Physical activity patterns by objective measurements in preschoolers from China

Congchao Lu *1,2, Rikstje Wiersma *1,3, Tong Shen4, Guowei Huang2,5 and Eva Corpeleijn1

1 Department of Epidemiology, University Medical Center Groningen, University of Groningen, Groningen, the Netherlands
2 Tianjin Key Laboratory of Environment, Nutrition and Public Health, Centre for International Collaborative Research on Environment, Nutrition and Public Health, School of Public Health, Tianjin Medical University, Tianjin, China
3 Center for Human Movement Sciences Groningen, University of Groningen, Groningen, the Netherlands
4 Tianjin University kindergarten, Tianjin University, Tianjin, China
5 Department of Nutrition and Food Science, School of Public Health, Tianjin Medical University, Tianjin, China

ABSTRACT

Introduction: This cross-sectional study aims to describe the objectively measured sedentary time (ST) and physical activity (PA) patterns of preschool children during the day, and to compare these patterns between non-overweight and overweight children.

Methods: Healthy children aged 3–6 years were recruited from urban preschools in Tianjin, China. Light PA (LPA), moderate-to-vigorous PA (MVPA), and ST of children were measured using ActiGraph accelerometry (at least 3 wearing days, more than 10 hours per day). Multiple adjusted, generally linear mixed models were used for statistical analysis.

Results: The time children (n = 134) spent in MVPA was 50.5 ± 17.1 min/day, and there were 28% of the children met the PA recommendation of one hour MVPA per day. Children were less active during recess (12:00–14:00) and afternoon (14:00–17:00), and more active during late afternoon (17:00–18:00) and evening (18:00–21:00). Between active and less active children, the difference of MVPA was highest in the evening (4.1 min/hour) and on weekends/holidays (42.7 min/day). Overweight children were more sedentary overall (44.6 min/day) compared to non-overweight children.

Conclusion: Chinese preschoolers have low levels of PA, especially during school days. Enhancing PA both in school and the home environment should be taken into consideration to prevent childhood obesity.

Keywords: Sedentary behaviors; obesity; accelerometry; time segments
INTRODUCTION

The increasing prevalence of childhood obesity has become one of the most important threats to public health worldwide. This is not only limited to high-income countries but is also increasingly found in low- and middle-income countries. Data from the China Health and Nutrition Survey showed that the prevalence of overweight and obesity increased in boys and girls between 1997 and 2011, from 6.5% to 15.5% in boys and from 4.6% to 10.4% in girls. This trend was not only found in school children but also in preschoolers (aged 3–6 years old). For example, the prevalence of obesity in Tianjin preschoolers increased from 8.8% in 2006 to 10.1% in 2010, and then remained stable until 2014 among children aged 5–6 years old. Chinese people are facing huge changes in the local environment due to the rapid economic development experienced over the past three decades. As a result of urbanization, citizens’ daily lives are accompanied by a lack of physical activity (PA), more sedentary lifestyles, and high-caloric diets, all contributors to the rapid rise in obesity in China.

The health benefits of sufficient PA during preschool years are increasingly being recognized. In addition to preventing obesity, the promotion of PA also improves physical fitness, motor skills, and psychological development. A lack of PA is also a growing problem in China nowadays. A systematic review summarized the levels of PA among Chinese children and adolescents, and found a low level of PA in most studies. Half of the studies reported that less than 50% of the participants were able to meet the recommendation of one-hour moderate-to-vigorous PA (MVPA) daily. However, none of these studies focused on preschoolers. The Chinese government has published PA recommendations for preschoolers in June 2018, it emphasized that preschoolers should accumulate 60 minutes MVPA per day. To our knowledge, less known is about objectively measured PA patterns among preschoolers in mainland China.

Given the widespread problem of physical inactivity, and the continued growth in the prevalence of childhood obesity, promotion of regular PA among young people has become a worldwide public-health priority. Future efforts to effectively promote PA in young children through policy initiatives will depend on a full understanding of PA behavior in this age group. The patterns of PA and sedentary behaviors in preschoolers are still unclear, while the associations between objective measurement of PA and Body Mass Index (BMI) remain inconclusive. Identifying periods during the day, which are characterized by high levels of PA in some children and low levels in others, will help to identify key time slots for intervening and potentially changing PA behaviors. Objective measurement of PA with accelerometry can provide a reliable and valid estimate of energy/calorie expenditure in preschoolers, as well as offer the opportunity to specify the PA pattern over the day using time-stamped data. The aim of this cross-sectional study is to describe the objectively measured PA and sedentary behaviors of Chinese urban preschoolers during the day, and to compare the PA patterns of non-overweight and overweight children.
METHODS

Study design
Data were derived from the Physical Activity and Health in Tianjin Chinese Children study (PATH-CC), which focuses on identifying the relationship between environmental determinants, PA, and overweight in childhood in Tianjin, China. Tianjin is the fourth largest city in northern China with over 15 million residents in 2015. Preschools generally include 3- to 6-year-old children, and most of these children attend local preschools in the urban city. Four preschools, located in four different districts, were selected at random. Healthy children aged 3–6 years of age, growing up in Tianjin, were recruited in preschools using advertising posters. There were 1031 preschool children, who, along with their parents, joined in the study from March to April 2015. The participant rate was 93.7% of the total number of 1100 children in the recruited preschools. Written informed consent was obtained from 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.

Data collection
All children (n = 1031) in the PATH-CC study were asked to join the physical activity measurement by recruitment letters to their parents. In total, 169 parent-child pairs responded to the invitation, of which 6 children dropped out. Accelerometry data of participants were collected from June to November 2015 in Tianjin, China. The height and weight of children were measured without shoes and in light clothes by trained school nurses. Standing height was measured using a stadiometer (to the nearest 0.1 cm, SZG-180, Shanghai Zhengdahengqi Company, Shanghai, China), and weight was measured using digital scale (to the nearest 0.01 kg, TCS-60, Tianjin weighting apparatus, Tianjin, China). The standardized BMI (zBMI) of children was calculated using the LMS method; overweight and obesity were classified according to the age- and gender-specific cut-offs of Cole and colleagues (2012). Educational level of the parents (low/middle education or higher education), ethnicity, and information about children’s napping in the afternoon were both addressed in questionnaires. Parents reported whether their children had a nap during the day, and the duration of napping on average, for school days as well as weekends/holidays.

Sedentary time and physical activity
Sedentary time (ST) and PA in children were assessed using ActiGraph GT3X (Actigraph, Pensacola, FL) accelerometry. Parents were instructed to have their child wear the ActiGraph on the iliac crest of the right hip with an elastic belt for seven days during all waking hours, except while bathing or swimming. Data were collected using a frequency of 30 Hz. Collected data were analyzed in 15-second epochs. Non-wearing time of the ActiGraph was classified as a minimum length of 90 minutes, small window length 30 minutes, and with 2 minutes of spike tolerance. Cut-off points recommended by Butte and colleagues were used to calculate the time spent on ST (≤ 819 CPM), LPA (820 – 3907 CPM), moderate physical activity (3908 – 6111 CPM), vigorous physical activity (≥ 6112 CPM) and MVPA.
The valid wearing period was selected as being from 6:00 until midnight. For valid measurements in this study, wearing time had to be at least 600 minutes/day for at least three days, regardless of whether these were weekdays or weekend days. Time of day, weekday or weekend day, and season were obtained from the ActiGraph output. School days and weekends/holidays were defined according to the schedule of the local government; data were not collected during summer holidays.

MVPA accrued in bouts was calculated, including sporadic sessions (1–4 minutes), short bouts (5–9 minutes, interruption periods of 1 minute), and medium-to-long bouts (≥ 10 minutes, interruption periods of 2 minutes). That is, participants were allowed an occasional rest period of 1 or 2 minutes respectively during the short and medium-to-long bouts of MVPA. Another reason for allowing interruption periods is that no child had one time of medium-to-long bouts per day without any interruption in this study, and only four children had one time of short bouts per day without any interruption. Bout frequency was calculated by total number of bouts performed on valid days divided by the number of valid days.

