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Original article

Environmental correlates of sedentary behaviors and physical activity in Chinese preschool children: A cross-sectional study

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Abstract

Objective: This cross-sectional study examined environmental correlates of sedentary behavior (SB) and physical activity (PA) in preschool children in the urban area of Tianjin, China.

Methods: Data were collected from the Physical Activity and Health in Tianjin Chinese Children study, involving healthy children 3–6 years old and their families. In all children ($n = 980$), leisure-time SB (LTSB) and leisure-time PA (LTPA) were reported in min/day by parents. In a subgroup ($n = 134$), overall sedentary time, light PA, and moderate-to-vigorous PA (MVPA) were objectively measured using ActiGraph accelerometry (≥ 3 days, ≥ 10 h/day). Environmental correlates were collected using a questionnaire that included home and neighborhood characteristics (e.g., traffic safety, presence of physical activity facilities) and children's behaviors. Potential correlates were identified using linear regression analysis.

Results: Multiple linear regression analysis showed that “having grandparents as primary caregivers” (β s and 95% confidence intervals (95%CI) for overall sedentary time: 29.7 (2.1–57.2); LTSB (ln): 0.19 (0.11–0.28)) and “having a television (for LTSB (ln): 0.13 (0.00–0.25)) or computer (for LTSB (ln): 0.13 (0.03–0.23)) in the child's bedroom” were both associated with higher SB. Furthermore, “having grandparents as primary caregivers” was associated with less MVPA (β (95%CI): -7.6 (-14.1 to -1.2)), and “active commuting to school by walking” correlated with more MVPA (β (95%CI): 9.8 (2.2–17.4)). The path model showed that “more neighborhood PA facilities close to home” was indirectly related to higher LTPA (ln), which was partly mediated by “outdoor play” (path coefficients (95%CI): 0.005 (0.002–0.008)) and “going to these facilities more often” (path coefficients (95%CI): 0.013 (0.008–0.018)). Traffic safety was not a correlate.

Conclusion: Family structure and media exposure in the home maybe important factors in shaping preschoolers' PA patterns. Built environmental correlates could indirectly influence preschoolers' LTPA through parental help with engaging in active behaviors.

Keywords: Active commuting; Built environment; Family structure; Media exposure; Traffic safety

1. Introduction

As the 4th leading cause of death worldwide, physical inactivity is responsible for a substantial economic burden and is becoming a growing problem across the world.^{1,2} After 4 decades of open reforms since 1979, China has undergone a tremendous transformation in terms of economic development

and environmental changes. In this increasingly urbanized country, the daily lives of Chinese citizens have been accompanied by higher community urbanicity, which includes higher vehicle, TV, and computer ownership. All of these have contributed to the rapid decline in physical activity (PA) in China.³ The World Health Organization (WHO) has recommended that children and young people 5–17 years old should accumulate at least 60 min of moderate-to-vigorous PA (MVPA) daily.⁴ However, the proportion of Chinese children and adolescents who engage in recommended levels of PA has

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been declining for decades.^{5,6} Data from the 2017 national survey of 131,859 school students in China showed that only 34.1% of children and adolescents met the PA guidelines of 1 h of MVPA daily.⁷ Moreover, sedentary behaviors (SBs) of school students increased moderately between 2004 and 2011.⁸

It is widely accepted that sufficient PA and less sedentary time (ST) have a positive effect on improving both fitness and energy balance in adults,⁹ as well as in school-aged children and adolescents.^{10,11} Over the past 4 decades, the rapid increase in overweight and obesity among school-aged children and adolescents, particularly in urban cities in the mainland of China, is becoming a public health challenge.¹² For example, a national survey in China in 1985 showed that about 2% of school students were overweight or obese,¹³ whereas data from the 2017 national survey showed that 15.1% of 131,859 school students were overweight, and 10.7% were obese.⁷ This upward trend is also seen in Chinese preschoolers (3–6 years old).¹⁴

The preschool years are a critical period of growth and development. It is believed that sufficient PA during the early years of life improves bone and cardiovascular health, assists with the development of mental health, and has a positive influence on cognitive function.¹⁵ PA promotion in preschool years is considered a key component in early interventions for childhood overweight and obesity.¹⁶ In April 2019, the WHO published recommendations for children under 5 years of age. It was recommended that preschool children (3–4 years old) take part in at least 180 min of activity (with at least 60 min of MVPA) each day, with ST of no more than 1 h per day and less being better.¹⁷ The 60 min of MVPA (energetic play) for preschoolers was also recommended by Canada (3–4 years old),¹⁸ Australia (3–5 years old),¹⁹ and China (3–6 years old),²⁰ but was not mentioned in the 2018 Physical Activity Guidelines for American preschoolers (3–5 years old).²¹ However, a recent report showed that only 28% of Chinese preschool children would meet this guideline based on accelerometer-derived PA.²² Thus, to develop evidence-based public health strategies to reduce SB and promote PA from early childhood, there is a need to understand the determinants of the behaviors themselves.

