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Original article

School and community physical activity characteristics and moderate-to-vigorous physical activity among Chinese school-aged children: A multilevel path model analysis

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Abstract

Purpose: The purpose of this study was to examine the association between school and community physical activity (PA) characteristics and levels of moderate-to-vigorous physical activity (MVPA) among Chinese school children.
Methods: Data were obtained from the 2016 Physical Activity and Fitness in China—The Youth Study project. Participants were 80,928 school children (Grades 4–12; 39,747 boys, 41,181 girls; mean age = 13 years) and 935 physical education (PE) teachers who completed a study survey. Independent variables included both school-related factors (school-level PA support, availability of and access to PA facilities, and the duration of school PE classes) and community-related factors (the frequency of sports events, sports training opportunities, availability of sports clubs and organizations, and access to PA facilities). The dependent variable was the children's self-reported participation in MVPA. The data were analyzed, in 2017, via multilevel modeling.
Results: PA support from school administrators was the only school-level factor significantly related to children's participation in MVPA. Children's perceptions of the frequency of community-sponsored sports events, availability of sports clubs and organizations, and convenient access to PA facilities were associated with a high level of MVPA participation. In regard to residency in urban and rural areas, children attending urban schools who perceived high availability of PA facilities were associated with a low level of participation in MVPA.
Conclusion: School support for PA and community PA resources are associated with MVPA among Chinese school children. School PA facilities appear underutilized among urban schools as evidenced by low levels of MVPA among school children.

Keywords: Facilities; Physical activity support; Physical education; Rural areas; Teachers; Urban areas

1. Introduction

Physical activity (PA) has been considered an important health-enhancing behavior for school-aged children and adolescents.[1,2] Mounting evidence shows that regular PA in childhood and adolescence improves muscular strength and endurance, reduces cardiovascular disease risk, builds healthy bones and maintains healthy weight, and increases physical and mental wellbeing.[3,4] However, in addition to various individual factors,[5,6] motivation to exercise is often influenced by social and built environmental factors in schools and around communities. Accordingly, there is an increased interest in understanding contextual factors or correlates that contribute to levels of PA participation in these environmental settings so that appropriate school- and after-school-based interventions to increase PA for children and adolescents can be developed.[6-12]

While both schools and communities have been shown to provide an important PA promotion venue where children can be taught to adopt and maintain a healthy, active lifestyle,[13,14] there is little available research in China that examines how these settings affect or influence children's levels of PA, which has been shown to be low,[15,16] especially outside of school.[17] An early regional study has identified several factors, such as

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school environment, access to public facilities in the community, availability of sidewalks and open space near homes, and residential density, that were important in promoting PA among Chinese children and adolescents.[18] However, additional research is needed in order to understand the extent to which school and community environments may either facilitate or impede the engagement of children in PA in the Mainland of China.

Using a national dataset and a multilevel analysis, we examined the association between school and community PA characteristics and levels of moderate-to-vigorous physical activity (MVPA) among Chinese school-aged children. On the basis of prior research,[6,17] we hypothesized that school-level factors, such as PA support, availability of and access to PA facilities, and the duration of school physical education (PE) classes would be associated with MVPA among children and adolescents at the school level, and perceived individual-level community resources factors, such as the frequency of sponsored sports events, PA skill training opportunities, availability of sports clubs and organizations, and convenient access to PA facilities, would be associated with child-level MVPA.

2. Methods

2.1. Study design and participants

Data were extracted from the 2016 Physical Activity and Fitness in China—The Youth Study (PAFCTYS) project, a cross-sectional and nationwide survey of PA and fitness among Chinese school-aged children. Conducted between October and November 2016, the PAFCTYS involved a stratified 3-stage cluster sample design to select a representative sample of the Chinese school-aged children population. Details on the study design, methodologies, and research protocol are described elsewhere.[19] Briefly, a total of 125,281 students, Grades 4–12, from 991 (primary (Grades 4–6), junior middle (Grades 7–9), and junior high (Grades 10–12)) schools in China participated in the survey portion of the PAFCTYS. Children from Grades 1 through 3 were not included in the survey because of concerns about their cognitive ability to understand and complete the questionnaire items. As part of the study, 1 PE teacher from each participating school was also invited to participate.

This study was approved by the Institutional Review Board of Shanghai University of Sport. Permission to conduct the study was obtained from principals of each school. Verbal consent was obtained from the children's parents or guardians and from all participating children and PE teachers prior to data collection.

