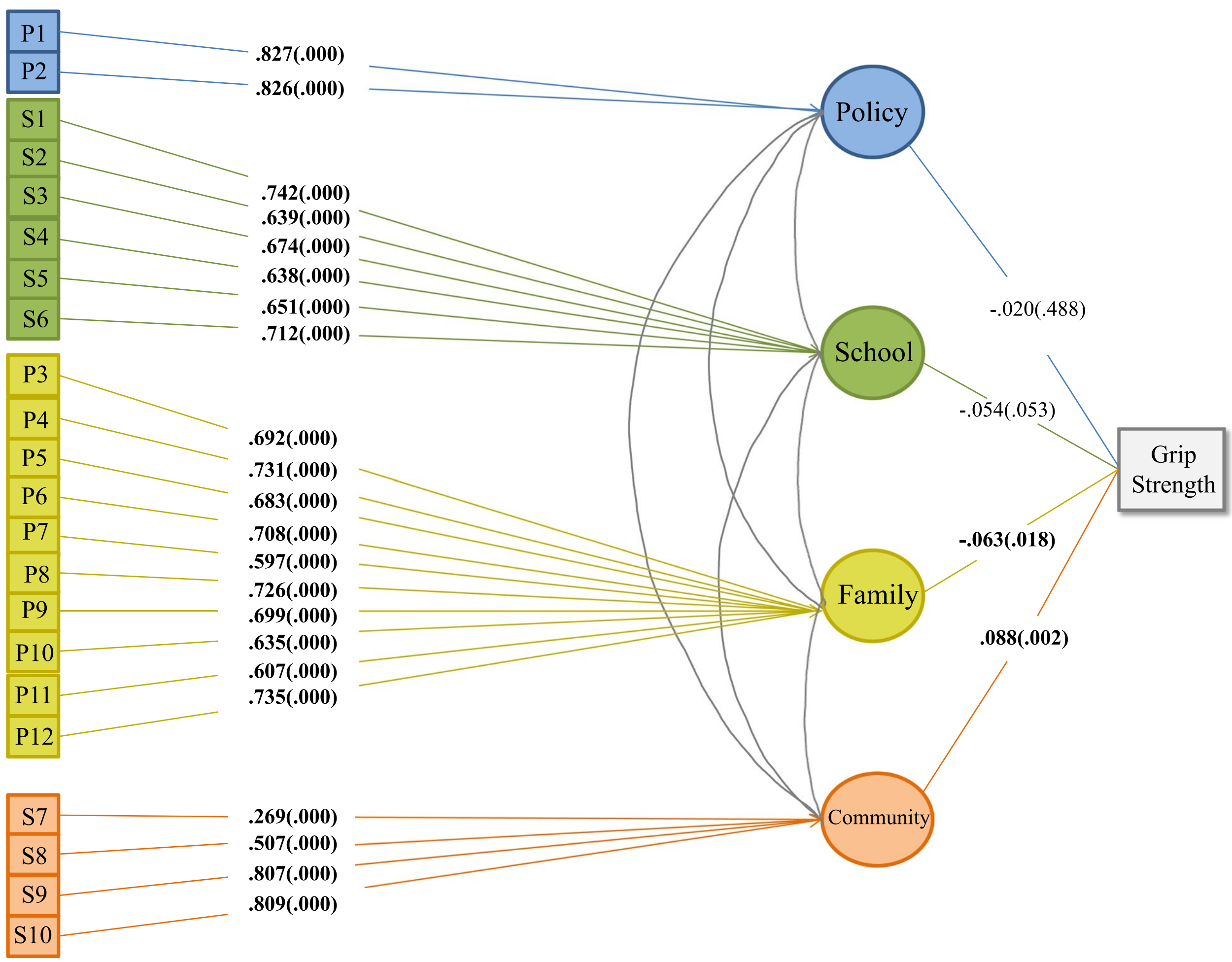

Fig. 5 Environmental factors affect on Grip Strength. The figures presented outside of the brackets correspond to the estimated values, and those enclosed within the brackets signify the *P*-values. Numbers highlighted in bold represent statistically significant findings