Children's behaviors are influenced at different levels by a range of individual and social factors, as well as factors relating to the home, community, school environment, and policy.²³ The 2018 Physical Activity Guidelines for Americans indicated that caregivers have a critical role in supporting and encouraging young children to be physically active and in modeling participation in regular PA.²¹ In Chinese society, the 1-child generation has dramatically changed family structure and lifestyle for almost 35 years (from 1980²⁴ to 2015²⁵) on the mainland of China, resulting in the child's becoming the focus of the entire family.²⁶ The literature shows that Chinese adolescents residing with grandparents are less active than those not living with grandparents.²⁷ However, less is known about the role played by grandparents in developing and shaping children's PA patterns during preschool years,²⁸ especially in families in which 2 parents work full time, so the grandparents have taken responsibility for the children's before-school

or out-of-school activity (e.g., transportation to school). Home PA facilities or barriers may directly impact children's behaviors because these facilities or barriers provide caregivers with an opportunity to either encourage children to be active or to inhibit their participation in activities.^{23,29} For example, 1 study found consistent evidence across 12 countries that children (9–11 years old) with at least 1 electronic media device in their bedrooms did less MVPA (4 min/day) than children with no devices.³⁰ In another study, children spent more time using electronic media indoors at the expense of engaging in outdoor play.³¹ Furthermore, in present-day China, the neighborhood's built environment may influence children's PA behaviors,^{32,33} especially for those with reduced access to public spaces (such as sports areas, parks, and open recreational fields) suitable for leisure-time activities.³⁴ A study in the Netherlands indicated that convenient neighborhood PA facilities had an indirect positive effect (through parental support) on PA behaviors of Dutch preschoolers, even in relatively rural areas.³⁵ It is important to note that leisure-time PA is considered a dominant form of overall PA among children in developed countries.³⁶ Identifying these correlations between built environments and overall and leisure-time PA may help with specific interventions that can promote active lifestyles from an early age. A supportive social environment is also an essential component for enhancing PA in communities, and effective social support is essential for creating active communities.²³ For example, young children in the United States were found to be more likely to participate in PA in safe neighborhoods.³⁷ In contrast, a cross-sectional analysis of a population-based cohort study found that a safe neighborhood was positively associated with higher SB in Swiss preschoolers.³⁸ Thus, the influence of the environmental characteristics may vary by country and should be further studied.

The aim of this study was to examine which home and neighborhood environmental characteristics correlated with preschoolers' sedentary time (ST_{acc}) and PA—composed of light physical activity (LPA_{acc}) and moderate-to-vigorous physical activity (MVPA_{acc})—as measured by ActiGraph accelerometry, as well as their correlation with leisure-time sedentary behaviors (LTSB_q) and leisure-time physical activity (LTPA_q) based on a questionnaire reported by parents. It was hypothesized that children living in a supportive environment (e.g., less media exposure in the home or more PA facilities in the neighborhood) would be less sedentary and more active than those living in a nonsupportive environment. Understanding the associations between environmental factors and children's behaviors in particular settings could be critical for designing specific PA promotion projects. Such evidence would support key strategies for reducing SB and increasing PA among young children in modern urban cities in China.

2. Methods

2.1. The PATH-CC study

Data were derived from the Physical Activity and Health in Tianjin Chinese Children (PATH-CC) study, which focuses on identifying the relationship between environmental determinants,

PA, and overweight among children in Tianjin, China. Details of the study have been reported elsewhere.²² Tianjin is the 4th largest city in northern China, with more than 15 million residents in 2015. Preschools in China generally cater to children 3–6 years old and are under the guidance of the national ministry of education. For example, in Tianjin, most children 3–6 years old attend local preschools in the city.³⁹ Four preschools located in 4 different districts were selected at random for the study. Healthy children were recruited by means of advertising posters in preschools. Children with any disease or disability that could seriously influence daily PA (such as movement difficulties, asthma, or cardiovascular diseases) were excluded from the study. In total, 1031 healthy children and their parents participated in the study between March 2015 and November 2015. The participation rate was 93.7% (i.e., 1031 out of 1100 children in the recruited preschools) (flowchart, Fig. 1). Written informed consent was obtained from the parents, and the study was approved by the Medical Ethics Committee of the Tianjin Medical University and performed in accordance with the Declaration of Helsinki.

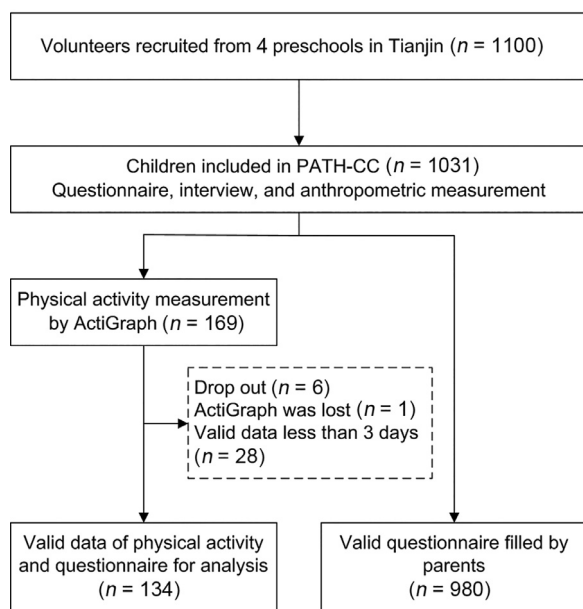


Fig. 1. Flowchart of participants in the PATH-CC study. PATH-CC = Physical Activity and Health in Tianjin Chinese Children.

