

# BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email [info.bmjopen@bmj.com](mailto:info.bmjopen@bmj.com)

# BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-024090
Article Type:	Research
Date Submitted by the Author:	09-May-2018
Complete List of Authors:	<p>Quan, minghui; Shanghai University of Sport, School of kinesiology  Zhang, Hanbin; Zhejiang Provincial People's Hospital, Health Promotion Center  Zhang, Jiayi; China Science Publishing and Media Ltd., Editorial Department of Medicine and Health  Zhou, Tang; Shanghai University of Sport, School of kinesiology  Zhang, Jinming; Taishan Medical University, College of Sport Medicine and Rehabilitation  Zhao, Guanggao; Nanchang University, Department of Physical Education  Fang, Hui; Shanghai University of Sport, School of kinesiology  Sun, Shunli; Shanghai University of Sport, School of kinesiology  Wang, Ru; Shanghai University of Sport, School of Kinesiology  Chen, Peijie; Shanghai University of Sport, School of kinesiology</p>
Keywords:	accelerometry, physical activity, preschool children

SCHOLARONE™  
Manuscripts

Only

1  
2  
3  
4 **Are preschool children active enough in Shanghai—An accelerometer-based**  
5  
6 **cross-sectional study**  
7  
8  
9

10 Minghui Quan<sup>1</sup>, Hanbin Zhang<sup>2</sup>, Jiayi Zhang<sup>3</sup>, Tang Zhou<sup>1</sup>, Jinming Zhang<sup>4</sup>,  
11  
12 Guanggao Zhao<sup>5</sup>, Hui Fang<sup>1</sup>, Shunli Sun<sup>1</sup>, Ru Wang<sup>1,\*</sup>, Peijie Chen<sup>1,\*</sup>  
13  
14  
15

- 16  
17  
18 1. School of kinesiology, Shanghai University of Sport, Shanghai 200438, China.  
19  
20 2. Health Promotion Center, Zhejiang Provincial People's Hospital, Hangzhou,  
21  
22 Zhejiang 310014, China.  
23  
24 3. Editorial Department of Medicine and Health, China Science Publishing and Media  
25  
26 Ltd., Shanghai 200032, China.  
27  
28 4. Department of Kinesiology, College of Sport Medicine and Rehabilitation, Taishan  
29  
30 Medical University, Taian, Shandong 271016, China.  
31  
32 5. Department of Physical Education, Nanchang University, Nanchang, Jiangxi  
33  
34 330031, China.  
35  
36  
37  
38  
39  
40  
41  
42

43 **\*Corresponding author:**  
44

45 Professor Ru Wang; Phone: 86-21-51253240; E-mail: wangru0612@163.com  
46

47 Professor Peijie Chen; Phone: 86-21-51253003; E-mail: chenpeijie@sus.edu.cn  
48  
49  
50  
51

52 **Word counts:** Abstract: 226; Body of manuscript: 1951.  
53  
54  
55  
56  
57  
58  
59  
60

## 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<sup>+</sup> 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.<sup>1</sup> Moreover, establishing robust PA habits in childhood has positive long-term effects on lifestyle that persist into adulthood,<sup>2</sup> including reducing the risk of chronic diseases, such as coronary artery disease, diabetes, stroke, and hypertension.<sup>3,4</sup> 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.<sup>5,6</sup>

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.<sup>7</sup> Thus, accelerometers have become increasingly popular as a feasible strategy for capturing preschoolers' movement behavior accurately.<sup>8</sup>

Although there is a perception that preschool children are constantly active,<sup>9</sup> 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.<sup>10</sup> In a similar study of Australian preschool aged children, 22% of the sample met this guideline.<sup>11</sup> Moreover,

1  
2  
3 a meta-analysis of 29 reports encompassing 6,309 preschool children in Canada and  
4  
5 Australia yielded an average daily MVPA of only 42.8 (95% CI: 28.9–56.8) min.<sup>12</sup> As  
6  
7  
8 of yet, accelerometer-based PA data for Chinese preschool children are lacking.  
9

10 The aim of this study was to assess PA levels quantitatively in a sample of  
11  
12 preschool aged children in Shanghai, China with accelerometers and to determine the  
13  
14 proportion of children meeting the aforementioned age-specific PA recommendations.  
15  
16  
17  
18  
19

## 20 **MATERIALS AND METHODS**

### 21 **Participants**

22  
23  
24 This cross-sectional study forms a baseline dataset for The Physical Activity and  
25  
26 Cognitive Function Study (Trial registration: ChiCTR-OOC-15007439), in which a  
27  
28 total of 346 preschool children (boys, 201; girls, 145) were recruited from eight  
29  
30 kindergarten classes in the Yangpu and Baoshan Districts of Shanghai, China. The  
31  
32 aims and procedures of this study were explained comprehensively to the  
33  
34 parents/guardians of all potential participants, including the right to withdraw from  
35  
36 the study at any time. Signed informed consent forms were obtained from the  
37  
38 participants' parents/guardians. This study was approved by the Ethics Advisory  
39  
40 Committee of Shanghai University of Sport.  
41  
42  
43  
44  
45  
46  
47  
48  
49

### 50 **Measures and procedures**

51  
52 PA was assessed with GT3X<sup>+</sup> accelerometers (ActiGraph, Pensacola, FL), worn  
53  
54 on the right hip attached to an elastic adjustable belt for seven consecutive days.  
55  
56  
57  
58  
59  
60

1  
2  
3  
4 Parents or guardians agreed to have their children wear the accelerometers during all  
5  
6 waking, including water-based activities such as bathing and swimming. They were  
7  
8 instructed on the proper way to wear and remove the accelerometers, and asked to  
9  
10 encourage their children to wear them as much as possible during their school hours.  
11  
12 The accelerometers were collected at the end of a 7-d study period, and the  
13  
14 accelerometer data were transferred to a computer via ActiLife version 6.11.6  
15  
16 software. Non-wear time was determined by the Choi algorithm;<sup>13</sup> children were  
17  
18 required to have data from at least two weekdays and one weekend day, with a  
19  
20 minimum daily wear time of 480 min to be included in the analysis. Based on these  
21  
22 criteria, 43 participants were excluded from the final analysis.  
23  
24  
25  
26  
27

28       Body mass index (BMI) was calculated with the formula  $\text{weight}/\text{height}^2$  ( $\text{kg}/\text{m}^2$ ).  
29  
30 Based on his or her BMI, each child was categorized as normal, overweight, or obese  
31  
32 based on the International Obesity Task Force scale.<sup>14</sup>  
33  
34  
35  
36  
37

### 38 **Interpretation of accelerometer data**

39  
40       Data were collected in 1-second epochs, because short epochs have been  
41  
42 recommended for capturing movement behavior in this age group.<sup>15</sup> Raw output was  
43  
44 expressed as counts per minute (CPM), and cut-off count levels previously developed  
45  
46 for preschool children by Pate and colleagues were used to analyze MVPA time.<sup>7</sup> We  
47  
48 classified PA into three levels: light (LPA), 101–1679 CPMs; moderate (MPA), 1680–  
49  
50 3367 CPMs; and vigorous (VPA),  $\geq 3368$  CPMs. Total physical activity (TPA) was  
51  
52 calculated as the sum of LPA, MPA, and VPA time periods. TPA values were  
53  
54  
55  
56  
57  
58  
59  
60



1  
2  
3 compared to the established recommendations of  $\geq 60$  min of MVPA or  $\geq 180$  min of  
4  
5  
6 PA at any intensity to evaluate the proportion of participants meeting these  
7  
8  
9 recommendations.

### 13 **Data analysis**

14  
15 The data are reported as means  $\pm$  standard deviations (SDs) for normally  
16  
17 distributed variables or as medians with interquartile ranges (IQRs) for non-normally  
18  
19 distributed variables. Independent *t* tests, Mann-Whitney *U* tests, and chi-square tests  
20  
21 were used to assess gender differences in characteristics for normally distributed, non-  
22  
23 normally distributed, and categorical variables, respectively. When necessary, PA  
24  
25 data were normalized by a log or square root methods prior to analysis. Differences in  
26  
27 PA by gender and day were determined with independent *t* tests, and differences in  
28  
29 PA by BMI category were determined by one-way analysis of variance (ANOVA)  
30  
31 with Bonferroni *post hoc* tests. Analyses were performed in SPSS version 22.0 (IBM  
32  
33 Inc., Armonk, NY). A two-sided *P* value  $\leq .05$  was considered statistically significant.  
34  
35  
36  
37  
38  
39  
40  
41  
42

## 43 **RESULTS**

### 45 **Characteristics of participants**

46  
47 The descriptive characteristics of the 303 participants included in the present  
48  
49 cohort analysis are shown in **Table 1**. Weight, BMI, and the proportion of  
50  
51 overweight/obese children were significantly higher in boys than in girls.  
52  
53  
54  
55  
56  
57  
58  
59  
60

### **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.<sup>16</sup>

### **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.<sup>17</sup> Notably, a Canadian study

1  
2  
3 with a much longer 60-second epoch found that 83.8% of young children met the 180  
4 min/d TPA guideline,<sup>10</sup> while only 13.7% engaged in at least 60 min/d of MVPA.  
5  
6 This methodological inconsistency makes it quite difficult to conduct reliable  
7  
8 inter-study comparisons. Here, we chose a shorter epoch because it has been  
9  
10 recommended for capturing movement in young children owing to the particularly  
11  
12 sporadic and intermittent nature of activity exhibited by children in this age group.<sup>18</sup>  
13  
14  
15  
16  
17  
18  
19