performance. This underscores the critical role of the community in promoting MVPA and enhancing PF among children and adolescents. Our findings align with previous research, which has established a positive correlation between the availability of community sports facilities and increased MVPA [37]. For example, a study in the UK emphasized the significant impact of community sports in elevating students' MVPA levels, suggesting that community facilities and programs primarily encourage higher intensity physical activities [38]. The inverse relationship between the community environment and LPA and its positive association with MVPA may be influenced by several factors. Communities with accessible and attractive sports facilities may prioritize structured and high-energy activities, inadvertently reducing low-intensity activities [39]. This dynamic reflects the broader influence of community settings on PA choices, steering children towards more vigorous forms of exercise that offer social appeal or competitive rewards [40]. Communities with higher scores typically possess superior sports facilities, such as sports fields, swimming pools, or gyms, which provide essential venues for organized sports and training. These facilities effectively enhance children's MVPA levels and subsequently improve their PF, particularly in speed, endurance, and coordination, which are crucial for better grip and 20-mSRT performance [41]. Moreover, regularly organized community sports activities and training programs, such as track and field training, football clubs, or other team sports, offer opportunities for engaging in moderate-to-high intensity activities and foster social interactions. These diverse sports activities not only enhance children's physical capabilities but also promote social skills and team spirit development [42]. Therefore, we advocate for actively encouraging children's participation in community activities as an effective means to boost physical fitness and social abilities. To further enhance children's athletic performance and

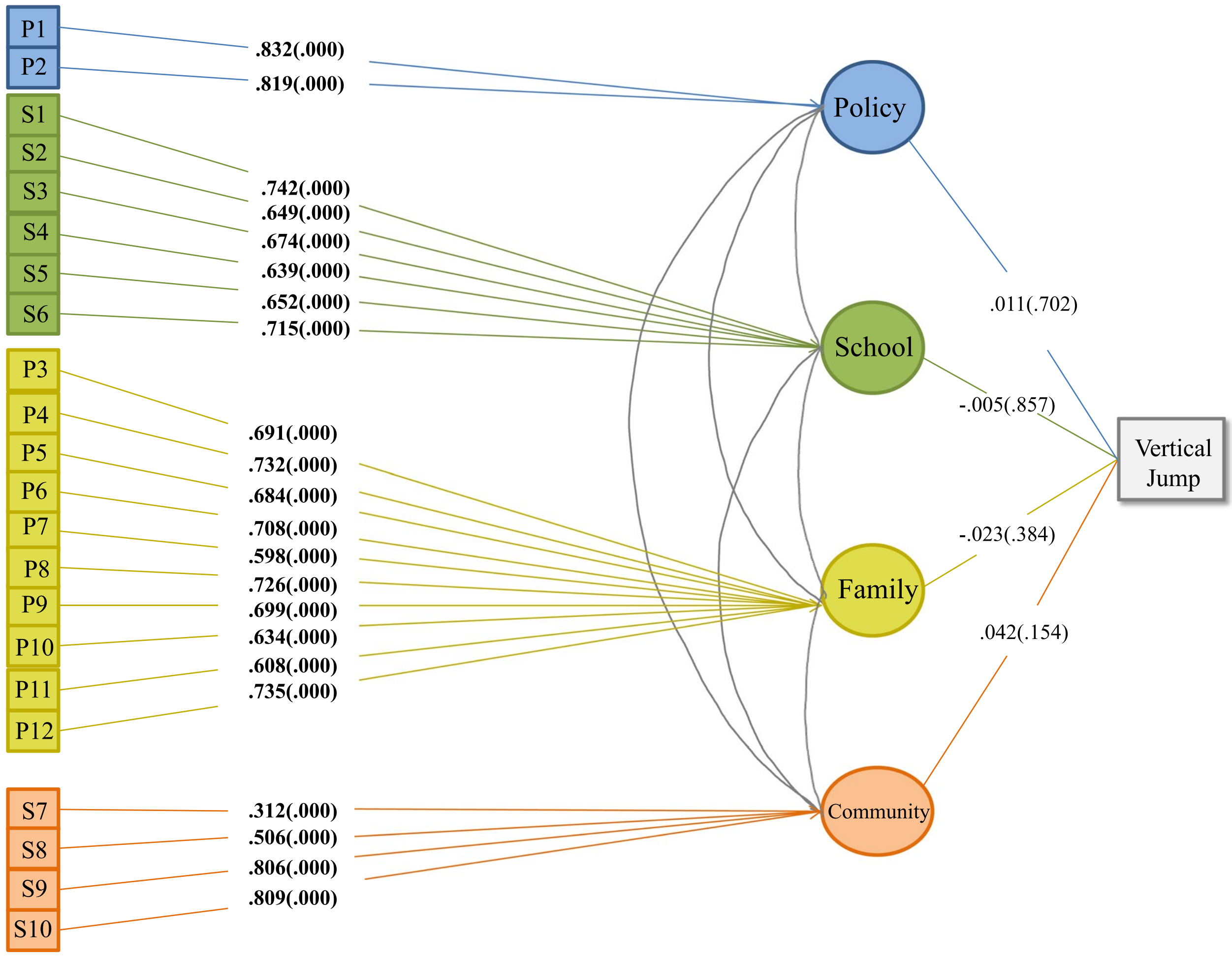

Fig. 6 Environmental factors affect on Vertical Jump. The figures presented outside of the brackets correspond to the estimated values, and those enclosed within the brackets signify the *P*-values. Numbers highlighted in bold represent statistically significant findings

overall health, communities should continue investing in and improving sports facilities, while also organizing a variety of regular sports activities. Creating a positive and healthy sports culture enriches children's sports experiences and strengthens their physical abilities.