2.2. Data collection

The questionnaire data and child anthropometry measurements used in this study were collected in May 2015. Child and family information and environmental characteristics of the home and neighborhood were addressed in the questionnaires, which were sent to parents for data-collection purposes, along with the child leisure-time activities questionnaires. The children's height and weight were measured by trained school nurses in preschools. Children's overweight and obesity were classified according to the age-specific and gender-specific cut-offs of Cole and Lobstein.⁴⁰ From June 2015 to November 2015 (except for summer holidays from July 17 to August

31), daily ST, LPA, and MVPA were assessed in a group of child volunteers participating in the study by using ActiGraph GT3X (Actigraph, Pensacola, FL, USA) accelerometry, and the season (summer or autumn) was recorded for later adjustment.

2.3. Measures of ST, LPA, and MVPA using accelerometry

The ActiGraph has been shown to be a reliable and valid device to measure PA volume and intensity in preschool children. Details of the ActiGraph measurements used in this study have been reported elsewhere.²² Parents were instructed to have their children wear the ActiGraph with an elastic belt on the iliac crest of the right hip for 7 consecutive days during all waking hours, except when bathing or swimming.⁴¹ Data were collected using a frequency of 30 Hz. Collected data were analyzed in 15-s epochs. The time spent wearing and not wearing the accelerometer was classified as recommended by Choi et al.,⁴² and the cut-off points for calculating time spent in ST, LPA, and MVPA were used as recommended by Butte et al.⁴³ To obtain valid measurements in this study, participants had to wear the accelerometer for at least 10 h/day for at least 3 days, regardless of whether these were weekdays or weekend days.⁴⁴ Time spent doing ST, LPA, and MVPA was calculated as means over at least 3 wearing days.

2.4. Measures of LTSB behaviors and LTPA

Children's LTSB_q and LTPA_q were reported by parents or guardians through questionnaires. In this study, leisure time was defined as time spent outside of school hours on weekdays (including interest classes after school and time spent outdoors and at home, but not travel time) and entire weekend days. The LTSB_q questionnaire used in this study was adapted from the Neighborhood Impact on Kids Survey—Sedentary Behaviors.⁴⁵ The LTPA_q questionnaire was adapted from a 7-day activity questionnaire for Chinese primary school pupils, and it showed a reliable estimate of the PA during the past week by Chinese children.⁴⁶ In a pilot study conducted before the survey, 50 parents (37 mothers and 13 fathers) of preschoolers answered questions about their children's common SB and activities during leisure time. The final version of the LTSB_q questionnaire included 5 sedentary behaviors that were found to be most prevalent in preschoolers; 12 activities were included in the LTPA_q questionnaire. Parents reported the frequency and duration of these behaviors. For example, the questionnaire asked how many minutes per day, on average, their children spent on each item during leisure time on school days in the past week (response categories ranged 0–5 days) and on days over the past weekend (response categories ranged 0–2 days). The average number of minutes was computed to obtain an overall average LTSB_q or LTPA_q per day. Details of these behaviors and activities carried out by the children participating in this study are presented in [Supplementary Table 1](#). In the validation study of the leisure-time questionnaire involving 41 children aged 5.3 ± 1.0 years (mean \pm SD), children were assessed for 7 continuous days by using both ActiGraph measurements and the questionnaire. A positive

correlation was found between LT_{SB_q} and ST_{acc} ($\rho = 0.365$, $p = 0.019$), as well as for ST_{acc} on weekends or holidays ($\rho = 0.425$, $p = 0.006$) and on school days ($\rho = 0.348$, $p = 0.026$). However, no correlation was found for $LTPA_q$ and ActiGraph-derived PA.

2.5. Environmental correlates

Home and neighborhood characteristics were assessed using a revised and translated questionnaire reported on elsewhere.^{35,47} The English questionnaire was translated into Mandarin Chinese by a professional translator and back-translated into English by 2 other translators. The discrepancies were reviewed by an independent translator. All these translators were fluent in both English and Mandarin Chinese. Following the back-translation, the Chinese environmental questionnaire was evaluated in the pilot study together with the leisure-time questionnaires mentioned above. The final version of the environmental questionnaire was adapted according to Chinese cultural background by an expert committee, and it was approved by the original authors.³⁵ Parents reported their home characteristics (household income; primary caregivers for their child; the presence or absence of an elevator, garden, or car; the number of televisions and computers in the household; and the presence or absence of a television or computer in the child's bedroom) and children's PA behaviors (outdoor play and the means of commuting to school). The children's outdoor play was reported in terms of frequency and duration and given in min per week. Parents reported the walking distance from home to 6 PA facilities (e.g., green area or park) in their neighborhoods and the frequency of taking their children to these facilities each week. A distance index was compiled by combining the 6 places; a higher score meant all places were close to home. The questionnaire also included a scale of social support within families and communities, a scale of traffic safety, and a scale of environmental quality in the neighborhood, assessed by 4 items. An acceptable internal consistency was found for each scale (Cronbach α : 0.614–0.712).⁴⁸ In this study, the sum score of each item was computed, with higher scores representing better quality. A description of these scales is presented in [Supplementary Table 2](#).

