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A study of the relationship and drivers between participation in sports program diversity and physical fitness

Deqiang Zhao, Xiaoxiao Chen, Aoyu Zhang, Yibei Wang, Yibo Gao, Jin He, Lupei Jiang & Yanfeng Zhang✉

Leisure-time physical activity has changed over the past few decades. Participation in diverse sports programs by children and adolescents is more conducive to increasing physical activity levels and promoting individual health. The purpose of this study was to explore the correlation between adherence to participation in diversity of sports programs and physical fitness among children and adolescents, in addition to analyzing individual attitudinal, family, and school dimensional factors that influence children's and adolescents' participation in diversity of sports programs. This study included cross-sectional data from 3309 child adolescents. Next, physical fitness indicators were also included. The study used Pearson correlation analysis, one-way ANOVA, and linear regression. Pearson correlation and one-way ANOVA were used to explore the correlation between diversity and physical fitness in participating sports and the differences in physical fitness between different sports groups. In addition, the linear regression method was used to analyze the impact of diversity on physical fitness. Finally, ordinal logistic regression was used to analyze the influencing factors of diversity in participating sports programs.Significant correlations were observed between diversity of participation in sports programs and various physical fitness indicators across all age groups, including muscular strength, speed, endurance, and flexibility ($p < 0.01$). Additionally, physical fitness levels significantly differed among groups with different numbers of sports participation ($p < 0.05$).Furthermore, misconceptions about physical activity were identified as a negative factor influencing sports program diversity (β = -0.193, $p < 0.01$), whereas willingness to consistently engage in physical activity was a strong positive predictor (β = 0.494, $p < 0.01$). Longer screen time negatively affected sports program diversity (β = -0.047, $p < 0.05$), and difficulty completing school physical education requirements was also a limiting factor (β = -0.112, $p < 0.05$). In contrast, peer influence served as a positive factor promoting sports program diversity (β = 0.071, $p < 0.01$).Conclusion: Greater diversity in sports program participation is associated with better physical fitness outcomes and contributes to overall health promotion in children and adolescents. Sustained participation in a variety of sports programs requires broader social support, especially from families and peers, which may enable more youth to remain engaged in diverse physical activities. Participation in diverse sports programs can bring lasting benefits and is recognized as a key element of a healthy lifestyle. Therefore, more targeted strategies are needed to increase participation in both diverse sports programs and general physical activity among youth.

Keywords Physical activity, Physical fitness, Sports programs, Cross-sectional analysis, Children and adolescents

Participation in a diverse range of sports improves the physical activity (PA) levels of children and adolescents, contributing to their physical health, and children and adolescents who are physically active are more likely to be physically active in adulthood than those who do not participate in sports[1,2]. There are two primary health-related reasons for focusing on children's and adolescents' sport program participation: first, to promote physical health at this life stage; and second, to promote future health by increasing the likelihood that (PA) will remain

China Institute of Sport Science, No.11 Tiyu Guan Road, Dongcheng District, Beijing 100061, China. ✉email: zhangyanfeng0310@126.com

active throughout the lifespan through sport program participation[3,4]. Of interest are the many lines of evidence demonstrating the importance and health benefits of higher levels of physical activity among children and adolescents: for example, adolescents with higher levels of (PA) have a reduced risk of cardiovascular disease in later life[5]. Cardiorespiratory health in adolescents is also directly related to mental health and quality of life[6,7]. Muscle health (e.g., strength and endurance) is associated with reduced risk of obesity and cardiometabolic parameters as well as bone health in later life[8,9]. The importance of physical exercise to an individual's health can be seen. However, the combined data show that over the past two decades, children and adolescents have had low levels of physical activity[10,11].It is important to identify more effective ways to encourage children and adolescents to participate in different sports programs to improve (PA) levels.

Most children and adolescents do not meet (PA) guidelines (60 min, 1 h) or more physical activity/day (PA)[12]. One reason for not meeting the guidelines may be that leisure-time physical exercise has changed over the past few decades[13]. For example, the dramatic increase in sedentary behavior, screen time[14](PA) declines annually during childhood and screen time increases with age. More than 80% of children and adolescents globally fail to meet PA guidelines and boys are found to be more active than girls[15]. Existing research evidence suggests a positive correlation between adolescent participation in sports and meeting recommended physical activity (PA) guidelines[16,17]. In summary, indisputable evidence exists for the need to increase (PA) levels during childhood and adolescence[18]. That is, by encouraging children and adolescents to participate in different sports programs and enriching the diversity of forms of participation, thereby enhancing the interest of children and adolescents in sports and promoting higher levels of (PA).

Children's and adolescents' participation in sports programs is also influenced by a number of factors, including individual attitudes, the family environment, and the organization of sports activities at school[19,20]. Both positively and negatively, physical education teachers and parents, as well as peers, play an important role in shaping youth physical activity experiences[21]. Therefore, it is important to clearly identify the social factors associated with sport participation in order to elucidate their plausible associations. Three variables were strongly associated with children's sport participation: use of afternoon hours for sport, positive individual attitudes towards physical activity and family support for physical activity[22,23]. Social support refers to the resources provided through interactions with others that may influence behavior. Social support has been recognized as having an important correlation with child and adolescent sport participation, and has even been identified as a key factor in promoting physical activity among children and adolescents[24]. Few studies have evaluated the effects of different types of support (i.e. the support of friends, support of teachers) on adolescent PA. For example, results from a previous study showed that friend support was significantly and positively associated with adolescent participation in physical activity[25]. In a South African study, parental influence was found to be physically active (PA) was the strongest influencer of the overall factor (stronger than PA self-efficacy, peer influence), suggesting that adolescents are more likely to participate in physical activity if they have parental support[26].