Prior research has emphasized the significant influence of parental behavior on children's PA levels [43], our SEM analysis further elucidates that family environment scores positively correlate with LPA levels but negatively correlate with MVPA levels among children and adolescents. This trend may reflect parents' emphasis on health and safety, leading them to encourage participation in low-risk activities such as walking or household chores. This is particularly evident in urban families, where spatial constraints may result in children engaging more in low-intensity activities [44]. Despite acknowledging the positive influence of parental factors on children's PA behavior [45, 46], parents might restrict the type and duration of MVPA to minimize potential injuries and the impact on academic time. Our study also reveals a negative correlation between family environment scores and BMI, indicating that a supportive family environment significantly contributes to lower BMI in adolescents. Given that participants in our study engaged in an average of 146.49 min of LPA daily, the positive correlation between family environment scores and LPA suggests that increased LPA helps maintain normal BMI. This finding is critical, as previous studies have predominantly supported the role of MVPA in maintaining a healthy weight and reducing the incidence of overweight and obesity [19, 47]. Our findings, however, suggest that sustained LPA, such as household chores, walking to school, and leisure walking, can also have a beneficial cumulative effect on maintaining a healthy BMI. Prior animal model studies have shown that continuous LPA can reduce caloric intake and significantly increase lean body mass [48]. This insight is particularly valuable for policymakers, educators, and researchers, as LPA is more accessible