The school schedule follows a five-day rotation in China, and lunch in school days for preschoolers between 11:00 and 12:00, followed by an obligatory resting time (nap time) until 14:00 or 15:00. In this study, the activity levels per segment were calculated as mean minutes per hour; incomplete hours were excluded. The incomplete hours were mainly found between 12:00 and 15:00 in nine children, since these children removed the ActiGraph for napping with an average of (105 ± 31) minutes according to parents’ reports. Furthermore, the activity levels per segment were calculated for school days and for weekends/holidays as well, separately. Incomplete hours were not imputed as missing data, because no difference for napping time was found between children wearing ActiGraphs or not, either on school days or on weekend/holidays (p > 0.05). Adherence to the PA guidelines was defined as at least 60 minutes of MVPA daily on average (with some measurement days exceeding the recommendation and some days not) according to the World Health Organization recommendation, as well as the Chinese PA guidelines for preschoolers. As for the seasons, summer was defined as June to August and autumn was defined as September to November. Children were also divided into active and less active groups, based on the highest (58.2 minutes/day) and lowest (41.6 minutes/day) tertile of MVPA per day, respectively.

**Statistical analysis**

To examine the distribution of PA and ST during the day and to identify which time slots differed from each other, a sensitivity analysis was performed, using repeated measures ANOVA with hours as dependent variables from 8:00 to 21:00, since children were not fully measured by the ActiGraph in the early morning (6:00–8:00) and late evening (21:00–24:00). To examine the differences in PA and ST of the children between school days and weekends/holidays, multiple linear mixed models, controlled for sex, age, and season, were performed, one for each segment and for the whole day (overall). School days and weekends/holidays were entered as fixed factors; gender was entered as a factor; age and season were entered...
as covariates; and the covariance type was set as unstructured. To compare active and less active children, and overweight and non-overweight children, multiple linear regressions were performed, one for each segment and one for the whole day, controlled for sex, age, and season. Dependent skewed variables were ln-transformed for linear regression. IBM SPSS Statistics 22 for Windows (SPSSInc., Chicago, IL) were used for this study, with test level $\alpha = 0.05$, and analyses were conducted in 2018.

**RESULTS**

A total of 163 children participated in the measurements of PA using ActiGraph accelerometry, and 134 children (82.2%) had valid data for analysis in this study. A flowchart of the participant recruitment is shown in Figure 1. The excluded children ($n=29$) did not differ in terms of gender, age, and maternal educational levels (all $p > 0.05$) compared to the included children ($n=134$). No significant differences were found between the total sample and the PA group for age, gender, BMI, ethnicity, and maternal educational levels. The time children spent in MVPA was 50.5 ± 17.1 minutes per day. The percentage of time spent in ST, LPA, and MVPA during a day was 60.8%, 32.6%, and 6.6%, respectively. The PA recommendation was met by 28% of children, and more boys (32%) than girls (22%) met the recommendation. During school days, 22% of the children were able to meet the recommendation, and 47% on weekends/holidays. The descriptive characteristics of the children for the total PATH-CC sample and PA group are shown in Table 1.

![Figure 1. Flowchart of the participants from the PATH-CC study in this analysis.](image-url)
Table 1. Characteristics of the study population.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total (n = 1031)</th>
<th>Physical activity group (n = 134)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>4.8 ± 1.1</td>
<td>5.4 ± 0.9</td>
</tr>
<tr>
<td>Boys</td>
<td>580 (56.3)</td>
<td>76 (56.7)</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>15.2 (14.4; 16.3)</td>
<td>15.2 (14.5; 16.3)</td>
</tr>
<tr>
<td>Obesity &amp; overweight a</td>
<td>125 (12.2)</td>
<td>16 (11.9)</td>
</tr>
<tr>
<td>Normal weight &amp; underweight</td>
<td>901 (87.8)</td>
<td>118 (88.1)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Han</td>
<td>969 (94.0)</td>
<td>127 (94.8)</td>
</tr>
<tr>
<td>Non-Han</td>
<td>62 (6.0)</td>
<td>7 (5.2)</td>
</tr>
<tr>
<td>Maternal education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low/middle</td>
<td>144 (14.3)</td>
<td>25 (19.1)</td>
</tr>
<tr>
<td>High</td>
<td>862 (85.7)</td>
<td>106 (80.9)</td>
</tr>
<tr>
<td>Sedentary time (min/day)</td>
<td>-</td>
<td>468.7 ± 80.5</td>
</tr>
<tr>
<td>Light physical activity (min/day)</td>
<td>-</td>
<td>249.6 ± 44.1</td>
</tr>
<tr>
<td>Moderate physical activity (min/day)</td>
<td>-</td>
<td>38.0 ± 12.7</td>
</tr>
<tr>
<td>Vigorous physical activity (min/day)</td>
<td>-</td>
<td>12.5 ± 5.4</td>
</tr>
<tr>
<td>Moderate and vigorous physical activity (min/day)</td>
<td>-</td>
<td>50.5 ± 17.1</td>
</tr>
<tr>
<td>Adherence to physical activity recommendation b</td>
<td>-</td>
<td>37 (27.6)</td>
</tr>
</tbody>
</table>

Data were presented as rates in N, and percentages as means with standard deviations, or, if data were skewed, as the median, along with the 25th to 75th percentile.

a Overweight based on Z-scores Cole.

b Moderate and vigorous physical activity, 60 min/day (with some measurement days exceeding the recommendation and some days not).

The percentage of time that children engaged in sporadic sessions (1–4 minutes), short bouts (5–9 minutes) and medium-to-long bouts (≥ 10 minutes) accounted for 31.4%, 12.7%, and 6.4%, respectively, of the total MVPA during a day. This means that 49.5% of the time in MVPA comprised of sporadic MVPA of less than one minute. A total of 7% of children engaged in at least one medium-to-long bout of MVPA on the average day, and 49% participated in at least one short bout of MVPA on the average day. During weekends/holidays, children showed a higher frequency of sporadic sessions [median and IQR, 12.0 (7.5, 17.0) bouts] compared to school days [median and IQR, 9.5 (6.6, 12.9) bouts, p < 0.05]. Active children showed a higher frequency in bouts compared to less active children for all bout types (p < 0.05). There were no differences in bouts frequency between overweight and non-overweight children. These outcomes are shown in Table 2.
Distribution of ST and PA during the day

Time segments were chosen based on sensitivity analysis and Chinese children’s daily schedules. The results of sensitivity analysis on the division of hours showed that there were significant differences between 8:00 and 9:00, 9:00 and 10:00, and 10:00 and 11:00 for LPA. However, those segments were not significantly different for ST and MVPA; therefore, these segments were combined as morning (8:00–11:00). The segments of 12:00–13:00 and 13:00–14:00 were combined as recess (12:00–14:00) since most of children would have a nap at school during this period on school days. According to parents’ reports, 105 children (78%) had nap with an average of (108 ± 29) minutes in school days, and 81 children (60%) had nap with an average of (108 ± 38) minutes during weekends/holidays. Furthermore, there were no significant differences for ST, LPA, and MVPA between the segments of 14:00–15:00 and 15:00–16:00, and also no significant differences for MVPA between 15:00–16:00 and 16:00–17:00; therefore, these segments were combined as afternoon (14:00–17:00). There were no significant differences for ST, LPA, and MVPA between the segments of 18:00–19:00 and 19:00–20:00, and also no significant differences for MVPA between 19:00–20:00 and 20:00–21:00; therefore, these segments were combined as evening (18:00–21:00). Finally, six time segments were used in this study for describing the distribution of ST and PA during the day, including morning (8:00–11:00), lunch (11:00–12:00), recess (12:00–14:00), afternoon (14:00–17:00), late afternoon (17:00–18:00) and evening (18:00–21:00).

Figure 2 shows the median, the 25th and 75th percentile, and the minimum and maximum for ST, LPA, and MVPA per time segment. A main effect for differences between segments over the day was found for ST, LPA, and MVPA ($F(6) = 81.2, p = 0.000; F(6) = 60.4, p = 0.000; F(6) = 90.3, p = 0.000$, respectively). The contrasts for ST, LPA, and MVPA showed significant differences between all segments ($p < 0.05$). The time children spent being sedentary was highest during recess (12:00–14:00) and afternoon (14:00–17:00), which accounted for 46% of total ST daily on school days (40% of total ST daily on weekends/holidays). The time spent being sedentary was lowest in the late afternoon (17:00–18:00), and it increased again in the evening (18:00–21:00). The time children spent in LPA was lowest around recess (12:00–14:00), and increased from afternoon (14:00–17:00) to late afternoon (17:00–18:00), while in the evening it decreased again. The time children spent in MVPA was lowest around recess (12:00–14:00) and highest in late afternoon (17:00–18:00). During school days, the time children spent in MVPA during recess and afternoon (12:00–17:00) only accounted for 20% of total MVPA daily, but the late afternoon and evening (17:00–21:00) accounted for 52% of the total MVPA.
Table 2. Characteristics of MVPA bouts of the study population.