### 20 **Differences in PA by gender, BMI category, and date**

21  
22  
23 Our empirical findings that boys spent 6.6% more time engaged in MVPA and  
24  
25 had 5.5% more TPA time than girls are consistent with our meta-analysis results. Trost  
26  
27 et al. suggested that a similar gender gap in PA was attributed to a VPA difference,  
28  
29 with boys spending approximately 45% more time engaged in VPA than girls in their  
30  
31 study.<sup>19</sup> Meanwhile, Crespo et al. found that familial, social, and environmental  
32  
33 characteristics correlated with higher MVPA in boys than in girls.<sup>20</sup> Possible factors in  
34  
35 this gender gap to explore in future studies include parental modeling and location.  
36  
37  
38  
39

40 Our finding of similar PA data across normal-weight and overweight/obesity  
41  
42 groups was somewhat surprising. Although we commonly thought that normal-weight  
43  
44 children must be more active than those who overweight/obese, accelerometer-based  
45  
46 evidence does not support this presumption for all studies.<sup>21</sup> Furthermore, the opposite  
47  
48 findings are more likely to be true in some studies.<sup>22 23</sup> These negative findings  
49  
50 suggest that other factors, such as diet and genetic background, play more important  
51  
52 roles in body weight. Future studies are needed to identify the relative importance of  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3  
4 and interactions among PA, diet, and genetics for weight status.  
5

6 Our observation of greater PA on weekend days than on weekdays may be  
7  
8 explained by participants having more opportunities to engage in PA on non-school  
9  
10 days. Further studies should investigate and compare the specific activities engaged in  
11  
12 on school days versus weekend days.  
13  
14  
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,<sup>1</sup>  
21  
22 there is an increasing body of research focusing on the PA levels on preschool  
23  
24 children from different population. Findings from a meta-analysis identified 29  
25  
26 studies indicated preschoolers' accelerometer-derived PA ranged from 19 min/d to 281  
27  
28 min/d.<sup>24</sup> However, the amounts of PA across different intensity levels varied widely  
29  
30 depending upon the assessment methodology selected, with MVPA cut-off CPM  
31  
32 levels having a particularly large effect on PA results.<sup>25</sup> Therefore, it is more  
33  
34 reasonable to compare the results that using the same cut-off value for PA levels.  
35  
36 Unfortunately, the amount of time spent engaged in MVPA in Shanghai preschool  
37  
38 children lower than data for the most prior populations assessed with the same cut-off  
39  
40 CPM levels by Pate (Range: 35.3-100.0 min/d; Median: 94.9 min/d).<sup>21 26-34</sup> The  
41  
42 pattern of our TPA results was comparable to that of the MVPA results (Range:  
43  
44 73.7-394.0 min/d; Median: 348.0 min/d).<sup>26-34</sup>  
45  
46  
47  
48  
49  
50  
51

52 Obviously, the results of this cross-sectional study indicate that Shanghai  
53  
54 preschool children tend to have insufficient PA, and less PA than other populations  
55  
56  
57  
58  
59  
60

1  
2  
3 examined with the same cut-off CPM levels. Based on these data, we suggest that  
4  
5  
6 interventions may be needed to promote PA in Shanghai preschool children.  
7  
8  
9

## 10 **CONCLUSIONS**

11  
12  
13 At least 27% of preschool children in Shanghai did not meet current age-specific  
14  
15 PA recommendations and preschool children in Shanghai were less active than most  
16  
17 of the populations assessed in comparable studies. These findings suggest that  
18  
19 interventions should be explored to promote PA in Shanghai preschoolers given that  
20  
21 the development of active lifestyle behaviors early in life are believed to yield health  
22  
23 benefits that extend into adulthood.  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

### **Acknowledgements**

We thank all the participants and kindergarten very much for their collaboration.

### **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.

### **Funding**

This work was supported by grants from the Science and Technology Commission of Shanghai Municipality, China (12XD1404500), the Humanity and Social Science Youth Foundation of the Ministry of Education of China (15YJC890029), National Natural Science Foundation of China (81703252), and a grant from the China Postdoctoral Science Foundation funded project (2017M620160).

### **Potential conflicts of interest**

The authors declare that they have no conflicts to report.

## REFERENCES

1. Poitras VJ, Gray CE, Borghese MM, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab* 2016;41(6 Suppl 3):S197-239.
2. Telama R, Yang X, Leskinen E, et al. Tracking of physical activity from early childhood through youth into adulthood. *Med Sci Sports Exerc* 2014;46(5):955-62. doi: 10.1249/MSS.000000000000181
3. Booth FW, Laye MJ, Lees SJ, et al. Reduced physical activity and risk of chronic disease: the biology behind the consequences. *Eur J Appl Physiol* 2008;102(4):381-90. doi: 10.1007/s00421-007-0606-5
4. Durstine JL, Gordon B, Wang Z, et al. Chronic disease and the link to physical activity. *J Sport Health Sci* 2013;2(1):3-11.
5. American Alliance for Health PE RaDA. NASPE releases first ever physical activity guidelines for infants and toddlers. *Illinois J Health Pe Rec Dance* 2002;50:31-31.
6. Tremblay MS, Chaput JP, Adamo KB, et al. Canadian 24-Hour Movement Guidelines for the Early Years (0–4 years): An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *Bmc Public Health* 2017;17(5):874.
7. Pate RR, Almeida MJ, McIver KL, et al. Validation and calibration of an accelerometer in preschool children. *Obesity (Silver Spring)* 2006;14(11):2000-6. doi: 10.1038/oby.2006.234



- 1  
2  
3  
4 8. Hnatiuk JA, Salmon J, Hinkley T, et al. A review of preschool children's physical  
5  
6 activity and sedentary time using objective measures. *Am J Prev Med*  
7  
8 2014;47(4):487-97.  
9
- 10  
11 9. Hesketh KD, Hinkley T, Campbell KJ. Children's physical activity and screen time:  
12  
13 qualitative comparison of views of parents of infants and preschool children. *Int J*  
14  
15 *Behav Nutr Phys Act* 2012;9(1):152.  
16
- 17  
18 10. Colley RC, Garriguet D, Adamo KB, et al. Physical activity and sedentary  
19  
20 behavior during the early years in Canada: a cross-sectional study. *Int J Behav*  
21  
22 *Nutr Phys Act* 2013;10:54. doi: 10.1186/1479-5868-10-54  
23
- 24  
25 11. Hinkley T, Salmon J, Okely AD, et al. Preschoolers' physical activity, screen time,  
26  
27 and compliance with recommendations. *Med Sci Sports Exerc*  
28  
29 2012;44(3):458-65.  
30  
31
- 32  
33 12. Bornstein DB, Beets MW, Byun W, et al. Accelerometer-derived physical activity  
34  
35 levels of preschoolers: a meta-analysis. *J Sci Med Sport* 2011;14(6):504-11. doi:  
36  
37 10.1016/j.jsams.2011.05.007  
38
- 39  
40 13. Choi L, Liu Z, Matthews CE, et al. Validation of accelerometer wear and nonwear  
41  
42 time classification algorithm. *Med Sci Sports Exerc* 2011;43(2):357-64. doi:  
43  
44 10.1249/MSS.0b013e3181ed61a3  
45
- 46  
47 14. Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for  
48  
49 child overweight and obesity worldwide: international survey. *BMJ*  
50  
51 2000;320(7244):1240-3.  
52  
53
- 54  
55 15. Hislop JF, Bulley C, Mercer TH, et al. Comparison of epoch and uniaxial versus  
56  
57

- 1  
2  
3 triaxial accelerometers in the measurement of physical activity in preschool  
4  
5 children: a validation study. *Pediatr Exerc Sci* 2012;24(3):450-60.  
6  
7
- 8 16. Cliff DP, Reilly JJ, Okely AD. Methodological considerations in using  
9  
10 accelerometers to assess habitual physical activity in children aged 0-5 years.  
11  
12 *Journal of Science & Medicine in Sport* 2010;12(5):557-67.  
13  
14
- 15 17. Vale S, Santos R, Silva P, et al. Preschool children physical activity measurement:  
16  
17 importance of epoch length choice. *Pediatric Exercise Science*  
18  
19 2009;21(4):413-20.  
20  
21
- 22 18. Obeid J, Nguyen T, Gabel L, et al. Physical activity in Ontario preschoolers:  
23  
24 prevalence and measurement issues. *Applied physiology, nutrition, and*  
25  
26 *metabolism* 2011;36(2):291-97.  
27  
28
- 29 19. Trost SG, Pate RR, Sallis JF, et al. Age and gender differences in objectively  
30  
31 measured physical activity in youth. *Med Sci Sports Exerc* 2002;34(2):350-5.  
32  
33
- 34 20. Crespo NC, Corder K, Marshall S, et al. An examination of multilevel factors that  
35  
36 may explain gender differences in children's physical activity. *J Phys Act Health*  
37  
38 2013;10(7):982-92.  
39  
40
- 41 21. Niederer I, Kriemler S, Zahner L, et al. BMI group-related differences in physical  
42  
43 fitness and physical activity in preschool-age children: a cross-sectional analysis.  
44  
45 *Res Q Exerc Sport* 2012;83(1):12-19.  
46  
47
- 48 22. Tanaka C, Tanaka S. Objectively-measured physical activity and body weight in  
49  
50 Japanese pre-schoolers. *Ann Hum Biol* 2013;40(6):541-46.  
51  
52
- 53 23. Tucker P, Maltby AM, Burke SM, et al. Comparing physical activity and sedentary  
54  
55  
56  
57  
58  
59  
60