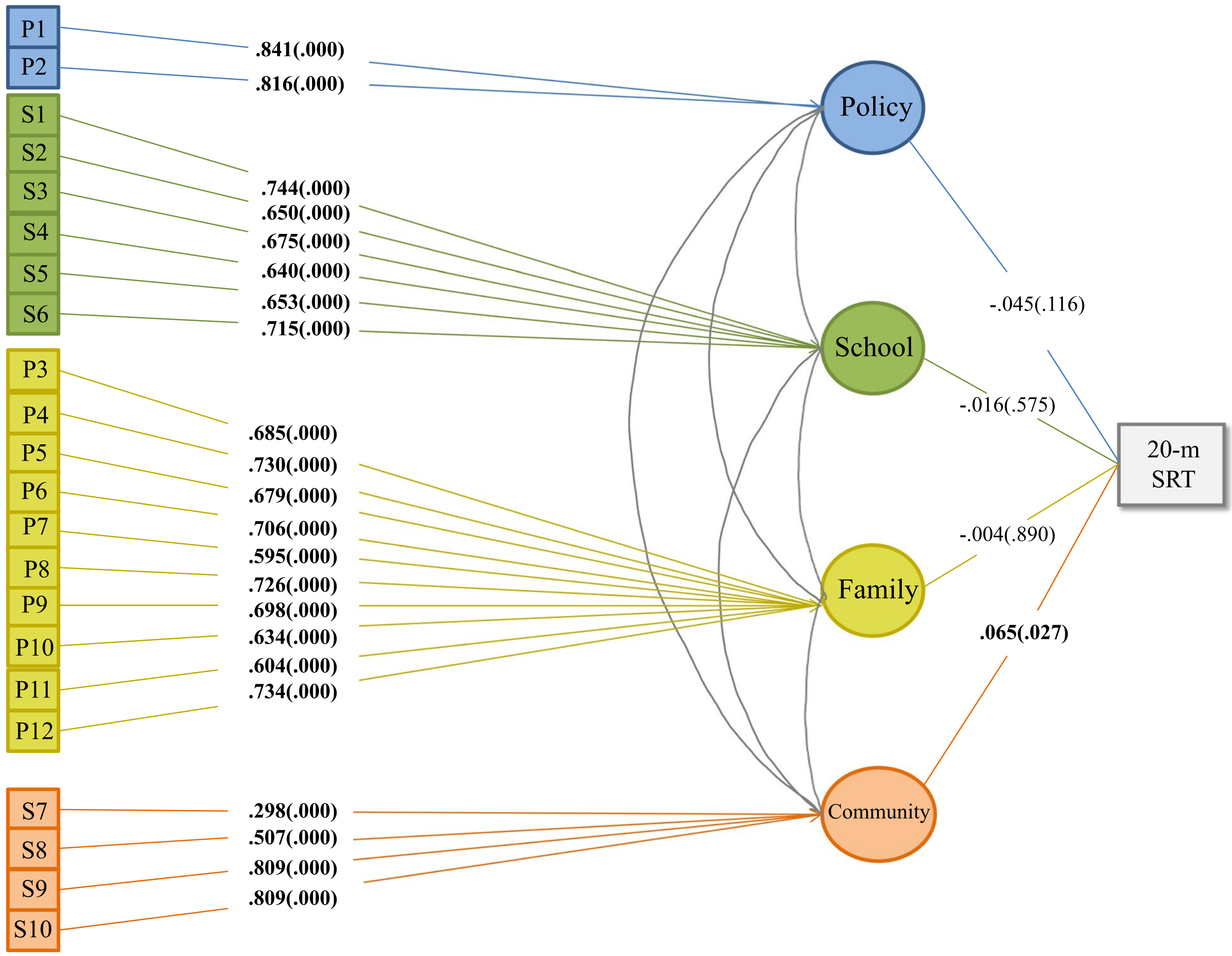

Fig. 7 Environmental factors affect on 20-mSRT. The figures presented outside of the brackets correspond to the estimated values, and those enclosed within the brackets signify the *P*-values. Numbers highlighted in bold represent statistically significant findings

and safer than MVPA. If LPA positively influences BMI, it could be a significant benefit for overweight and obese children and adolescents. However, current research on the relationship between LPA and BMI or body composition in children and adolescents is limited, necessitating further mechanistic and randomized controlled trial studies to explore the health benefits of LPA in this population.

Additionally, our study found a significant negative correlation between family environment scores and children's grip strength. Coupled with our earlier finding that family environment scores positively correlate with LPA, we suggest that in higher-scoring family environments, parents often prioritize safety and academic achievement, potentially limiting children's participation in activities deemed risky or overly strenuous. This tendency reduces children's engagement in activities requiring higher physical strength and coordination, such as climbing and basketball, which are crucial for enhancing grip strength and muscle power [49]. Conversely, the LPA frequently encouraged in family environments, such as walking and light play, while beneficial for overall health, may be insufficient to significantly improve strength qualities. Furthermore, family environments may lack support and resources for professional physical training, including access to strength training facilities and guidance, further contributing to inadequate muscle strength development in children [50]. To comprehensively improve children's muscle strength, activity encouragement within family environments should be more balanced, supporting participation in activities that promote both basic health and strength endurance. Parents should provide diverse physical activity opportunities, including those that develop muscle strength, and offer necessary support and resources, such as access to professional training facilities and expert guidance.

Our study provides valuable evidence for developing effective interventions aimed at promoting PA and PF among children and adolescents, offering new perspectives for policy formulation. These recommendations are particularly important for encouraging school-aged children and adolescents to engage in MVPA and enhance their physical capabilities. It is well-established that sports policies play a crucial role in shaping healthy behavior patterns and promoting physical health among youth, and parental awareness of these policies is essential [51]. In this study, parents' awareness of sports policies scored relatively high (70.1 points), and this awareness was positively associated with MVPA levels but had no significant impact on LPA or other PF indicators. This finding highlights the importance of policy awareness in encouraging higher intensity activities. Effective communication and implementation of sports policies can motivate parents to support their children's participation in structured and vigorous activities, which are critical for improving overall fitness levels. To maximize the benefits of these policies, it is imperative to enhance parents' understanding and engagement with sports policies. This can be achieved through targeted education campaigns and community programs that emphasize the importance of MVPA for children's health [52]. Additionally, schools and communities should collaborate to create environments that support and facilitate the practical application of these policies, ensuring that children have ample opportunities to engage in diverse and high-quality physical activities.

Family and community environments play distinct but equally important roles in promoting PA among children and adolescents. To effectively enhance PA levels, integrated strategies that encompass both family and community efforts are crucial. Health education for parents should be strengthened to improve their understanding and support of their children's participation in MVPA. Parents should be encouraged to promote diverse physical activities, including both structured sports and unstructured play, while ensuring that exercise restrictions are relaxed within safe limits. Communities need to prioritize not only the construction and enhancement of sports facilities but also the creation of safe and accessible spaces for all types of PA, such as parks and playgrounds. Organizing community events that promote PA, like walkathons, dance classes, and cycling groups, can provide more opportunities for participation and social interaction, thus fostering a more active lifestyle among children. Furthermore, schools and local governments should work together to create policies that encourage active transportation, such as walking or biking to school, and integrate PA as a fundamental part of the daily routine for children and adolescents. This holistic approach to PA promotion, which includes various forms and settings of activity, is essential for nurturing an active and healthy lifestyle among youth. By adopting an integrated, collaborative approach involving families, communities, schools, and local governments, we can create a supportive environment that encourages PA among children and adolescents. Addressing the multiple determinants of PA through coordinated interventions across different settings will significantly enhance the physical health and overall well-being of the younger population.