Previous studies have reported findings on body composition, physical fitness, lipid levels, blood pressure, correlations with physical activity[27,28]. However, no studies have reported correlations between the diversity of sports participation and physical fitness (e.g., strength, endurance, flexibility). In general, when studying youth physical activity, it is important to consider the influence of different factors (i.e., age, gender, type of support, type of sport, and socioeconomic status)[29]. In addition, family influences, such as parental weight status and physical activity (PA) levels, have been shown to play an important role in child adolescent participation in physical exercise and sports[30,31]. Therefore, the purpose of this study is to identify the correlation between the diversity of sports participation and physical fitness among children and adolescents and whether there are differences in physical fitness among children and adolescents participating in different numbers of sports. In addition, we explored the factors influencing children's and adolescents' participation in sports diversity, including the three dimensions of personal attitudes, family environment, and school sports activities. We hypothesize that the more a child or adolescent participates in a variety of sports, the higher their level of physical fitness (strength, endurance, speed, flexibility), thus promoting better overall health.

We hypothesize that diversified sports participation enhances children and adolescents' physical fitness (muscular strength, endurance, speed, and flexibility) by fostering positive exercise attitudes and increasing cumulative physical activity duration, ultimately promoting holistic health outcomes.

Method

Participants

The data were obtained from the 2020 Survey on Physical Fitness and Fitness Activities in Macao[32]China, which adopted the principle of stratified randomized cluster sampling, with every 1 year of age as an age group. Children and adolescents were randomly selected at the class level from two schools within each of Macao's six districts. Participants with more than 30% missing data on key variables ($n=21$) were excluded from the analysis, yielding an overall exclusion rate of 0.6%. For the children and adolescents population, two "schools" were randomly selected from each of the six districts in Macao, and the sample size was drawn on a class-by-class basis. In this study, 3309 children and adolescents aged 8 to 18 were selected for the study. As this was a large-scale, stratified cluster sampling survey designed to ensure population representativeness, the sample size was determined a priori based on demographic coverage rather than a specific statistical hypothesis. To assess whether the achieved sample was adequate for detecting meaningful effects in the planned analyses, a post hoc power analysis was conducted using G*Power. For the overall design (24 groups defined by age, sports participation diversity, and sex), the achieved power to detect medium effect sizes(Cohen's $f=0.25$) was excellent (>0.99). However, subgroup analyses with smaller cell sizes (approximately 25–100 participants per cell) had more limited power to detect small effects, and these results should be interpreted with caution.

The survey of children and adolescents included two parts: the survey of fitness activities and the physical fitness monitoring. Among them, the survey on fitness activities was in the form of a questionnaire, including basic personal information and sports participation-related information. The basic demographic information includes age, gender, etc.; the sports participation related information mainly includes individual attitude, sports skills, family environment, school sports organization and other information. Survey respondents with congenital or hereditary diseases (e.g. congenital heart disease, developmental delays, etc.), chronic diseases (e.g. hypertension, etc.), and physical limitations were excluded from the survey.

All investigators or guardians signed an informed consent form before the official survey. The study was approved by the Ethics Committee of China Institute of Sport Science (protocol code CISS-2019-06-07).

Variable selection

In this study, the dependent variable "number of sports continuously participated in" was used as a measure of sports participation diversity. This variable was operationalized via a structured questionnaire comprising three key components:

1. Sport selection: Participants were asked, "Which sports have you continuously participated in over the past year?"with the option to select up to four items from a list of 24 standardized sports (e.g., football, swimming, martial arts) and an open-ended field for additional entries.
2. Criteria for continuous participation: For each selected sport, participants reported (a) their weekly participation frequency (options ranging from 1 to 7 days), and (b) typical session duration (options: A: <30 min; B: 30–60 min; C: 60–90 min; D: 90–120 min; E: >120 min). A sport was counted as valid continuous participation only if it met both of the following criteria: participation frequency of at least 3 days per week, and a minimum session duration of 30 min. These thresholds were set with reference to the World Health Organization's physical activity recommendations for children and adolescents.
3. Final scoring: The total score represented the number of sports meeting these criteria, with a possible range of 0 to 4. For example, if a participant selected three sports but only two met the continuous participation criteria, their score would be 2; if all four selected sports met the criteria, the score would be 4.

This detailed operationalization ensures that the measure reflects meaningful engagement across multiple sports rather than mere exposure or occasional participation.

The independent variables were selected as control variables for the personal information (age and gender) in the questionnaire, and as explanatory variables for the attitudinal level of participation in physical activity, the family level, and the organizational level of school sports. In this study, items assessing parents' attitudes toward exercise were adapted from the National Fitness Activity Status Questionnaire in China[33,34]which has been administered every five years since 2000 (four rounds to date) and has been widely adopted and adapted in prior studies. The overall index system of this questionnaire was developed by integrating classic scales such as the Pre-PAQ, HOME, and AHEMD-SR, and finalized through two rounds of expert consultation. Its psychometric properties have been tested and demonstrated good reliability, with a reported Cronbach's α coefficient of 0.82[35]. In the present study, attitude items employed a three-point Likert scale format. For example, the item "Physical activity is very boring" was rated as 1 = strongly disagree, 2 = neutral, or 3 = strongly agree.

This study assessed participants' physical fitness strictly following the National Student Physical Health Standards of China, covering five key dimensions: speed, muscular strength, endurance, explosiveness, aerobic endurance, and flexibility. Specific tests included: muscle strength endurance (BMS), standing long jump (SLJ), 50-meter run, endurance run, and sit-and-reach (SR).

All tests were administered by professional physical education teachers who underwent standardized operational training in advance. Testing venues and equipment were calibrated and standardized to ensure consistency.

Explosiveness was measured using the standing long jump (SLJ). Participants stood with feet parallel to the starting line, were allowed to pre-swing their arms, but steps or run-ups were prohibited. Each participant performed three consecutive jumps, with the best distance (cm) recorded using an electronic distance-measuring pad (accuracy:0.1 cm).