<table>
<thead>
<tr>
<th>Bouts frequency (n/day)</th>
<th>Medium-to-long bout (IQR)</th>
<th>Short bout (IQR)</th>
<th>Sporadic sessions (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical activity group (n = 134)</td>
<td>0.2 (0.0, 0.5)</td>
<td>0.9 (0.3, 1.6)</td>
<td>9.8 (7.2, 14.1)</td>
</tr>
<tr>
<td>During schooldays (n = 134)</td>
<td>0.2 (0.0, 0.5)</td>
<td>0.8 (0.3, 1.5)</td>
<td>9.5 (6.6, 12.9)</td>
</tr>
<tr>
<td>During weekend/holidays (n = 107)</td>
<td>0.0 (0.0, 0.5)</td>
<td>1.0 (0.0, 2.3)</td>
<td>12.0 (7.5, 17.0)a</td>
</tr>
<tr>
<td>Overweight children (n = 16)</td>
<td>0.3 (0.0, 0.4)</td>
<td>0.6 (0.2, 1.4)</td>
<td>9.2 (4.9, 14.7)</td>
</tr>
<tr>
<td>Non-overweight children (n = 118)</td>
<td>0.2 (0.0, 0.5)</td>
<td>0.9 (0.3, 1.6)</td>
<td>9.9 (7.3, 14.1)</td>
</tr>
<tr>
<td>Active children (n = 44)</td>
<td>0.5 (0.2, 0.9)b</td>
<td>1.8 (1.0, 2.5)b</td>
<td>15.4 (13.2, 17.5)b</td>
</tr>
<tr>
<td>Less active children (n = 44)</td>
<td>0.0 (0.0, 0.2)</td>
<td>0.3 (0.1, 0.8)</td>
<td>6.5 (4.1, 7.7)</td>
</tr>
</tbody>
</table>

Data for bouts frequency of MVPA are presented as the median in number/day, along with the 25th and 75th percentiles.

a p < 0.05; derived from Mann-Whitney U test assessing whether differences of bouts frequency between schooldays and weekend/holidays.

b p < 0.05; derived from Mann-Whitney U test assessing whether differences of bouts frequency between active children and less active children.

Figure 2. Daily physical activity patterns per time segment.

Moderate to vigorous physical activity (MVPA), light physical activity (LPA), and sedentary time (ST) are given per time segment with the median, the 25th and 75th percentile, and minimum and maximum. All time segments differed significantly (p < 0.05).
School days compared to weekends/holidays
During school days, children showed more ST (51.3 min/day), less LPA (45.4 min/day), and less MVPA (13.5 min/day) for the whole day (overall) compared to weekends/holidays. Data per segments indicated that children were more sedentary in daytime for each segment (8:00–17:00) compared to weekends/holidays, and the largest difference for more time spent on ST was found during recess (12:00–14:00, $M_{\text{diff}} = 15.2$ min/hour); however, children were more active for MVPA ($M_{\text{diff}} = 3.1$ min/hour) during late afternoon (17:00–18:00) on school days compared to weekends/holidays (Figure 3). No difference was found in the evening (18:00–21:00). In total, boys spent more time in MVPA ($M_{\text{diff}} = 6.9$ min/day, $p = 0.021$) than girls, the largest difference was during weekends/holidays ($M_{\text{diff}} = 10.1$ min/day, $p = 0.020$). These outcomes are shown in Table S1.

**Figure 3.** Daily physical activity patterns for school days and holidays.

Moderate to vigorous physical activity (MVPA), light physical activity (LPA), and sedentary time (ST) are given per time segment for school days and weekends/holidays, with the mean per behavior and per group. Only the evening (18:00–21:00) showed no significant differences for ST, LPA, and MVPA between school days and weekends/holidays ($p > 0.05$). P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA was performed using Ln-transformed MVPA.

Active children compared to less active children
When comparing active children to less active children, active children showed less ST (58.5 min/day), more LPA (57.3 min/day) and MVPA (37.3 min/day) for the whole day (overall) compared to less active children. Data per segments indicated that all segments throughout the day differed significantly for ST, LPA, and MVPA ($p < 0.05$), except for ST (17:00–18:00), and LPA (11:00–12:00, 17:00–18:00). The largest difference in time spent on MVPA per segment was found in the evening (18:00–21:00, 4.1 min/hour), between active and less active.
children, as shown in Figure 4. When the PA outcomes were separated into school days and weekends/holidays, this showed that the difference in time spent overall on MVPA between active and less active children was higher during weekends/holidays (42.7 min/day) compared to school days (32.9 min/day). These outcomes are shown in Table S2.

**Figure 4.** Daily physical activity patterns for active children and less active children.

*Moderate to vigorous physical activity (MVPA), light physical activity (LPA), and sedentary time (ST) are given per time segment for active children and less active children, with the mean per behavior and per group. Only the segments of lunch (11:00–12:00) and late afternoon (17:00–18:00) for LPA, and the segment of late afternoon for ST showed no significant differences between active children and less active children (p > 0.05). P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA was performed using Ln-transformed MVPA.*

**Non-overweight children compared to overweight children**

There were no differences in overall LPA and MVPA between overweight and non-overweight children. However, overweight children showed more ST overall compared to non-overweight children (44.6 min/day), especially in the morning (8:00–11:00, 3.6 min/hour) and lunch (11:00–12:00, 4.8 min/hour) and in the late afternoon (17:00–18:00, 4.9 min/hour), as shown in Figure 5. On school days, overweight children showed less time in LPA in the morning (2.9 min/hour) and evening (3.0 min/hour), and were more sedentary in the late afternoon (4.6 min/hour) compared to non-overweight children. During weekends/holidays, overweight children showed more ST (6.3 min/hour) in the morning, at the cost of less LPA (5.1 min/hour), compared to non-overweight children (Table S3).
**Figure 5.** Daily physical activity patterns for overweight and non-overweight children.

Moderate to vigorous physical activity (MVPA), light physical activity (LPA), and sedentary time (ST) are given per time segment for overweight and non-overweight children, with the mean per behavior and per group. Only the segments of morning (8:00–11:00) and lunch (11:00–12:00) for LPA and ST, and the segment of late afternoon (17:00–18:00) for MVPA, LPA, and ST showed significant differences between overweight and non-overweight children (p < 0.05). P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA was performed using Ln-transformed MVPA.

**DISCUSSION**

Examining time-segment-specific patterns in objectively measured PA is helpful for effective PA promotion in children. In order to find the time segments, in which interventions aiming to increase the PA levels in Chinese preschoolers might enjoy the most success, different approaches were followed in this study. A low level of PA was found among Chinese preschoolers in this study, especially during afternoons in the school environment. Active children are more active than less active children outside of school hours. Children are more sedentary during school days compared to weekends/holidays, and overweight children are even more sedentary both on school days and weekends/holidays compared to non-overweight children.

This study indicated that, compared to weekends/holidays, patterns of preschoolers’ activity during a day in school were more variable with more peaks and troughs. This pattern was also found in British and Belgian preschoolers, which were characterized by structured routine timetables and scheduled recesses. For Chinese preschoolers, during school days, the percentage (22%) of children who met the PA recommendation was much lower than a
worldwide systematic review reported (54%, N = 10,316, aged 2–6 years) \(^{22}\). The increased time spent on indoor activities and the lack of opportunities for outside play often comes at the price of time for PA, partly due to air pollution there is less opportunity for outdoor physical activities in Chinese children \(^{23}\). Therefore, classroom-based PA interventions such as physically active academic lessons, or providing children more opportunity for structured physical activities indoors are recommended \(^{24}\). In addition, perhaps to reduce the long duration of napping would be possible for children to gain the opportunity to be active, since cancel napping would not be culturally acceptable in China. Furthermore, literature showed that daytime naps increased sleep problems \(^{25,26}\), for example, longer nap durations were found to be related to later bed time on the corresponding night in Japanese toddlers (2–5 years old) \(^{27}\). In nowadays Chinese urban cities, most preschools perform the similar timetables and scheduled recess (at school) for children, thus, implications from this study could also be considered by other cities. Effective school policies and programs are needed in China in order to fight the growing epidemic of physical inactivity and obesity; strong support from local governments is paramount \(^{28}\).

Between less active and more active children, i.e. the lowest and highest tertile of MVPA, the largest differences in MVPA were found outside of school hours. For example, active children spent 4.1 min/hour more on MVPA in the evening on an average day, and spent 42.7 min/day more in MVPA during weekend/holidays than less active children. Thus, weekends/holidays or during after-school hours on school days may be a critical period for promotion of PA at preschool age, especially for less active children. We assume that transport and leisure time activities might play an important role in urban preschoolers’ activity, and large improvements in PA would be gained if active commuting and sufficient active leisure-time opportunities were embedded in their daily life. Therefore, the weekends might be a good time for improving PA in less active children, since it would then be possible for parents to support children’s activities efficiently by having enough time. PA-promotion strategies targeting low active children may be effectuated via parents’ support at home and in neighborhood community groups \(^{29-31}\). Health education for parents is needed, both in order to learn how important adequate PA is for a child’s health and development, as well as to learn strategies for stimulating children’s PA \(^{32}\).

