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Are preschool children active enough in Shanghai—An accelerometer-based cross-sectional study

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4 **Are preschool children active enough in Shanghai—An accelerometer-based**
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6 **cross-sectional study**
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ABSTRACT

Objective: Engaging in physical activity (PA) play an important roles in promoting physical and mental health, but the PA data for Chinese preschool children are lacking. This study is aim to objectively assess the PA levels of preschool children in Shanghai, China and to evaluate their PA levels relative to age-specific recommendations.

Design, Setting and Participants: A cross-sectional study was conducted among preschool children in Shanghai city of China. There were a total of 303 preschool children (boys, 174; girls, 129) were recruited from eight kindergarten classes in the Yangpu and Baoshan Districts of Shanghai.

Main outcome measures: Daily PA was assessed using ActiGraph GT3X⁺ accelerometers for seven consecutive days. children were required to have data from at least two weekdays and one weekend day, with a minimum daily wear time of 480 min to be included in the analysis.

Results: Preschool children in Shanghai accumulated, on average, 70.9 minutes (min) of moderate-to-vigorous PA (MVPA) and 168.0 min of total PA (TPA) per day (d). Boys engaged in more MVPA and TPA than girls (72.8 min/d vs. 68.3 min/d and 171.9 min/d vs. 162.9 min/d, respectively). Overall, 72.9% of the participants met the age-specific recommendations of MVPA, while 35.3% met TPA recommendations.

Conclusions: Findings of this study warn of the insufficiency of PA in Shanghai preschool children, suggesting there is substantial room to improve their PA.

Key words: accelerometry, physical activity, preschool children.

Strength and limitation of this study

- Objective measures of daily physical activity were obtained by accelerometers in a sample of preschool children from Shanghai, China.
- Daily physical activity levels in Shanghai preschool children were evaluated by both moderate to vigorous physical activity and activity at any intensity recommended guidelines.
- For feasibility, this study sample was not a random sample recruited from the population.

INTRODUCTION

Engaging in physical activity (PA) and minimizing sedentary time play important roles in promoting physical, psychological, and cognitive health.¹ Moreover, establishing robust PA habits in childhood has positive long-term effects on lifestyle that persist into adulthood,² including reducing the risk of chronic diseases, such as coronary artery disease, diabetes, stroke, and hypertension.^{3,4} Accordingly, US and Canadian PA guidelines for preschoolers suggest that, to achieve health benefits, children aged 3 to 6 years old should participate in at least 60 minutes (min) of moderate-to-vigorous PA (MVPA) or 180 min of activity at any intensity level per day (d), cumulatively.^{5,6}

Researchers and public health professionals are interested in establishing what percentage of preschool children meet the aforementioned PA recommendations. Accelerometers can be used as an objective tool to facilitate and improve the accuracy of PA monitoring, overcoming the limitations of self-reported data from children and the potential for recall bias in proxy reports from parents or teachers.⁷ Thus, accelerometers have become increasingly popular as a feasible strategy for capturing preschoolers' movement behavior accurately.⁸

Although there is a perception that preschool children are constantly active,⁹ accelerometer-based evidence does not support this presumption for all children. In a sample of 3–5-year-old Canadian children, only 13.7% of participants met the PA recommendation for at least 60 min per day of MVPA.¹⁰ In a similar study of Australian preschool aged children, 22% of the sample met this guideline.¹¹ Moreover,

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3 a meta-analysis of 29 reports encompassing 6,309 preschool children in Canada and
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5 Australia yielded an average daily MVPA of only 42.8 (95% CI: 28.9–56.8) min.¹² As
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7
8 of yet, accelerometer-based PA data for Chinese preschool children are lacking.
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10 The aim of this study was to assess PA levels quantitatively in a sample of
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12 preschool aged children in Shanghai, China with accelerometers and to determine the
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14 proportion of children meeting the aforementioned age-specific PA recommendations.
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18 19 20 **MATERIALS AND METHODS**

21 22 **Participants**

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24 This cross-sectional study forms a baseline dataset for The Physical Activity and
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26 Cognitive Function Study (Trial registration: ChiCTR-OOC-15007439), in which a
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28 total of 346 preschool children (boys, 201; girls, 145) were recruited from eight
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30 kindergarten classes in the Yangpu and Baoshan Districts of Shanghai, China. The
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32 aims and procedures of this study were explained comprehensively to the
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34 parents/guardians of all potential participants, including the right to withdraw from
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36 the study at any time. Signed informed consent forms were obtained from the
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38 participants' parents/guardians. This study was approved by the Ethics Advisory
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40 Committee of Shanghai University of Sport.
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50 51 **Measures and procedures**

52 PA was assessed with GT3X⁺ accelerometers (ActiGraph, Pensacola, FL), worn
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54 on the right hip attached to an elastic adjustable belt for seven consecutive days.
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4 Parents or guardians agreed to have their children wear the accelerometers during all
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6 waking, including water-based activities such as bathing and swimming. They were
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8 instructed on the proper way to wear and remove the accelerometers, and asked to
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10 encourage their children to wear them as much as possible during their school hours.
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12 The accelerometers were collected at the end of a 7-d study period, and the
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14 accelerometer data were transferred to a computer via ActiLife version 6.11.6
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16 software. Non-wear time was determined by the Choi algorithm;¹³ children were
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18 required to have data from at least two weekdays and one weekend day, with a
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20 minimum daily wear time of 480 min to be included in the analysis. Based on these
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22 criteria, 43 participants were excluded from the final analysis.
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28 Body mass index (BMI) was calculated with the formula $\text{weight}/\text{height}^2$ (kg/m^2).
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30 Based on his or her BMI, each child was categorized as normal, overweight, or obese
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32 based on the International Obesity Task Force scale.¹⁴
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38 **Interpretation of accelerometer data**

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40 Data were collected in 1-second epochs, because short epochs have been
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42 recommended for capturing movement behavior in this age group.¹⁵ Raw output was
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44 expressed as counts per minute (CPM), and cut-off count levels previously developed
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46 for preschool children by Pate and colleagues were used to analyze MVPA time.⁷ We
47
48 classified PA into three levels: light (LPA), 101–1679 CPMs; moderate (MPA), 1680–
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50 3367 CPMs; and vigorous (VPA), ≥ 3368 CPMs. Total physical activity (TPA) was
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52 calculated as the sum of LPA, MPA, and VPA time periods. TPA values were
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3 compared to the established recommendations of ≥ 60 min of MVPA or ≥ 180 min of
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6 PA at any intensity to evaluate the proportion of participants meeting these
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9 recommendations.

10 11 12 13 **Data analysis**

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15 The data are reported as means \pm standard deviations (SDs) for normally
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17 distributed variables or as medians with interquartile ranges (IQRs) for non-normally
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19 distributed variables. Independent *t* tests, Mann-Whitney *U* tests, and chi-square tests
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21 were used to assess gender differences in characteristics for normally distributed, non-
22
23 normally distributed, and categorical variables, respectively. When necessary, PA
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25 data were normalized by a log or square root methods prior to analysis. Differences in
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27 PA by gender and day were determined with independent *t* tests, and differences in
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29 PA by BMI category were determined by one-way analysis of variance (ANOVA)
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31 with Bonferroni *post hoc* tests. Analyses were performed in SPSS version 22.0 (IBM
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33 Inc., Armonk, NY). A two-sided *P* value $\leq .05$ was considered statistically significant.
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43 **RESULTS**

44 45 **Characteristics of participants**

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47 The descriptive characteristics of the 303 participants included in the present
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49 cohort analysis are shown in **Table 1**. Weight, BMI, and the proportion of
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51 overweight/obese children were significantly higher in boys than in girls.
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The amount of different intensities of PA

On average, the number of valid accelerometer days among participants was 6.3 days (95%CI = 6.2–6.4 d), and the mean duration of wear time across all valid days was 748.7 min/d (95%CI = 740.3–756.7 min/d). The absolute and relative time spent engaged in CPM and each PA intensity level are presented in **Table 2**. On average, participants in this study accumulated 168.0 min/d of TPA, and spent 13.0% (~97.2 min) of their daily waking time engaged in LPA and 9.5% (~70.9 min) of their days was spent engaged in MVPA. In general, boys were more active than girls, and participants engaged in more PA on weekend days than on week days. No significant difference in PA was identified with respect to BMI category.

Meeting the current PA recommendations

Almost three quarters of the participants spent at least 60 min/d engaged in MVPA across all valid days, while only a little more than a third accumulated at least 180 min/d of PA at any intensity. Boys met the PA recommendations more frequently than girls (**Table 3**).

DISCUSSION

In this accelerometer-based cross-sectional study of preschool children in Shanghai, we found that, on average, boys accumulated 72.8 min/d of MVPA and 171.9 min/d of TPA, while girls accumulated 68.3 min/d of MVPA and 162.9 min/d of TPA. At least 27% of the participants did not meet the established PA guidelines.

Strengths and limitations

To the best of our knowledge, this is the first study to evaluate PA in Chinese preschool children with accelerometers, which eliminating the recall bias associated with other PA measurements. Additionally, our PA data were evaluated relative to both MVPA and TPA recommended guidelines.