Muscle strength endurance (BMS) was assessed by age- and gender-specific tests: boys aged 8–12 completed inclined pull-ups (chin above bar, full-body extension at rest), boys aged 13–18 performed standard pull-ups (same standard), and all girls performed 60-second sit-ups (shoulder and elbow touching knees, ankles stabilized). For all tests, the maximum number of correctly executed repetitions was recorded.

Speed was assessed via the 50-meter run. Participants used a standing start, initiated by an electronic whistle system, with finish times recorded by an infrared timing device (accuracy:0.01 s). Each participant completed one trial.

Aerobic endurance tests varied by age: participants aged 8–12 ran 50 m*8 round-trips(total 400 m), boys aged 13–18 completed a 1000 m run, and girls aged 13–18 completed an 800 m run. All runs were conducted on standard 400 m synthetic tracks, with times automatically recorded via electronic timing systems.

Flexibility was measured using the sit-and-reach (SR)test. Participants sat on the ground with legs straight against an electronic measuring device(accuracy: 0.1 cm), pushed the sliding board forward at a constant speed to their maximum reach, held the position for one second, and completed two trials with the best score(cm) recorded[36,37].

Procedures

The survey was divided into a questionnaire and a physical fitness test, which was conducted after the person or guardian signed an informed consent form. The questionnaires were asked and answered electronically on site

and were filled out by 1 investigator who asked. Data collection for this study was conducted at the school where the children and adolescents were enrolled. Physical fitness testing Trained physical fitness assessment researchers conducted the measurements to ensure proficiency in the use of tools and techniques. Basic Activation Phase (5 min): Core body temperature was elevated through low-intensity aerobic activities such as jogging around the field and jumping jacks, combined with dynamic games involving "follow-the-leader" movement imitation. Dynamic Stretching Phase (5 min): Targeted dynamic stretching was performed for both lower and upper limbs. Lower limb movements included leg raises, knee hugs, and ankle circles; upper limb movements included lunge twists. Each exercise was performed for 30 s and repeated for two sets.Neural Activation and Sport-Specific Simulation Phase (5 min): Exercises were tailored to the testing requirements, including standing long jump rehearsals (five repetitions of unloaded half-squat jumps) and sprint initiation drills (two sets of 20-meter acceleration runs with stepping starts). Coaches provided real-time feedback to ensure correct technique and reduce injury risk.

The tests were conducted simultaneously between 9 and 11 a.m. and 2 and 4 p.m. on multiple daytime days at a temperature of approximately 26 degrees Celsius. Fatigue was reduced while maintaining consistent conditions. All tests were conducted uniformly to ensure reliable indoor and outdoor conditions and consistent measurements across days. To ensure that participants were adequately prepared and to minimize potential discrepancies due to unfamiliarity with the testing procedures, acclimatization training was conducted prior to the actual testing. All monitoring instruments and testing methods were in accordance with the Chinese National Physical Fitness Monitoring Standards, and scores were recorded by infrared sensors to avoid manual bias[38].To control for measurement bias, evaluator blinding was implemented: fitness assessors had access only to participant ID numbers and were unaware of other participant details. Data entry blinding was also applied: scores were entered by research assistants who were independent of the field testing and did not participate in the assessment process. For each test, participants were allowed two attempts, with the best score recorded.

Data analysis

The dependent variables of this study were firstly processed by summing up the options of the question "sports that have been consistently participated in the last 1 year" and defined as the diversity of youth participation in sports, and all the samples of the dependent variables took the value of 1 to 4 range. SPSS was then used to perform descriptive statistics on the samples, which were expressed as means, standard deviations, and frequencies. First, Pearson correlation analysis was used to analyze whether there was a correlation between the diversity of adherence to participation programs and physical fitness indicators among children and adolescents, using R4.3.0 for visual presentation. A one-way ANOVA was also used to verify the differences between the physical fitness of children and adolescents between the different groups participating in the diversity of sports programs. Then, stratified regression analysis was used to verify the effect of the diversity of participation in sports programs on the physical fitness of children and adolescents. Finally, the analysis of the factors affecting the influence of the diversity of participation in sports programs among children and adolescents was performed using ordered logistic regression analysis, progressively incorporating will control variables (age, gender, BMI), attitudinal, family, and school level factors. All data analysis for this study was done in IBM SPSS Statistics (Version 27.0) and R Programming Language (Version 4.3.0).

Results

Descriptive statistical analysis

Descriptive statistics for BMI across age groups, gender, and diversity of sports participation are presented in Table 1. In the 8–9 years group, BMI increased slightly with higher diversity of sports participation,. A one-way ANOVA revealed a statistically significant difference in BMI among the four levels of sports participation diversity in this age group ($F = 3.705$, $p = 0.012$). However, for the 10–12 years and 13–18 years groups, no significant differences in BMI were found across levels of sports participation diversity ($F = 2.289$, $p = 0.077$;$F = 1.49$, $p = 0.215$).

Independent-samples t-tests examining gender differences in BMI showed that overall, differences between boys and girls were small and generally non-significant across most age groups and diversity levels. A significant difference was observed only in the 8–9 years group at the 1-item participation level($p = 0.035$), where boys exhibited higher BMI. Additionally, a marginally significant difference was found in the 13–18 years group at the 4-item level ($p = 0.032$), with boys having slightly higher BMI.

The relationship between adherence to diversity of participation in sports programs and physical fitness

For the 8–9 year old group, diversity of sport participation was moderately negatively associated with speed qualities in the 50 m run (r = -0.248, $p < 0.01$) and endurance qualities in the 50 m × 8 shuttle run (r = -0.242, $p < 0.01$). For the 10–12 year old group, diversity of sport participation was weakly negatively associated with speed qualities in the 50 m run (r = -0.121, $p < 0.01$), endurance qualities in the 50 m × 8 shuttle run (r = -0.118, $p < 0.01$), and seated forward bending (r = -0.118, $p < 0.01$). In addition, a weak positive correlation was found between seated forward bending and physical fitness in the standing long jump ($r = 0.085$, $p < 0.01$). 090, $p < 0.01$), a weak negative correlation with the 50-meter run (r = -0.173, $p < 0.01$), a weak negative correlation with the 8-endurance run (r = -0.173, $p < 0.01$), and a weak positive correlation with seated forward body flexion ($r = 0.074$, $p < 0.01$). See Fig. 1for details. The specific correlation coefficients for these associations are presented in Supplementary Table 1.