2.6. Statistical analysis

Data were presented as rates in number (n) and percentages, as means \pm standard deviations (SDs) or, if data were skewed, as the median within the 25th–75th percentile. Dependent skewed variables (e.g., LT_{SB_q} and $LTPA_q$) were transformed as natural logarithms (\ln) for linear regression. ST_{acc} , LPA_{acc} , and $MVPA_{acc}$ were normally distributed and presented as means by min/day. Differences among groups were tested using a t test: the Mann-Whitney U test or the χ^2 test. To determine the relationships between potential correlates and PA outcomes, linear regression analysis, adjusted for age, gender, and body mass index (BMI), was used. For ActiGraph outcomes, models were also adjusted for season (summer/autumn), because season has been found to be associated with accelerometer-determined PA measurements.⁴⁹ Multiple

regression models were then used for potential factors (variables with $p < 0.05$ in the univariate analyses) for each outcome. Because “outdoor play” ($\rho = 0.143$, $p < 0.05$) and “frequency of taking children to PA facilities” ($\rho = 0.558$, $p < 0.05$) were both correlated with “distance index”, ordinary least square regression-based path analysis was used to estimate the direct and indirect effects of “distance index” on $LTPA_q$ in mediation models with the PROCESS macro for SPSS (Hayes, 2018, <http://www.afhayes.com/>). In the path model, the “distance index” was entered as an independent variable, “outdoor play” and “frequency of taking children to PA facilities” were entered as mediators, and the other variables were entered as covariates. For the indirect effects, 10,000 bootstrap samples were used for bias-corrected bootstrap confidence intervals. The given path coefficients were shown as unstandardized β . Missing data were not imputed because only a small proportion (less than 3%) was missing. IBM SPSS Statistics 22 for Windows (IBM Corp., Armonk, NY, USA) was used for this study, with test level $\alpha = 0.05$.

3. Results

The characteristics of the study population are presented in [Table 1](#). A total of 980 children, aged 4.8 ± 1.1 years, had complete data on parent-reported environmental characteristics, LT_{SB_q} , and $LTPA_q$. Of these children, 836 (85%) and their families had lived in their current neighborhood for 1 or more years, and 92 (9%) had lived there for 6 months to 1 year. There were 469 (48%) families who reported living in an apartment that was smaller than 90 m². Thirty-seven mothers and 7 fathers reported having no job during the study. Most children (85%) had a mother with a university degree. The questionnaire data were reported mainly by mothers ($n = 693$; 71%), with fathers ($n = 210$; 21%) and grandparents ($n = 77$; 8%) reporting less often.

With regard to the levels of SB and PA, the questionnaire data on leisure-time activities showed that, on average, children spent more than 2 h per day in SB, LT_{SB_q} (132.9 (85.7–188.6)), and more than 1.5 h per day in more active behaviors, $LTPA_q$ (104.3 (60.0–168.2)), in min/day. No difference in the level of LT_{SB_q} or $LTPA_q$ was found between data reported by the mother and data reported by the father (all $p > 0.05$). The subgroup of 134 children aged 5.4 ± 0.9 years who had valid ActiGraph data ([Fig. 1](#)) spent almost 8 h/day being sedentary, ST_{acc} (468.6 ± 80.5 min/day); more than 4 h doing LPA, LPA_{acc} (249.6 ± 17.1 min/day); and an average of 50 min doing MVPA, $MVPA_{acc}$ (50.5 ± 17.1 min/day).

The children in the ActiGraph group ($n = 134$) were older than the children in the total questionnaire group ($n = 980$, $p < 0.05$) because the ActiGraph measurements, which took 6 months, were initiated after the data collection by questionnaire. Most characteristics were comparable between the 2 groups, except for the presence or absence of a lift in the household ($p < 0.05$). Univariate associations between potential correlates and children's ST and PA outcomes are presented in [Supplementary Table 3](#). No correlation was found between these outcomes and household income; the presence

Table 1
 Characteristics of the study population in the Physical Activity and Health in Tianjin Chinese Children study.