- 1  
2  
3 time among overweight and nonoverweight preschoolers enrolled in early  
4 learning programs: a cross-sectional study. *Appl Physiol Nutr Metab*  
5  
6 2016;41(9):971-6. doi: 10.1139/apnm-2016-0021  
7  
8  
9  
10 24. Bornstein DB, Beets MW, Byun W, et al. Accelerometer-derived physical activity  
11 levels of preschoolers: a meta-analysis. *Journal of Science & Medicine in Sport*  
12 2011;14(6):504-11.  
13  
14  
15 25. Kahan D, Nicaise V, Reuben K. Convergent validity of four accelerometer  
16 cutpoints with direct observation of preschool children's outdoor physical activity.  
17  
18 *Research Quarterly for Exercise & Sport* 2013;84(1):59-67.  
19  
20  
21  
22  
23 26. Pfeiffer KA, Dowda M, McIver KL, et al. Factors related to objectively measured  
24 physical activity in preschool children. *Pediatr Exerc Sci* 2009;21(2):196.  
25  
26  
27  
28 27. Pate RR, O'Neill JR, Byun W, et al. Physical activity in preschool children:  
29 comparison between Montessori and traditional preschools. *J Sch Health*  
30 2014;84(11):716-21. doi: 10.1111/josh.12207  
31  
32  
33  
34  
35 28. Caldwell HA, Proudfoot NA, King-Dowling S, et al. Tracking of physical activity  
36 and fitness during the early years. *Appl Physiol Nutr Metab* 2016;41(5):504-10.  
37 doi: 10.1139/apnm-2015-0338 [published Online First: 2016/04/06]  
38  
39  
40  
41 29. Pate RR, Brown WH, Pfeiffer KA, et al. An Intervention to Increase Physical  
42 Activity in Children: A Randomized Controlled Trial With 4-Year-Olds in  
43 Preschools. *Am J Prev Med* 2016;51(1):12-22. doi:  
44 10.1016/j.amepre.2015.12.003 [published Online First: 2016/01/25]  
45  
46  
47  
48  
49 30. Barkin SL, Lamichhane AP, Banda JA, et al. Parent's Physical Activity Associated

- 1  
2  
3 With Preschooler Activity in Underserved Populations. *Am J Prev Med*  
4  
5  
6 2017;52(4):424-32. doi: 10.1016/j.amepre.2016.11.017  
7
- 8 31. French SA, Sherwood NE, Mitchell NR, et al. Park use is associated with less  
9  
10 sedentary time among low-income parents and their preschool child: The  
11  
12 NET-Works study. *Preventive medicine reports* 2017;5:7-12. doi:  
13  
14 10.1016/j.pmedr.2016.11.003  
15  
16
- 17 32. Moller NC, Christensen LB, Molgaard C, et al. Descriptive analysis of preschool  
18  
19 physical activity and sedentary behaviors - a cross sectional study of 3-year-olds  
20  
21 nested in the SKOT cohort. *BMC Public Health* 2017;17(1):613. doi:  
22  
23 10.1186/s12889-017-4521-3  
24  
25  
26
- 27 33. Leeger-Aschmann CS, Schmutz EA, Radtke T, et al. Regional sociocultural  
28  
29 differences as important correlate of physical activity and sedentary behaviour in  
30  
31 Swiss preschool children. *Swiss Med Wkly* 2016;146:w14377. doi:  
32  
33 10.4414/smw.2016.14377  
34  
35  
36
- 37 34. Vale S, Silva P, Santos R, et al. Compliance with physical activity guidelines in  
38  
39 preschool children. *J Sports Sci* 2010;28(6):603-08.  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**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 <sup>2</sup>	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)	<b>498.3 ± 120.3*</b> (478.7–516.7)	<b>99.2 ± 18.4*</b> (96.8–102.0)	40.9 ± 9.7 (39.5–42.3)	<b>31.9 ± 10.7*</b> (30.4–33.4)	<b>72.8 ± 18.8*</b> (70.1–75.4)	<b>171.9 ± 34.0*</b> (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)	<b>471.0 ± 117.4†</b> (457.8–484.6)	96.4 ± 17.9 (94.5–98.3)	<b>39.3 ± 9.3†</b> (38.3–40.4)	30.9 ± 9.9 (29.9–32.1)	70.2 ± 17.5 (68.4–72.1)	<b>166.6 ± 32.3†</b> (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.

## 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:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotsche PC, Vandembroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

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



1		<a href="#">#7</a>	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 /	<a href="#">#8</a>	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.	
11				
12				
13				
14	Bias	<a href="#">#9</a>	Describe any efforts to address potential sources of bias	6
15				
16				
17	Study size	<a href="#">#10</a>	Explain how the study size was arrived at	none
18				
19	Quantitative	<a href="#">#11</a>	Explain how quantitative variables were handled in the	7
20	variables		analyses. If applicable, describe which groupings were chosen,	
21			and why	
22				
23				
24	Statistical	<a href="#">#12a</a>	Describe all statistical methods, including those used to control	7
25	methods		for confounding	
26				
27				
28		<a href="#">#12b</a>	Describe any methods used to examine subgroups and	none
29			interactions	
30				
31				
32		<a href="#">#12c</a>	Explain how missing data were addressed	none
33				
34		<a href="#">#12d</a>	If applicable, describe analytical methods taking account of	none
35			sampling strategy	
36				
37				
38		<a href="#">#12e</a>	Describe any sensitivity analyses	none
39				
40				
41	Participants	<a href="#">#13a</a>	Report numbers of individuals at each stage of study—eg	7
42			numbers potentially eligible, examined for eligibility, confirmed	
43			eligible, included in the study, completing follow-up, and	
44			analysed. Give information separately for for exposed and	
45			unexposed groups if applicable.	
46				
47				
48				
49		<a href="#">#13b</a>	Give reasons for non-participation at each stage	6
50				
51		<a href="#">#13c</a>	Consider use of a flow diagram	none
52				
53				
54	Descriptive data	<a href="#">#14a</a>	Give characteristics of study participants (eg demographic,	7
55			clinical, social) and information on exposures and potential	
56			confounders. Give information separately for exposed and	
57			unexposed groups if applicable.	
58				
59				
60				

1		<a href="#">#14b</a>	Indicate number of participants with missing data for each	6
2			variable of interest	
3				
4				
5	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures.	8
6			Give information separately for exposed and unexposed	
7			groups if applicable.	
8				
9				
10	Main results	<a href="#">#16a</a>	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				
15				
16				
17		<a href="#">#16b</a>	Report category boundaries when continuous variables were	None
18			categorized	
19				
20				
21		<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into	none
22			absolute risk for a meaningful time period	
23				
24	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and	none
25			interactions, and sensitivity analyses	
26				
27				
28	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	8
29				
30				
31	Limitations	<a href="#">#19</a>	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.	
34				
35				
36	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives,	11-12
37			limitations, multiplicity of analyses, results from similar studies,	
38			and other relevant evidence.	
39				
40				
41	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study	9-11
42			results	
43				
44				
45	Funding	<a href="#">#22</a>	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	
48				
49				

The STROBE checklist is distributed under the terms of the Creative Commons Attribution License CC-BY. This checklist can be completed online using <https://www.goodreports.org/>, a tool made by the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)

# BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-024090.R1
Article Type:	Research
Date Submitted by the Author:	24-Aug-2018
Complete List of Authors:	<p>Quan, minghui; Shanghai University of Sport, School of kinesiology  Zhang, Hanbin; Zhejiang Provincial People's Hospital, Health Promotion Center  Zhang, Jiayi; China Science Publishing and Media Ltd., Editorial Department of Medicine and Health  Zhou, Tang; Shanghai University of Sport, School of kinesiology  Zhang, Jinming; Taishan Medical University, College of Sport Medicine and Rehabilitation  Zhao, Guanggao; Nanchang University, Department of Physical Education  Fang, Hui; Shanghai University of Sport, School of kinesiology  Sun, Shunli; Shanghai University of Sport, School of kinesiology  Wang, Ru; Shanghai University of Sport, School of Kinesiology  Chen, Peijie; Shanghai University of Sport, School of kinesiology</p>
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Public health, Paediatrics
Keywords:	accelerometry, physical activity, preschool children

SCHOLARONE™  
Manuscripts

1  
2  
3  
4 **1 Are preschool children active enough in Shanghai—An accelerometer-based**  
5  
6 **2 cross-sectional study**  
7

8  
9  
10  
11 4 Minghui Quan<sup>1</sup>, Hanbin Zhang<sup>2</sup>, Jiayi Zhang<sup>3</sup>, Tang Zhou<sup>1</sup>, Jinming Zhang<sup>4</sup>,  
12  
13 5 Guanggao Zhao<sup>5</sup>, Hui Fang<sup>1</sup>, Shunli Sun<sup>1</sup>, Ru Wang<sup>1,\*</sup>, Peijie Chen<sup>1,\*</sup>  
14  
15

16  
17  
18 7 1. School of kinesiology, Shanghai University of Sport, Shanghai 200438, China.  
19

20  
21 8 2. Health Promotion Center, Zhejiang Provincial People's Hospital, Hangzhou,  
22  
23 9 Zhejiang 310014, China.  
24

25  
26 10 3. Editorial Department of Medicine and Health, China Science Publishing and Media  
27  
28 11 Ltd., Shanghai 200032, China.  
29

30  
31 12 4. Department of Kinesiology, College of Sport Medicine and Rehabilitation, Taishan  
32  
33 13 Medical University, Taian, Shandong 271016, China.  
34

35  
36 14 5. Department of Physical Education, Nanchang University, Nanchang, Jiangxi  
37  
38 15 330031, China.  
39

40  
41  
42  
43 17 **\*Corresponding author:**

44  
45 18 Professor Ru Wang; Phone: 86-21-51253240; E-mail: wangru0612@163.com  
46

47  
48 19 Professor Peijie Chen; Phone: 86-21-51253003; E-mail: chenpeijie@sus.edu.cn  
49

50  
51 20

52  
53 21 **Word counts:** Abstract: 226; Body of manuscript: 2473.  
54  
55  
56  
57  
58  
59  
60

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## 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<sup>+</sup> 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.