Age(years)	Diversity of sports participation (items)	Total ($n=3309$)	BMI	Male ($n=1789$)	BMI	Female ($n=1520$)	BMI
8～9	1	114	17.95 ± 3.42	63	18.45 ± 3.81	51	17.32 ± 2.78
	2	83	17.63 ± 3.54	45	17.77 ± 3.51	38	17.46 ± 3.62
	3	64	17.83 ± 2.81	39	17.68 ± 2.81	25	18.07 ± 2.85
	4	144	19.05 ± 4.11	77	19.27 ± 4.18	67	18.8 ± 4.04
10～12	1	325	20.20 ± 4.73	174	20.28 ± 4.98	151	20.10 ± 4.45
	2	183	20.21 ± 4.06	90	20.47 ± 4.44	93	19.96 ± 3.66
	3	149	20.21 ± 4.23	83	19.94 ± 4.47	66	20.55 ± 3.90
	4	405	20.94 ± 4.53	239	21.03 ± 4.56	166	20.82 ± 4.49
13～18	1	764	19.60 ± 3.73	412	19.60 ± 3.73	352	19.56 ± 3.77
	2	390	20.07 ± 4.06	209	20.10 ± 4.29	181	20.05 ± 3.78
	3	264	19.75 ± 3.69	135	19.88 ± 3.83	129	19.61 ± 3.55
	4	424	19.81 ± 3.63	223	20.12 ± 3.83	201	19.47 ± 3.37

Table 1. Descriptive statistics for BMI by age group, sex, and diversity of sports participation levels (mean ± SD). BMI values are presented as mean ± standard deviation. One-way ANOVA indicated a significant difference in BMI across participation diversity levels in the 8–9 years age group (F = 3.705,p = 0 0.012). No significant differences were found in the 10–12 and 13–18 years groups ($p > 0.05$). Independent-samples t-tests showed significant gender differences only at 8–9 years, 1-item level (p = 0 0.035), and marginally at 13–18 years, 4-item level ($p = 0$ 0.032, one-tailed), with boys having higher BMI.

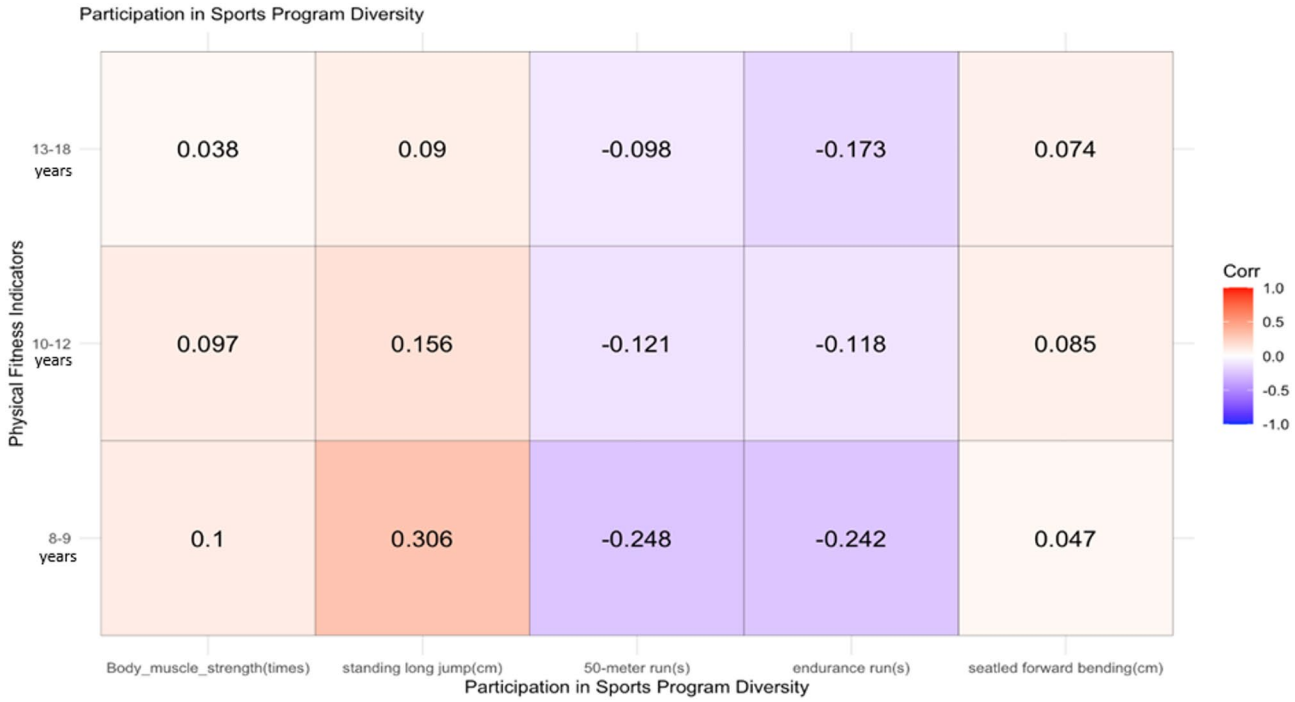

Fig. 1. Correlation analysis between diversity of sports participation and physical fitness in different age groups. 50-meter run and endurance run are low superiority indicators, others are high superiority indicators; Body Muscle Strength (BMS): incline pull-ups for boys 8–12 years old, pull-ups for 13–18 years old, and sit-ups for girls 8–18 years old; Endurance run: 50-meter x 8 round-trip run for 8–12 years old, and 1,000-meter run for boys and 800-meter run for girls 13–18 years old.