2.2. Procedures

Following a standardized protocol, trained research staff administered the survey during regular school hours. Some of the students (44.2%) completed the survey online, while the remainder (55.8%) completed a paper version of the survey. The purpose of the study was explained to the PE teachers and students prior to survey administration. Participants were given detailed instructions on how to fill out the survey and were provided ample time for questions. PE teachers completed their surveys individually whereas students completed their surveys as a group in the classroom.

2.3. Measures

The measures used in this study were gathered from the PE teacher and student surveys, which are described in detail below.

2.3.1. MVPA

Children's self-reported MVPA was assessed by the validated Chinese version[20] of the International Physical Activity Questionnaire Short Form (IPAQ-SF).[21] The IPAQ-SF questionnaire consists of 4 questions that ask participants to recall aspects of their PA over the previous 7 days, including information on the amount of time (i.e., number of days and average time per day) spent on sitting, walking, and participating in moderate-intensity and vigorous-intensity activities. In the current study, total weekly accumulation of minutes spent on engaging in moderate-intensity and vigorous-intensity activities for at least 10 min in duration were used as a study outcome variable.

2.3.2. PA measures at the school level

Four subscales were used; each was ascertained from the school PE teachers. Specifically, teachers were asked about (1) the school principal's support of PE work (4 items); (2) the availability of school PA facilities (2 items); (3) access to school PA facilities (2 items); and (4) the number of minutes of school PE class time offered weekly (2 items). The items about principal support included queries on the provision of PE staff, professional training of PE teachers, remuneration, and financial support for PE. The response to each item was anchored on a 5-point scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Availability of school PA facilities was measured by whether the teachers were satisfied that the PA facilities met the needs of PE teaching and extracurricular PA by students. Access to school PA facilities was measured by whether school PA facilities were open at no cost to students on weekends and holidays. Items in each of these 2 subscales were anchored to a 3-point scale, ranging from 1 (*not satisfied*) to 3 (*completely satisfied*) for availability of school PA facilities, and from 1 (*not open*) to 3 (*open all day*) for access to school PA facilities. Finally, the amount of PE class time was measured by responses to 2 items regarding the number of 30–45 min PE classes and 60–90 min PE classes offered each week. The overall minutes of PE class time per week were calculated by multiplying the number of classes taught by the number of class minutes per week. Scores from these 4 subscales were aggregated from individual teacher responses, with higher scores indicating favorable school-level PA environments.

2.3.3. PA resource measures in communities

Children were asked to respond to a series of survey questions about PA resources in their neighborhood communities. These included 4 single-item scales: (1) frequency of sponsoring sports events; (2) convenient access to PA facilities; (3) free PA skill training opportunities; and (4) availability of sports clubs and organizations. Convenient access to PA facilities and

availability of sports clubs and organizations were measured using a 2-point scale (*no* or *yes*), and the remaining 2 measures were assessed using a 5-point scale, ranging from 1 (*none*) to 5 (*much*), with high scores on each of these measures indicating favorable community PA resources. A 2-week interval test–retest reliability was assessed by the intraclass correlation coefficient (ICC) on 270 children in Grades 5, 8, and 11, with a coefficient of 0.51 for the single-item community's frequency of sponsoring sports events scale and 0.47 for the free PA skill training opportunities scale.

2.3.4. Attitude toward PA and academic burden

These 2 measures were used as control variables in the structural path model evaluated (see the section "Statistical analysis" for details). Attitude toward PA was measured by the question regarding children's attitude toward PA participation in the future with responses recorded on a 5-point scale, ranging from 1 (*no plan to exercise*) to 5 (*keeping physically active every day*). Academic burden was assessed by a single question: "How pressured do you feel by the schoolwork you have to do?"[22] with responses being recorded on a 5-point scale, ranging from 1 (*not at all*) to 5 (*a lot*). Test–retest reliabilities of these 2 scales, as measured by ICC, were 0.64 for attitude toward PA and 0.53 for academic burden.

2.3.5. Demographic information

Demographic information was obtained from the children's survey. This information included age, school grade (primary, junior middle, or junior high school), sex, height, and weight. Children's height and weight were measured objectively by a portable instrument (GMCS-IV; Jianmin, Beijing, China). Their body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/m^2).