This study had two noteworthy limitations. First, for sampling feasibility, all participants were recruited from Northeast Shanghai. Thus, it remains to be determined whether similar findings would be obtained for children in other regions of Shanghai. Second, the accelerometer was worn over the right hip limited to capture activities with little displacement of the body, such as cycling. However, hip was probably the best placement to capture whole-body movements and on the side of the hip was also the most often site by various studies.¹⁶

PA status of Shanghai preschoolers

Approximately 73% of participants in our Shanghai cohort met the recommendation of spending more than 60 min/d engaged in MVPA. However, less than 36% accumulated at least 180 min/d of TPA. The gap between these proportions is due largely to the shift from intensity to volume. The short 1-second sampling intervals used in this study may have resulted in an underestimation of LPA time, which would then yield an underestimation of TPA time, relative to, for example, a 15-second epoch. A longer epoch is more likely to result in an underestimation of MVPA and an overestimation of LPA in young children.¹⁷ Notably, a Canadian study

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4 with a much longer 60-second epoch found that 83.8% of young children met the 180
5 min/d TPA guideline,¹⁰ while only 13.7% engaged in at least 60 min/d of MVPA.

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8 This methodological inconsistency makes it quite difficult to conduct reliable
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10 inter-study comparisons. Here, we chose a shorter epoch because it has been
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12 recommended for capturing movement in young children owing to the particularly
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14 sporadic and intermittent nature of activity exhibited by children in this age group.¹⁸
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20 **Differences in PA by gender, BMI category, and date**

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23 Our empirical findings that boys spent 6.6% more time engaged in MVPA and
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25 had 5.5% more TPA time than girls are consistent with our meta-analysis results. Trost
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27 et al. suggested that a similar gender gap in PA was attributed to a VPA difference,
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29 with boys spending approximately 45% more time engaged in VPA than girls in their
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31 study.¹⁹ Meanwhile, Crespo et al. found that familial, social, and environmental
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33 characteristics correlated with higher MVPA in boys than in girls.²⁰ Possible factors in
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35 this gender gap to explore in future studies include parental modeling and location.
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41 Our finding of similar PA data across normal-weight and overweight/obesity
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43 groups was somewhat surprising. Although we commonly thought that normal-weight
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45 children must be more active than those who overweight/obese, accelerometer-based
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47 evidence does not support this presumption for all studies.²¹ Furthermore, the opposite
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49 findings are more likely to be true in some studies.^{22 23} These negative findings
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51 suggest that other factors, such as diet and genetic background, play more important
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53 roles in body weight. Future studies are needed to identify the relative importance of
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3 and interactions among PA, diet, and genetics for weight status.
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6 Our observation of greater PA on weekend days than on weekdays may be
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8 explained by participants having more opportunities to engage in PA on non-school
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10 days. Further studies should investigate and compare the specific activities engaged in
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12 on school days versus weekend days.
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15 16 17 18 **PA in Shanghai preschool children versus children elsewhere** 19

20 Given the important of PA for physical, psychological, and cognitive health,¹
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22 there is an increasing body of research focusing on the PA levels on preschool
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24 children from different population. Findings from a meta-analysis identified 29
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26 studies indicated preschoolers' accelerometer-derived PA ranged from 19 min/d to 281
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28 min/d.²⁴ However, the amounts of PA across different intensity levels varied widely
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30 depending upon the assessment methodology selected, with MVPA cut-off CPM
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32 levels having a particularly large effect on PA results.²⁵ Therefore, it is more
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34 reasonable to compare the results that using the same cut-off value for PA levels.
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36 Unfortunately, the amount of time spent engaged in MVPA in Shanghai preschool
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38 children lower than data for the most prior populations assessed with the same cut-off
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40 CPM levels by Pate (Range: 35.3-100.0 min/d; Median: 94.9 min/d).^{21 26-34} The
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42 pattern of our TPA results was comparable to that of the MVPA results (Range:
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44 73.7-394.0 min/d; Median: 348.0 min/d).²⁶⁻³⁴
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52 Obviously, the results of this cross-sectional study indicate that Shanghai
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54 preschool children tend to have insufficient PA, and less PA than other populations
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3 examined with the same cut-off CPM levels. Based on these data, we suggest that
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6 interventions may be needed to promote PA in Shanghai preschool children.
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10 **CONCLUSIONS**

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13 At least 27% of preschool children in Shanghai did not meet current age-specific
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15 PA recommendations and preschool children in Shanghai were less active than most
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17 of the populations assessed in comparable studies. These findings suggest that
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19 interventions should be explored to promote PA in Shanghai preschoolers given that
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21 the development of active lifestyle behaviors early in life are believed to yield health
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23 benefits that extend into adulthood.
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Author Contributions

Minghui Quan conceived and designed the study, analyzed the data and drafted the manuscript. Hanbin Zhang, Jiayi Zhang, Tang Zhou, Jinming Zhang, Guanggao Zhao, Hui Fang and Shunli Sun conducted the experiments and collected the data. Minghui Quan and Guanggao Zhao performed the literature search. Ru Wang and Peijie Chen advised on analysis and interpretation of the data, and critically revised the manuscript.

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Potential conflicts of interest

The authors declare that they have no conflicts to report.

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Table 1 Characteristics of participants with valid accelerometer data.

Characteristic	Boys (N = 174; 57.4%)	Girls (N = 129; 42.6%)	All (N = 303)
Mean age \pm SD, months	58.3 \pm 5.6	57.1 \pm 5.3	57.8 \pm 5.5
Mean height \pm SD, cm	111.4 \pm 5.0	110.3 \pm 4.9	111.0 \pm 5.0
Median weight (IQR), kg	20.6 (20.1–21.1)*	19.3 (18.8–19.8)	20.0 (19.7–20.4)
Median BMI (IQR), kg/m ²	16.5 (16.2–16.8)*	15.8 (15.5–16.1)	16.2 (16.0–16.4)
<i>BMI category, %</i>			
Normal	76.4*	86.8	80.9
Overweight	15.5*	10.1	13.2
Obesity	8.0*	3.1	5.9

Note: * $p < .05$, boys vs. girls.

Table 2 Analysis of time spent engaged in PA categories by gender, BMI category, and day.

Factor	Mean CPM ± SD (95% CI)	Mean PA by category ± SD, min/d (95%CI)				
		LPA	MPA	VPA	MVPA	TPA
<i>Gender</i>						
Boys (N = 174)	498.3 ± 120.3* (478.7–516.7)	99.2 ± 18.4* (96.8–102.0)	40.9 ± 9.7 (39.5–42.3)	31.9 ± 10.7* (30.4–33.4)	72.8 ± 18.8* (70.1–75.4)	171.9 ± 34.0* (167.1–176.8)
Girls (N = 129)	468.0 ± 109.3 (447.3–486.2)	94.6 ± 15.9 (91.8–97.3)	38.8 ± 8.0 (37.3–40.1)	29.6 ± 8.6 (28.0–31.1)	68.3 ± 15.1 (65.7–70.9)	162.9 ± 27.6 (158.0–167.6)
<i>BMI</i>						
Normal (N = 245)	484.7 ± 113.6 (470.0–501.4)	96.9 ± 17.4 (94.7–99.1)	39.8 ± 8.8 (38.7–41.0)	30.9 ± 9.6 (29.7–32.0)	70.7 ± 17.0 (68.7–72.9)	167.6 ± 31.1 (163.8–171.5)
Overweight (N = 40)	476.0 ± 121.5 (437.3–514.6)	99.0 ± 18.2 (93.5–104.9)	40.0 ± 9.7 (37.1–43.4)	30.3 ± 10.9 (27.1–34.0)	70.3 ± 19.7 (64.4–76.9)	169.3 ± 35.5 (158.2–181.2)
Obesity (N = 18)	509.9 ± 144.2 (444.0–580.5)	97.7 ± 16.9 (89.3–105.2)	42.1 ± 11.1 (37.4–47.2)	32.3 ± 12.1 (26.7–37.9)	74.4 ± 19.0 (65.7–83.0)	171.0 ± 32.4 (156.0–186.4)
<i>Type of day</i>						
Week (N = 303)	471.0 ± 117.4† (457.8–484.6)	96.4 ± 17.9 (94.5–98.3)	39.3 ± 9.3† (38.3–40.4)	30.9 ± 9.9 (29.9–32.1)	70.2 ± 17.5 (68.4–72.1)	166.6 ± 32.3† (163.2–170.1)
Weekend (N = 303)	517.4 ± 166.2 (497.4–536.5)	98.6 ± 24.8 (95.8–101.4)	41.6 ± 12.0 (40.1–43.1)	30.6 ± 13.3 (29.2–32.2)	72.1 ± 24.0 (69.6–75.0)	170.6 ± 44.3 (165.8–175.6)
ALL (N = 303)	485.0 ± 116.4 (472.6–500.0)	97.2 ± 17.5 (95.2–99.2)	40.0 ± 9.1 (39.0–40.1)	30.9 ± 9.9 (29.8–32.0)	70.9 ± 17.5 (68.9–72.9)	168.0 ± 31.7 (164.6–171.6)
Relative time, %	-----	13.1 ± 2.1 (12.8–13.3)	5.4 ± 1.1 (5.2–5.5)	4.2 ± 1.3 (4.0–4.3)	9.5 ± 2.2 (9.3–9.8)	22.6 ± 3.7 (22.1–23.0)

Note: Mean ± SD and 95% CI are reported for normally distributed variables; Significant data are shown in bold; * $p < .05$, boys vs. girls; † $p < .05$, weekdays vs. weekend days.