Differences in physical fitness among groups persistently participating in different sports programs

The results showed that in the boys' group, there were significant differences ($p < 0.01$) in the physical fitness indexes of standing long jump, 50-meter run and endurance run between the age groups of 8–9 years old and the age groups of 10–12 years old in the following categories: muscular strength, standing long jump, 50-meter run, endurance run, and seated body flexion, and the age groups of 13–18 years old in the following categories: muscular strength, standing long jump, 50-meter run, endurance run, and seated body flexion, and the age groups of 13 – 12 years old in the following categories: muscular strength, standing long jump, 50-meter run,

endurance run, and seated body flexion. : There was significant difference ($p < 0.01$) in muscle strength, standing long jump, 50-meter dash, endurance run and sitting forward bend. See Table 2 for details.

In the girls' group: 8–9 years age group adhered to the diversity of participation in sports program between different groups of physical fitness indicators: muscle strength, standing long jump, endurance running there is a significant difference ($p < 0.01$). 10–12 years age group: standing long jump, 50-meter dash, endurance running there is a significant difference.

($p < 0.01$). 13–18 years age group: muscle strength, standing long jump, 50-meter run, Endurance running were significantly different ($p < 0.01$). See Table 3 for details.

Impact of diversity of participation in sports on physical fitness

In order to further examine the effect of sports participation diversity on the physical fitness of children and adolescents, we conducted linear regression analyses, constructing five models that included gender, age, and BMI as control variables. The Durbin-Watson statistics for these models were all greater than 1.5, indicating no significant autocorrelation of residuals and satisfying the assumption of independence in linear regression. Additionally, all variance inflation factor (VIF) values were below 5, suggesting no issues with multicollinearity. The results showed that sports participation diversity had a significant positive effect on muscle strength ($\beta = 0.069$, $p < 0.01$), standing long jump ($\beta = 0.113$, $p < 0.01$), and flexibility as measured by the sit-and-reach test ($\beta = 0.078$, $p < 0.01$). Significant beneficial associations were also observed for the 50-meter run (β = -0.105, $p < 0.01$) and the endurance run (β = -0.088, $p < 0.01$), with lower times indicating better performance. These findings strengthen the robustness of the observed relationship between sports participation diversity and physical fitness outcomes. These results are presented in detail in Table 4.

Analysis of factors influencing the diversity of participation in sports programs

We used ordered logistic regression to stepwise incorporate control variables, attitude-level factors, family-level factors, and school-level factors to analyze the factors influencing children's and adolescents' participation in sports programs.

The results showed that the inclusion of control variables BMI ($\beta = 0.008$, $p < 0.01$) and age were statistically significantly associated with the diversity of children's and adolescents' participation in sports programs ($\beta = 0.013$, $p < 0.01$). Individual factors at the level of attitudes towards physical activity: the perception of boredom with physical activity is an unfavorable factor for the participation of children and adolescents in the diversity of sports programs (β=--0.145, $p < 0.05$), unpleasantness of physical activity is a risk factor for the participation in the diversity of sports programs (β=-0.123, $p < 0.05$), and the willingness to insist on exercising all the time is an advantageous factor for the participation in the diversity of sports programs ($\beta = 0.111$, $p < 0.01$). Model 3 incorporates home-level factors: the number of home physical activity is the more is a favorable factor for participation in sports program diversity ($\beta = 0.0.019$, $p < 0.01$), and the length of time on electronic screens at home is an unfavorable factor for participation in sports program diversity (β=-0.016, $p < 0.01$). School-level factors: moderate-intensity physical education program was a favorable factor for children and adolescents to participate in sports program diversity (β=-0.084, $p < 0.05$), difficulty in completing school physical education requirements was an unfavorable factor for participation in sports program diversity (β=-0.125, $p < 0.05$), and being influenced by classmates to participate in physical education was a favorable factor for participation in sports program diversity ($\beta = 0.098$, $p < 0.05$). See Table 5 for details.

Discussions

The present study indicates that the diversity of participation in sports programs for children and adolescents is related to physical fitness, and it was found that there is variability in physical fitness between groups with different numbers of participation in sports programs. It was also verified that participation in diverse sports programs has a positive effect on the physical fitness of children and adolescents. In addition, the influencing factors affecting the attitudes, family, and school dimensions of children and adolescents' participation in sports programs were indicated. The higher number of children and adolescents' adherence to sports programs showed a high positive correlation with physical fitness performance, and there were significant differences in physical fitness performance between groups with different numbers of adherence to sports programs. It can be inferred that the more children and adolescents consistently participate in sports programs, the higher the level of physical activity and the better the physical performance, which is more conducive to the promotion of their physical health.

The results of this study showed that adherence to sport variety was strongly associated with speed, endurance, explosiveness, and flexibility in children of both sexes in three age groups: 8–9 years, 10–12 years, and 13–18 years. The results of regression analyses further validated that participation in a variety of sports improves a number of physical qualities in children, increasing the robustness of the correlation analysis results.The richer the consistent participation in sports programs, the better the performance of these qualities, and previous studies have demonstrated that physical activity participation enhances physical fitness[39,40]. The results of the present study further explain that the greater the number of sports programs participated in the better the performance of physical fitness and thus better the physical fitness of the individual. Previous research has shown that better physical and mental benefits are associated with greater participation in sport, including psychological and social benefits[41]. These results emphasize that the greater the number of adherent sports programs involved, the greater the contribution to health benefits, such as aerobic fitness, muscular strength, and endurance training increase bone density and more favorable cardiovascular health[41,42]. However, our study found that in the 13–18 age group, seated forward bending data performed best in the adherent 2-sport group. We believe that this may be related to the characteristics of muscle strength development and the tendency of sport specialization during adolescence, because muscle strength grows rapidly in this age group, and adherent multi-sport athletes may not