2.4. Statistical analysis

Data were preliminarily analyzed using SPSS (Version 21.0; IBM Corp., Armonk, NY, USA) to check for data normality and to conduct a descriptive analysis of the study variables. A listwise deletion approach (complete-case analysis) was used. Given the multilevel structure of the PAFCTYS data, a multilevel path analysis was used to analyze the 2-level model shown in Fig. 1, in which all variables across between-parts and within-parts of the model were observed or manifested. As shown, the model was specified on the 2 levels of the data hierarchy (i.e., student-level data, school-level data) in the PAFCTYS. School-level variation in MVPA was assessed by calculating the ICC (intra school) and design effects (defined as $1 + (\text{average class size} - 1) \times \text{ICC}$).[23] This correlation describes the degree of similarity among students of the same school on MVPA and is defined as a ratio of (between-school variability)/(between-school variability + within-school variability).

For the between-school part of the model (with a sample size of 935 schools), MVPA was regressed on 4 school-level exogenous variables. In the within-school part of the model (with a sample size of 80,928 students), student-level MVPA was regressed on the 5 individual variables (i.e., school grades, sex, BMI, attitude toward PA, academic burden) and 4 variables measuring children's perceived PA resources in communities.

The multilevel path model was tested using the M*plus*[24] structural equation modeling software, which allows estimation of multilevel models that contain random variation in intercepts

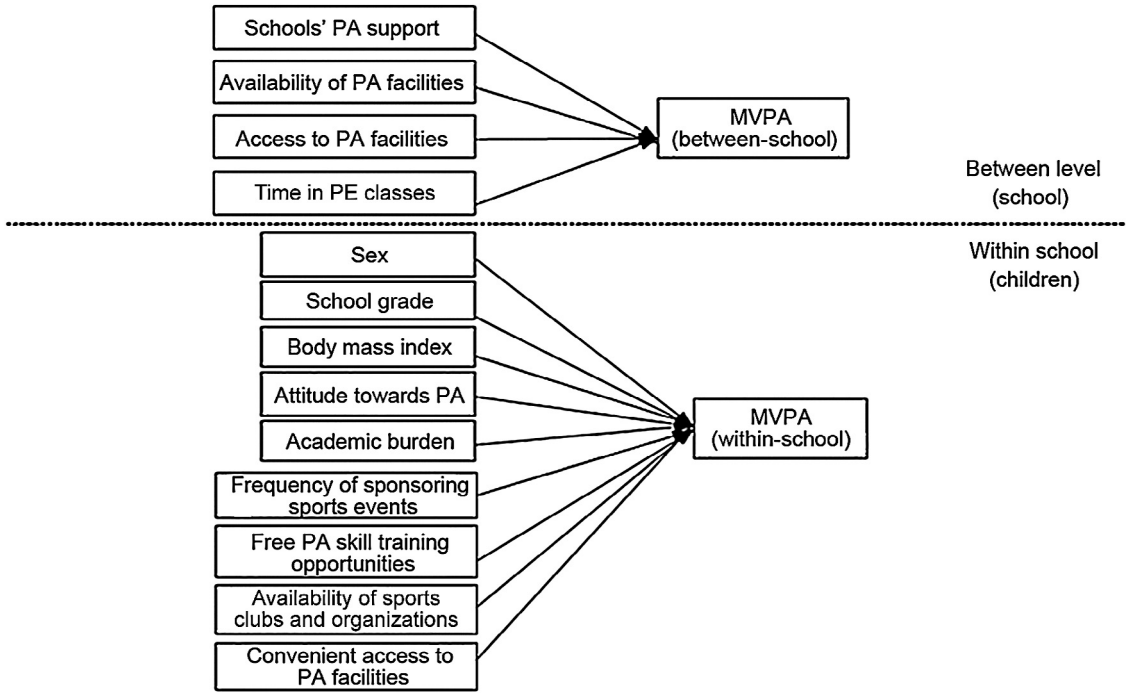

Fig. 1. Hypothesized path model examining associations between school and community PA characteristics and MVPA among Chinese school-aged children. MVPA = moderate-to-vigorous physical activity; PA = physical activity.

and between-group regression slopes (i.e., a regression with random coefficients) while adjusting for clustering due to the complex sampling of the PAFCTYS. A maximum likelihood estimation with robust standard errors was used to generate the estimates of the model's parameters. Goodness-of-fit of the hypothesized model was evaluated using the χ^2 statistic and root mean square error of approximation, with values of 0.06 or less indicating an acceptable level of fit.[25] Both standardized and unstandardized regression coefficients are reported. Estimates with a p value of ≤ 0.05 (2-tailed) are interpreted as statistically significant.