The strength of this study lies in its methodical exploration of the impact of awareness of sports policies, school, family, and community environmental factors on the PA and PF levels of children and adolescents in China through the use of SEM analysis. Additionally, the selection of a diverse sample from 32 schools across five distinct regions in China, encompassing both urban and rural areas and including children and adolescents aged 9 to 18, enhances the representativeness and generalizability of our findings. However, the study also presents several limitations. Firstly, the reliance on self-reported questionnaires to measure levels of PA, while validated in previous research for reliability and validity, does not entirely negate the potential for selection bias, particularly concerning the possible overestimation or underestimation of physical activity levels. Future studies should consider incorporating objective measures, such as accelerometers, to provide more accurate and reliable data. Secondly, the use of the IPAQ-SF for measuring PA among children under 15 years old, although validated in previous large-scale surveys in China involving children and adolescents aged 9–18, may still present limitations due to its original design for older adolescents and adults. Future research should consider developing and validating age-specific PA measurement tools for younger children to ensure more accurate assessments. Thirdly, our analysis did not account for the potential clustering effects of students within different schools and residential areas due to convergence issues encountered with the SEM for the 20-m shuttle run test. Future research should incorporate multilevel modeling techniques to address this limitation and provide more precise estimates of the effects of environmental factors. Existing research indicates that self-efficacy and intrinsic motivation are significant factors influencing PA among children and adolescents, with higher sports motivation positively correlating with PA and sports participation [53]. Self-efficacy and intrinsic motivation may serve as mediating variables between environmental factors and PA and PF in children and adolescents. However, our study did not delve into the impact of self-efficacy, intrinsic motivation, or age stratification on the relationship between environmental factors and PA and PF among children and adolescents. Future research should deeply investigate the potential variables between these environmental factors and PA and PF in children and adolescents, aiming to identify effective strategies to enhance PA and PF levels among youth.

Conclusion

This study highlights that while school environments score highest, they do not significantly impact PA and PF among Chinese youth. In contrast, community environments, despite lower scores, positively influence MVPA, grip strength, and 20-mSRT performance. Awareness of sports policies enhances MVPA, and family environments support LPA and BMI but are inversely related to MVPA and grip strength. To improve youth PA and PF, integrated strategies enhancing community infrastructure, family support, and policy awareness are essential. A coordinated approach involving schools, families, communities, and policymakers is crucial for promoting healthy, active lifestyles among children and adolescents.

Abbreviations

PA	Physical Activity
PF	Physical Fitness
MVPA	Moderate-to-Vigorous physical activity
LPA	Light Physical Activity
BMI	Body Mass Index
20-mSRT	20-Meter Shuttle Run Test
CRF	Cardiorespiratory Function
WHO	World Health Organization
SEM	Structural Equation Modeling
RMSEA	Root Mean Square Error of Approximation
CFI	Comparative Fit Index
TLI	Tucker-Lewis Index
MI	Modification Indices

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

JYW significantly contributed to the study's conception, design, and manuscript drafting. SYW was responsible for conducting the statistical analysis. XHC managed the data cleanup and database management. YY critically reviewed and revised the manuscript for important intellectual content. WQR, BJX, JFW, PPG, XLL, and TX were instrumental in data collection. KYY was in charge of visualizing the images. JZ played a pivotal role in conceptualizing and designing the study, overseeing all facets of its execution. All authors have read, contributed to, and approved the final version of the manuscript for publication.

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Availability of data and materials

Data and materials for this project are available in the repository of the Shanghai University of Sport. The specific datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The Ethics Review Committee of Shanghai University of Sport granted approval for this study under the protocol number 2017037. The Committee recognized the low-risk nature of the research and its large sample size, allowing for verbal consent from teachers, school principals, and the parents of participating students. Before data collection commenced, detailed explanations regarding potential risks and benefits were provided to all participants, including students, teachers, principals, and parents, to ensure informed participation. Verbal consents obtained were meticulously documented by research assistants, assigning each participant a unique numerical identifier for confidentiality. These records were securely stored in a digital database, accessible solely to designated members of the research team, ensuring the privacy and integrity of participant data.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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