This study showed that compared to non-overweight children, overweight children were more sedentary overall (44.6 min/day) and spent less time on LPA in the morning (3.6 min/hour), lunch (4.8 min/hour) and late afternoon (4.9 min/hour). A systematic review found moderate evidence for the association between television viewing and overweight in preschoolers \(^{33}\). One study in China indicated that sedentary behaviors might be positively and independently related to fat mass among Chinese children \(^{34}\). While the cross-sectional nature of this study does not allow for any conclusions vis-à-vis cause and effect, our findings are consistent with the hypothesis that ST or LPA constitutes a major contributing factor in the development and continuation of childhood obesity \(^{35}\). This study indicated that interventions should focus on both the promotion of PA and the limitation of ST. Both the school and home environments
should be taken into consideration in order to promote an effective intervention. Parents’ involvement is essential 36,37.

**Limitations**
This study has some limitations. Firstly, children included in this study were volunteers and derived from a random sample in a large city in China. Further studies are needed to confirm the results in larger sample sizes. Secondly, the participating parents were well-educated, since young parents that finished college/university are common in Chinese large urban cities nowadays, e.g. Beijing, Shanghai or Tianjin. Thirdly, not all children covered all segments during the day. However, the results were comparable when only children who covered all segments during the day were included. Furthermore, it is unknown how these results would translate to other populations in a different part of the world, since different cultures effecting different cultural habits and different school schedules play an important role in children’s activity patterns.

**CONCLUSION**
As far as is known, this is the first study that has examined PA patterns during the day using ActiGraph along with time-stamped data in Chinese preschoolers. This study showed that Chinese preschoolers have low levels of PA, especially during school days, and overweight children are more sedentary. In this preschool age group longer bouts of MVPA are rare, but smaller bouts are common and differ greatly between active and inactive children. Results of this study indicated that enhancing PA both in school and in the home environment should be taken into consideration to prevent childhood obesity. Preschools could provide children with more opportunities to be active in the afternoon. For less active children, the weekends might be a possible time to enhance their PA, and a suitable way to promote PA should be taken into consideration by their parents. Strong support from local governments in terms of effective school policies and building a neighborhood around active living is essential.
REFERENCES


### SUPPLEMENTARY MATERIALS

**Table S1-1.** Comparison of PA patterns during the day between schooldays and weekends/holidays.

<table>
<thead>
<tr>
<th>Segment</th>
<th>School days (n = 134)</th>
<th>Holidays (n = 107)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 8:00–11:00</td>
<td>37.4 [36.1; 38.7]</td>
<td>31.4 [29.9; 32.9]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 11:00–12:00</td>
<td>36.7 [35.1; 38.3]</td>
<td>30.1 [28.4; 31.7]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 12:00–14:00</td>
<td>48.5 [46.5; 50.5]</td>
<td>33.3 [31.4; 35.3]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 14:00–17:00</td>
<td>41.3 [40.0; 42.6]</td>
<td>34.2 [32.7; 35.7]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 17:00–18:00</td>
<td>25.9 [24.4; 27.4]</td>
<td>30.8 [29.1; 32.5]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 18:00–21:00</td>
<td>32.3 [31.0; 33.7]</td>
<td>31.9 [30.4; 33.4]</td>
<td>0.661</td>
</tr>
<tr>
<td>ST overall</td>
<td>478.9 [464.3; 493.4]</td>
<td>427.6 [411.3; 443.8]</td>
<td>0.000</td>
</tr>
<tr>
<td>LPA 8:00–11:00</td>
<td>20.0 [19.0; 21.1]</td>
<td>23.9 [22.7; 25.1]</td>
<td>0.000</td>
</tr>
<tr>
<td>LPA 11:00–12:00</td>
<td>19.7 [18.5; 20.9]</td>
<td>25.2 [23.9; 26.4]</td>
<td>0.000</td>
</tr>
<tr>
<td>LPA 12:00–14:00</td>
<td>9.9 [8.3; 11.6]</td>
<td>22.2 [20.6; 23.8]</td>
<td>0.000</td>
</tr>
<tr>
<td>LPA 14:00–17:00</td>
<td>16.6 [15.6; 17.6]</td>
<td>21.0 [19.8; 22.2]</td>
<td>0.000</td>
</tr>
<tr>
<td>LPA 17:00–18:00</td>
<td>25.8 [24.7; 26.9]</td>
<td>24.0 [22.7; 25.2]</td>
<td>0.032</td>
</tr>
<tr>
<td>LPA 18:00–21:00</td>
<td>22.2 [21.2; 23.2]</td>
<td>22.9 [21.8; 24.0]</td>
<td>0.379</td>
</tr>
<tr>
<td>LPA overall</td>
<td>238.7 [230.4; 247.1]</td>
<td>284.1 [274.8; 293.4]</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 8:00–11:00</td>
<td>2.2 (1.2 – 3.4)</td>
<td>4.0 (2.1 – 6.0)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 11:00–12:00</td>
<td>3.0 (1.9 – 4.5)</td>
<td>3.5 (2.0 – 6.8)</td>
<td>0.032</td>
</tr>
<tr>
<td>MVPA 12:00–14:00</td>
<td>0.6 (0.1 – 2.5)</td>
<td>4.0 (2.4 – 5.8)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 14:00–17:00</td>
<td>1.8 (1.1 – 2.7)</td>
<td>3.8 (1.8 – 7.2)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 17:00–18:00</td>
<td>7.4 (4.9 – 11.2)</td>
<td>4.1 (1.8 – 7.3)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 18:00–21:00</td>
<td>4.9 (3.2 – 7.2)</td>
<td>4.6 (2.8 – 6.9)</td>
<td>0.137</td>
</tr>
<tr>
<td>MVPA overall</td>
<td>47.4 [44.0; 50.8]</td>
<td>60.9 [57.1; 64.7]</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Data for sedentary time (ST) overall, light physical activity (LPA) overall and moderate-to-vigorous physical activity (MVPA) overall are presented as the mean in minutes/day and with a 95% confidence interval. Data for each segment of ST and LPA per segment are presented as the mean in minutes/hour and with a 95% confidence interval. Data for MVPA per segment are presented as the median in minutes/hour, along with the 25th and 75th percentiles. P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA per segment was performed using Ln-transformed MVPA.
<table>
<thead>
<tr>
<th>Segment</th>
<th>Boys (n = 76)</th>
<th>Girls (n = 58)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 8:00–11:00</td>
<td>37.1 [35.7; 38.6]</td>
<td>37.8 [36.1; 39.5]</td>
<td>0.544</td>
</tr>
<tr>
<td>ST 11:00–12:00</td>
<td>36.8 [35.0; 38.6]</td>
<td>36.5 [34.4; 38.7]</td>
<td>0.828</td>
</tr>
<tr>
<td>ST 12:00–14:00</td>
<td>45.5 [43.2; 47.8]</td>
<td>46.3 [43.6; 49.0]</td>
<td>0.630</td>
</tr>
<tr>
<td>ST 14:00–17:00</td>
<td>41.0 [39.8; 42.1]</td>
<td>41.7 [40.3; 43.0]</td>
<td>0.433</td>
</tr>
<tr>
<td>ST 17:00–18:00</td>
<td>26.8 [25.2; 28.4]</td>
<td>24.7 [22.8; 26.5]</td>
<td>0.081</td>
</tr>
<tr>
<td>ST 18:00–21:00</td>
<td>32.4 [30.7; 34.1]</td>
<td>32.2 [30.3; 34.1]</td>
<td>0.864</td>
</tr>
<tr>
<td>ST overall</td>
<td>479.1 [459.6; 498.6]</td>
<td>478.5 [456.3; 500.8]</td>
<td>0.969</td>
</tr>
<tr>
<td>LPA 8:00–11:00</td>
<td>20.2 [19.0; 21.4]</td>
<td>19.8 [18.4; 21.2]</td>
<td>0.641</td>
</tr>
<tr>
<td>LPA 11:00–12:00</td>
<td>19.4 [18.1; 20.7]</td>
<td>20.2 [18.6; 21.8]</td>
<td>0.438</td>
</tr>
<tr>
<td>LPA 12:00–14:00</td>
<td>12.6 [10.6; 14.5]</td>
<td>11.9 [9.5; 14.2]</td>
<td>0.638</td>
</tr>
<tr>
<td>LPA 14:00–17:00</td>
<td>16.9 [15.9; 17.8]</td>
<td>16.2 [15.1; 17.3]</td>
<td>0.394</td>
</tr>
<tr>
<td>LPA 17:00–18:00</td>
<td>24.7 [23.6; 25.8]</td>
<td>27.2 [25.9; 28.5]</td>
<td>0.004</td>
</tr>
<tr>
<td>LPA 18:00–21:00</td>
<td>21.9 [20.7; 23.2]</td>
<td>22.6 [21.2; 24.0]</td>
<td>0.489</td>
</tr>
<tr>
<td>LPA overall</td>
<td>240.2 [230.5; 249.9]</td>
<td>236.9 [225.7; 248.0]</td>
<td>0.657</td>
</tr>
<tr>
<td>MVPA 8:00–11:00</td>
<td>2.4 (1.3 – 3.7)</td>
<td>2.0 (1.2 – 3.3)</td>
<td>0.350</td>
</tr>
<tr>
<td>MVPA 11:00–12:00</td>
<td>3.0 (2.1 – 4.6)</td>
<td>3.0 (1.5 – 4.5)</td>
<td>0.550</td>
</tr>
<tr>
<td>MVPA 12:00–14:00</td>
<td>1.5 (0.5 – 2.9)</td>
<td>0.9 (0.5 – 2.3)</td>
<td>0.357</td>
</tr>
<tr>
<td>MVPA 14:00–17:00</td>
<td>1.9 (1.0 – 2.9)</td>
<td>1.7 (1.2 – 2.5)</td>
<td>0.620</td>
</tr>
<tr>
<td>MVPA 17:00–18:00</td>
<td>8.1 (4.2 – 11.5)</td>
<td>7.3 (5.4 – 11.2)</td>
<td>0.750</td>
</tr>
<tr>
<td>MVPA 18:00–21:00</td>
<td>4.9 (3.0 – 7.7)</td>
<td>4.8 (3.6 – 6.6)</td>
<td>0.758</td>
</tr>
<tr>
<td>MVPA overall</td>
<td>49.7 [46.0; 53.4]</td>
<td>44.4 [40.2; 48.7]</td>
<td>0.101</td>
</tr>
</tbody>
</table>