Variable	Code/Range	Leisure-time group (<i>n</i> = 980)	ActiGraph group (<i>n</i> = 134)
Gender	0 = male 1 = female	550 (56.1%) 430 (43.9%)	76 (56.7%) 58 (43.3%)
Age ^a	3–6 (year)	4.8 ± 1.1	5.4 ± 0.9
Body mass index	12.7–22.5	15.2 (14.4–16.3)	15.2 (14.5–16.3)
Body weight status	0 = normal weight/under weight 1 = obesity and overweight	856 (87.8%) 119 (12.2%)	118 (88.1%) 16 (11.9%)
Ethnicity	0 = other nationality 1 = Han nationality	59 (6.0%) 921 (94.0%)	7 (5.2%) 127 (94.8%)
Season in which accelerometer was worn	0 = summer (June and July) 1 = autumn (September, October, and November)	— —	58 (43.3%) 76 (56.7%)
Person who filled in questionnaires	0 = mother 1 = father 2 = grandparents	693 (70.7%) 210 (21.4%) 77 (7.9%)	94 (70.1%) 30 (22.4%) 10 (7.5%)
Duration of residency	0 = less than 1 year 1 = 1 to 3 years 2 = more than 3 years	121 (12.6%) 278 (29.0%) 558 (58.3%)	16 (12.5%) 42 (32.8%) 70 (54.7%)
Home characteristics			
Household income	0 = low (less than RMB 30,000/person/year) 1 = middle (RMB 30,000–RMB 50,000/person/year) 2 = high (more than RMB 50,000/person/year)	274 (28.0%) 307 (31.3%) 399 (40.7%)	36 (26.9%) 47 (35.1%) 51 (38.1%)
Having grandparents as primary caregivers	0 = no 1 = yes	627 (64.0%) 353 (36.0%)	83 (61.9%) 51 (38.1%)
Presence/absence of an elevator ^b	0 = no 1 = yes	715 (73.0%) 265 (27.0%)	113 (84.3%) 21 (15.7%)
Presence/absence of a garden	0 = no 1 = yes	930 (94.9%) 50 (5.1%)	126 (94.0%) 8 (6.0%)
Presence/absence of a car	0 = no 1 = yes	152 (15.6%) 825 (84.4%)	26 (19.8%) 105 (80.2%)
Number of televisions in the household	0 = no/1 TV 1 = 2 or more TVs	687 (70.2%) 291 (29.8%)	87 (65.9%) 45 (34.1%)
Number of computers in the household	0 = no/1 computer 1 = 2 or more computers	437 (45.4%) 525 (54.6%)	51 (40.5%) 75 (59.5%)
Having a television in the bedroom	0 = no 1 = yes	851 (88.0%) 116 (12.0%)	110 (83.3%) 22 (16.7%)
Having a computer in the child's bedroom	0 = no 1 = yes	773 (81.1%) 180 (18.9%)	98 (76.0%) 31 (24.0%)
Children's behaviors			
Children's outdoor play	0–17.5 (h/week)	3.0 (2.0; 5.3)	3.1 (2.3; 5.3)
Active commuting to school	0 = inactive 1 = walking	798 (81.9%) 176 (18.1%)	106 (80.9%) 25 (19.1%)
Frequency of going to physical activity facilities	0 = no/1 time per week 1 = 2 or 3 times per week 2 = more than 3 times per week	316 (32.2%) 301 (30.7%) 363 (37.0%)	42 (31.3%) 50 (37.3%) 42 (31.3%)
Parental perception of neighborhood environment (number of physical activity facilities)			
Within 5 mins walk	0 = no facility 1 = 1 facility 2 = 2 or more facilities	431 (44.0%) 339 (34.6%) 210 (21.4%)	57 (42.5%) 51 (38.1%) 26 (19.4%)
Within 10 mins walk	0 = no facility 1 = 1 facility 2 = 2 or more facilities	235 (24.0%) 355 (36.2%) 390 (39.8%)	31 (23.1%) 44 (32.8%) 59 (44.0%)
Within 20 mins walk	0 = no/1 facility 1 = 2 or more facilities	406 (41.4%) 574 (58.6%)	46 (34.3%) 88 (65.7%)
Within 30 mins walk	0 = no/1 facility 1 = 2 or more facilities	340 (34.7%) 640 (65.3%)	41 (30.6%) 93 (69.4%)
Distance index ^c	0–29 (high—close to home)	8 (5 to 13)	9 (5 to 13)
Social support	4–20 (high—better quality)	15 (13 to 16)	14 (13 to 16)
Traffic safety	4–20 (high—better quality)	11 (9 to 12)	11 (9 to 12)
Environmental quality	4–20 (high—better quality)	11 (9 to 13)	11 (10 to 12)

Note: Data were presented as rates in number and percentages, mean ± SD, or if data were skewed, as the median, along with the 25th to 75th percentile.

^a $p < 0.05$, t test was used.

^b $p < 0.05$, χ^2 test was used.

^c The distance index was synthesized by the 6 PA facilities in the neighborhood; a higher score meant these places were close to home. Missing data in Leisure-time group: “Body weight status”, $n = 5$; “Duration of residency”, $n = 23$; “Presence/absence of a car”, $n = 3$; “Number of televisions in the household”, $n = 2$; “Number of computers in the household”, $n = 18$; “Having a television in the bedroom”, $n = 13$; “Having a computer in the child's bedroom”, $n = 27$; and “Active commuting to school”, $n = 6$. Missing data in ActiGraph group: “Duration of residency”, $n = 6$; “Presence/absence of a car”, $n = 3$; “Number of televisions in the household”, $n = 2$; “Number of computers in the household”, $n = 8$; “Having a television in the bedroom”, $n = 2$; “Having a computer in the child's bedroom”, $n = 5$; and “Active commuting to school”, $n = 3$.

or absence of an elevator garden, or car; the number of computers in the household; or parental perception of traffic safety in the neighborhood.