Table 3 Adherence to common established PA recommendations for preschool aged children.*

PA metric	Guideline target	Subjects, % (95%CI)		
		Boys (N = 174)	Girls (N = 129)	All (N = 303)
MVPA	≥60 min/d accumulated, averaged across valid d	74.1 (67.2–79.9)	71.3 (63.6–79.1)	72.9 (68.3–77.9)
TPA	≥180 min/d accumulated, averaged across valid d	42.0 (34.5–48.9)	26.4 (19.4–34.1)	35.3 (30.0–40.9)

Note: * $p < .05$, boys vs. girls.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	6

1		#7	Clearly define all outcomes, exposures, predictors, potential	6-7
2			confounders, and effect modifiers. Give diagnostic criteria, if	
3			applicable	
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6	Data sources /	#8	For each variable of interest give sources of data and details of	5-6
7	measurement		methods of assessment (measurement). Describe	
8			comparability of assessment methods if there is more than one	
9			group. Give information separately for for exposed and	
10			unexposed groups if applicable.	
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14	Bias	#9	Describe any efforts to address potential sources of bias	6
15				
16				
17	Study size	#10	Explain how the study size was arrived at	none
18				
19	Quantitative	#11	Explain how quantitative variables were handled in the	7
20	variables		analyses. If applicable, describe which groupings were chosen,	
21			and why	
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24	Statistical	#12a	Describe all statistical methods, including those used to control	7
25	methods		for confounding	
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28		#12b	Describe any methods used to examine subgroups and	none
29			interactions	
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31				
32		#12c	Explain how missing data were addressed	none
33				
34		#12d	If applicable, describe analytical methods taking account of	none
35			sampling strategy	
36				
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38		#12e	Describe any sensitivity analyses	none
39				
40	Participants	#13a	Report numbers of individuals at each stage of study—eg	7
41			numbers potentially eligible, examined for eligibility, confirmed	
42			eligible, included in the study, completing follow-up, and	
43			analysed. Give information separately for for exposed and	
44			unexposed groups if applicable.	
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48		#13b	Give reasons for non-participation at each stage	6
49				
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51		#13c	Consider use of a flow diagram	none
52				
53	Descriptive data	#14a	Give characteristics of study participants (eg demographic,	7
54			clinical, social) and information on exposures and potential	
55			confounders. Give information separately for exposed and	
56			unexposed groups if applicable.	
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1		#14b	Indicate number of participants with missing data for each	6
2			variable of interest	
3				
4	Outcome data	#15	Report numbers of outcome events or summary measures.	8
5			Give information separately for exposed and unexposed	
6			groups if applicable.	
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10	Main results	#16a	Give unadjusted estimates and, if applicable, confounder-	8
11			adjusted estimates and their precision (eg, 95% confidence	
12			interval). Make clear which confounders were adjusted for and	
13			why they were included	
14				
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17		#16b	Report category boundaries when continuous variables were	None
18			categorized	
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21		#16c	If relevant, consider translating estimates of relative risk into	none
22			absolute risk for a meaningful time period	
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24	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and	none
25			interactions, and sensitivity analyses	
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28	Key results	#18	Summarise key results with reference to study objectives	8
29				
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31	Limitations	#19	Discuss limitations of the study, taking into account sources of	9
32			potential bias or imprecision. Discuss both direction and	
33			magnitude of any potential bias.	
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36	Interpretation	#20	Give a cautious overall interpretation considering objectives,	11-12
37			limitations, multiplicity of analyses, results from similar studies,	
38			and other relevant evidence.	
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41	Generalisability	#21	Discuss the generalisability (external validity) of the study	9-11
42			results	
43				
44				
45	Funding	#22	Give the source of funding and the role of the funders for the	13
46			present study and, if applicable, for the original study on which	
47			the present article is based	
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Are preschool children active enough in Shanghai—An accelerometer-based cross-sectional study

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4 **1 Are preschool children active enough in Shanghai—An accelerometer-based**
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6 **2 cross-sectional study**
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ABSTRACT

Objective: Engaging in physical activity (PA) play an important roles in promoting physical and mental health, but the PA data for Chinese preschool children are lacking. This study is aim to objectively assess the PA levels of preschool children in Shanghai, China and to evaluate their PA levels relative to age-specific recommendations.

Design, Setting and Participants: A cross-sectional study was conducted among preschool children in Shanghai city of China. There were a total of 303 preschool children (boys, 174; girls, 129) were recruited from eight kindergarten classes in the Yangpu and Baoshan Districts of Shanghai.

Main outcome measures: Daily PA was assessed using ActiGraph GT3X⁺ accelerometers for seven consecutive days. children were required to have data from at least two weekdays and one weekend day, with a minimum daily wear time of 480 min to be included in the analysis.

Results: Preschool children in Shanghai accumulated, on average, 70.9 minutes (min) of moderate-to-vigorous PA (MVPA) and 168.0 min of total PA (TPA) per day (d). Boys engaged in more MVPA and TPA than girls (72.8 min/d vs. 68.3 min/d and 171.9 min/d vs. 162.9 min/d, respectively). Overall, 72.9% of the participants met the age-specific recommendations of MVPA, while 35.3% met TPA recommendations.

Conclusions: Findings of this study warn of the insufficiency of PA in Shanghai preschool children, suggesting there is substantial room to improve their PA.

Key words: accelerometry, physical activity, preschool children, meta-analysis.

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3 43 **Strength and limitation of this study**
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5 44 ● Objective measures of daily physical activity were obtained by accelerometers in
6 a sample of preschool children from Shanghai, China.
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10 46 ● Daily physical activity levels in Shanghai preschool children were evaluated by
11 both moderate to vigorous physical activity and activity at any intensity
12 recommended guidelines.
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16 49 ● For feasibility, this study sample was not a random sample recruited from the
17 population.
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51 INTRODUCTION

52 Engaging in physical activity (PA) play an important roles in promoting physical,
53 psychological, and cognitive health.¹ Moreover, establishing robust PA habits in
54 childhood has positive long-term effects on lifestyle that persist into adulthood,²
55 including reducing the risk of chronic diseases, such as coronary artery disease,
56 diabetes, stroke, and hypertension.^{3 4} Accordingly, Canadian PA guideline for
57 preschool children suggests that, to achieve health benefits, children aged 3 to 6 years
58 old should participate in at least 180 minutes (min) of PA at any intensity and
59 progression toward at least 60 min moderate-to-vigorous PA (MVPA) per day (d),
60 cumulatively.⁵

61 Researchers and public health professionals are interested in establishing what
62 percentage of preschool children meet the aforementioned PA recommendations.
63 Accelerometers can be used as an objective tool to facilitate and improve the accuracy
64 of PA monitoring, overcoming the limitations of self-reported data from children and
65 the potential for recall bias in proxy reports from parents or teachers.⁶ When
66 compared with pedometer, accelerometer can provide the data not only about the total
67 amount of daily activities, but also the pattern of daily activities,⁷ which were
68 considered to be more important to achieve health benefits based on the current PA
69 guideline.⁵ Thus, accelerometers have become increasingly popular as a feasible
70 strategy for capturing preschoolers' movement behavior accurately.⁸ Furthermore,
71 accelerometer-based PA has become an important data source for examining the
72 association between PA and health-related outcomes in recent years, even in the

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4 73 national health survey with large sample size.^{9 10}

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6 74 Although there is a perception that preschool children are constantly active,¹¹
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8 75 accelerometer-based evidence does not support this presumption for all children. In a
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10 76 sample of 3–5-year-old Canadian children, only 13.7% of participants met the PA
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12 77 recommendation for at least 60 min per day of MVPA.¹² In a similar study of
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14 78 Australian preschool aged children, 22% of the sample met this guideline.¹³ Moreover,
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16 79 a meta-analysis of 29 reports encompassing 6,309 preschool children in Canada and
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18 80 Australia yielded an average daily MVPA of only 42.8 (95% CI: 28.9–56.8) min.¹⁴ As
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20 81 of yet, accelerometer-based PA data for Chinese preschool children are lacking.
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25 82 The aim of this study was to assess PA levels quantitatively in a sample of
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27 83 preschool aged children in Shanghai, China with accelerometers and to determine the
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29 84 proportion of children meeting the aforementioned age-specific PA recommendations.
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31 85 Findings of this study will help us to understand the PA levels from a sample of
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33 86 Shanghai, which may serve as a foundation for making strategies to maintain and
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35 87 promote PA for preschool children.
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41 42 89 **MATERIALS AND METHODS**

43 44 45 90 **Participants**

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47 91 This cross-sectional study forms a baseline dataset for The Physical Activity and
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49 92 Cognitive Function Study (Trial registration: ChiCTR-OOC-15007439), in which a
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51 93 convenience sample of 346 participants (boys, 201; girls, 145) were recruited from
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53 94 eight kindergarten classes in the Yangpu and Baoshan Districts of Shanghai, China.
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4 95 After contacting the kindergarten director by phone and interested in this study,
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6 96 the aims and procedures of this study were to explain comprehensively to the
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8 97 parents/guardians of all potential participants by parents' meeting held in the
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10 98 kindergarten, including the right to withdraw from the study at any time. Parents
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12 99 interested in having their children participate subsequently signed an informed
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14 100 consent document. The inclusion criteria for the participants in this study were: (1)
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16 101 aged 3-6 years; (2) without a diagnosed physical and mental disability; and (3) with
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18 102 signed informed consent from the participants' parents/guardians. This study was
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20 103 approved by the Ethics Advisory Committee of Shanghai University of Sport.
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28 105 **Procedures**

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30 106 Before accelerometer data collection, parents or guardians were instructed on the
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32 107 proper way to wear and remove the accelerometers by well-trained research staff.
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34 108 Parents or guardians agreed to have their children wear the accelerometers during all
35
36 109 waking, including water-based activities such as bathing and swimming. And, Parents
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38 110 or guardians asked to encourage their children to wear them as much as possible
39
40 111 during their school hours. The accelerometers were collected at the end of a
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42 112 consecutive 7-d study period, and the accelerometer data were transferred to a
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44 113 computer via ActiLife version 6.11.6 software.
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52 115 **Measures**