1  
2  
3 **43 Strength and limitation of this study**  
4

5  
6 ● Objective measures of daily physical activity were obtained by accelerometers in  
7 a sample of preschool children from Shanghai, China.  
8

9  
10 ● 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.  
13  
14

15  
16 ● For feasibility, this study sample was not a random sample recruited from the  
17 population.  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50

## 51 INTRODUCTION

52 Engaging in physical activity (PA) play an important roles in promoting physical,  
53 psychological, and cognitive health.<sup>1</sup> Moreover, establishing robust PA habits in  
54 childhood has positive long-term effects on lifestyle that persist into adulthood,<sup>2</sup>  
55 including reducing the risk of chronic diseases, such as coronary artery disease,  
56 diabetes, stroke, and hypertension.<sup>3 4</sup> 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.<sup>5</sup>

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.<sup>6</sup> 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,<sup>7</sup> which were  
68 considered to be more important to achieve health benefits based on the current PA  
69 guideline.<sup>5</sup> Thus, accelerometers have become increasingly popular as a feasible  
70 strategy for capturing preschoolers' movement behavior accurately.<sup>8</sup> 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

1  
2  
3  
4 73 national health survey with large sample size.<sup>9 10</sup>

5  
6 74 Although there is a perception that preschool children are constantly active,<sup>11</sup>  
7  
8 75 accelerometer-based evidence does not support this presumption for all children. In a  
9  
10 76 sample of 3–5-year-old Canadian children, only 13.7% of participants met the PA  
11  
12 77 recommendation for at least 60 min per day of MVPA.<sup>12</sup> In a similar study of  
13  
14 78 Australian preschool aged children, 22% of the sample met this guideline.<sup>13</sup> Moreover,  
15  
16 79 a meta-analysis of 29 reports encompassing 6,309 preschool children in Canada and  
17  
18 80 Australia yielded an average daily MVPA of only 42.8 (95% CI: 28.9–56.8) min.<sup>14</sup> As  
19  
20 81 of yet, accelerometer-based PA data for Chinese preschool children are lacking.  
21  
22  
23  
24

25 82 The aim of this study was to assess PA levels quantitatively in a sample of  
26  
27 83 preschool aged children in Shanghai, China with accelerometers and to determine the  
28  
29 84 proportion of children meeting the aforementioned age-specific PA recommendations.  
30  
31 85 Findings of this study will help us to understand the PA levels from a sample of  
32  
33 86 Shanghai, which may serve as a foundation for making strategies to maintain and  
34  
35 87 promote PA for preschool children.  
36  
37  
38  
39

40 88

## 41 42 89 **MATERIALS AND METHODS**

### 43 44 90 **Participants**

45  
46 91 This cross-sectional study forms a baseline dataset for The Physical Activity and  
47  
48 92 Cognitive Function Study (Trial registration: ChiCTR-OOC-15007439), in which a  
49  
50 93 convenience sample of 346 participants (boys, 201; girls, 145) were recruited from  
51  
52 94 eight kindergarten classes in the Yangpu and Baoshan Districts of Shanghai, China.  
53  
54  
55  
56



1  
2  
3  
4 95 After contacting the kindergarten director by phone and interested in this study,  
5  
6 96 the aims and procedures of this study were to explain comprehensively to the  
7  
8 97 parents/guardians of all potential participants by parents' meeting held in the  
9  
10 98 kindergarten, including the right to withdraw from the study at any time. Parents  
11  
12 99 interested in having their children participate subsequently signed an informed  
13  
14 100 consent document. The inclusion criteria for the participants in this study were: (1)  
15  
16 101 aged 3-6 years; (2) without a diagnosed physical and mental disability; and (3) with  
17  
18 102 signed informed consent from the participants' parents/guardians. This study was  
19  
20 103 approved by the Ethics Advisory Committee of Shanghai University of Sport.  
21  
22  
23  
24  
25  
26  
27

## 104 105 **Procedures**

106 Before accelerometer data collection, parents or guardians were instructed on the  
107 proper way to wear and remove the accelerometers by well-trained research staff.  
108 Parents or guardians agreed to have their children wear the accelerometers during all  
109 waking, including water-based activities such as bathing and swimming. And, Parents  
110 or guardians asked to encourage their children to wear them as much as possible  
111 during their school hours. The accelerometers were collected at the end of a  
112 consecutive 7-d study period, and the accelerometer data were transferred to a  
113 computer via ActiLife version 6.11.6 software.  
114

## 115 **Measures**

116 Anthropometric data

1  
2  
3  
4 117 Height and weight were measured with participants dressed in light clothing.  
5  
6 118 Height was measured to the nearest 0.1 cm using a freestanding portable stadiometer,  
7  
8 119 and weight was measured to the nearest 0.1 kg with an electronic weighting scale  
9  
10  
11 120 (HN-358, Omron, Tokyo, Japan). Body mass index (BMI) was calculated with the  
12  
13 121 formula  $\text{weight}/\text{height}^2$  ( $\text{kg}/\text{m}^2$ ). Based on his or her BMI, each child was categorized  
14  
15 122 as normal, overweight, or obese based on the International Obesity Task Force scale.<sup>15</sup>  
16  
17

### 18 123 Physical activity data

19  
20 124 PA was assessed with GT3X<sup>+</sup> accelerometers (ActiGraph, Pensacola, FL), worn  
21  
22  
23 125 on the right hip attached to an elastic adjustable belt from 7 am to 11 pm every day for  
24  
25 126 seven consecutive days. Non-wear time was determined by the Choi algorithm;<sup>16</sup>  
26  
27  
28 127 children were required to have data from at least two weekdays and one weekend day,  
29  
30 128 with a minimum daily wear time of 480 min to be included in the analysis. Based on  
31  
32  
33 129 these criteria, 43 participants were excluded from the final analysis.  
34

35 130 Data were collected in 1-second epochs, because short epochs have been  
36  
37  
38 131 recommended for capturing movement behavior in this age group.<sup>17</sup> Raw output was  
39  
40 132 expressed as counts per minute (CPM), and cut-off count levels previously developed  
41  
42  
43 133 for preschool children by Pate and colleagues were used to analyze MVPA time.<sup>6</sup> We  
44  
45 134 classified PA into three levels: light (LPA), 101–1679 CPMs; moderate (MPA), 1680–  
46  
47 135 3367 CPMs; and vigorous (VPA),  $\geq 3368$  CPMs. Total physical activity (TPA) was  
48  
49  
50 136 calculated as the sum of LPA, MPA, and VPA time periods. PA values were  
51  
52  
53 137 compared to the established recommendations of  $\geq 60$  min of MVPA or  $\geq 180$  min of  
54  
55 138 PA at any intensity to evaluate the proportion of participants meeting these  
56  
57  
58  
59  
60

1  
2  
3  
4 139 recommendations.  
5  
6 140

7  
8 141 **Data analysis**  
9

10  
11 142 Assuming the coefficient of variation (CV) of MVPA ( $CV = 0.28$ ) based on the  
12  
13 143 previous study,<sup>18</sup> confidence level as 95%, and 5% level of precision, the required  
14  
15 144 sample size was at least 125 in this study. The data are reported as means  $\pm$  standard  
16  
17 145 deviations (SDs) for normally distributed variables or as medians with interquartile  
18  
19 146 ranges (IQRs) for non-normally distributed variables. Independent *t* tests,  
20  
21 147 Mann-Whitney *U* tests, and chi-square tests were used to assess gender differences in  
22  
23 148 characteristics for normally distributed, non- normally distributed, and categorical  
24  
25 149 variables, respectively. When necessary, PA data were normalized by a log or square  
26  
27 150 root methods prior to analysis. Differences in PA by gender and day were determined  
28  
29 151 with independent *t* tests, and differences in PA by BMI category were determined by  
30  
31 152 one-way analysis of variance (ANOVA) with Bonferroni *post hoc* tests. Analyses  
32  
33 153 were performed in SPSS version 22.0 (IBM Inc., Armonk, NY). A two-sided *P* value  
34  
35 154  $\leq .05$  was considered statistically significant.  
36  
37  
38  
39  
40  
41  
42  
43  
44

45 156 **Patient and public involvement**  
46

47 157 No patients or public were involved in this study.  
48  
49  
50 158  
51  
52 159  
53  
54  
55 160

## 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.

176

### 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.<sup>19</sup> 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,<sup>12</sup> 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.<sup>20</sup>

204

1  
2  
3  
4 205 **Differences in PA by gender, BMI category, and date**  
5

6 206 Our empirical findings that boys spent 6.6% more time engaged in MVPA and  
7  
8 207 had 5.5% more TPA time than girls are consistent with our meta-analysis results. Trost  
9  
10 208 et al. suggested that a similar gender gap in PA was attributed to a VPA difference,  
11  
12 209 with boys spending approximately 45% more time engaged in VPA than girls in their  
13  
14 210 study.<sup>21</sup> Meanwhile, Crespo et al. found that familial, social, and environmental  
15  
16 211 characteristics correlated with higher MVPA in boys than in girls.<sup>22</sup> Possible factors in  
17  
18 212 this gender gap to explore in future studies include parental modeling and location.  
19  
20  
21  
22