The multiple regression analysis in Table 2 shows the associations between significant factors found in Supplementary Table 3 and these outcomes, with adjustment for the children’s genders, ages, and BMIs; the season; and the household income. “Number of televisions” was not included because of colinearity with “having a television in the child’s bedroom” ($\rho=0.424$, $p=0.000$). “Distance index” was selected because it represents a synthesized variable for the accessibility of PA facilities. Table 2 shows that girls spent fewer minutes in MVPA_{acc} than boys, and older children and children with higher BMIs showed more LTSB_q. “Having grandparents as primary care givers” was associated with higher ST_{acc} (29.7 (2.1–57.2), $p=0.035$) and LTSB_q (ln: 0.19 (0.11–0.28), $p=0.000$), and lower MVPA_{acc} (–7.6 (–14.1 to –1.2), $p=0.020$). Having a television (ln: 0.13 (0.00–0.25), $p=0.047$) or a computer (ln: 0.13 (0.03–0.23), $p=0.015$) in the child’s bedroom were both associated with higher LTSB_q. More “outdoor play” correlated with lower ST_{acc} (–6.8 (–12.0 to –1.7), $p=0.010$) and higher LTPA_q (0.08 (0.07–0.10), $p=0.000$). “Active commuting to school by walking” correlated with lower ST_{acc} (–45.5 (–78.1 to –12.9), $p=0.007$) and higher MVPA_{acc} (9.8 (2.2–17.4), $p=0.012$). “Children went to PA facilities more often” was associated with higher LTPA_q (ln: 0.18 (0.11–0.25), $p=0.000$). However, no correlation was found between “distance index” and these outcomes. No significant factor was found for LPA_{acc} (all $p > 0.05$). No correlation was found between “social support” or “environmental quality” and these outcomes when both variables were added to these models; the directions of correlation for other variables were not changed.

In Fig. 2, the path coefficient model shows that if parents perceived more PA facilities close to home, they showed more support for taking children to “outdoor play” (path coefficients (95% confidence interval (95%CI)) for LTPA_q (ln): 0.005 (0.002–0.008)) and “going to these facilities more often” (path coefficients (95%CI) for LTPA_q ((ln): 0.013 (0.008–0.018)), which were associated with more LTPA_q than for children who had PA facilities far from home. This indirect effect on children’s active behaviors was also significant for “number of PA facilities” and children’s LTPA_q; for example, the number of PA facilities within 10 min, 20 min, and 30 min of walking distance. Thus, it was shown that having access to more PA facilities was, indeed, reflected in greater use of these facilities.

A sensitivity analysis was used for accelerometry data by including in the defined valid measurements that participants also needed to have for at least 1 weekend day. This shows that the findings were materially unchanged, despite lower power (107 children were included). The findings changed for 2 factors: for “season”, which became significant; and for “having grandparents as primary caregivers”; the association attenuated with ST_{acc} (30.6 (–0.2 to 61.4), $p=0.052$), and the

Table 2 Results of multiple regression analysis of correlates among preschoolers in the PATH-CC study.

Variable	ST _{acc}		LPA _{acc}		MVPA _{acc}		LTSB _q (ln)		LTPA _q (ln)	
	β (95%CI)	<i>p</i>	β (95%CI)	<i>p</i>	β (95%CI)	<i>p</i>	β (95%CI)	<i>p</i>	β (95%CI)	<i>p</i>
Constant	394.3 (204.4 to 584.2)	0.000	370.2 (252.9 to 487.5)	0.000	86.8 (42.6 to 131.0)	0.000	4.00 (3.58 to 4.42)	0.000	3.85 (3.37 to 4.34)	0.000
Female	12.9 (–13.5 to 39.3)	0.335	–12.8 (–29.1 to 3.5)	0.123	–8.2 (–14.4 to –2.1)	0.009	–0.01 (–0.09 to 0.07)	0.773	–0.03 (–0.13 to 0.06)	0.472
Age	9.9 (–9.6 to 29.4)	0.318	–8.9 (–21.0 to 3.1)	0.146	–1.0 (–5.6 to 3.5)	0.652	0.10 (0.06 to 0.13)	0.000	0.02 (–0.02 to 0.06)	0.356
Body mass index	3.7 (–4.4 to 11.7)	0.370	–3.5 (–8.5 to 1.5)	0.168	–1.1 (–2.9 to 0.8)	0.267	0.02 (0.00 to 0.04)	0.038	0.01 (–0.01 to 0.04)	0.410
Season	–29.6 (–67.1 to 7.8)	0.120	–8.0 (–31.1 to 15.2)	0.497	–3.4 (–12.2 to 5.3)	0.436	—	—	—	—
Household income	–1.0 (–17.6 to 15.7)	0.908	–5.1 (–15.3 to 5.2)	0.331	–1.3 (–5.2 to 2.6)	0.513	–0.02 (–0.07 to 0.03)	0.388	–0.03 (–0.08 to 0.03)	0.356
Having grandparents as primary caregivers	29.7 (2.1 to 57.2)	0.035	–9.5 (–26.5 to 7.5)	0.271	–7.6 (–14.1 to –1.2)	0.020	0.19 (0.11 to 0.28)	0.000	0.01 (–0.09 to 0.10)	0.900
Having a TV in the child’s bedroom	31.2 (–5.1 to 67.5)	0.092	–1.6 (–24.1 to 20.8)	0.885	2.3 (–6.2 to 10.7)	0.594	0.13 (0.00 to 0.25)	0.047	0.06 (–0.08 to 0.21)	0.381
Having a computer in the child’s bedroom	–28.5 (–59.6 to 2.5)	0.071	2.2 (–16.9 to 21.4)	0.817	–1.0 (–8.3 to 6.2)	0.775	0.13 (0.03 to 0.23)	0.015	0.03 (–0.09 to 0.15)	0.632
Child’s outdoor play	–6.8 (–12.0 to –1.7)	0.010	2.0 (–1.2 to 5.2)	0.213	0.5 (–0.7 to 1.7)	0.432	–0.01 (–0.02 to 0.00)	0.153	0.08 (0.07 to 0.10)	0.000
Active commuting to school by walking	–45.5 (–78.1 to –12.9)	0.007	0.0 (–20.1 to 20.2)	0.997	9.8 (2.2 to 17.4)	0.012	–0.03 (–0.13 to 0.07)	0.590	0.05 (–0.07 to 0.16)	0.443
Frequency of going to PA facilities	–7.7 (–27.5 to 12.2)	0.444	5.1 (–7.2 to 17.3)	0.415	2.2 (–2.4 to 6.8)	0.348	–0.04 (–0.09 to 0.02)	0.236	0.18 (0.11 to 0.25)	0.000
Distance index ^a	–0.4 (–2.8 to 2.1)	0.759	0.0 (–1.5 to 1.6)	0.955	–0.2 (–0.8 to 0.3)	0.396	0.00 (–0.01 to 0.01)	0.437	0.00 (–0.01 to 0.01)	0.766