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55 116 Anthropometric data
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4 117 Height and weight were measured with participants dressed in light clothing.
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6 118 Height was measured to the nearest 0.1 cm using a freestanding portable stadiometer,
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8 119 and weight was measured to the nearest 0.1 kg with an electronic weighting scale
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11 120 (HN-358, Omron, Tokyo, Japan). Body mass index (BMI) was calculated with the
12
13 121 formula weight/height² (kg/m²). Based on his or her BMI, each child was categorized
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16 122 as normal, overweight, or obese based on the International Obesity Task Force scale.¹⁵
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18 123 Physical activity data

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20 124 PA was assessed with GT3X⁺ accelerometers (ActiGraph, Pensacola, FL), worn
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23 125 on the right hip attached to an elastic adjustable belt from 7 am to 11 pm every day for
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25 126 seven consecutive days. Non-wear time was determined by the Choi algorithm;¹⁶
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28 127 children were required to have data from at least two weekdays and one weekend day,
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30 128 with a minimum daily wear time of 480 min to be included in the analysis. Based on
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33 129 these criteria, 43 participants were excluded from the final analysis.
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35 130 Data were collected in 1-second epochs, because short epochs have been
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38 131 recommended for capturing movement behavior in this age group.¹⁷ Raw output was
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40 132 expressed as counts per minute (CPM), and cut-off count levels previously developed
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43 133 for preschool children by Pate and colleagues were used to analyze MVPA time.⁶ We
44
45 134 classified PA into three levels: light (LPA), 101–1679 CPMs; moderate (MPA), 1680–
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47 135 3367 CPMs; and vigorous (VPA), ≥3368 CPMs. Total physical activity (TPA) was
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50 136 calculated as the sum of LPA, MPA, and VPA time periods. PA values were
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53 137 compared to the established recommendations of ≥60 min of MVPA or ≥180 min of
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55 138 PA at any intensity to evaluate the proportion of participants meeting these
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139 recommendations.

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141 **Data analysis**

142 Assuming the coefficient of variation (CV) of MVPA ($CV = 0.28$) based on the
143 previous study,¹⁸ confidence level as 95%, and 5% level of precision, the required
144 sample size was at least 125 in this study. The data are reported as means \pm standard
145 deviations (SDs) for normally distributed variables or as medians with interquartile
146 ranges (IQRs) for non-normally distributed variables. Independent *t* tests,
147 Mann-Whitney *U* tests, and chi-square tests were used to assess gender differences in
148 characteristics for normally distributed, non- normally distributed, and categorical
149 variables, respectively. When necessary, PA data were normalized by a log or square
150 root methods prior to analysis. Differences in PA by gender and day were determined
151 with independent *t* tests, and differences in PA by BMI category were determined by
152 one-way analysis of variance (ANOVA) with Bonferroni *post hoc* tests. Analyses
153 were performed in SPSS version 22.0 (IBM Inc., Armonk, NY). A two-sided *P* value
154 $\leq .05$ was considered statistically significant.

155

156 **Patient and public involvement**

157 No patients or public were involved in this study.

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161 RESULTS

162 Characteristics of participants

163 The descriptive characteristics of the 303 participants included in the present
164 cohort analysis are shown in **Table 1**. Weight, BMI, and the proportion of
165 overweight/obese children were significantly higher in boys than in girls.

166 The amount of different intensities of PA

167 On average, the number of valid accelerometer days among participants was 6.3
168 days (95%CI = 6.2–6.4 d), and the mean duration of wear time across all valid days
169 was 748.7 min/d (95%CI = 740.3–756.7 min/d). The actual and percent time spent
170 engaged in CPM and each PA intensity level are presented in **Table 2**. On average,
171 participants in this study accumulated 168.0 min/d of TPA, and spent 13.0% (~97.2
172 min) of their daily waking time engaged in LPA and 9.5% (~70.9 min) of their days
173 was spent engaged in MVPA. In general, boys were more active than girls, and
174 participants engaged in more PA on weekend days than on week days. No significant
175 difference in PA was identified with respect to BMI category.

177 Meeting the current PA recommendations

178 There were 72.9% of the participants met the MVPA recommendation that spent
179 at least 60 min/d engaged in MVPA across all valid days, while only 35.3% of the
180 participants met the TPA recommendation that accumulated at least 180 min/d of PA
181 at any intensity. Boys met the PA recommendations more frequently than girls (**Table**
182 **3**).

183 **DISCUSSION**

184 In this accelerometer-based cross-sectional study of preschool children in
185 Shanghai, we found that, on average, boys accumulated 72.8 min/d of MVPA and
186 171.9 min/d of TPA, while girls accumulated 68.3 min/d of MVPA and 162.9 min/d of
187 TPA. At least 27% of the participants did not meet the established PA guidelines.

188

189 **PA status of Shanghai preschoolers**

190 Approximately 73% of participants in our Shanghai cohort met the
191 recommendation of spending more than 60 min/d engaged in MVPA. However, less
192 than 36% accumulated at least 180 min/d of TPA. The gap between these proportions
193 is due largely to the shift from intensity to volume. The short 1-second sampling
194 intervals used in this study may have resulted in an underestimation of LPA time,
195 which would then yield an underestimation of TPA time, relative to, for example, a
196 15-second epoch. A longer epoch is more likely to result in an underestimation of
197 MVPA and an overestimation of LPA in young children.¹⁹ Notably, a Canadian study
198 with a much longer 60-second epoch found that 83.8% of young children met the 180
199 min/d TPA guideline,¹² while only 13.7% engaged in at least 60 min/d of MVPA.

200 This methodological inconsistency makes it quite difficult to conduct reliable
201 inter-study comparisons. Here, we chose a shorter epoch because it has been
202 recommended for capturing movement in young children owing to the particularly
203 sporadic and intermittent nature of activity exhibited by children in this age group.²⁰

204

205 **Differences in PA by gender, BMI category, and date**

206 Our empirical findings that boys spent 6.6% more time engaged in MVPA and
207 had 5.5% more TPA time than girls are consistent with our meta-analysis results. Trost
208 et al. suggested that a similar gender gap in PA was attributed to a VPA difference,
209 with boys spending approximately 45% more time engaged in VPA than girls in their
210 study.²¹ Meanwhile, Crespo et al. found that familial, social, and environmental
211 characteristics correlated with higher MVPA in boys than in girls.²² Possible factors in
212 this gender gap to explore in future studies include parental modeling and location.

213 Our finding of similar PA data across normal-weight and overweight/obesity
214 groups was somewhat surprising. Although we commonly thought that normal-weight
215 children must be more active than those who overweight/obese, accelerometer-based
216 evidence does not support this presumption for all studies.²³ Furthermore, the opposite
217 findings are more likely to be true in some studies.^{24 25} These negative findings
218 suggest that other factors, such as diet and genetic background, play more important
219 roles in body weight. Future studies are needed to identify the relative importance of
220 and interactions among PA, diet, and genetics for weight status.

221 Our observation of greater PA on weekend days than on weekdays may be
222 explained by participants having more opportunities to engage in PA on non-school
223 days. Further studies should investigate and compare the specific activities engaged in
224 on school days versus weekend days.

225
226

227 **PA in Shanghai preschool children versus children elsewhere**

228 Given the important of PA for physical, psychological, and cognitive health,¹
229 there is an increasing body of research focusing on the PA levels on preschool
230 children from different population. Findings from a meta-analysis identified 29
231 studies indicated preschoolers' accelerometer-derived PA ranged from 19 min/d to 281
232 min/d.²⁶ However, the amounts of PA across different intensity levels varied widely
233 depending upon the assessment methodology selected, with MVPA cut-off CPM
234 levels having a particularly large effect on PA results.²⁷ Therefore, it is more
235 reasonable to compare the results that using the same cut-off value for PA levels.
236 Unfortunately, the amount of time spent engaged in MVPA in Shanghai preschool
237 children lower than data for the most prior populations assessed with the same cut-off
238 CPM levels by Pate (Range: 35.3-100.0 min/d; Median: 94.9 min/d).^{18 23 28-35} The
239 pattern of our TPA results was comparable to that of the MVPA results (Range:
240 73.7-394.0 min/d; Median: 348.0 min/d).^{18 28-35}

241 Obviously, the results of this cross-sectional study indicate that Shanghai
242 preschool children tend to have insufficient PA, and less PA than other populations
243 examined with the same cut-off CPM levels. Although the current Shanghai Preschool
244 Education Curriculum Guide requires daily outdoor activities for preschool children
245 to be no less than two hours,³⁶ we also suggest that interventions and policies may
246 need to promote PA in Shanghai preschool children based on the data in this study.
247 Similar to children, adolescents and adults, a variety of settings can promote the level
248 of PA in children aged 3-5. However, in the early childhood stage, preschool is an

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4 249 important settings for the promotion of PA.³⁷ Although the findings of PA intervention
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6 250 on preschool setting are inconsistent,³⁸⁻⁴¹ the extant literatures also provide us with
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8 251 some strategies that may be useful for promoting young children's PA levels. These
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10 252 included: (1) increasing time of outdoor activities, (2) providing materials that are
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12 253 easy to get and play, such as balls and hula hoops, and (3) activities held both indoor
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14 254 and outdoor by teacher-planned.⁴² Furthermore, there was a growing evidence that
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16 255 technology applications, such as exergaming, seemed to be an effective approach to
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18 256 promote PA levels in children.⁴³⁻⁴⁵ It should be noted that technology applications may
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20 257 be a viable supplemental way to promote PA levels in young children in
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22 258 preschool-based setting.
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30 **Strengths and limitations**