Data for sedentary time (ST) overall, light physical activity (LPA) overall and moderate-to-vigorous physical activity (MVPA) overall are presented as the mean in minutes/day and with a 95% confidence interval. Data for each segment of ST and LPA per segment are presented as the mean in minutes/hour and with a 95% confidence interval. Data for MVPA per segment are presented as the median in minutes/hour, along with the 25th and 75th percentiles. P-values are based on t-test and Mann-Whitney U test.
Table S1-3. Comparison of PA patterns during the day between boys and girls on weekends/holidays.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Boys (n = 76)</th>
<th>Girls (n = 58)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 8:00–11:00</td>
<td>30.7 [28.3; 33.0]</td>
<td>32.3 [29.5; 35.1]</td>
<td>0.374</td>
</tr>
<tr>
<td>ST 11:00–12:00</td>
<td>29.5 [27.1; 31.9]</td>
<td>30.9 [28.0; 33.7]</td>
<td>0.478</td>
</tr>
<tr>
<td>ST 12:00–14:00</td>
<td>32.1 [29.7; 34.5]</td>
<td>35.0 [32.2; 37.8]</td>
<td>0.124</td>
</tr>
<tr>
<td>ST 14:00–17:00</td>
<td>34.1 [31.4; 36.9]</td>
<td>34.3 [31.2; 37.4]</td>
<td>0.945</td>
</tr>
<tr>
<td>ST 17:00–18:00</td>
<td>30.8 [28.1; 33.5]</td>
<td>30.9 [27.8; 34.0]</td>
<td>0.983</td>
</tr>
<tr>
<td>ST 18:00–21:00</td>
<td>30.0 [27.9; 32.2]</td>
<td>34.3 [31.8; 36.7]</td>
<td>0.011</td>
</tr>
<tr>
<td>ST overall</td>
<td>418.4 [396.7; 440.0]</td>
<td>439.7 [414.8; 464.7]</td>
<td>0.203</td>
</tr>
<tr>
<td>LPA 8:00–11:00</td>
<td>24.3 [22.5; 26.1]</td>
<td>23.4 [21.2; 25.5]</td>
<td>0.516</td>
</tr>
<tr>
<td>LPA 11:00–12:00</td>
<td>26.0 [24.1; 27.9]</td>
<td>24.0 [21.8; 26.3]</td>
<td>0.196</td>
</tr>
<tr>
<td>LPA 12:00–14:00</td>
<td>23.4 [21.4; 25.3]</td>
<td>20.5 [18.3; 22.8]</td>
<td>0.058</td>
</tr>
<tr>
<td>LPA 14:00–17:00</td>
<td>20.8 [18.7; 22.9]</td>
<td>21.3 [18.9; 23.7]</td>
<td>0.746</td>
</tr>
<tr>
<td>LPA 17:00–18:00</td>
<td>23.6 [21.6; 25.7]</td>
<td>24.4 [22.0; 26.7]</td>
<td>0.650</td>
</tr>
<tr>
<td>LPA 18:00–21:00</td>
<td>24.1 [22.4; 25.7]</td>
<td>21.4 [19.5; 23.3]</td>
<td>0.037</td>
</tr>
<tr>
<td>LPA overall</td>
<td>295.0 [281.2; 308.8]</td>
<td>269.7 [253.8; 285.6]</td>
<td>0.019</td>
</tr>
<tr>
<td>MVPA 8:00–11:00</td>
<td>4.3 (2.3 – 6.1)</td>
<td>3.9 (1.8 – 5.8)</td>
<td>0.416</td>
</tr>
<tr>
<td>MVPA 11:00–12:00</td>
<td>3.5 (2.0 – 6.2)</td>
<td>3.8 (1.8 – 8.0)</td>
<td>0.646</td>
</tr>
<tr>
<td>MVPA 12:00–14:00</td>
<td>4.1 (2.4 – 5.9)</td>
<td>3.9 (1.8 – 5.7)</td>
<td>0.643</td>
</tr>
<tr>
<td>MVPA 14:00–17:00</td>
<td>4.3 (1.9 – 7.5)</td>
<td>3.2 (1.7 – 6.7)</td>
<td>0.471</td>
</tr>
<tr>
<td>MVPA 17:00–18:00</td>
<td>5.0 (2.0 – 7.7)</td>
<td>3.3 (1.7 – 7.0)</td>
<td>0.411</td>
</tr>
<tr>
<td>MVPA 18:00–21:00</td>
<td>5.3 (3.3 – 8.3)</td>
<td>3.9 (2.2 – 5.3)</td>
<td>0.007</td>
</tr>
<tr>
<td>MVPA overall</td>
<td>65.3 [59.3; 71.2]</td>
<td>55.1 [48.3; 62.0]</td>
<td>0.020</td>
</tr>
</tbody>
</table>