Note: Boldface numbers mean $p < 0.05$.

^a The distance index was synthesized by the 6 PA facilities in the neighborhood; a higher score meant these places were close to home.

Abbreviations: 95%CI = 95% confidence interval; ln = natural logarithm; LPA_{acc} = light physical activity measured by accelerometer; LTPA_q (ln) = leisure-time physical activity measured by questionnaire was natural logarithm (ln)-transformed; LTBSB_q (ln) = leisure-time sedentary behaviors measured by questionnaire was natural logarithm (ln)-transformed; MVPA_{acc} = moderate-to-vigorous physical activity measured by accelerometry; PA = physical activity; PATH-CC = Physical Activity and Health in Tianjin Chinese Children; ST_{acc} = sedentary time measured by accelerometer.

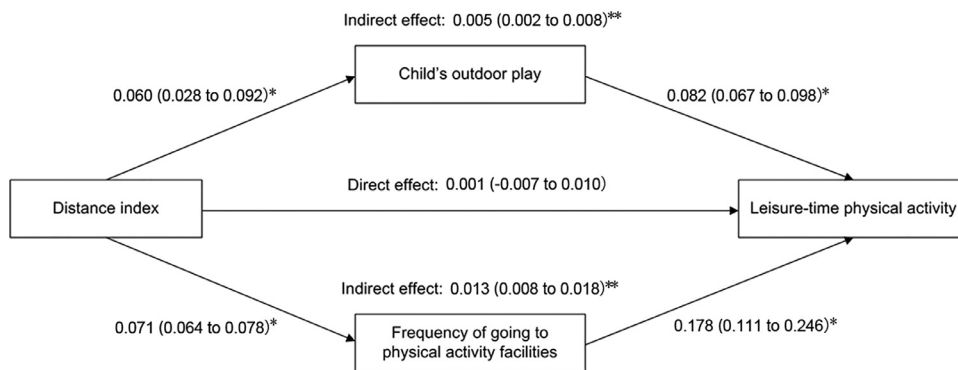


Fig. 2. Direct and indirect pathways of neighborhood PA facilities on leisure-time PA among preschoolers in the PATH-CC study. Ordinary least square regression-based path analysis was used for direct and indirect effects; unstandardized β was given in the model, adjusted for the child's age and gender, body mass index, household income, primary caregivers, having a TV or computer in the child's bedroom, and active commuting to school. Children's leisure-time PA was natural logarithm (ln)-transformed of means by min/day. The distance index was synthesized by the 6 PA facilities in the neighborhood; a higher score meant these places were close to home. * $p < 0.05$; ** 95%CI does not include 0. 95%CI = 95% confidence interval; PA = physical activity; PATH-CC = Physical Activity and Health in Tianjin Chinese Children.

p value was at the boundary of 0.05. Outcomes of this sensitivity analysis are presented in [Supplementary Table 4](#).

4. Discussion

This study examined the associations of the environmental correlates of SB and PA over the whole day by using Acti-Graphs and during leisure time by using questionnaires among preschool children living in a rapidly urbanizing city in the mainland of China. The results showed that the Chinese social culture of children having grandparents as their main caregivers correlated with preschoolers spending more time in SB and less time in MVPA. Children's outdoor play and active commuting also correlated with more PA (e.g., $LTPA_q$ or $MVPA_{acc}$) and less ST_{acc} . Furthermore, parental perception of more PA facilities in the neighborhood may indirectly enhance children's $LTPA_q$ by supporting children in engaging in active behaviors.