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33 261 To the best of our knowledge, this is the first study to evaluate PA in Chinese
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35 262 preschool children using accelerometers, which eliminating the recall bias associated
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37 263 with other PA measurements. Additionally, our PA data were evaluated relative to
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39 264 both MVPA and TPA recommended guidelines.
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43 265 This study had some limitations. First, for sampling feasibility, all participants
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45 266 were recruited from Northeast Shanghai. Thus, it remains to be determined whether
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47 267 similar findings would be obtained for children in other regions of Shanghai. Second,
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49 268 the accelerometer was worn over the right hip limited to capture activities with little
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51 269 displacement of the body, such as cycling. However, hip was probably the best
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53 270 placement to capture whole-body movements and on the side of the hip was also the
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4 271 most often site by various studies.⁴⁶ Third, the accelerometer-based PA collection
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6 272 process spans different seasons that may have an impact on the result, although the
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8 273 seasonal variation in accelerometer-determined PA was not always observed in
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11 274 different region's studies.⁴⁷
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14 15 276 **CONCLUSIONS**

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18 277 At least 27% of preschool children in Shanghai did not meet current age-specific
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20 278 PA recommendations, and preschool children in Shanghai were less active than most
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22 279 of the populations assessed in comparable studies. Findings of this study implication
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24 280 that there remains a lot of room for improvement in PA behaviors among preschool
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26 281 children in Shanghai, particular in girls and weekday period. It was suggesting that
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28 282 public health interventions and policies regarding PA should be explored to promote
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30 283 PA levels in Shanghai preschoolers, given that the development of active lifestyle
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33 284 behaviors early in life are believed to yield health benefits that extend into adulthood.
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Author Contributions

Minghui Quan conceived and designed the study, analyzed the data and drafted the manuscript. Hanbin Zhang, Jiayi Zhang, Tang Zhou, Jinming Zhang, Guanggao Zhao, Hui Fang and Shunli Sun conducted the experiments and collected the data. Minghui Quan and Guanggao Zhao performed the literature search. Ru Wang and Peijie Chen advised on analysis and interpretation of the data, and critically revised the manuscript.

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Potential conflicts of interest

The authors declare that they have no conflicts to report.

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Table 1 Characteristics of participants with valid accelerometer data.

Characteristic	Boys (N = 174; 57.4%)	Girls (N = 129; 42.6%)	All (N = 303)
Mean age \pm SD, months	58.3 \pm 5.6	57.1 \pm 5.3	57.8 \pm 5.5
Mean height \pm SD, cm	111.4 \pm 5.0	110.3 \pm 4.9	111.0 \pm 5.0
Median weight (IQR), kg	20.6 (20.1–21.1)*	19.3 (18.8–19.8)	20.0 (19.7–20.4)
Median BMI (IQR), kg/m ²	16.5 (16.2–16.8)*	15.8 (15.5–16.1)	16.2 (16.0–16.4)
<i>BMI category, %</i>			
Normal	76.4*	86.8	80.9
Overweight	15.5*	10.1	13.2
Obesity	8.1*	3.1	5.9

Note: * $p < .05$, boys vs. girls.

Table 2 Analysis of time spent engaged in PA categories by gender, BMI category, and day.

Factor	Mean CPM ± SD (95% CI)	Mean PA by category ± SD, min/d (95%CI)				
		LPA	MPA	VPA	MVPA	TPA
<i>Gender</i>						
Boys (N = 174)	498.3 ± 120.3* (478.7–516.7)	99.2 ± 18.4* (96.8–102.0)	40.9 ± 9.7 (39.5–42.3)	31.9 ± 10.7* (30.4–33.4)	72.8 ± 18.8* (70.1–75.4)	171.9 ± 34.0* (167.1–176.8)
Girls (N = 129)	468.0 ± 109.3 (447.3–486.2)	94.6 ± 15.9 (91.8–97.3)	38.8 ± 8.0 (37.3–40.1)	29.6 ± 8.6 (28.0–31.1)	68.3 ± 15.1 (65.7–70.9)	162.9 ± 27.6 (158.0–167.6)
<i>BMI</i>						
Normal (N = 245)	484.7 ± 113.6 (470.0–501.4)	96.9 ± 17.4 (94.7–99.1)	39.8 ± 8.8 (38.7–41.0)	30.9 ± 9.6 (29.7–32.0)	70.7 ± 17.0 (68.7–72.9)	167.6 ± 31.1 (163.8–171.5)
Overweight (N = 40)	476.0 ± 121.5 (437.3–514.6)	99.0 ± 18.2 (93.5–104.9)	40.0 ± 9.7 (37.1–43.4)	30.3 ± 10.9 (27.1–34.0)	70.3 ± 19.7 (64.4–76.9)	169.3 ± 35.5 (158.2–181.2)
Obesity (N = 18)	509.9 ± 144.2 (444.0–580.5)	97.7 ± 16.9 (89.3–105.2)	42.1 ± 11.1 (37.4–47.2)	32.3 ± 12.1 (26.7–37.9)	74.4 ± 19.0 (65.7–83.0)	171.0 ± 32.4 (156.0–186.4)
<i>Type of day</i>						
Week (N = 303)	471.0 ± 117.4[†] (457.8–484.6)	96.4 ± 17.9 (94.5–98.3)	39.3 ± 9.3[†] (38.3–40.4)	30.9 ± 9.9 (29.9–32.1)	70.2 ± 17.5 (68.4–72.1)	166.6 ± 32.3[†] (163.2–170.1)
Weekend (N = 303)	517.4 ± 166.2 (497.4–536.5)	98.6 ± 24.8 (95.8–101.4)	41.6 ± 12.0 (40.1–43.1)	30.6 ± 13.3 (29.2–32.2)	72.1 ± 24.0 (69.6–75.0)	170.6 ± 44.3 (165.8–175.6)
ALL (N = 303)	485.0 ± 116.4 (472.6–500.0)	97.2 ± 17.5 (95.2–99.2)	40.0 ± 9.1 (39.0–40.1)	30.9 ± 9.9 (29.8–32.0)	70.9 ± 17.5 (68.9–72.9)	168.0 ± 31.7 (164.6–171.6)
Percentage time spent in different intensities of PA, %						
	-----	13.1 ± 2.1 (12.8–13.3)	5.4 ± 1.1 (5.2–5.5)	4.2 ± 1.3 (4.0–4.3)	9.5 ± 2.2 (9.3–9.8)	22.6 ± 3.7 (22.1–23.0)

Note: LPA, light physical activity; MPA, moderate physical activity; MVPA, moderate to vigorous physical activity; PA, physical activity; TPA, total physical activity; VPA, vigorous physical activity; Mean ± SD and 95% CI are reported for normally distributed variables; Significant data are shown in bold; * $p < .05$, boys vs. girls; [†] $p < .05$, weekdays vs. weekend days.

Table 3 Adherence to common established PA recommendations for preschool aged children.*

PA metric	Guideline target	Participants, % (95% CI)		
		Boys (N = 174)	Girls (N = 129)	All (N = 303)
MVPA	≥60 min/d accumulated, averaged across valid d	74.1 (67.2–79.9)	71.3 (63.6–79.1)	72.9 (68.3–77.9)
TPA	≥180 min/d accumulated, averaged across valid d	42.0 (34.5–48.9)	26.4 (19.4–34.1)	35.3 (30.0–40.9)

Note: MVPA, moderate to vigorous physical activity; PA, physical activity; TPA, total physical activity;

* $p < .05$, boys vs. girls.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	6

1		#7	Clearly define all outcomes, exposures, predictors, potential	6-7
2			confounders, and effect modifiers. Give diagnostic criteria, if	
3			applicable	
4				
5				
6	Data sources /	#8	For each variable of interest give sources of data and details of	6-7
7	measurement		methods of assessment (measurement). Describe comparability	
8			of assessment methods if there is more than one group. Give	
9			information separately for for exposed and unexposed groups if	
10			applicable.	
11				
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14	Bias	#9	Describe any efforts to address potential sources of bias	6
15				
16				
17	Study size	#10	Explain how the study size was arrived at	8
18				
19	Quantitative	#11	Explain how quantitative variables were handled in the analyses.	8
20	variables		If applicable, describe which groupings were chosen, and why	
21				
22				
23	Statistical	#12a	Describe all statistical methods, including those used to control	8
24	methods		for confounding	
25				
26				
27		#12b	Describe any methods used to examine subgroups and	none
28			interactions	
29				
30				
31		#12c	Explain how missing data were addressed	none
32				
33		#12d	If applicable, describe analytical methods taking account of	8
34			sampling strategy	
35				
36				
37		#12e	Describe any sensitivity analyses	none
38				
39	Participants	#13a	Report numbers of individuals at each stage of study—eg	8
40			numbers potentially eligible, examined for eligibility, confirmed	
41			eligible, included in the study, completing follow-up, and	
42			analysed. Give information separately for for exposed and	
43			unexposed groups if applicable.	
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47		#13b	Give reasons for non-participation at each stage	8
48				
49				
50		#13c	Consider use of a flow diagram	none
51				
52	Descriptive data	#14a	Give characteristics of study participants (eg demographic,	8
53			clinical, social) and information on exposures and potential	
54			confounders. Give information separately for exposed and	
55			unexposed groups if applicable.	
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1		#14b	Indicate number of participants with missing data for each	9
2			variable of interest	
3				
4	Outcome data	#15	Report numbers of outcome events or summary measures. Give	9
5			information separately for exposed and unexposed groups if	
6			applicable.	
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10	Main results	#16a	Give unadjusted estimates and, if applicable, confounder-	9-10
11			adjusted estimates and their precision (eg, 95% confidence	
12			interval). Make clear which confounders were adjusted for and	
13			why they were included	
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17		#16b	Report category boundaries when continuous variables were	10-11
18			categorized	
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21		#16c	If relevant, consider translating estimates of relative risk into	none
22			absolute risk for a meaningful time period	
23				
24	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and	none
25			interactions, and sensitivity analyses	
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28	Key results	#18	Summarise key results with reference to study objectives	12-13
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31	Limitations	#19	Discuss limitations of the study, taking into account sources of	13
32			potential bias or imprecision. Discuss both direction and	
33			magnitude of any potential bias.	
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36	Interpretation	#20	Give a cautious overall interpretation considering objectives,	10-13
37			limitations, multiplicity of analyses, results from similar studies,	
38			and other relevant evidence.	
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41	Generalisability	#21	Discuss the generalisability (external validity) of the study results	14
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44	Funding	#22	Give the source of funding and the role of the funders for the	15
45			present study and, if applicable, for the original study on which	
46			the present article is based	
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BMJ Open

Are preschool children active enough in Shanghai—An accelerometer-based cross-sectional study

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4 **Are preschool children active enough in Shanghai—An accelerometer-based**
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6 **cross-sectional study**
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ABSTRACT

Objective: Engaging in physical activity (PA) play an important role in promoting physical and mental health, but the PA data for Chinese preschool children are lacking. This study is aims to objectively assess the PA levels of preschool children in Shanghai, China and to evaluate their PA levels relative to age-specific recommendations.