In an exploratory mode, we examined urban–rural differences in the structural relationships under scrutiny. We used a multigroup approach in which we started an unconstrained model (M_0, i.e., no urban–rural cross-group equality constraints on the structural regression paths) followed by a series of increasingly constrained models (i.e., constraining the structural paths of interest across the urban and rural groups to be equal: $M_{1\text{-}8}$). Differences between each of the constrained and unconstrained (nested) models (e.g., M_0 and M_1) were tested by calculating the difference between the χ^2 statistic ($\Delta\chi^2$) for the 2 models under comparison.

3. Results

3.1. Preliminary analysis

An initial inspection of the raw data showed that 33 schools (3%; 4711 children) did not have the school-level information relevant to this study, and 39,642 children (32%) had either missing individual data or provided data that were out of normal range. These children ($n = 39{,}642$) and the schools they attended ($n = 23$) were subsequently removed. Removal of the missing and outliers' data resulted in a total of 935 schools (94%) and 80,928 children (65%) that were included in the current analyses. The average number of children in each school was 87 children.

Descriptive statistics for the study population of children and the outcome measures for the total sample (also segmented by residence locale) are presented in Table 1. The children in the study were equally distributed in terms of sex (50.9% girls) and school grades (primary, junior middle, and junior high schools), and had an age of 13.71 ± 2.94 years old. The MVPA among the participating children was 52.34 ± 50.58 min/day (366 ± 346 min/week).

A bivariate correlation matrix including all observed variables in the structural path model is shown in Table S1 in the online supplement. An ICC value of 0.08 was estimated in the school MVPA, indicating a small, but possibly important, 8% variation at the school level, with a strong design effect of 7.9, calculated by $1 + (87 - 1) \times 0.08$. Both the ICC and the design effect provided justification for a multilevel path analysis.

3.2. Relationships between school and community factors and MVPA

The path model estimated using the total sample (935 schools, 80,982 children) resulted in a χ^2 of 11,389.61 ($df = 40$, $p < 0.001$) with an acceptable fit as judged by 0.068 in root mean square error of approximation. Table 2 shows parameter estimates generated from the multilevel path model. At the school level, an inspection of the path coefficients indicates that school PA support was the only variable that was significantly ($p = 0.014$) related to high levels of school-level MVPA ($b = 1.192$, where b is the unstandardized path coefficient). None of the remaining 3 factors was significantly related to school-level MVPA in children.

At the student level, results indicate that children who reported high scores on frequency of community-sponsored sports events ($b = 4.038$, $p < 0.001$), availability of sports clubs and organizations ($b = 4.489$, $p < 0.001$), and convenient access to PA facilities ($b = 5.278$, $p < 0.001$) were significantly more likely to report high levels of MVPA. Free PA skill training was not significantly related ($p = 0.418$) to the children's MVPA. In

Table 1
Descriptive statistics of the study population—the 2016 Physical Activity and Fitness in China—The Youth Study.

Measure	Total ($n = 80{,}928$)	Urban ($n = 40{,}721$)	Rural ($n = 40{,}207$)
Children level			
Age (year)[a]	13.71 ± 2.94	13.57 ± 2.38	13.92 ± 2.51
Sex[b]			
Boy	39,747 (49.1)	20,089 (49.3)	19,658 (48.9)
Girl	41,181 (50.9)	20,632 (50.7)	20,549 (51.1)
BMI (kg/m^2)[a]	19.76 ± 3.54	20.02 ± 3.71	19.49 ± 3.34
Grade[b,d]			
4–6	27,053 (33.5)	14,814 (36.3)	12,239 (30.4)
7–9	27,133 (33.5)	13,072 (32.2)	14,061 (35.0)
10–12	26,742 (33.0)	12,835 (31.5)	13,907 (34.6)
Attitude toward PA[a,c]	3.80 ± 1.01	3.83 ± 0.99	3.77 ± 1.02
Academic burden[a,c]	3.10 ± 1.09	3.12 ± 1.11	3.07 ± 1.06
Community sports clubs and organizations[b]			
Yes	26,141 (32.4)	11,733 (28.8)	14,394 (35.8)
No	54,787 (76.6)	28,988 (71.2)	25,813 (64.2)
Access to community PA facilities[b]			
Yes	29,317 (36.2)	12,619 (31.0)	16,698 (41.5)
No	51,611 (63.8)	28,102 (69.0)	23,509 (58.5)
MVPA (min/day)[a]	52.34 ± 50.58	53.16 ± 51.31	51.52 ± 49.82
Community sports event[a,c]	2.71 ± 1.08	2.77 ± 1.09	2.66 ± 1.06
Community free PA training[a,c]	2.58 ± 1.23	2.66 ± 1.23	2.50 ± 1.21
School level			
School principal support of PA[a,c]	4.51 ± 0.69	4.52 ± 0.68	4.49 ± 0.69
Availability of school PA facilities[a,c]	2.40 ± 0.44	2.40 ± 0.43	2.39 ± 0.44
Access to school PA facilities[a,c]	2.49 ± 0.47	2.42 ± 0.64	2.56 ± 0.46
School PE class time (min/week)[a]	183.78 ± 87.15	178.21 ± 82.15	189.41 ± 91.60