23 213 Our finding of similar PA data across normal-weight and overweight/obesity  
24  
25 214 groups was somewhat surprising. Although we commonly thought that normal-weight  
26  
27 215 children must be more active than those who overweight/obese, accelerometer-based  
28  
29 216 evidence does not support this presumption for all studies.<sup>23</sup> Furthermore, the opposite  
30  
31 217 findings are more likely to be true in some studies.<sup>24 25</sup> These negative findings  
32  
33 218 suggest that other factors, such as diet and genetic background, play more important  
34  
35 219 roles in body weight. Future studies are needed to identify the relative importance of  
36  
37 220 and interactions among PA, diet, and genetics for weight status.  
38  
39  
40  
41

42 221 Our observation of greater PA on weekend days than on weekdays may be  
43  
44 222 explained by participants having more opportunities to engage in PA on non-school  
45  
46 223 days. Further studies should investigate and compare the specific activities engaged in  
47  
48 224 on school days versus weekend days.  
49  
50

51  
52 225  
53  
54  
55 226

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

228       Given the important of PA for physical, psychological, and cognitive health,<sup>1</sup>  
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.<sup>26</sup> 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.<sup>27</sup> 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).<sup>18 23 28-35</sup> 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).<sup>18 28-35</sup>

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,<sup>36</sup> 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

1  
2  
3  
4 249 important settings for the promotion of PA.<sup>37</sup> Although the findings of PA intervention  
5  
6 250 on preschool setting are inconsistent,<sup>38-41</sup> the extant literatures also provide us with  
7  
8 251 some strategies that may be useful for promoting young children's PA levels. These  
9  
10 252 included: (1) increasing time of outdoor activities, (2) providing materials that are  
11  
12 253 easy to get and play, such as balls and hula hoops, and (3) activities held both indoor  
13  
14 254 and outdoor by teacher-planned.<sup>42</sup> Furthermore, there was a growing evidence that  
15  
16 255 technology applications, such as exergaming, seemed to be an effective approach to  
17  
18 256 promote PA levels in children.<sup>43-45</sup> It should be noted that technology applications may  
19  
20 257 be a viable supplemental way to promote PA levels in young children in  
21  
22 258 preschool-based setting.  
23  
24  
25  
26  
27  
28  
29

### 30 **Strengths and limitations**

31  
32  
33 261 To the best of our knowledge, this is the first study to evaluate PA in Chinese  
34  
35 262 preschool children using accelerometers, which eliminating the recall bias associated  
36  
37 263 with other PA measurements. Additionally, our PA data were evaluated relative to  
38  
39 264 both MVPA and TPA recommended guidelines.  
40  
41

42  
43 265 This study had some limitations. First, for sampling feasibility, all participants  
44  
45 266 were recruited from Northeast Shanghai. Thus, it remains to be determined whether  
46  
47 267 similar findings would be obtained for children in other regions of Shanghai. Second,  
48  
49 268 the accelerometer was worn over the right hip limited to capture activities with little  
50  
51 269 displacement of the body, such as cycling. However, hip was probably the best  
52  
53 270 placement to capture whole-body movements and on the side of the hip was also the  
54  
55  
56  
57  
58  
59  
60



1  
2  
3  
4 271 most often site by various studies.<sup>46</sup> Third, the accelerometer-based PA collection  
5  
6 272 process spans different seasons that may have an impact on the result, although the  
7  
8 273 seasonal variation in accelerometer-determined PA was not always observed in  
9  
10  
11 274 different region's studies.<sup>47</sup>  
12

13  
14 275

## 15 276 **CONCLUSIONS**

16  
17  
18 277 At least 27% of preschool children in Shanghai did not meet current age-specific  
19  
20 278 PA recommendations, and preschool children in Shanghai were less active than most  
21  
22  
23 279 of the populations assessed in comparable studies. Findings of this study implication  
24  
25 280 that there remains a lot of room for improvement in PA behaviors among preschool  
26  
27  
28 281 children in Shanghai, particular in girls and weekday period. It was suggesting that  
29  
30 282 public health interventions and policies regarding PA should be explored to promote  
31  
32  
33 283 PA levels in Shanghai preschoolers, given that the development of active lifestyle  
34  
35 284 behaviors early in life are believed to yield health benefits that extend into adulthood.  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

### **Acknowledgements**

We thank all the participants and kindergarten very much for their collaboration.

### **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.

### **Funding**

This work was supported by grants from the Science and Technology Commission of Shanghai Municipality, China (12XD1404500), the Humanity and Social Science Youth Foundation of the Ministry of Education of China (15YJC890029), National Natural Science Foundation of China (81703252), and a grant from the China Postdoctoral Science Foundation funded project (2017M620160).

### **Potential conflicts of interest**

The authors declare that they have no conflicts to report.

## REFERENCES

1. Poitras VJ, Gray CE, Borghese MM, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab* 2016;41:S197-239.
2. Telama R, Yang X, Leskinen E, et al. Tracking of physical activity from early childhood through youth into adulthood. *Med Sci Sports Exerc* 2014;46:955-62.
3. Booth FW, Laye MJ, Lees SJ, et al. Reduced physical activity and risk of chronic disease: the biology behind the consequences. *Eur J Appl Physiol* 2008;102:381-90.
4. Durstine JL, Gordon B, Wang Z, et al. Chronic disease and the link to physical activity. *J Sport Health Sci* 2013;2:3-11.
5. Tremblay MS, Chaput JP, Adamo KB, et al. Canadian 24-Hour Movement Guidelines for the Early Years (0–4 years): An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *BMC Public Health* 2017;17:874.
6. Pate RR, Almeida MJ, McIver KL, et al. Validation and calibration of an accelerometer in preschool children. *Obesity (Silver Spring)* 2006;14:2000-6.
7. Bjornson KF. Physical activity monitoring in children and youths. *Pediatr Phys Ther* 2005;17:37-45.
8. Hnatiuk JA, Salmon J, Hinkley T, et al. A review of preschool children's physical activity and sedentary time using objective measures. *Am J Prev Med* 2014;47:487-97.
9. Troiano RP, Berrigan D, Dodd KW, et al. Physical activity in the United States

- 1  
2  
3 measured by accelerometer. *Med Sci Sports Exerc* 2008;40:181-88.  
4  
5  
6 10. Colley RC, Garriguet D, Janssen I, et al. Physical activity of Canadian children  
7  
8 and youth: accelerometer results from the 2007 to 2009 Canadian Health  
9  
10 Measures Survey. *Health Rep* 2011;22:15-23.  
11  
12  
13 11. Hesketh KD, Hinkley T, Campbell KJ. Children's physical activity and screen time:  
14  
15 qualitative comparison of views of parents of infants and preschool children. *Int J*  
16  
17 *Behav Nutr Phys Act* 2012;9:152.  
18  
19  
20 12. Colley RC, Garriguet D, Adamo KB, et al. Physical activity and sedentary  
21  
22 behavior during the early years in Canada: a cross-sectional study. *Int J Behav*  
23  
24 *Nutr Phys Act* 2013;10:54.  
25  
26  
27 13. Hinkley T, Salmon J, Okely AD, et al. Preschoolers' physical activity, screen time,  
28  
29 and compliance with recommendations. *Med Sci Sports Exerc* 2012;44:458-65.  
30  
31  
32 14. Bornstein DB, Beets MW, Byun W, et al. Accelerometer-derived physical activity  
33  
34 levels of preschoolers: a meta-analysis. *J Sci Med Sport* 2011;14:504-11.  
35  
36  
37 15. Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for  
38  
39 child overweight and obesity worldwide: international survey. *BMJ*  
40  
41 2000;320:1240-3.  
42  
43  
44 16. Choi L, Liu Z, Matthews CE, et al. Validation of accelerometer wear and nonwear  
45  
46 time classification algorithm. *Med Sci Sports Exerc* 2011;43:357-64.  
47  
48  
49 17. Hislop JF, Bulley C, Mercer TH, et al. Comparison of epoch and uniaxial versus  
50  
51 triaxial accelerometers in the measurement of physical activity in preschool  
52  
53 children: a validation study. *Pediatr Exerc Sci* 2012;24:450-60.  
54  
55  
56  
57  
58  
59  
60

- 1  
2  
3  
4 18. Moller NC, Christensen LB, Molgaard C, et al. Descriptive analysis of preschool  
5  
6 physical activity and sedentary behaviors - a cross sectional study of 3-year-olds  
7  
8 nested in the SKOT cohort. *BMC Public Health* 2017;17:613.  
9  
10  
11 19. Vale S, Santos R, Silva P, et al. Preschool children physical activity measurement:  
12  
13 importance of epoch length choice. *Pediatr Exerc Sci* 2009;21:413-20.  
14  
15  
16 20. Obeid J, Nguyen T, Gabel L, et al. Physical activity in Ontario preschoolers:  
17  
18 prevalence and measurement issues. *Appl Physiol Nutr Metab* 2011;36:291-97.  
19  
20  
21 21. Trost SG, Pate RR, Sallis JF, et al. Age and gender differences in objectively  
22  
23 measured physical activity in youth. *Med Sci Sports Exerc* 2002;34:350-5.  
24  
25  
26 22. Crespo NC, Corder K, Marshall S, et al. An examination of multilevel factors that  
27  
28 may explain gender differences in children's physical activity. *J Phys Act Health*  
29  
30 2013;10:982-92.  
31  
32  
33 23. Niederer I, Kriemler S, Zahner L, et al. BMI group-related differences in physical  
34  
35 fitness and physical activity in preschool-age children: a cross-sectional analysis.  
36  
37 *Res Q Exerc Sport* 2012;83:12-19.  
38  
39  
40 24. Tanaka C, Tanaka S. Objectively-measured physical activity and body weight in  
41  
42 Japanese pre-schoolers. *Ann Hum Biol* 2013;40:541-46.  
43  
44  
45 25. Tucker P, Maltby AM, Burke SM, et al. Comparing physical activity and sedentary  
46  
47 time among overweight and nonoverweight preschoolers enrolled in early  
48  
49 learning programs: a cross-sectional study. *Appl Physiol Nutr Metab*  
50  
51 2016;41:971-6.  
52  
53  
54  
55 26. Bornstein DB, Beets MW, Byun W, et al. Accelerometer-derived physical activity  
56  
57