Design, Setting and Participants: A cross-sectional study was conducted among preschool children in Shanghai city of China. There were a total of 303 preschool children (boys, 174; girls, 129) were recruited from eight kindergarten classes in the Yangpu and Baoshan Districts of Shanghai.

Main outcome measures: Daily PA was assessed using ActiGraph GT3X⁺ accelerometers for seven consecutive days. children were required to have data from at least two weekdays and one weekend day, with a minimum daily wear time of 480 min to be included in the analysis.

Results: Preschool children in Shanghai accumulated, on average, 70.9 minutes (min) of moderate-to-vigorous PA (MVPA) and 168.0 min of total PA (TPA) per day (d). Boys engaged in more MVPA and TPA than girls (72.8 min/d vs. 68.3 min/d and 171.9 min/d vs. 162.9 min/d, respectively). Overall, 72.9% of the participants met the age-specific recommendations of MVPA, while 35.3% met TPA recommendations.

Conclusions: Findings of this study warn of the insufficiency of PA in Shanghai preschool children, suggesting there is substantial room to improve their PA.

Key words: accelerometry, physical activity, preschool children.

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4 23 **Strength and limitation of this study**
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6 24 ● Objective measures of daily physical activity were obtained by accelerometers in
7
8 25 a sample of preschool children from Shanghai, China.
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11 26 ● Daily physical activity levels in Shanghai preschool children were evaluated by
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13 27 both moderate to vigorous physical activity and activity at any intensity
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15 28 recommended guidelines.
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17 29 ● For feasibility, this study sample was not a random sample recruited from the
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19 30 population.
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31 INTRODUCTION

32 Engaging in physical activity (PA) play an important role in promoting physical,
33 psychological, and cognitive health.¹ Moreover, establishing robust PA habits in
34 childhood has positive long-term effects on lifestyle that persist into adulthood,²
35 including reducing the risk of chronic diseases, such as coronary artery disease,
36 diabetes, stroke, and hypertension.^{3 4} Accordingly, Canadian PA guideline for
37 preschool children suggests that, to achieve health benefits, children aged 3 to 6 years
38 old should participate in at least 180 minutes (min) of PA at any intensity and
39 progression toward at least 60 min moderate-to-vigorous PA (MVPA) per day (d),
40 cumulatively.⁵

41 Researchers and public health professionals are interested in establishing what
42 percentage of preschool children meet the aforementioned PA recommendations.
43 Accelerometers can be used as an objective tool to facilitate and improve the accuracy
44 of PA monitoring, overcoming the limitations of self-reported data from children and
45 the potential for recall bias in proxy reports from parents or teachers.⁶ When
46 compared with pedometer, accelerometer can provide the data not only about the total
47 amount of daily activities, but also the pattern of daily activities,⁷ which were
48 considered to be more important to achieve health benefits based on the current PA
49 guideline.⁵ Thus, accelerometers have become increasingly popular as a feasible
50 strategy for capturing preschoolers' movement behavior accurately.⁸ Furthermore,
51 accelerometer-based PA has become an important data source for examining the
52 association between PA and health-related outcomes in recent years, even in the

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4 53 national health survey with large sample size.^{9 10}
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7 54 Although there is a perception that preschool children are constantly active,¹¹
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9 55 accelerometer-based evidence does not support this presumption for all children. In a
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11 56 sample of 3–5-year-old Canadian children, only 13.7% of participants met the PA
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14 57 recommendation for at least 60 min per day of MVPA.¹² In a similar study of
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17 58 Australian preschool aged children, 22% of the sample met this guideline.¹³
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19 59 Moreover, a meta-analysis of 29 reports encompassing 6,309 preschool children in
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22 60 Canada and Australia yielded an average daily MVPA of only 42.8 (95% CI: 28.9–
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25 61 56.8) min.¹⁴ As of yet, objectively-measured PA data for Chinese preschool children
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28 62 are lacking. However, a questionnaire-based national survey in China reported that
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31 63 only 29.9% of the children and youth met the guideline of PA.¹⁵ This phenomenon of
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34 64 lack of PA in children and youth may be more pronounced in the developed region.
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37 65 Take Shanghai, a highly-developed city in China, for example, it was only 18.4% of
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40 66 children and youth met the PA guideline in a representative sample.¹⁶ Considered
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43 67 accelerometer-based PA data for Chinese preschool children are lacking so far, and
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46 68 the facts that many health-related benefits are achieved by regular PA. There is urgent
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49 69 need to objectively assess the PA levels in Chinese preschool children, especially in
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52 70 the developed regions like Shanghai.

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55 71 Therefore, the aim of this study was to assess PA levels objectively in a sample
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58 72 of preschool aged children in Shanghai, China with accelerometers and to determine
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61 73 the proportion of children meeting the aforementioned age-specific PA
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64 74 recommendations. Findings of this study will help us to understand the levels of PA

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4 75 from a sample of Shanghai, which may serve as a foundation for making strategies to
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6 76 maintain or promote PA for preschool children.
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10 11 78 **MATERIALS AND METHODS**

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17 80 This cross-sectional study forms a baseline dataset for The Physical Activity and
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19 81 Cognitive Function Study (Trial registration: ChiCTR-OOC-15007439), in which a
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22 82 convenience sample of 346 participants (boys, 201; girls, 145) were recruited from
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25 83 eight kindergarten classes in the Yangpu and Baoshan Districts of Shanghai, China.

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27 84 After contacting the kindergarten director by phone and interested in this study,
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30 85 the aims and procedures of this study were explained comprehensively to the
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33 86 parents/guardians of all potential participants by parents' meeting held in the
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36 87 kindergarten, including the right to withdraw from the study at any time. Parents
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39 88 interested in having their child participate subsequently signed an informed consent
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42 89 document. The inclusion criteria for the participants in this study were: (1) aged 3-6
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45 90 years; (2) without a diagnosed physical and mental disability; and (3) with signed
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48 91 informed consent from the participants' parents/guardians. This study was approved
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51 92 by the Ethics Advisory Committee of Shanghai University of Sport.

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53 94 **Procedures**

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56 95 Before accelerometer data collection, parents or guardians were instructed on the
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59 96 proper way to wear and remove the accelerometers by trained research staff. Parents
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4 97 or guardians agreed to have their children wear the accelerometers during all waking,
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6 98 including water-based activities such as bathing and swimming. And, Parents or
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9 99 guardians asked to encourage their children to wear them as much as possible during
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11 100 their school hours. The accelerometers were collected at the end of a consecutive 7-d
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14 101 study period, and the accelerometer data were transferred to a computer via ActiLife
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17 102 version 6.11.6 software.

103 104 **Measures**

105 Anthropometric data

106 Height and weight were measured with participants dressed in light clothing.
107 Height was measured to the nearest 0.1 cm using a freestanding portable stadiometer,
108 and weight was measured to the nearest 0.1 kg with an electronic weighting scale
109 (HN-358, Omron, Tokyo, Japan). Body mass index (BMI) was calculated with the
110 formula $\text{weight}/\text{height}^2$ (kg/m²). Based on his or her BMI, each child was categorized
111 as normal, overweight, or obese based on the International Obesity Task Force
112 scale.¹⁷

113 Physical activity data

114 PA was assessed with GT3X⁺ accelerometers (ActiGraph, Pensacola, FL), worn
115 on the right hip attached to an elastic adjustable belt from 7 am to 11 pm every day for
116 seven consecutive days. Non-wear time was determined by the Choi algorithm;¹⁸
117 children were required to have data from at least two weekdays and one weekend day,
118 with a minimum daily wear time of 480 min to be included in the analysis. Based on

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4 119 these criteria, 43 participants were excluded from the final analysis.
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6 120 Data were collected in 1-second epochs, because short epochs have been
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9 121 recommended for capturing movement behavior in this age group.¹⁹ Raw output was
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11 122 expressed as counts per minute (CPM), and cut-off count levels previously developed
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13 123 for preschool children by Pate and colleagues were used to analyze MVPA time.⁶ We
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15 124 classified PA into three levels: light (LPA), 101–1679 CPMs; moderate (MPA),
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17 125 1680–3367 CPMs; and vigorous (VPA), ≥ 3368 CPMs. Total physical activity (TPA)
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19 126 was calculated as the sum of LPA, MPA, and VPA time periods. PA values were
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21 127 compared to the established recommendations of ≥ 60 min of MVPA or ≥ 180 min of
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23 128 PA at any intensity to evaluate the proportion of participants meeting these
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25 129 recommendations.
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34 35 131 **Data analysis**