[a] Data presented as mean ± SD.
[b] Data presented as n (%).
[c] Measured on a 1–5 point scale.
[d] Grades 4–6 represent primary school; Grades 7–9 represent junior middle school; Grades 10–12 represent junior high school.
Abbreviations: BMI = body mass index; MVPA = moderate-to-vigorous physical activity; PA = physical activity; PE = physical education.

Table 2
Parameter estimates of the multilevel path model.

Structural path	Unstandardized coefficients (*b*)	*SE*	Standardized coefficients	*t*	*p*
School level					
Schools' PA support → MVPA	1.192	0.775	0.097	2.466	0.014
Availability of PA facilities → MVPA	−0.119	1.247	−0.004	−0.095	0.924
Access to PA facilities → MVPA	0.249	1.092	0.008	0.228	0.820
Time of PE classes → MVPA	−0.004	0.006	−0.025	−0.689	0.491
Student level					
Sex → MVPA	−7.346	0.327	−0.076	−22.494	<0.001
School grade[a]→ MVPA	−0.517	0.071	−0.075	−7.279	<0.001
BMI → MVPA	0.187	0.051	0.014	3.630	<0.001
Attitude toward PA → MVPA	8.815	0.175	0.185	50.426	<0.001
Academic burden → MVPA	0.947	0.178	0.021	5.327	<0.001
Community's frequency of sponsoring sports events → MVPA	4.038	0.197	0.091	20.518	<0.001
Free PA skill training → MVPA	0.139	0.172	0.004	0.809	0.418
Availability of sports clubs/organizations →MVPA	4.489	0.505	0.035	8.890	<0.001
Convenient access to PA facilities → MVPA	5.278	0.417	0.047	12.667	<0.001

[a] This variable has 3 school grade categories: primary school children, junior middle school children, and junior high school children.
Abbreviations: BMI = body mass index; MVPA = moderate-to-vigorous physical activity; PA = physical activity; PE = physical education; SE = standard error.

addition to these perceived community factors by children, boys ($b = –7.346$, $p < 0.001$) and children who were in the lower school grades ($b = –0.517$, $p < 0.001$), who had higher BMI ($b = 0.187$, $p < 0.001$) and highly positive attitudes toward PA ($b = 8.815$, $p < 0.001$), were significantly and positively related to high levels of within-school MVPA. Children who reported experiencing a heavy academic burden were significantly related to high levels of within-school MVPA ($b = 0.947$, $p < 0.001$) (Table 2).

Overall, the school-level variables jointly accounted for 1% of the between-school variation in MVPA, whereas the individual-level variables jointly accounted for about 9% of the within-school variation in MVPA.

3.3. Urban and rural differences

Details of model testing statistics are shown in Table S2 in the online supplement. Differences in χ^2 statistics show that the path from availability of PA facilities to MVPA varied across urban and rural samples ($\Delta\chi^2 = 5.749$, $\Delta df = 1$, $p = 0.016$). Specifically, compared with those living in rural areas ($b = 0.29$, $p = 0.6$), availability of PA facilities was significantly related to decreased levels of MVPA among children living in urban areas ($b = −1.744$, $p = 0.004$). None of the remaining paths in the model was found to be significant in regard to urban versus rural areas.

4. Discussion

In this study of the PAFCTYS data, we show that PA support from school administrators was significantly associated with an increased level of school children's participation in MVPA. None of the other school-level factors (the availability of school PA facilities, access to school PA facilities, weekly school PE class time) were found to be related to school-level MVPA. However, across urban–rural settings, availability of school PA facilities was significantly but inversely related to school-level MVPA among urban children. At the individual level, children's perceptions of the frequency of community-sponsored sports events, availability of clubs and organizations, and convenient access to PA facilities were found to be associated with a high level of MVPA participation.