- 1  
2  
3 levels of preschoolers: a meta-analysis. *J Sci Med Sport* 2011;14:504-11.  
4  
5  
6 27. Kahan D, Nicaise V, Reuben K. Convergent validity of four accelerometer  
7  
8 cutpoints with direct observation of preschool children's outdoor physical activity.  
9  
10  
11 *Res Q Exerc Sport* 2013;84:59-67.  
12  
13 28. Pfeiffer KA, Dowda M, McIver KL, et al. Factors related to objectively measured  
14  
15 physical activity in preschool children. *Pediatr Exerc Sci* 2009;21:196.  
16  
17  
18 29. Pate RR, O'Neill JR, Byun W, et al. Physical activity in preschool children:  
19  
20 comparison between Montessori and traditional preschools. *J Sch Health*  
21  
22 2014;84:716-21.  
23  
24  
25 30. Caldwell HA, Proudfoot NA, King-Dowling S, et al. Tracking of physical activity  
26  
27 and fitness during the early years. *Appl Physiol Nutr Metab* 2016;41:504-10.  
28  
29  
30 31. Pate RR, Brown WH, Pfeiffer KA, et al. An Intervention to Increase Physical  
31  
32 Activity in Children: A Randomized Controlled Trial With 4-Year-Olds in  
33  
34 Preschools. *Am J Prev Med* 2016;51:12-22.  
35  
36  
37 32. Barkin SL, Lamichhane AP, Banda JA, et al. Parent's Physical Activity Associated  
38  
39 With Preschooler Activity in Underserved Populations. *Am J Prev Med*  
40  
41 2017;52:424-32.  
42  
43  
44 33. French SA, Sherwood NE, Mitchell NR, et al. Park use is associated with less  
45  
46 sedentary time among low-income parents and their preschool child: The  
47  
48 NET-Works study. *Prev med rep* 2017;5:7-12.  
49  
50  
51 34. Leeger-Aschmann CS, Schmutz EA, Radtke T, et al. Regional sociocultural  
52  
53 differences as important correlate of physical activity and sedentary behaviour in  
54  
55  
56  
57  
58  
59  
60

- 1  
2  
3 Swiss preschool children. *Swiss Med Wkly* 2016;146:w14377.  
4  
5  
6 35. Vale S, Silva P, Santos R, et al. Compliance with physical activity guidelines in  
7  
8 preschool children. *J Sports Sci* 2010;28:603-08.  
9  
10  
11 36. Shanghai Preschool Education. Shanghai Preschool Education Curriculum Guide.  
12  
13 2004  
14  
15 <http://www.age06.com/Age06.web/Detail.aspx?CategoryID=e4b37c4b-499b-4cd>  
16  
17 [c-bb5e-e76d24ba0701&InfoGuid=c098a514-b66e-45a4-9457-a9676fa19bee2009](http://www.age06.com/Age06.web/Detail.aspx?CategoryID=e4b37c4b-499b-4cd)  
18  
19 (cited Aug 17 2018).  
20  
21  
22  
23 37. Ward DS, Vaughn A, McWilliams C, et al. Interventions for increasing physical  
24  
25 activity at child care. *Med Sci Sports Exerc* 2010;42:526-34.  
26  
27  
28 38. Reilly JJ, Kelly L, Montgomery C, et al. Physical activity to prevent obesity in  
29  
30 young children: cluster randomised controlled trial. *BMJ* 2006;333:1041.  
31  
32  
33 39. Trost SG, Fees B, Dzewaltowski D. Feasibility and efficacy of a "move and learn"  
34  
35 physical activity curriculum in preschool children. *J Phys Act Health*  
36  
37 2008;5:88-103.  
38  
39  
40 40. Fitzgibbon ML, Stolley MR, Schiffer LA, et al. Hip-Hop to Health Jr. Obesity  
41  
42 Prevention Effectiveness Trial: postintervention results. *Obesity (Silver Spring)*  
43  
44 2011;19:994-1003.  
45  
46  
47 41. Alhassan S, Sirard JR, Robinson TN. The effects of increasing outdoor play time  
48  
49 on physical activity in Latino preschool children. *Int J Pediatr Obes*  
50  
51 2007;2:153-8.  
52  
53  
54 42. Institute of Medicine. *Early childhood obesity prevention policies*. Washington,  
55  
56

- 1  
2  
3 DC: National Academies, 2011.  
4  
5  
6 43. Gao Z, Huang C, Liu T, et al. Impact of interactive dance games on urban  
7  
8 children's physical activity correlates and behavior. *J Exerc Sci Fit*  
9  
10 2012;10:107-12.  
11  
12  
13 44. Gao Z, Xiang P. Effects of exergaming based exercise on urban children's physical  
14  
15 activity participation and body composition. *J Phys Act Health* 2014;11:992-8.  
16  
17  
18 45. Gao Z, Pope Z, Lee JE, et al. Impact of exergaming on young children's school  
19  
20 day energy expenditure and moderate-to-vigorous physical activity levels. *J Sport*  
21  
22 *Health Sci* 2017;6:11-16.  
23  
24  
25 46. Cliff DP, Reilly JJ, Okely AD. Methodological considerations in using  
26  
27 accelerometers to assess habitual physical activity in children aged 0-5 years. *J*  
28  
29 *Sci Med Sport* 2010;12:557-67.  
30  
31  
32  
33 47. Rich C, Griffiths LJ, Dezateux C. Seasonal variation in accelerometer-determined  
34  
35 sedentary behaviour and physical activity in children: a review. *Int J Behav Nutr*  
36  
37 *Phys Act* 2012;9:49.  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



**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 <sup>2</sup>	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)	<b>498.3 ± 120.3*</b> (478.7–516.7)	<b>99.2 ± 18.4*</b> (96.8–102.0)	40.9 ± 9.7 (39.5–42.3)	<b>31.9 ± 10.7*</b> (30.4–33.4)	<b>72.8 ± 18.8*</b> (70.1–75.4)	<b>171.9 ± 34.0*</b> (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)	<b>471.0 ± 117.4<sup>†</sup></b> (457.8–484.6)	96.4 ± 17.9 (94.5–98.3)	<b>39.3 ± 9.3<sup>†</sup></b> (38.3–40.4)	30.9 ± 9.9 (29.9–32.1)	70.2 ± 17.5 (68.4–72.1)	<b>166.6 ± 32.3<sup>†</sup></b> (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; <sup>†</sup>  $p < .05$ , 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:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotsche PC, Vandembroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

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

1		<a href="#">#7</a>	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 /	<a href="#">#8</a>	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				
12				
13				
14	Bias	<a href="#">#9</a>	Describe any efforts to address potential sources of bias	6
15				
16				
17	Study size	<a href="#">#10</a>	Explain how the study size was arrived at	8
18				
19	Quantitative	<a href="#">#11</a>	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	<a href="#">#12a</a>	Describe all statistical methods, including those used to control	8
24	methods		for confounding	
25				
26				
27		<a href="#">#12b</a>	Describe any methods used to examine subgroups and	none
28			interactions	
29				
30				
31		<a href="#">#12c</a>	Explain how missing data were addressed	none
32				
33		<a href="#">#12d</a>	If applicable, describe analytical methods taking account of	8
34			sampling strategy	
35				
36				
37		<a href="#">#12e</a>	Describe any sensitivity analyses	none
38				
39	Participants	<a href="#">#13a</a>	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.	
44				
45				
46				
47		<a href="#">#13b</a>	Give reasons for non-participation at each stage	8
48				
49				
50		<a href="#">#13c</a>	Consider use of a flow diagram	none
51				
52	Descriptive data	<a href="#">#14a</a>	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.	
56				
57				
58				
59				
60				

1		<a href="#">#14b</a>	Indicate number of participants with missing data for each	9
2			variable of interest	
3				
4				
5	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give	9
6			information separately for exposed and unexposed groups if	
7			applicable.	
8				
9				
10	Main results	<a href="#">#16a</a>	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		<a href="#">#16b</a>	Report category boundaries when continuous variables were	10-11
18			categorized	
19				
20				
21		<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into	none
22			absolute risk for a meaningful time period	
23				
24	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and	none
25			interactions, and sensitivity analyses	
26				
27				
28	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	12-13
29				
30				
31	Limitations	<a href="#">#19</a>	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	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives,	10-13
37			limitations, multiplicity of analyses, results from similar studies,	
38			and other relevant evidence.	
39				
40				
41	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	14
42				
43				
44	Funding	<a href="#">#22</a>	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				

49 The STROBE checklist is distributed under the terms of the Creative Commons Attribution License  
50 CC-BY. This checklist can be completed online using <https://www.goodreports.org/>, a tool made by  
51 the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)  
52  
53  
54  
55  
56  
57  
58  
59

# BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-024090.R2
Article Type:	Research
Date Submitted by the Author:	03-Dec-2018
Complete List of Authors:	<p>Quan, minghui; Shanghai University of Sport, School of kinesiology  Zhang, Hanbin; Zhejiang Provincial People's Hospital, Health Promotion Center  Zhang, Jiayi; China Science Publishing and Media Ltd., Editorial Department of Medicine and Health  Zhou, Tang; Shanghai University of Sport, School of kinesiology  Zhang, Jinming; Taishan Medical University, College of Sport Medicine and Rehabilitation  Zhao, Guanggao; Nanchang University, Department of Physical Education  Fang, Hui; Shanghai University of Sport, School of kinesiology  Sun, Shunli; Shanghai University of Sport, School of kinesiology  Wang, Ru; Shanghai University of Sport, School of Kinesiology  Chen, Peijie; Shanghai University of Sport, School of kinesiology</p>
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Public health, Paediatrics
Keywords:	accelerometry, physical activity, preschool children

SCHOLARONE™  
Manuscripts

1  
2  
3  
4 **Are preschool children active enough in Shanghai—An accelerometer-based**  
5  
6 **cross-sectional study**  
7  
8  
9

10  
11 Minghui Quan<sup>1</sup>, Hanbin Zhang<sup>2</sup>, Jiayi Zhang<sup>3</sup>, Tang Zhou<sup>1</sup>, Jinming Zhang<sup>4</sup>, Guanggao  
12  
13 Zhao<sup>5</sup>, Hui Fang<sup>1</sup>, Shunli Sun<sup>1</sup>, Ru Wang<sup>1,\*</sup>, Peijie Chen<sup>1,\*</sup>  
14  
15  
16

- 17  
18  
19  
20 1. School of kinesiology, Shanghai University of Sport, Shanghai 200438, China.  
21  
22 2. Health Promotion Center, Zhejiang Provincial People's Hospital, Hangzhou,  
23  
24 Zhejiang 310014, China.  
25  
26 3. Editorial Department of Medicine and Health, China Science Publishing and Media  
27  
28 Ltd., Shanghai 200032, China.  
29  
30 4. Department of Kinesiology, College of Sport Medicine and Rehabilitation, Taishan  
31  
32 Medical University, Taian, Shandong 271016, China.  
33  
34 5. Department of Physical Education, Nanchang University, Nanchang, Jiangxi 330031,  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

**\*Corresponding author:**

Professor Ru Wang; Phone: 86-21-65507323; E-mail: wangru0612@163.com

Professor Peijie Chen; Phone: 86-21-65508039; E-mail: chenpeijie@sus.edu.cn

**Word counts:** Abstract: 226; Body of manuscript: 2574.



## 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.

1  
2  
3  
4 23 **Strength and limitation of this study**  
5

6 24 ● Objective measures of daily physical activity were obtained by accelerometers in  
7  
8 25 a sample of preschool children from Shanghai, China.  
9

10  
11 26 ● Daily physical activity levels in Shanghai preschool children were evaluated by  
12  
13 27 both moderate to vigorous physical activity and activity at any intensity  
14  
15 28 recommended guidelines.  
16

17 29 ● For feasibility, this study sample was not a random sample recruited from the  
18  
19 30 population.  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## 31 INTRODUCTION

32 Engaging in physical activity (PA) play an important role in promoting physical,  
33 psychological, and cognitive health.<sup>1</sup> Moreover, establishing robust PA habits in  
34 childhood has positive long-term effects on lifestyle that persist into adulthood,<sup>2</sup>  
35 including reducing the risk of chronic diseases, such as coronary artery disease,  
36 diabetes, stroke, and hypertension.<sup>3 4</sup> 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.<sup>5</sup>

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.<sup>6</sup> 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,<sup>7</sup> which were  
48 considered to be more important to achieve health benefits based on the current PA  
49 guideline.<sup>5</sup> Thus, accelerometers have become increasingly popular as a feasible  
50 strategy for capturing preschoolers' movement behavior accurately.<sup>8</sup> 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

1  
2  
3  
4 53 national health survey with large sample size.<sup>9 10</sup>  
5  
6

7 54 Although there is a perception that preschool children are constantly active,<sup>11</sup>  
8  
9 55 accelerometer-based evidence does not support this presumption for all children. In a  
10  
11 56 sample of 3–5-year-old Canadian children, only 13.7% of participants met the PA  
12  
13  
14 57 recommendation for at least 60 min per day of MVPA.<sup>12</sup> In a similar study of  
15  
16  
17 58 Australian preschool aged children, 22% of the sample met this guideline.<sup>13</sup>  
18  
19 59 Moreover, a meta-analysis of 29 reports encompassing 6,309 preschool children in  
20  
21  
22 60 Canada and Australia yielded an average daily MVPA of only 42.8 (95% CI: 28.9–  
23  
24  
25 61 56.8) min.<sup>14</sup> As of yet, objectively-measured PA data for Chinese preschool children  
26  
27  
28 62 are lacking. However, a questionnaire-based national survey in China reported that  
29  
30  
31 63 only 29.9% of the children and youth met the guideline of PA.<sup>15</sup> This phenomenon of  
32  
33  
34 64 lack of PA in children and youth may be more pronounced in the developed region.  
35  
36  
37 65 Take Shanghai, a highly-developed city in China, for example, it was only 18.4% of  
38  
39  
40 66 children and youth met the PA guideline in a representative sample.<sup>16</sup> Considered  
41  
42  
43 67 accelerometer-based PA data for Chinese preschool children are lacking so far, and  
44  
45  
46 68 the facts that many health-related benefits are achieved by regular PA. There is urgent  
47  
48  
49 69 need to objectively assess the PA levels in Chinese preschool children, especially in  
50  
51  
52 70 the developed regions like Shanghai.

53 71 Therefore, the aim of this study was to assess PA levels objectively in a sample  
54  
55  
56 72 of preschool aged children in Shanghai, China with accelerometers and to determine  
57  
58  
59 73 the proportion of children meeting the aforementioned age-specific PA  
60  
61  
62 74 recommendations. Findings of this study will help us to understand the levels of PA

1  
2  
3  
4 75 from a sample of Shanghai, which may serve as a foundation for making strategies to  
5  
6 76 maintain or promote PA for preschool children.  
7  
8

9 77

## 10 11 78 **MATERIALS AND METHODS**

### 12 13 14 79 **Participants**

15  
16  
17 80 This cross-sectional study forms a baseline dataset for The Physical Activity and  
18  
19 81 Cognitive Function Study (Trial registration: ChiCTR-OOC-15007439), in which a  
20  
21  
22 82 convenience sample of 346 participants (boys, 201; girls, 145) were recruited from  
23  
24  
25 83 eight kindergarten classes in the Yangpu and Baoshan Districts of Shanghai, China.

26  
27 84 After contacting the kindergarten director by phone and interested in this study,  
28  
29  
30 85 the aims and procedures of this study were explained comprehensively to the  
31  
32  
33 86 parents/guardians of all potential participants by parents' meeting held in the  
34  
35  
36 87 kindergarten, including the right to withdraw from the study at any time. Parents  
37  
38  
39 88 interested in having their child participate subsequently signed an informed consent  
40  
41  
42 89 document. The inclusion criteria for the participants in this study were: (1) aged 3-6  
43  
44  
45 90 years; (2) without a diagnosed physical and mental disability; and (3) with signed  
46  
47  
48 91 informed consent from the participants' parents/guardians. This study was approved  
49  
50  
51 92 by the Ethics Advisory Committee of Shanghai University of Sport.

52 93

### 53 94 **Procedures**

54  
55  
56 95 Before accelerometer data collection, parents or guardians were instructed on the  
57  
58  
59 96 proper way to wear and remove the accelerometers by trained research staff. Parents  
60

1  
2  
3  
4 97 or guardians agreed to have their children wear the accelerometers during all waking,  
5  
6 98 including water-based activities such as bathing and swimming. And, Parents or  
7  
8  
9 99 guardians asked to encourage their children to wear them as much as possible during  
10  
11 100 their school hours. The accelerometers were collected at the end of a consecutive 7-d  
12  
13  
14 101 study period, and the accelerometer data were transferred to a computer via ActiLife  
15  
16  
17 102 version 6.11.6 software.

## 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/m<sup>2</sup>). 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.<sup>17</sup>

### 113 Physical activity data

114 PA was assessed with GT3X<sup>+</sup> 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;<sup>18</sup>  
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

1  
2  
3  
4 119 these criteria, 43 participants were excluded from the final analysis.  
5

6 120 Data were collected in 1-second epochs, because short epochs have been  
7  
8  
9 121 recommended for capturing movement behavior in this age group.<sup>19</sup> Raw output was  
10  
11 122 expressed as counts per minute (CPM), and cut-off count levels previously developed  
12  
13 123 for preschool children by Pate and colleagues were used to analyze MVPA time.<sup>6</sup> We  
14  
15 124 classified PA into three levels: light (LPA), 101–1679 CPMs; moderate (MPA),  
16  
17 125 1680–3367 CPMs; and vigorous (VPA),  $\geq 3368$  CPMs. Total physical activity (TPA)  
18  
19 126 was calculated as the sum of LPA, MPA, and VPA time periods. PA values were  
20  
21 127 compared to the established recommendations of  $\geq 60$  min of MVPA or  $\geq 180$  min of  
22  
23 128 PA at any intensity to evaluate the proportion of participants meeting these  
24  
25 129 recommendations.  
26  
27  
28  
29  
30  
31