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37 132 Assuming the coefficient of variation (CV) of MVPA ($CV = 0.28$) based on the
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39 133 previous study,²⁰ confidence level as 95%, and 5% level of precision, the required
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41 134 sample size was at least 125 in this study. The data are reported as means \pm standard
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43 135 deviations (SDs) for normally distributed variables or as medians with interquartile
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45 136 ranges (IQRs) for non-normally distributed variables. Independent *t* tests, Mann-
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47 137 Whitney *U* tests, and chi-square tests were used to assess gender differences in
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49 138 characteristics for normally distributed, non-normally distributed, and categorical
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51 139 variables, respectively. When necessary, PA data were normalized by a log or square
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53 140 root methods prior to analysis. Differences in PA by gender and day were determined
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4 141 with independent *t* tests, and differences in PA by BMI category were determined by
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6 142 one-way analysis of variance (ANOVA) with Bonferroni *post hoc* tests. Analyses
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9 143 were performed in SPSS version 22.0 (IBM Inc., Armonk, NY). A two-sided *P* value
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12 144 $\leq .05$ was considered statistically significant.
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17 146 **Patient and public involvement**

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19 147 No patients or public were involved in this study.
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23 149 **RESULTS**

24 25 26 150 **Characteristics of participants**

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29 151 The descriptive characteristics of the 303 participants included in the present
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31 152 cohort analysis are shown in **Table 1**. Weight, BMI, and the proportion of
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33 153 overweight/obese children were significantly higher in boys than in girls.
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39 155 **The amount of different intensities of PA**

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42 156 On average, the number of valid accelerometer days among participants was 6.3
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44 157 days (95%CI = 6.2–6.4 d), and the mean duration of wear time across all valid days
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46 158 was 748.7 min/d (95%CI = 740.3–756.7 min/d). The actual and percent time spent
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49 159 engaged in CPM and each PA intensity level are presented in **Table 2**. On average,
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52 160 participants in this study accumulated 168.0 min/d of TPA, and spent 13.0% (~97.2
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54 161 min) of their daily waking time engaged in LPA and 9.5% (~70.9 min) of their days
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57 162 was spent engaged in MVPA. In general, boys were more active than girls, and
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60 163 participants engaged in more PA on weekend days than on week days. No significant

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4 164 difference in PA was identified with respect to BMI category.
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9 166 **Meeting the current PA recommendations**

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11 167 There were 72.9% of the participants met the MVPA recommendation that spent
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14 168 at least 60 min/d engaged in MVPA across all valid days, while only 35.3% of the
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17 169 participants met the TPA recommendation that accumulated at least 180 min/d of PA
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20 170 at any intensity. Boys met the PA recommendations more frequently than girls (**Table**
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22 171 **3**).
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27 173 **DISCUSSION**

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30 174 In this accelerometer-based cross-sectional study of preschool children in
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33 175 Shanghai, we found that, on average, boys accumulated 72.8 min/d of MVPA and
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35 176 171.9 min/d of TPA, while girls accumulated 68.3 min/d of MVPA and 162.9 min/d
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38 177 of TPA. At least 27% of the participants did not meet the established PA guidelines.
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42 43 179 **PA status of Shanghai preschoolers**

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45 180 Approximately 73% of participants in our Shanghai cohort met the
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48 181 recommendation of spending more than 60 min/d engaged in MVPA. However, less
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51 182 than 36% accumulated at least 180 min/d of TPA. The gap between these proportions
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54 183 is due largely to the shift from intensity to volume. The short 1-second sampling
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56 184 intervals used in this study may have resulted in an underestimation of LPA time,
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58 185 which would then yield an underestimation of TPA time, relative to, for example, a
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4 186 15-second epoch. A longer epoch is more likely to result in an underestimation of
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6 187 MVPA and an overestimation of LPA in young children.²¹ Notably, a Canadian study
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9 188 with a much longer 60-second epoch found that 83.8% of young children met the 180
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11 189 min/d TPA guideline,¹² while only 13.7% engaged in at least 60 min/d of MVPA.
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14 190 This methodological inconsistency makes it quite difficult to conduct reliable inter-
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17 191 study comparisons. Here, we chose a shorter epoch because it has been recommended
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19 192 for capturing movement in young children owing to the particularly sporadic and
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21 193 intermittent nature of activity exhibited by children in this age group.²²
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195 **Differences in PA by gender, BMI category, and date**

196 Our empirical findings that boys spent 6.6% more time engaged in MVPA and
197 had 5.5% more TPA time than girls are consistent with meta-analysis results.¹⁴ Trost
198 et al. suggested that a similar gender gap in PA was attributed to a VPA difference,
199 with boys spending approximately 45% more time engaged in VPA than girls in their
200 study.²³ Meanwhile, Crespo et al. found that familial, social, and environmental
201 characteristics correlated with higher MVPA in boys than in girls.²⁴ Possible factors
202 in this gender gap to explore in future studies include parental modeling and location.

203 Our finding of similar PA data across normal-weight and overweight/obesity
204 groups was somewhat surprising. Although we commonly thought that normal-weight
205 children must be more active than those who overweight/obese, accelerometer-based
206 evidence does not support this presumption for all studies.²⁵ Furthermore, the opposite
207 findings are more likely to be true in some studies.^{26 27} These negative findings

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4 208 suggest that other factors, such as diet and genetic background, play more important
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6 209 roles in body weight. Future studies are needed to identify the relative importance of
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9 210 and interactions among PA, diet, and genetics for weight status.
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11 Our observation of greater PA on weekend days than on weekdays may be
12 explained by participants having more opportunities to engage in PA on non-school
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14 212 explained by participants having more opportunities to engage in PA on non-school
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17 213 days. Further studies should investigate and compare the specific activities engaged in
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20 214 on school days versus weekend days.
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23 24 25 216 **PA in Shanghai preschool children versus children elsewhere**

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27 217 Given the important of PA for physical, psychological, and cognitive health,¹
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30 218 there is an increasing body of research focusing on the PA levels on preschool
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33 219 children from different population. Findings from a meta-analysis identified 29
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36 220 studies indicated preschoolers' accelerometer-derived PA ranged from 19 min/d to
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38 221 281 min/d.²⁸ However, the amounts of PA across different intensity levels varied
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41 222 widely depending upon the assessment methodology selected, with MVPA cut-off
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44 223 CPM levels having a particularly large effect on PA results.²⁹ Therefore, it is more
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46 224 reasonable to compare the results that using the same cut-off value for PA levels.
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48 225 Unfortunately, the amount of time spent engaged in MVPA in Shanghai preschool
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51 226 children lower than data for the most prior populations assessed with the same cut-off
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54 227 CPM levels by Pate (Range: 35.3-100.0 min/d; Median: 94.9 min/d).^{20 25 30-37} The
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56 228 pattern of our TPA results was comparable to that of the MVPA results (Range: 73.7-
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59 229 394.0 min/d; Median: 348.0 min/d).^{20 30-37}
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4 230 Obviously, the results of this cross-sectional study indicate that Shanghai
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6 231 preschool children tend to have insufficient PA, and less PA than other populations
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9 232 examined with the same cut-off CPM levels. Although the current Shanghai Preschool
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11 233 Education Curriculum Guide requires daily outdoor activities for preschool children
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14 234 to be no less than two hours,³⁸ we also suggest that interventions and policies may be
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17 235 needed to promote PA in Shanghai preschool children based on the data in this study.
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19 236 Similar to children, adolescents and adults, a variety of settings can promote the level
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22 237 of PA in children aged 3-5. However, in the early childhood stage, preschool is an
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25 238 important settings for the promotion of PA.³⁹ Although the findings of PA
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28 239 intervention on preschool setting are inconsistent,⁴⁰⁻⁴³ the extant literatures also
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31 240 provide us with some strategies that may be useful for promoting PA levels of young
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34 241 children. These included: (1) increasing time of outdoor activities, (2) providing
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37 242 materials that are easy to get and play, such as balls and hula hoops, and (3) activities
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40 243 held both indoor and outdoor by teacher-planned.⁴⁴ Furthermore, there was a growing
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43 244 evidence that technology applications, such as exergaming, seem to be an effective
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46 245 approach to promote PA levels in children.⁴⁵⁻⁴⁷ It should be noted that technology
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49 246 applications may be a viable supplemental way to promote PA levels in young
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52 247 children in preschool-based setting.

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249 **Strengths and limitations**

250 To the best of our knowledge, this is the first study to evaluate PA in Chinese
251 preschool children with accelerometers, which eliminating the recall bias associated

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4 252 with other PA measurements. Additionally, our PA data were evaluated relative to
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6 253 both MVPA and TPA recommended guidelines.
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9 254 This study had some limitations. First, for sampling feasibility, all participants
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11 255 were recruited from Northeast Shanghai. Thus, it remains to be determined whether
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13 256 similar findings would be obtained for children in other regions of Shanghai. Second,
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15 257 the accelerometer was worn over the right hip limited to capture activities with little
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17 258 displacement of the body, such as cycling. However, hip was probably the best
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19 259 placement to capture whole-body movements and on the side of the hip was also the
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21 260 most often site by various studies.⁴⁸ Third, the accelerometer-based PA collection
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23 261 process spans different seasons that may have an impact on the result, although the
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25 262 seasonal variation in accelerometer-determined PA was not always observed in
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27 263 different region's studies.⁴⁹
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38 265 **CONCLUSIONS**

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40 266 At least 27% of preschool children in Shanghai did not meet current age-specific
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42 267 PA recommendations and preschool children in Shanghai were less active than most
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44 268 of the populations assessed in comparable studies. Findings of this study implication
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46 269 that there remains a lot of room for improvement in PA behaviors among preschool
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48 270 children in Shanghai, suggesting that public health interventions and policies
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50 271 regarding PA should be explored to promote PA levels in Shanghai preschoolers
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52 272 given that the development of active lifestyle behaviors early in life are believed to
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54 273 yield health benefits that extend into adulthood.
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Author Contributions

Minghui Quan conceived and designed the study, analyzed the data and drafted the manuscript. Hanbin Zhang, Jiayi Zhang, Tang Zhou, Jinming Zhang, Guanggao Zhao, Hui Fang and Shunli Sun conducted the experiments and collected the data. Minghui Quan and Guanggao Zhao performed the literature search. Ru Wang and Peijie Chen advised on analysis and interpretation of the data, and critically revised the manuscript.