Grandparents may play an important role in influencing Chinese preschoolers' PA patterns, such as a correlation with higher SB and lower MVPA. Grandparent care is a traditional sociocultural custom in Chinese societies.⁵⁰ Previous researchers have reported that Chinese grandparents had an influence on children's weight status because of their limited understanding of risk factors for obesity and because they overindulge their grandchildren.⁵¹ This may be because many of the older generation experienced a lengthy famine during childhood⁵² and because the single grandchild is the focus of attention in the Chinese families of today.⁵³ When it comes to PA, they may be overprotective and encourage their grandchildren to engage in less vigorous or even sedentary indoor activities because they are less active themselves and transfer this inclination to a restriction of their grandchildren's vigorous activities.⁵⁴ However, a study of preschoolers in Japan found that grandparents had no impact on their grandchildren's PA.⁵⁵ One Spanish research study indicated that when parents' work leads to a difficult and tough situation, the role of grandparents was very important in the life of the family.⁵⁶ Therefore,

family-based education about healthy lifestyle behaviors in young children should involve not only the parents but also the grandparents who care for the children.

Our results showed that access to media equipment, particularly a television or computer in the child's bedroom, was associated with higher levels of LT_{SB}_q in preschoolers. Similar findings have been reported for British children.⁵⁷ A systematic review found that reducing the parents' own screen time could lead to a decrease in the children's screen time.⁵⁸ A study in Finland examined parental educational levels and preschoolers' screen time and found that parental role models, attitudes, and norms were important mediators of preschoolers' screen time.⁵⁹ Thus, to reduce SB in the household, support and behavioral interventions by parents are needed. Family-based strategies to limit media access may be an important way to reduce children's SB during leisure time. For example, "removing electronic media from children's bedrooms" was seen as useful in targeted obesity-prevention initiatives.⁶⁰ This strategy could also be used to minimize ST in the early years.⁶¹ Furthermore, recommendations about the use of mobile media for young children are needed.⁶² Our study showed that 62% of children interact with a mobile phone, tablet, or electronic games for 30 min per day 5 days per week ([Supplementary Table 1](#)).

Our study also confirmed a correlation between families' having and using PA facilities in their neighborhood and young children's $LTPA_q$. This finding was consistent with that of a previous study, which demonstrated that access to PA destinations correlates with $LTPA$ in Chinese adults.⁶³ Another study, in Hong Kong, China, reported that building more neighborhood sports facilities may help active adolescents to maintain or increase their $LTPA$.⁶⁴ For preschool children, as expected, the influence of the built environment was indirect and required the parents' or caregivers' support because young children are less autonomous than adults.³⁵ More and more evidence shows that parents' PA has a positive influence on children's PA.^{65,66} For example, a study in Canada found that maternal support was significantly related to preschoolers'

objectively measured ST, LPA, and MVPA.⁶⁷ Thus, improving the availability of PA facilities is a sensible action to take, not least because children and their caregivers can then do activities together, which benefits both groups.

In addition, some environmental correlates may influence other PA domains, and this needs to be studied further. Although no evidence was found in our study that parental perception of “traffic safety” was a correlate of children’s PA behaviors, parental perception of greater “traffic safety” was associated with children’s active commuting to school ($\rho = 0.102$, $p < 0.05$), and more “social support” was associated with children spending more time in “outdoor play” ($\rho = 0.223$, $p < 0.05$). In addition, more “social support” ($\rho = 0.272$, $p < 0.05$) and “higher quality of neighborhood environments” were both associated with children going to PA facilities more frequently ($\rho = 0.165$, $p < 0.05$). Therefore, comprehensive correlation of supportive school environments, active transportation, safe neighborhoods, and supportive home environments should be studied further; multiple approaches to public health policy should be made to promote sufficient PA.^{6,23,68}

To the best of our knowledge, this is the first study that examined correlates of home and neighborhood characteristics in the PA patterns of Chinese preschool children. An important strength of this study was that it investigated both correlates of objectively measured PA throughout the day and subjectively measured PA and SB during leisure time. This provided a better understanding of how different environmental factors influence children’s behaviors in particular settings. Limitations of the present study include its cross-sectional design, which means that causality cannot be addressed. Also, environmental characteristics, LTPA_q, and LTSA_q were reported by parents, so findings must be interpreted with caution. Furthermore, it is not known how these results would translate to other populations in a different part of the world because the children in this study were recruited in a single Chinese city, and the correlates for being sedentary or active are likely to depend on the area-specific context.

5. Conclusion

This study provides evidence showing that children’s caregivers, children’s active behaviors, media exposure at home, and better neighborhood facilities are important factors in shaping Chinese preschoolers’ PA patterns. The promotion of PA for young children should take into consideration the children’s caregivers and their influence on children’s active behaviors. Having convenient neighborhood PA facilities may not be enough to enhance children’s PA throughout the day. Thus, a comprehensive approach, including supportive home environments, active transportation, and safe and supportive school and neighborhood environments, is needed to prevent deterioration in young children’s PA patterns.

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Authors’ contributions

EC and CL designed the study; EC, CL, TS and GH were involved in the data analysis and interpretation, and CL drafted the manuscript. All authors were involved in the revision of the manuscript and approved the final version of the submitted manuscript. All authors have read and approved the final manuscript and agree with the order of the presentation of authors.

Competing interests

The authors declare that they have no competing interests.

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