Data for sedentary time (ST) overall, light physical activity (LPA) overall and moderate-to-vigorous physical activity (MVPA) overall are presented as the mean in minutes/day and with a 95% confidence interval. Data for each segment of ST and LPA per segment are presented as the mean in minutes/hour and with a 95% confidence interval. Data for MVPA per segment are presented as the median in minutes/hour, along with the 25th and 75th percentiles. P-values are based on t-test and Mann-Whitney U test.
Table S2-1. Comparison of PA patterns during the day between active and less active children.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Active (n = 44)</th>
<th>Less active (n = 44)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 8:00–11:00</td>
<td>32.9 [31.2; 34.6]</td>
<td>40.1 [38.3; 41.8]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 11:00–12:00</td>
<td>32.8 [30.6; 35.0]</td>
<td>36.7 [34.5; 38.9]</td>
<td>0.015</td>
</tr>
<tr>
<td>ST 12:00–14:00</td>
<td>37.8 [34.7; 40.9]</td>
<td>44.9 [41.8; 48.0]</td>
<td>0.002</td>
</tr>
<tr>
<td>ST 14:00–17:00</td>
<td>35.7 [34.1; 37.3]</td>
<td>42.0 [40.3; 43.6]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 17:00–18:00</td>
<td>26.8 [24.8; 28.8]</td>
<td>28.5 [26.5; 30.5]</td>
<td>0.226</td>
</tr>
<tr>
<td>ST 18:00–21:00</td>
<td>28.0 [26.4; 29.6]</td>
<td>36.8 [35.2; 38.4]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST overall</td>
<td>437.4 [413.3; 461.4]</td>
<td>495.8 [471.8; 519.9]</td>
<td>0.001</td>
</tr>
<tr>
<td>LPA 8:00–11:00</td>
<td>22.8 [21.4; 24.3]</td>
<td>18.1 [16.7; 19.6]</td>
<td>0.000</td>
</tr>
<tr>
<td>LPA 11:00–12:00</td>
<td>22.2 [20.5; 23.9]</td>
<td>20.3 [18.5; 22.0]</td>
<td>0.114</td>
</tr>
<tr>
<td>LPA 12:00–14:00</td>
<td>18.0 [15.4; 20.5]</td>
<td>13.3 [10.7; 15.9]</td>
<td>0.013</td>
</tr>
<tr>
<td>LPA 14:00–17:00</td>
<td>19.8 [18.4; 21.2]</td>
<td>16.3 [15.0; 17.7]</td>
<td>0.001</td>
</tr>
<tr>
<td>LPA 17:00–18:00</td>
<td>24.7 [23.2; 26.2]</td>
<td>25.6 [24.1; 27.2]</td>
<td>0.388</td>
</tr>
<tr>
<td>LPA 18:00–21:00</td>
<td>24.5 [23.2; 25.8]</td>
<td>19.8 [18.5; 21.1]</td>
<td>0.000</td>
</tr>
<tr>
<td>LPA overall</td>
<td>277.3 [265.5; 289.1]</td>
<td>219.9 [208.1; 231.7]</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 8:00–11:00</td>
<td>4.6 (3.0 – 5.8)</td>
<td>1.7 (1.2 – 2.4)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 11:00–12:00</td>
<td>4.8 (3.4 – 6.3)</td>
<td>2.2 (1.5 – 3.2)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 12:00–14:00</td>
<td>3.7 (2.6 – 6.0)</td>
<td>0.9 (0.4 – 2.8)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 14:00–17:00</td>
<td>4.6 (2.7 – 5.5)</td>
<td>1.6 (1.1 – 2.2)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 17:00–18:00</td>
<td>7.8 (5.0 – 11.5)</td>
<td>5.4 (2.9 – 7.9)</td>
<td>0.002</td>
</tr>
<tr>
<td>MVPA 18:00–21:00</td>
<td>7.3 (5.6 – 9.5)</td>
<td>3.2 (2.2 – 4.3)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA overall</td>
<td>69.8 [67.1; 72.5]</td>
<td>32.5 [29.8; 35.2]</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Data for sedentary time (ST) overall, light physical activity (LPA) overall and moderate-to-vigorous physical activity (MVPA) overall are presented as the mean in minutes/day and with a 95% confidence interval. Data for each segment of ST and LPA per segment are presented as the mean in minutes/hour and with a 95% confidence interval. Data for MVPA per segment are presented as the median in minutes/hour, along with the 25th and 75th percentiles. P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA per segment was performed using Ln-transformed MVPA.
Table S2-2. Comparison of PA patterns during the day between active and less active children on school days.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Active (n = 44)</th>
<th>Less active (n = 44)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 8:00–11:00</td>
<td>34.7 [32.9; 36.5]</td>
<td>40.9 [39.1; 42.7]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 11:00–12:00</td>
<td>36.0 [33.4; 38.5]</td>
<td>39.2 [36.5; 41.8]</td>
<td>0.084</td>
</tr>
<tr>
<td>ST 12:00–14:00</td>
<td>42.9 [39.7; 46.1]</td>
<td>47.6 [44.3; 50.8]</td>
<td>0.044</td>
</tr>
<tr>
<td>ST 14:00–17:00</td>
<td>39.0 [37.4; 40.6]</td>
<td>43.2 [41.6; 44.8]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 17:00–18:00</td>
<td>25.2 [23.0; 27.5]</td>
<td>27.2 [25.0; 29.5]</td>
<td>0.217</td>
</tr>
<tr>
<td>ST 18:00–21:00</td>
<td>27.8 [25.9; 29.6]</td>
<td>36.0 [34.2; 37.9]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST overall</td>
<td>453.0 [427.1; 478.9]</td>
<td>504.4 [478.5; 530.3]</td>
<td>0.006</td>
</tr>
<tr>
<td>LPA 8:00–11:00</td>
<td>21.6 [20.1; 23.2]</td>
<td>17.4 [15.9; 19.0]</td>
<td>0.000</td>
</tr>
<tr>
<td>LPA 11:00–12:00</td>
<td>19.8 [18.0; 21.7]</td>
<td>18.1 [16.2; 20.0]</td>
<td>0.196</td>
</tr>
<tr>
<td>LPA 12:00–14:00</td>
<td>14.1 [11.3; 16.9]</td>
<td>11.4 [8.6; 14.2]</td>
<td>0.173</td>
</tr>
<tr>
<td>LPA 14:00–17:00</td>
<td>18.1 [16.7; 19.4]</td>
<td>15.4 [14.1; 16.8]</td>
<td>0.007</td>
</tr>
<tr>
<td>LPA 17:00–18:00</td>
<td>25.1 [23.5; 26.6]</td>
<td>26.3 [24.7; 27.9]</td>
<td>0.261</td>
</tr>
<tr>
<td>LPA 18:00–21:00</td>
<td>24.7 [23.1; 26.2]</td>
<td>20.4 [18.9; 22.0]</td>
<td>0.000</td>
</tr>
<tr>
<td>LPA overall</td>
<td>263.8 [252.1; 275.5]</td>
<td>212.0 [200.3; 223.6]</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 8:00–11:00</td>
<td>3.4 (2.3 – 5.1)</td>
<td>1.4 (0.9 – 2.2)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 11:00–12:00</td>
<td>4.1 (2.1 – 5.5)</td>
<td>2.1 (1.3 – 3.0)</td>
<td>0.006</td>
</tr>
<tr>
<td>MVPA 12:00–14:00</td>
<td>2.1 (0.8 – 4.9)</td>
<td>0.6 (0.4 – 1.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>MVPA 14:00–17:00</td>
<td>2.5 (1.5 – 3.9)</td>
<td>1.2 (0.7 – 2.0)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 17:00–18:00</td>
<td>8.5 (5.3 – 14.2)</td>
<td>5.6 (3.5 – 10.0)</td>
<td>0.003</td>
</tr>
<tr>
<td>MVPA 18:00–21:00</td>
<td>7.1 (5.5 – 9.6)</td>
<td>3.4 (2.2 – 4.8)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA overall</td>
<td>64.3 [61.2; 67.4]</td>
<td>31.4 [28.3; 34.5]</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Data for sedentary time (ST) overall, light physical activity (LPA) overall and moderate-to-vigorous physical activity (MVPA) overall are presented as the mean in minutes/day and with a 95% confidence interval. Data for each segment of ST and LPA per segment are presented as the mean in minutes/hour and with a 95% confidence interval. Data for MVPA per segment are presented as the median in minutes/hour, along with the 25th and 75th percentiles. P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA per segment was performed using Ln-transformed MVPA.
Table S2-3. Comparison of PA patterns during the day between active and less active children on weekends/holidays.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Active (n = 44)</th>
<th>Less active (n = 44)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 8:00–11:00</td>
<td>26.0 [23.4; 28.6]</td>
<td>35.3 [32.3; 38.4]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST 11:00–12:00</td>
<td>28.6 [25.7; 31.6]</td>
<td>31.4 [27.9; 35.0]</td>
<td>0.228</td>
</tr>
<tr>
<td>ST 12:00–14:00</td>
<td>31.5 [28.6; 34.4]</td>
<td>33.9 [30.4; 37.4]</td>
<td>0.304</td>
</tr>
<tr>
<td>ST 14:00–17:00</td>
<td>30.5 [27.1; 33.9]</td>
<td>36.5 [32.6; 40.4]</td>
<td>0.024</td>
</tr>
<tr>
<td>ST 17:00–18:00</td>
<td>30.3 [27.0; 33.7]</td>
<td>32.6 [28.6; 36.5]</td>
<td>0.387</td>
</tr>
<tr>
<td>ST 18:00–21:00</td>
<td>28.0 [25.5; 30.5]</td>
<td>37.8 [34.9; 40.7]</td>
<td>0.000</td>
</tr>
<tr>
<td>ST overall</td>
<td>394.0 [367.9; 420.0]</td>
<td>451.2 [421.0; 481.4]</td>
<td>0.006</td>
</tr>
<tr>
<td>LPA 8:00–11:00</td>
<td>27.1 [25.1; 29.2]</td>
<td>21.9 [19.4; 24.3]</td>
<td>0.002</td>
</tr>
<tr>
<td>LPA 11:00–12:00</td>
<td>25.5 [23.2; 27.8]</td>
<td>24.8 [22.0; 27.6]</td>
<td>0.697</td>
</tr>
<tr>
<td>LPA 12:00–14:00</td>
<td>22.8 [20.5; 25.1]</td>
<td>22.7 [19.9; 25.4]</td>
<td>0.946</td>
</tr>
<tr>
<td>LPA 14:00–17:00</td>
<td>22.6 [19.9; 25.2]</td>
<td>20.3 [17.2; 23.4]</td>
<td>0.271</td>
</tr>
<tr>
<td>LPA 17:00–18:00</td>
<td>24.1 [21.6; 26.7]</td>
<td>23.6 [20.5; 26.6]</td>
<td>0.762</td>
</tr>
<tr>
<td>LPA 18:00–21:00</td>
<td>24.9 [22.9; 27.0]</td>
<td>19.3 [16.9; 21.7]</td>
<td>0.001</td>
</tr>
<tr>
<td>LPA overall</td>
<td>310.0 [293.9; 326.1]</td>
<td>258.0 [239.3; 276.6]</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 8:00–11:00</td>
<td>5.6 (4.1 – 8.3)</td>
<td>1.9 (1.5 – 4.3)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 11:00–12:00</td>
<td>5.6 (3.4 – 8.0)</td>
<td>2.2 (1.6 – 3.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>MVPA 12:00–14:00</td>
<td>1.5 (1.3 – 2.0)</td>
<td>1.0 (0.5 – 1.5)</td>
<td>0.006</td>
</tr>
<tr>
<td>MVPA 14:00–17:00</td>
<td>7.3 (3.6 – 9.2)</td>
<td>2.4 (1.3 – 4.1)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA 17:00–18:00</td>
<td>5.0 (2.8 – 7.7)</td>
<td>2.3 (1.5 – 5.4)</td>
<td>0.017</td>
</tr>
<tr>
<td>MVPA 18:00–21:00</td>
<td>5.7 (4.3 – 9.2)</td>
<td>2.5 (1.6 – 3.9)</td>
<td>0.000</td>
</tr>
<tr>
<td>MVPA overall</td>
<td>81.9 [76.8; 87.0]</td>
<td>39.2 [33.3; 45.1]</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Data for sedentary time (ST) overall, light physical activity (LPA) overall and moderate-to-vigorous physical activity (MVPA) overall are presented as the mean in minutes/day and with a 95% confidence interval. Data for each segment of ST and LPA per segment are presented as the mean in minutes/hour and with a 95% confidence interval. Data for MVPA per segment are presented as the median in minutes/hour, along with the 25th and 75th percentiles. P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA per segment was performed using Ln-transformed MVPA.
Table S3-1. Comparison of PA patterns during the day between non-overweight children and overweight children.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Non-overweight (n = 118)</th>
<th>Overweight (n = 16)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 8:00–11:00</td>
<td>35.9 [34.8; 37.0]</td>
<td>39.5 [36.5; 42.5]</td>
<td>0.029</td>
</tr>
<tr>
<td>ST 11:00–12:00</td>
<td>33.7 [32.5; 34.9]</td>
<td>38.5 [35.2; 41.8]</td>
<td>0.009</td>
</tr>
<tr>
<td>ST 12:00–14:00</td>
<td>41.6 [39.7; 43.6]</td>
<td>42.8 [37.6; 48.0]</td>
<td>0.680</td>
</tr>
<tr>
<td>ST 14:00–17:00</td>
<td>39.5 [38.4; 40.5]</td>
<td>38.7 [35.8; 41.7]</td>
<td>0.654</td>
</tr>
<tr>
<td>ST 17:00–18:00</td>
<td>26.5 [25.4; 27.7]</td>
<td>31.4 [28.3; 34.6]</td>
<td>0.005</td>
</tr>
<tr>
<td>ST 18:00–21:00</td>
<td>32.5 [31.3; 33.8]</td>
<td>34.0 [30.7; 37.2]</td>
<td>0.427</td>
</tr>
<tr>
<td>ST overall</td>
<td>463.3 [448.9; 477.8]</td>
<td>508.0 [468.6; 547.3]</td>
<td>0.037</td>
</tr>
<tr>
<td>LPA 8:00–11:00</td>
<td>21.1 [20.2; 22.0]</td>
<td>17.9 [15.4; 20.4]</td>
<td>0.016</td>
</tr>
<tr>
<td>LPA 11:00–12:00</td>
<td>22.2 [21.3; 23.2]</td>
<td>18.3 [15.7; 20.9]</td>
<td>0.006</td>
</tr>
<tr>
<td>LPA 12:00–14:00</td>
<td>15.4 [13.8; 17.1]</td>
<td>14.6 [10.3; 18.9]</td>
<td>0.726</td>
</tr>
<tr>
<td>LPA 14:00–17:00</td>
<td>17.7 [16.8; 18.5]</td>
<td>18.0 [15.7; 20.3]</td>
<td>0.760</td>
</tr>
<tr>
<td>LPA 17:00–18:00</td>
<td>25.6 [24.8; 26.5]</td>
<td>22.9 [20.5; 25.3]</td>
<td>0.034</td>
</tr>
<tr>
<td>LPA 18:00–21:00</td>
<td>22.2 [21.3; 23.1]</td>
<td>20.2 [17.8; 22.6]</td>
<td>0.129</td>
</tr>
<tr>
<td>LPA overall</td>
<td>251.5 [243.5; 259.5]</td>
<td>235.5 [213.7; 257.2]</td>
<td>0.172</td>
</tr>
<tr>
<td>MVPA 8:00–11:00</td>
<td>2.6 (1.7 – 4.2)</td>
<td>2.2 (1.4 – 3.7)</td>
<td>0.498</td>
</tr>
<tr>
<td>MVPA 11:00–12:00</td>
<td>3.6 (2.3 – 5.3)</td>
<td>3.4 (2.0 – 4.2)</td>
<td>0.329</td>
</tr>
<tr>
<td>MVPA 12:00–14:00</td>
<td>2.3 (0.8 – 3.9)</td>
<td>2.6 (0.9 – 3.0)</td>
<td>0.792</td>
</tr>
<tr>
<td>MVPA 14:00–17:00</td>
<td>2.4 (1.6 – 3.8)</td>
<td>2.2 (1.7 – 5.1)</td>
<td>0.511</td>
</tr>
<tr>
<td>MVPA 17:00–18:00</td>
<td>7.4 (4.9 – 10.4)</td>
<td>5.0 (3.9 – 7.6)</td>
<td>0.039</td>
</tr>
<tr>
<td>MVPA 18:00–21:00</td>
<td>4.8 (3.3 – 6.8)</td>
<td>4.8 (4.2 – 6.3)</td>
<td>0.411</td>
</tr>
<tr>
<td>MVPA overall</td>
<td>50.5 [47.4; 53.6]</td>
<td>50.4 [41.9; 58.9]</td>
<td>0.985</td>
</tr>
</tbody>
</table>