Physical fitness indicators	Diversity of sports programs(items)	8–9 years					10–12 years					13–18 years				
		N	M ± SD	F	η^2	post-hoc(LSD)	N	M ± SD	F	η^2	post-hoc(LSD)	N	M ± SD	F	η^2	post-hoc(LSD)
Body muscle strength (times)	1	63	20.06 ± 18.12	0.258	0.004		173	21.86 ± 12.38	3.339**	0.017	1 < 2,3,4	412	1.16 ± 2.23	2.939**	0.009	1 < 3
	2	45	21.22 ± 17.42				90	26.26 ± 15.96			2 > 1	208	1.33 ± 2.28			2 < 3
	3	39	22.26 ± 14.27				82	27.29 ± 19.10			3 > 1	135	1.90 ± 3.01			3 > 1,2
	4	76	22.26 ± 14.11				239	26.09 ± 17.10			4 > 1	222	1.52 ± 3.32			
Standing long jump (cm)	1	63	117.67 ± 18.36	11.284**	0.133	1 < 3,4	174	137.22 ± 25.22	4.673**	0.024	1 < 4	411	177.89 ± 32.29	8.034**	0.024	1 < 2,3,4
	2	45	122.98 ± 16.72			2 < 4	88	142.5 ± 25.57				209	187.13 ± 30.77			2 > 1
	3	39	127.59 ± 17.85			3 > 1;3 < 4	83	141.58 ± 25.88				134	189.66 ± 32.96			3 > 1
	4	77	134.84 ± 18.28			4 > 1,2,3	239	146.47 ± 24.03			4 > 1	222	187.55 ± 31.14			4 > 1
50-meter run (s)	1	61	11.96 ± 1.84	11.478**	0.137	1 > 2,3,4	161	10.68 ± 1.81	3.223**	0.017	1 > 2,4	366	8.56 ± 1.17	5.501**	0.018	1 > 2,3,4
	2	44	10.94 ± 0.99			2 < 1	82	10.29 ± 1.46			2 < 1	192	8.26 ± 0.90			2 < 1
	3	38	10.89 ± 1.04			3 < 1	82	10.39 ± 1.26				122	8.30 ± 1.27			3 < 1
	4	77	10.70 ± 1.12			4 < 1	231	10.22 ± 1.24			4 < 1	207	8.24 ± 0.95			4 < 1
endurance run (s)	1	59	156.87 ± 30.73	7.193**	0.094	1 > 2,3,4	152	145.63 ± 41.94	3.126**	0.017	1 > 4	348	343.37 ± 76.07	12.75**	0.043	1 > 2,3,4
	2	43	144.56 ± 20.98			2 < 1	77	146.11 ± 59.28			2 > 4	187	316.95 ± 62.33			2 < 1
	3	35	139.43 ± 19.69			3 < 1	79	136.09 ± 19.73				121	320.29 ± 64.55			3 < 1
	4	75	138.21 ± 22.52			4 < 1	223	135.35 ± 30.62			4 < 1	203	309.13 ± 64.35			4 < 1
Seated forward bending (cm)	1	63	4.55 ± 7.43	1.084	0.015		174	0.57 ± 7.11	2.856**	0.015	1 < 4	411	3.12 ± 8.99	5.375**	0.016	1 < 2,3,4
	2	45	2.26 ± 7.03				90	2.36 ± 7.08				209	5.59 ± 8.97			2 > 1
	3	39	3.89 ± 5.85				83	1.41 ± 7.17				135	5.40 ± 8.79			3 > 1
	4	77	4.19 ± 6.77				239	2.52 ± 6.96			4 > 1	222	5.29 ± 8.69			4 > 1

Table 2. Analysis of differences in physical fitness between groups of boys' participation in sports diversity at different ages. **$p < 0.01$; 50-meter run and endurance run are low superiority indicators, others are high superiority indicators; Body Muscle Strength (BMS): incline pull-ups for boys 8–12 years old, pull-ups for boys 13–18 years old, sit-ups for girls 8–18 years old; Endurance run: 50-meter × 8 round trip run for 8–12 years old, 1000-meter for boys 13–18 years old, 800-meter run for girls. Run, Girls 800 m run. Post-hoc results based on LSD test. "<" indicates significantly lower mean at $p < 0.05$.

be able to balance strength and flexibility training, which is more likely to lead to the overuse of localized muscle groups, limiting the range of joint movement This may lead to overuse of local muscle groups, limiting the range of motion of the joints, resulting in a decrease in flexibility[43,44].

Therefore, children and adolescents should be encouraged to consistently participate in different sports programs, thereby increasing overall physical activity levels and promoting physical fitness development to improve individual health. The attitudinal dimension refers to the value judgments and evaluations that children and adolescents make about their participation in physical activity and is intrinsic to children's motivation to participate in physical activity.The analysis of influencing factors showed that the diversity of children and adolescents' adherence to participation in sports programs is influenced by several dimensional factors[45]. We found that individual perceptions of attitudes toward physical activity are important factors influencing the diversity of children's and adolescents' adherence to sports programs[46,47]. The results showed that perceiving physical activity as not boring and willingness to persist in physical activity were favorable factors for participation in diverse sports programs. This is consistent with previous research findings that individual attitudes are important determinants of individual behavior, and that positive attitudes are more conducive to children's and adolescents' adherence to diversified sports programs[48,49].

In addition, we found that at the family level, the number of family sports sessions and the length of each session were positively influencing the diversity of sports programs in which children and adolescents participated. This result also suggests that sport participation requires time to maintain, and previous research has shown that more leisure time for individuals is conducive to sport participation[50]. Numerous studies have shown that e-addiction increases children's sedentary behavior and constrains children's physical activity participation, consistent with the results of this study[51,52]. Electronic screen time at the family level as a disadvantage to child adolescents' adherence to diversity in sports programs[53]. Previous studies have shown that children and adolescents' electronic screen time is a serious risk to their physical health and visual health[54]. The use of electronic products hinders the participation of children and youth in physical activities and has a serious impact on the health of individuals, especially as children and youth are in a critical period of physical development and need to be involved in more outdoor activities, reducing the use of electronic screens[55]. Parents can make a positive contribution to children's activity practices. Promoting joint participation in physical activity and reducing sedentary activity are useful goals for increasing physical activity among parents and adolescents[56,57].