Within a multilevel modeling framework, this is the first study that examined the influence of school-level factors on MVPA of Chinese school-aged children. We show that, among several factors examined, PA support from the school principals was the only factor positively associated with school children's MVPA participation. This finding is consistent with another report in the United States that students' perceptions of being supported for PA at school was related to adolescents participating in more PA,[26] which suggests the importance of the role that school plays in promoting school-level MVPA among Chinese school-aged children.

Unlike the findings reported elsewhere,[10] our hypotheses regarding the influence of the availability of PA facilities, access to those facilities, and the duration of school PE classes on overall school-level MVPA were not supported. Notably though, when urban–rural differences were explored, the findings show that the availability of school facilities for PA was negatively related to MVPA among children living in urban areas. Although limited availability of recreational facilities creates barriers to PA,[26] findings from this study suggest that availability of PA facilities at urban schools were associated with low levels of MVPA among school students. One speculation may be that the overemphasis of and high expectations for academic performance and achievement in urban elite schools[27] may have made led to underutilization of the PA facilities in urban schools, thus impeding school-wide PA promotion.

The failure to show significant differences related to other school-level factors in this study suggests that there may be limited utility in our use of subjective measures for effectively capturing MVPA variation among schools and school children. Self-reports such as those used in our study are subject to response biases (e.g., socially desirable reporting). Future

studies should incorporate objectively measured school-level factors, including policies related to the actual availability of PA facilities, assessments resulting from direct field observations, assessments of availability that are audited or generated by geographic information systems, and factors related to access to and use of play areas, sports fields, and sports facilities.

At the level of children, our results indicate the importance of children's perceptions of their immediate community's (neighborhood's) PA-related resources in either facilitating or maximizing their MVPA participation. These findings are consistent with those reported in the current literature, which shows that use of community-based facilities,[28] availability of PA facilities near school areas,[29] and accessibility to sports and PA equipment[30] were associated with active participation in PA among children.

Interestingly, children in our study who perceived a high burden of academic pressure reported high levels of MVPA, a finding that is contrary to those reported in other studies in which academic pressure was seen as a barrier for participation in PA.[31,32] Although the reasons underlying this counterintuitive finding are not clear, it may be that in the highly academic-focused culture of China, children see their participation in MVPA as a coping mechanism to combat the heavy academic burden and pressure. Future studies should examine the potential mechanisms that mediate the academic burden and PA relationship.

A strength of this study is that it provides the first attempt aimed at delineating variation in MVPA at the school level and at the child level. This type of multilevel analysis approach is underutilized, especially in China, but it is important because it allows us to examine the potential impact of school support and school policies on promoting PA in schools, which can in turn lead to the development and implementation of school-level policies and initiatives aimed at increasing multilevel (e.g., school level, community level, or a combination of both) PA interventions and promotion programs among school-aged children.

Interpretation of the results from this study should be made with caution due to a few inherent limitations. First, the cross-sectional data preclude any causal inference from being made on the observed structural relationships. Second, a significant number of study children (35%) were excluded due to missing data or non-normality problems in the data. Our listwise approach for handling missing and non-normality data, therefore, threatens the generalizability of the findings to larger Chinese school-aged populations. A third limitation is that all study measures were based on self-reports, which are known to produce recall or response biases. For example, children and youths have been found to overestimate their PA when compared to measurements made through the use of objective measures such as accelerometers.[20,33] Similarly, the use of teachers' self-reports on school PA support may have reduced the objectivity of measuring support at schools, which may in turn have led to the statistical insignificance of many of the school-level results, which might yield a less robust model that explained only 1% of school-level variation. Last but not least, our data were unable to delineate children's MVPA in schools, in after-school periods, or in communities. Therefore, specific influences of school- or community-related factors on MVPA among Chinese school-aged children remain unknown and require future investigation.

In conclusion, findings from this study indicate that school support for PA and availability of and access to community PA resources are associated with school-level and individual-level MVPA participation among Chinese school-aged children. Our findings also indicate that school PA facilities appear to be underutilized at urban schools, where low levels of MVPA among school children were observed. Taken together, our findings suggest that strengthening policies on PA support at school and maximizing PA resources and opportunities in school environments and communities may help promote PA in school-aged children in the Mainland of China.

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Authors' contributions

LW participated in the data analysis and drafted the manuscript; YT conceived of the study, participated in its design and coordination, and helped to draft the manuscript; JL performed the statistical analysis and helped to interpret the data. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

Appendix: Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.jshs.2017.09.001

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