Data for sedentary time (ST) overall, light physical activity (LPA) overall and moderate-to-vigorous physical activity (MVPA) overall are presented as the mean in minutes/day and with a 95% confidence interval. Data for each segment of ST and LPA per segment are presented as the mean in minutes/hour and with a 95% confidence interval. Data for MVPA per segment are presented as the median in minutes/hour, along with the 25th and 75th percentiles. P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA per segment was performed using Ln-transformed MVPA.
Table S3-2. Comparison of PA patterns during the day between non-overweight children and overweight children on school days.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Non-overweight (n = 118)</th>
<th>Overweight (n = 16)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 8:00–11:00</td>
<td>37.1 [35.9; 38.2]</td>
<td>40.1 [37.0; 43.2]</td>
<td>0.074</td>
</tr>
<tr>
<td>ST 11:00–12:00</td>
<td>36.3 [34.8; 37.8]</td>
<td>39.1 [35.5; 42.8]</td>
<td>0.164</td>
</tr>
<tr>
<td>ST 12:00–14:00</td>
<td>46.1 [44.2; 48.0]</td>
<td>44.1 [39.6; 48.7]</td>
<td>0.421</td>
</tr>
<tr>
<td>ST 14:00–17:00</td>
<td>41.6 [40.6; 42.5]</td>
<td>39.1 [36.6; 41.6]</td>
<td>0.067</td>
</tr>
<tr>
<td>ST 17:00–18:00</td>
<td>25.3 [24.1; 26.6]</td>
<td>30.0 [26.5; 33.4]</td>
<td>0.014</td>
</tr>
<tr>
<td>ST 18:00–21:00</td>
<td>32.1 [30.7; 33.4]</td>
<td>34.2 [30.5; 37.8]</td>
<td>0.292</td>
</tr>
<tr>
<td>ST overall</td>
<td>473.2 [457.9; 488.6]</td>
<td>520.3 [478.6; 562.1]</td>
<td>0.038</td>
</tr>
<tr>
<td>LPA 8:00–11:00</td>
<td>20.4 [19.4; 21.3]</td>
<td>17.5 [14.9; 20.1]</td>
<td>0.042</td>
</tr>
<tr>
<td>LPA 11:00–12:00</td>
<td>20.0 [18.9; 21.1]</td>
<td>17.8 [15.1; 20.5]</td>
<td>0.132</td>
</tr>
<tr>
<td>LPA 12:00–14:00</td>
<td>12.1 [10.4; 13.7]</td>
<td>13.5 [9.6; 17.4]</td>
<td>0.507</td>
</tr>
<tr>
<td>LPA 14:00–17:00</td>
<td>16.4 [15.6; 17.1]</td>
<td>18.3 [16.2; 20.3]</td>
<td>0.097</td>
</tr>
<tr>
<td>LPA 17:00–18:00</td>
<td>26.0 [25.1; 27.0]</td>
<td>23.7 [21.2; 26.2]</td>
<td>0.079</td>
</tr>
<tr>
<td>LPA 18:00–21:00</td>
<td>22.6 [21.6; 23.6]</td>
<td>19.6 [16.9; 22.3]</td>
<td>0.045</td>
</tr>
<tr>
<td>LPA overall</td>
<td>240.3 [232.5; 248.1]</td>
<td>227.2 [206.1; 248.3]</td>
<td>0.253</td>
</tr>
<tr>
<td>MVPA 8:00–11:00</td>
<td>2.3 (1.3 – 3.4)</td>
<td>2.0 (1.0 – 3.3)</td>
<td>0.584</td>
</tr>
<tr>
<td>MVPA 11:00–12:00</td>
<td>3.1 (1.9 – 4.5)</td>
<td>2.6 (1.9 – 4.4)</td>
<td>0.816</td>
</tr>
<tr>
<td>MVPA 12:00–14:00</td>
<td>1.0 (0.5 – 2.3)</td>
<td>2.3 (1.0 – 3.5)</td>
<td>0.080</td>
</tr>
<tr>
<td>MVPA 14:00–17:00</td>
<td>1.7 (1.1 – 2.6)</td>
<td>2.2 (1.5 – 4.2)</td>
<td>0.074</td>
</tr>
<tr>
<td>MVPA 17:00–18:00</td>
<td>8.1 (5.0 – 11.6)</td>
<td>5.3 (4.5 – 8.3)</td>
<td>0.109</td>
</tr>
<tr>
<td>MVPA 18:00–21:00</td>
<td>4.9 (3.1 – 7.3)</td>
<td>4.9 (4.2 – 6.8)</td>
<td>0.483</td>
</tr>
<tr>
<td>MVPA overall</td>
<td>47.2 [44.2; 50.2]</td>
<td>49.0 [40.9; 57.1]</td>
<td>0.678</td>
</tr>
</tbody>
</table>