In addition to the home environment, the school environment plays a crucial role in youth participation in sports. the difficulty of completing the requirements of physical education classes is not conducive to the adherence of children and adolescents to participate in the diversity of sports programs. This finding also confirms that participation in sports activities requires a sense of superiority and that the difficulty of the content of the physical education curriculum tends to generate psychological frustration in students, which affects their adherence to the sports program[58,59]. Additionally we found that child adolescent participation in sports program diversity is influenced by school peers and that peer participation drives individual sports participation. Having friends to support and watch youth was highly positively associated with youth participation in sports activities[60]. A growing body of research also suggests that peer-driven or supported physical activity has a positive impact on children and youth[61]. Peer relations theory and research suggest that peers provide unique opportunities for companionship and recreation during childhood and adolescence. During childhood and adolescence, many physical activities typically involve some form of play, whether organized sports or spontaneous routines that require play partners[62].

This study has several limitations. First, we did not examine whether demographic variables such as gender, age, or BMI moderate the relationships between sport participation diversity and physical fitness outcomes. Including interaction terms or subgroup analyses could provide deeper insights, though this was beyond the scope of our current analysis. Future research should address this.Second, we did not control for potentially influential factors such as nutrition, sleep, and recent physical activity, which may have introduced variability. Finally, although some regression coefficients were statistically significant, their effect sizes were small, and practical significance may be limited. Interpretations should be cautious, and these results should be considered alongside other factors in health planning.

Conclusion

The results of this study indicate that participation in the diversity of sports programs that have been consistently involved in the most recent year is highly correlated with physical fitness. The higher the number of consistent participation in sports programs, the better the performance of physical fitness, and the better it promotes individual health. Moreover, there was a significant difference in physical fitness between the groups of consistent participation in sports program diversity. The need for more social support (from family and peers) for children and adolescents to persist in sports program diversity may enable more children and adolescents to persist in diverse sports programs. Participation in sports programs provides lasting benefits that are considered attributes of a healthy lifestyle. Therefore, it is important to encourage children and adolescents to participate in diverse forms of sport. More precise promotion strategies are needed to increase participation in diverse sports programs or physical activity in general among adolescents.

Suggestions: (1) Develop a diversified physical education curriculum at the school level to enable students to master sports skills and lay the foundation for participation in physical exercise. Physical education teachers should rationally arrange the teaching content and control the intensity of the curriculum to avoid the negative emotions brought by the burden of the curriculum on students' participation in sports. (2) The family sports atmosphere has an important influence on children's and adolescents' sports participation. Parents should encourage their children to participate in sports, cultivate their children's diversified sports skills, and increase their children's outdoor activities to reduce sedentary and electronic screen time.

Physical fitness indicators	Diversity of sports programs (items)	8–9 years					10–12 years					13–18 years				
		N	M ± SD	F	η^2	post-hoc(LSD)	N	M ± SD	F	η^2		N	M ± SD	F	η^2	
Body muscle strength (times)	1	51	17.88 ± 7.50	3.840**	0.061	1 < 3,4	151	23.65 ± 6.94	2.225	0.014	1 < 3,4	351	27.50 ± 7.91	2.702**	0.009	1 < 3
	2	38	20.39 ± 7.98				93	24.17 ± 7.02				180	28.97 ± 9.22			
	3	25	22.44 ± 8.76			3 > 1	65	25.91 ± 5.84			3 > 1	126	29.63 ± 8.24			3 > 1
	4	67	22.21 ± 6.48			4 > 1	166	25.2 ± 7.36			4 > 1	201	28.68 ± 7.81			
Standing long jump (cm)	1	51	113.25 ± 11.94	4.815**	0.075	1 < 2,3,4	151	128.81 ± 20.55	3.880**	0.024	1 < 4	352	138.07 ± 20.94	5.613**	0.019	1 < 2,3,4
	2	38	122.24 ± 15.66			2 > 1	93	129.27 ± 20.12				179	143.83 ± 24.45			2 > 1
	3	25	122.72 ± 16.81			3 > 1	65	134.78 ± 23.87				129	145.03 ± 22.04			3 > 1
	4	67	123.75 ± 17.98			4 > 1	166	135.9 ± 21.36			4 > 1	201	144.43 ± 22.72			4 > 1
50-meter run (s)	1	46	11.6 ± 0.85	1.336	0.023		149	10.72 ± 1.22	2.668**	0.018	1 > 3,4	316	9.99 ± 1.11	7.167**	0.027	1 > 2,3,4
	2	38	11.42 ± 0.80				88	10.75 ± 1.22				163	9.64 ± 0.91			2 < 1
	3	25	11.13 ± 1.03				59	10.36 ± 1.17			3 < 1	115	9.67 ± 0.97			3 < 1
	4	67	11.31 ± 1.18				157	10.44 ± 1.19			4 < 1	189	9.63 ± 0.94			4 < 1
endurance run(s)	1	45	154.86 ± 22.36	3.375**	0.057	1 > 3,4	143	141.96 ± 29.32	2.964**	0.02	1 > 3,4	286	297.77 ± 51.86	6.726**	0.028	1 > 3,4
	2	35	147.45 ± 17.28				85	138.31 ± 18.58				144	289.14 ± 47.65			
	3	25	140.19 ± 19.09			3 < 1	59	133.19 ± 18.03			3 < 1	106	281.82 ± 38.73			3 < 1
	4	67	145.56 ± 19.82			4 < 1	152	135.48 ± 18.78			4 < 1	179	279.07 ± 43.80			4 < 1
Seated forward bending (cm)	1	51	6.84 ± 7.40	2.03	0.033	1 < 3	151	6.32 ± 8.20	2.503	0.016	1 < 4	352	9.58 ± 9.28	1.882	0.007	1 < 2
	2	38	7.47 ± 7.01				93	7.29 ± 8.05				181	11.35 ± 9.74			2 > 1
	3	25	10.72 ± 5.69			3 > 1	66	7.51 ± 8.85				129	9.74 ± 8.32			
	4	67	8.18 ± 6.01				166	8.82 ± 7.95			4 > 1	201	10.89 ± 9.72			