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Potential conflicts of interest

The authors declare that they have no conflicts to report.

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4 **Data sharing statement**
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6 No additional data are available.
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Table 1 Characteristics of participants with valid accelerometer data.

Characteristic	Boys (N = 174; 57.4%)	Girls (N = 129; 42.6%)	All (N = 303)
Mean age ± SD, months	58.3 ± 5.6	57.1 ± 5.3	57.8 ± 5.5
Mean height ± SD, cm	111.4 ± 5.0	110.3 ± 4.9	111.0 ± 5.0
Median weight (IQR), kg	20.6 (20.1–21.1)*	19.3 (18.8–19.8)	20.0 (19.7–20.4)
Median BMI (IQR), kg/m ²	16.5 (16.2–16.8)*	15.8 (15.5–16.1)	16.2 (16.0–16.4)
<i>BMI category, %</i>			
Normal	76.4*	86.8	80.9
Overweight	15.5*	10.1	13.2
Obesity	8.1*	3.1	5.9

Note: * $p < .05$, boys vs. girls.

Table 2 Analysis of time spent engaged in PA categories by gender, BMI category, and day.

Factor	Mean CPM ± SD (95% CI)	Mean PA by category ± SD, min/d (95%CI)				
		LPA	MPA	VPA	MVPA	TPA
<i>Gender</i>						
Boys (N = 174)	498.3 ± 120.3* (478.7–516.7)	99.2 ± 18.4* (96.8–102.0)	40.9 ± 9.7 (39.5–42.3)	31.9 ± 10.7* (30.4–33.4)	72.8 ± 18.8* (70.1–75.4)	171.9 ± 34.0* (167.1–176.8)
Girls (N = 129)	468.0 ± 109.3 (447.3–486.2)	94.6 ± 15.9 (91.8–97.3)	38.8 ± 8.0 (37.3–40.1)	29.6 ± 8.6 (28.0–31.1)	68.3 ± 15.1 (65.7–70.9)	162.9 ± 27.6 (158.0–167.6)
<i>BMI</i>						
Normal (N = 245)	484.7 ± 113.6 (470.0–501.4)	96.9 ± 17.4 (94.7–99.1)	39.8 ± 8.8 (38.7–41.0)	30.9 ± 9.6 (29.7–32.0)	70.7 ± 17.0 (68.7–72.9)	167.6 ± 31.1 (163.8–171.5)
Overweight (N = 40)	476.0 ± 121.5 (437.3–514.6)	99.0 ± 18.2 (93.5–104.9)	40.0 ± 9.7 (37.1–43.4)	30.3 ± 10.9 (27.1–34.0)	70.3 ± 19.7 (64.4–76.9)	169.3 ± 35.5 (158.2–181.2)
Obesity (N= 18)	509.9 ± 144.2 (444.0–580.5)	97.7 ± 16.9 (89.3–105.2)	42.1 ± 11.1 (37.4–47.2)	32.3 ± 12.1 (26.7–37.9)	74.4 ± 19.0 (65.7–83.0)	171.0 ± 32.4 (156.0–186.4)
<i>Type of day</i>						
Week (N = 303)	471.0 ± 117.4† (457.8–484.6)	96.4 ± 17.9 (94.5–98.3)	39.3 ± 9.3† (38.3–40.4)	30.9 ± 9.9 (29.9–32.1)	70.2 ± 17.5 (68.4–72.1)	166.6 ± 32.3† (163.2–170.1)
Weekend (N = 303)	517.4 ± 166.2 (497.4–536.5)	98.6 ± 24.8 (95.8–101.4)	41.6 ± 12.0 (40.1–43.1)	30.6 ± 13.3 (29.2–32.2)	72.1 ± 24.0 (69.6–75.0)	170.6 ± 44.3 (165.8–175.6)
ALL (N = 303)	485.0 ± 116.4 (472.6–500.0)	97.2 ± 17.5 (95.2–99.2)	40.0 ± 9.1 (39.0–40.1)	30.9 ± 9.9 (29.8–32.0)	70.9 ± 17.5 (68.9–72.9)	168.0 ± 31.7 (164.6–171.6)
Percentage time spent in different intensities of PA, %						
	-----	13.1 ± 2.1 (12.8–13.3)	5.4 ± 1.1 (5.2–5.5)	4.2 ± 1.3 (4.0–4.3)	9.5 ± 2.2 (9.3–9.8)	22.6 ± 3.7 (22.1–23.0)

Note: LPA, light physical activity; MPA, moderate physical activity; MVPA, moderate to vigorous physical activity; PA, physical activity; TPA, total physical activity; VPA, vigorous physical activity; Mean ± SD and 95% CI are reported for normally distributed variables; Significant data are shown in bold; * $p < .05$, boys vs. girls; † $p < .05$, weekdays vs. weekend days.

Table 3 Adherence to common established PA recommendations for preschool aged children.*

PA metric	Guideline target	Participants, % (95%CI)		
		Boys (N = 174)	Girls (N = 129)	All (N = 303)
MVPA	≥60 min/d accumulated, averaged across valid d	74.1 (67.2–79.9)	71.3 (63.6–79.1)	72.9 (68.3–77.9)
TPA	≥180 min/d accumulated, averaged across valid d	42.0 (34.5–48.9)	26.4 (19.4–34.1)	35.3 (30.0–40.9)

Note: MVPA, moderate to vigorous physical activity; PA, physical activity; TPA, total physical activity;

* $p < .05$, boys vs. girls.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	6

1		#7	Clearly define all outcomes, exposures, predictors, potential	6-7
2			confounders, and effect modifiers. Give diagnostic criteria, if	
3			applicable	
4				
5				
6	Data sources /	#8	For each variable of interest give sources of data and details of	6-7
7	measurement		methods of assessment (measurement). Describe comparability	
8			of assessment methods if there is more than one group. Give	
9			information separately for for exposed and unexposed groups if	
10			applicable.	
11				
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13				
14	Bias	#9	Describe any efforts to address potential sources of bias	6
15				
16				
17	Study size	#10	Explain how the study size was arrived at	8
18				
19	Quantitative	#11	Explain how quantitative variables were handled in the analyses.	8
20	variables		If applicable, describe which groupings were chosen, and why	
21				
22				
23	Statistical	#12a	Describe all statistical methods, including those used to control	8
24	methods		for confounding	
25				
26				
27		#12b	Describe any methods used to examine subgroups and	none
28			interactions	
29				
30		#12c	Explain how missing data were addressed	none
31				
32				
33		#12d	If applicable, describe analytical methods taking account of	8
34			sampling strategy	
35				
36				
37		#12e	Describe any sensitivity analyses	none
38				
39	Participants	#13a	Report numbers of individuals at each stage of study—eg	8
40			numbers potentially eligible, examined for eligibility, confirmed	
41			eligible, included in the study, completing follow-up, and	
42			analysed. Give information separately for for exposed and	
43			unexposed groups if applicable.	
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47		#13b	Give reasons for non-participation at each stage	8
48				
49				
50		#13c	Consider use of a flow diagram	none
51				
52	Descriptive data	#14a	Give characteristics of study participants (eg demographic,	8
53			clinical, social) and information on exposures and potential	
54			confounders. Give information separately for exposed and	
55			unexposed groups if applicable.	
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1		#14b	Indicate number of participants with missing data for each	9
2			variable of interest	
3				
4	Outcome data	#15	Report numbers of outcome events or summary measures. Give	9
5			information separately for exposed and unexposed groups if	
6			applicable.	
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10	Main results	#16a	Give unadjusted estimates and, if applicable, confounder-	9-10
11			adjusted estimates and their precision (eg, 95% confidence	
12			interval). Make clear which confounders were adjusted for and	
13			why they were included	
14				
15				
16				
17		#16b	Report category boundaries when continuous variables were	10-11
18			categorized	
19				
20				
21		#16c	If relevant, consider translating estimates of relative risk into	none
22			absolute risk for a meaningful time period	
23				
24	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and	none
25			interactions, and sensitivity analyses	
26				
27				
28	Key results	#18	Summarise key results with reference to study objectives	12-13
29				
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31	Limitations	#19	Discuss limitations of the study, taking into account sources of	13
32			potential bias or imprecision. Discuss both direction and	
33			magnitude of any potential bias.	
34				
35				
36	Interpretation	#20	Give a cautious overall interpretation considering objectives,	10-13
37			limitations, multiplicity of analyses, results from similar studies,	
38			and other relevant evidence.	
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41	Generalisability	#21	Discuss the generalisability (external validity) of the study results	14
42				
43				
44	Funding	#22	Give the source of funding and the role of the funders for the	15
45			present study and, if applicable, for the original study on which	
46			the present article is based	
47				
48				

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