Data for sedentary time (ST) overall, light physical activity (LPA) overall and moderate-to-vigorous physical activity (MVPA) overall are presented as the mean in minutes/day and with a 95% confidence interval. Data for each segment of ST and LPA per segment are presented as the mean in minutes/hour and with a 95% confidence interval. Data for MVPA per segment are presented as the median in minutes/hour, along with the 25th and 75th percentiles. P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA per segment was performed using Ln-transformed MVPA.
Table S3-3. Comparison of PA patterns during the day between non-overweight children and overweight children on weekends/holidays.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Non-overweight (n = 92)</th>
<th>Overweight (n = 15)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 8:00–11:00</td>
<td>30.4 [28.5; 32.3]</td>
<td>36.7 [32.2; 41.2]</td>
<td>0.012</td>
</tr>
<tr>
<td>ST 11:00–12:00</td>
<td>29.0 [27.1; 31.0]</td>
<td>35.9 [31.2; 40.6]</td>
<td>0.009</td>
</tr>
<tr>
<td>ST 12:00–14:00</td>
<td>33.2 [31.1; 35.2]</td>
<td>34.4 [29.5; 39.3]</td>
<td>0.645</td>
</tr>
<tr>
<td>ST 14:00–17:00</td>
<td>34.1 [31.9; 36.3]</td>
<td>34.9 [29.5; 40.2]</td>
<td>0.795</td>
</tr>
<tr>
<td>ST 17:00–18:00</td>
<td>30.3 [28.1; 32.5]</td>
<td>33.9 [28.6; 39.3]</td>
<td>0.219</td>
</tr>
<tr>
<td>ST 18:00–21:00</td>
<td>31.7 [29.9; 33.5]</td>
<td>32.9 [28.5; 37.4]</td>
<td>0.609</td>
</tr>
<tr>
<td>ST overall</td>
<td>420.9 [403.5; 438.4]</td>
<td>468.1 [424.9; 511.3]</td>
<td>0.047</td>
</tr>
<tr>
<td>LPA 8:00–11:00</td>
<td>24.7 [23.2; 26.1]</td>
<td>19.5 [16.1; 23.0]</td>
<td>0.008</td>
</tr>
<tr>
<td>LPA 11:00–12:00</td>
<td>26.1 [24.5; 27.6]</td>
<td>20.1 [16.4; 23.8]</td>
<td>0.004</td>
</tr>
<tr>
<td>LPA 12:00–14:00</td>
<td>22.2 [20.6; 23.8]</td>
<td>21.9 [17.9; 25.8]</td>
<td>0.866</td>
</tr>
<tr>
<td>LPA 14:00–17:00</td>
<td>21.2 [19.5; 22.9]</td>
<td>19.9 [15.8; 24.0]</td>
<td>0.568</td>
</tr>
<tr>
<td>LPA 17:00–18:00</td>
<td>24.3 [22.6; 25.9]</td>
<td>22.0 [18.0; 26.0]</td>
<td>0.289</td>
</tr>
<tr>
<td>LPA 18:00–21:00</td>
<td>23.0 [21.7; 24.4]</td>
<td>22.1 [18.7; 25.4]</td>
<td>0.592</td>
</tr>
<tr>
<td>LPA overall</td>
<td>286.7 [275.2; 298.2]</td>
<td>268.3 [239.9; 296.7]</td>
<td>0.237</td>
</tr>
<tr>
<td>MVPA 8:00–11:00</td>
<td>4.0 (2.1 – 6.2)</td>
<td>3.2 (1.3 – 4.8)</td>
<td>0.114</td>
</tr>
<tr>
<td>MVPA 11:00–12:00</td>
<td>3.5 (2.0 – 6.8)</td>
<td>2.6 (1.6 – 7.3)</td>
<td>0.241</td>
</tr>
<tr>
<td>MVPA 12:00–14:00</td>
<td>4.1 (2.5 – 5.9)</td>
<td>2.8 (2.1 – 4.3)</td>
<td>0.721</td>
</tr>
<tr>
<td>MVPA 14:00–17:00</td>
<td>3.7 (1.8 – 6.8)</td>
<td>4.2 (1.5 – 9.3)</td>
<td>0.630</td>
</tr>
<tr>
<td>MVPA 17:00–18:00</td>
<td>4.1 (1.8 – 7.4)</td>
<td>3.8 (1.3 – 6.3)</td>
<td>0.581</td>
</tr>
<tr>
<td>MVPA 18:00–21:00</td>
<td>4.5 (2.8 – 7.2)</td>
<td>4.6 (2.8 – 6.8)</td>
<td>0.900</td>
</tr>
<tr>
<td>MVPA overall</td>
<td>61.3 [56.4; 66.3]</td>
<td>58.2 [46.0; 70.4]</td>
<td>0.640</td>
</tr>
</tbody>
</table>

Data for sedentary time (ST) overall, light physical activity (LPA) overall and moderate-to-vigorous physical activity (MVPA) overall are presented as the mean in minutes/day and with a 95% confidence interval. Data for each segment of ST and LPA per segment are presented as the mean in minutes/hour and with a 95% confidence interval. Data for MVPA per segment are presented as the median in minutes/hour, along with the 25th and 75th percentiles. P-values are based on linear mixed models and adjusted for sex, age, and season. Statistical testing for MVPA per segment was performed using Ln-transformed MVPA.