Table 3. Analysis of differences in physical fitness among groups of girls' participation in sports diversity at different ages. $^{**}p < 0.01$; 50-meter run and endurance run are low superiority indicators, others are high superiority indicators; Body Muscle Strength (BMS): incline pull-ups for boys 8–12 years old, pull-ups for boys 13–18 years old, sit-ups for girls 8–18 years old; Endurance run: 50-meter × 8 round trip run for 8–12 years old, 1000-meter for boys 13–18 years old, 800-meter run for girls. Run, Girls 800 m run.Post-hoc results based on LSD test. "<" indicates significantly lower mean at $p < 0.05$.

Y(Physical fitness indicators)	X	β	*p*	VIF	R2	ΔR2	F	Dubin-Watson test
Body muscle strength (times)	Gender	-0.488	0.01	1.002	0.327	0.326	379.338**	1.725
	Age	0.208	0.01	1.039				
	BMI	-0.118	0.01	1.007				
	Diversity of sports programs	0.069	0.01	1.038				
Standing long jump (cm)	Gender	-0.434	0.01	1.002	0.451	0.45	591.544**	1.645
	Age	0.577	0.01	1.039				
	BMI	-0.193	0.01	1.008				
	Diversity of sports programs	0.113	0.01	1.038				
50-meter run (s)	Gender	0.303	0.01	1.003	0.424	0.424	507.936**	1.586
	Age	-0.635	0.01	1.038				
	BMI	0.172	0.01	1.009				
	Diversity of sports programs	-0.105	0.01	1.036				
an endurance run(s)	Gender	-0.1	0.01	1.002	0.517	0.517	740.825**	1.562
	Age	0.636	0.01	1.036				
	BMI	0.136	0.01	1.008				
	Diversity of sports programs	-0.088	0.01	1.035				
Seated forward bending (cm)	Gender	0.31	0.01	1.002	0.12	0.119	112.739**	1.894
	Age	0.14	0.01	1.039				
	BMI	-0.009	0.6	1.007				
	Diversity of sports programs	0.078	0.01	1.038				

Table 4. Effect of diversity of participation in sports programs on physical fitness. *Note: BMI – body mass index.*

		β	wprd	OR	*p*	OR95%CI	
Thresholds	Diversity of sports participation (1 items)	0.349	55.754	0.074	0.001	-3.285	-1.919
	Diversity of sports participation (2 items)	0.347	23.673	0.185	0.001	-2.367	-1.008
	Diversity of sports participation (3 items)	0.346	8.167	0.372	0.004	-1.667	-0.311
Control Variables	BMI	0.008	10.874	1.027	0.001	0.011	0.043
	Age	0.013	50.93	0.912	0.001	-0.118	-0.067
	Gender	0.067	3.669	0.88	0.055	-0.259	0.003
Attitudinal level	Physical activity is very boring						
	Agree [Ref: Disagree]	-0.145	3.481	1.311	0.032	-0.014	0.555
	Neutral [Ref: Disagree]	0.15	2.781	1.285	0.095	-0.044	0.545
	Physical exercise is not enjoyable						
	Agree [Ref: Disagree]	-0.123	0.076	1.035	0.023	-0.208	0.276
	Neutral [Ref: Disagree]	0.124	1.142	0.876	0.285	-0.375	0.11
	Willing to stick to exercising all the time						
	Agree [Ref: Disagree]	0.111	19.311	0.614	0.001	-0.704	-0.27
	Neutral [Ref: Disagree]	0.077	12.059	0.765	0.001	-0.419	-0.117
Family level	Number of times of household physical activity	0.019	95.422	0.831	0.001	-0.223	-0.148
	Time spent using electronic screens at home	0.016	13.528	0.944	0.001	-0.089	-0.027
School level	Intensity of School Physical Education Classes						
	High intensity [Ref: low intensity]	0.131	0.742	0.893	0.389	-0.37	0.144
	Medium Intensity [Ref: Low Intensity]	0.084	0.47	0.943	0.024	-0.222	0.035
	Difficulty in completing PE requirements						
	Agree [Ref: Disagree]	-0.125	4.511	1.303	0.034	0.02	0.51
	Neutral [Ref: Disagree]	0.124	0.178	1.053	0.673	-0.191	0.296
	Wil Influenced by classmates to participate in sports						
	Agree [Ref: Disagree]	0.098	26.607	0.602	0.001	-0.699	-0.314
	Neutral [Ref: Disagree]	0.074	18.62	0.725	0.001	-0.467	-0.175
Goodness of fit		X2 = 9839.395, degrees of freedom = 9840, $p = 0.500$					
Test of proportional odds (parallel lines)		$\chi^2 = 42.22$, df = 36, $p = 0.22$					

Table 5. Multifactorial stratified linear regression analysis of children and adolescents' adherence to participation in sports program diversity. The model fit goodness of fit $p > 0.05$, indicating that the model is well fitted.

Data availability

The data concern the privacy of minors and are not available to the public. For further information concerning the data, please contact the corresponding author, Y.Z.

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Author contributions

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of China Institute of Sport Science (protocol code CISS-2019-06-07), and all experimental methods were conducted in accordance with the Declaration of Helsinki and relevant Chinese laws and regulations. All participants and/or their legal guardians gave informed consent.

Consent for publication

All participants have agreed on publication.

Additional information

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Correspondence and requests for materials should be addressed to Y.Z.