### 32 130 33 34 35 131 **Data analysis**

36  
37 132 Assuming the coefficient of variation (CV) of MVPA ( $CV = 0.28$ ) based on the  
38  
39 133 previous study,<sup>20</sup> confidence level as 95%, and 5% level of precision, the required  
40  
41 134 sample size was at least 125 in this study. The data are reported as means  $\pm$  standard  
42  
43 135 deviations (SDs) for normally distributed variables or as medians with interquartile  
44  
45 136 ranges (IQRs) for non-normally distributed variables. Independent *t* tests, Mann-  
46  
47 137 Whitney *U* tests, and chi-square tests were used to assess gender differences in  
48  
49 138 characteristics for normally distributed, non-normally distributed, and categorical  
50  
51 139 variables, respectively. When necessary, PA data were normalized by a log or square  
52  
53 140 root methods prior to analysis. Differences in PA by gender and day were determined  
54  
55  
56  
57  
58  
59  
60

1  
2  
3  
4 141 with independent *t* tests, and differences in PA by BMI category were determined by  
5  
6 142 one-way analysis of variance (ANOVA) with Bonferroni *post hoc* tests. Analyses  
7  
8  
9 143 were performed in SPSS version 22.0 (IBM Inc., Armonk, NY). A two-sided *P* value  
10  
11  
12 144  $\leq .05$  was considered statistically significant.  
13  
14  
15  
16

#### 17 146 **Patient and public involvement**

18  
19 147 No patients or public were involved in this study.  
20  
21  
22

## 23 149 **RESULTS**

### 24 25 26 150 **Characteristics of participants**

27  
28  
29 151 The descriptive characteristics of the 303 participants included in the present  
30  
31 152 cohort analysis are shown in **Table 1**. Weight, BMI, and the proportion of  
32  
33 153 overweight/obese children were significantly higher in boys than in girls.  
34  
35  
36  
37  
38

### 39 155 **The amount of different intensities of PA**

40  
41  
42 156 On average, the number of valid accelerometer days among participants was 6.3  
43  
44 157 days (95%CI = 6.2–6.4 d), and the mean duration of wear time across all valid days  
45  
46 158 was 748.7 min/d (95%CI = 740.3–756.7 min/d). The actual and percent time spent  
47  
48  
49 159 engaged in CPM and each PA intensity level are presented in **Table 2**. On average,  
50  
51  
52 160 participants in this study accumulated 168.0 min/d of TPA, and spent 13.0% (~97.2  
53  
54 161 min) of their daily waking time engaged in LPA and 9.5% (~70.9 min) of their days  
55  
56  
57 162 was spent engaged in MVPA. In general, boys were more active than girls, and  
58  
59  
60 163 participants engaged in more PA on weekend days than on week days. No significant



1  
2  
3  
4 164 difference in PA was identified with respect to BMI category.  
5  
6

7 165  
8

### 9 166 **Meeting the current PA recommendations**

10  
11 167 There were 72.9% of the participants met the MVPA recommendation that spent  
12  
13  
14 168 at least 60 min/d engaged in MVPA across all valid days, while only 35.3% of the  
15  
16  
17 169 participants met the TPA recommendation that accumulated at least 180 min/d of PA  
18  
19  
20 170 at any intensity. Boys met the PA recommendations more frequently than girls (**Table**  
21  
22 171 **3**).  
23  
24

25 172  
26

## 27 173 **DISCUSSION**

28  
29  
30 174 In this accelerometer-based cross-sectional study of preschool children in  
31  
32  
33 175 Shanghai, we found that, on average, boys accumulated 72.8 min/d of MVPA and  
34  
35 176 171.9 min/d of TPA, while girls accumulated 68.3 min/d of MVPA and 162.9 min/d  
36  
37  
38 177 of TPA. At least 27% of the participants did not meet the established PA guidelines.  
39

40 178  
41

### 42 43 179 **PA status of Shanghai preschoolers**

44  
45 180 Approximately 73% of participants in our Shanghai cohort met the  
46  
47  
48 181 recommendation of spending more than 60 min/d engaged in MVPA. However, less  
49  
50  
51 182 than 36% accumulated at least 180 min/d of TPA. The gap between these proportions  
52  
53  
54 183 is due largely to the shift from intensity to volume. The short 1-second sampling  
55  
56 184 intervals used in this study may have resulted in an underestimation of LPA time,  
57  
58 185 which would then yield an underestimation of TPA time, relative to, for example, a  
59  
60

1  
2  
3  
4 186 15-second epoch. A longer epoch is more likely to result in an underestimation of  
5  
6 187 MVPA and an overestimation of LPA in young children.<sup>21</sup> Notably, a Canadian study  
7  
8  
9 188 with a much longer 60-second epoch found that 83.8% of young children met the 180  
10  
11 189 min/d TPA guideline,<sup>12</sup> while only 13.7% engaged in at least 60 min/d of MVPA.  
12  
13  
14 190 This methodological inconsistency makes it quite difficult to conduct reliable inter-  
15  
16  
17 191 study comparisons. Here, we chose a shorter epoch because it has been recommended  
18  
19 192 for capturing movement in young children owing to the particularly sporadic and  
20  
21  
22 193 intermittent nature of activity exhibited by children in this age group.<sup>22</sup>  
23  
24  
25  
26

#### 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.<sup>14</sup> 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.<sup>23</sup> Meanwhile, Crespo et al. found that familial, social, and environmental  
201 characteristics correlated with higher MVPA in boys than in girls.<sup>24</sup> 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.<sup>25</sup> Furthermore, the opposite  
207 findings are more likely to be true in some studies.<sup>26 27</sup> These negative findings

1  
2  
3  
4 208 suggest that other factors, such as diet and genetic background, play more important  
5  
6 209 roles in body weight. Future studies are needed to identify the relative importance of  
7  
8  
9 210 and interactions among PA, diet, and genetics for weight status.  
10

11 Our observation of greater PA on weekend days than on weekdays may be  
12  
13  
14 212 explained by participants having more opportunities to engage in PA on non-school  
15  
16  
17 213 days. Further studies should investigate and compare the specific activities engaged in  
18  
19  
20 214 on school days versus weekend days.  
21

22 215

### 23 24 25 216 **PA in Shanghai preschool children versus children elsewhere**

26  
27 217 Given the important of PA for physical, psychological, and cognitive health,<sup>1</sup>  
28  
29  
30 218 there is an increasing body of research focusing on the PA levels on preschool  
31  
32  
33 219 children from different population. Findings from a meta-analysis identified 29  
34  
35 220 studies indicated preschoolers' accelerometer-derived PA ranged from 19 min/d to  
36  
37  
38 221 281 min/d.<sup>28</sup> However, the amounts of PA across different intensity levels varied  
39  
40  
41 222 widely depending upon the assessment methodology selected, with MVPA cut-off  
42  
43  
44 223 CPM levels having a particularly large effect on PA results.<sup>29</sup> Therefore, it is more  
45  
46 224 reasonable to compare the results that using the same cut-off value for PA levels.  
47  
48 225 Unfortunately, the amount of time spent engaged in MVPA in Shanghai preschool  
49  
50  
51 226 children lower than data for the most prior populations assessed with the same cut-off  
52  
53  
54 227 CPM levels by Pate (Range: 35.3-100.0 min/d; Median: 94.9 min/d).<sup>20 25 30-37</sup> The  
55  
56 228 pattern of our TPA results was comparable to that of the MVPA results (Range: 73.7-  
57  
58  
59 229 394.0 min/d; Median: 348.0 min/d).<sup>20 30-37</sup>  
60

1  
2  
3  
4 230 Obviously, the results of this cross-sectional study indicate that Shanghai  
5  
6 231 preschool children tend to have insufficient PA, and less PA than other populations  
7  
8  
9 232 examined with the same cut-off CPM levels. Although the current Shanghai Preschool  
10  
11 233 Education Curriculum Guide requires daily outdoor activities for preschool children  
12  
13  
14 234 to be no less than two hours,<sup>38</sup> we also suggest that interventions and policies may be  
15  
16  
17 235 needed to promote PA in Shanghai preschool children based on the data in this study.  
18  
19 236 Similar to children, adolescents and adults, a variety of settings can promote the level  
20  
21  
22 237 of PA in children aged 3-5. However, in the early childhood stage, preschool is an  
23  
24  
25 238 important settings for the promotion of PA.<sup>39</sup> Although the findings of PA  
26  
27  
28 239 intervention on preschool setting are inconsistent,<sup>40-43</sup> the extant literatures also  
29  
30  
31 240 provide us with some strategies that may be useful for promoting PA levels of young  
32  
33  
34 241 children. These included: (1) increasing time of outdoor activities, (2) providing  
35  
36  
37 242 materials that are easy to get and play, such as balls and hula hoops, and (3) activities  
38  
39  
40 243 held both indoor and outdoor by teacher-planned.<sup>44</sup> Furthermore, there was a growing  
41  
42  
43 244 evidence that technology applications, such as exergaming, seem to be an effective  
44  
45  
46 245 approach to promote PA levels in children.<sup>45-47</sup> It should be noted that technology  
47  
48  
49 246 applications may be a viable supplemental way to promote PA levels in young  
50  
51  
52 247 children in preschool-based setting.

248

### 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

1  
2  
3  
4 252 with other PA measurements. Additionally, our PA data were evaluated relative to  
5  
6  
7 253 both MVPA and TPA recommended guidelines.  
8

9 254 This study had some limitations. First, for sampling feasibility, all participants  
10  
11 255 were recruited from Northeast Shanghai. Thus, it remains to be determined whether  
12  
13  
14 256 similar findings would be obtained for children in other regions of Shanghai. Second,  
15  
16  
17 257 the accelerometer was worn over the right hip limited to capture activities with little  
18  
19  
20 258 displacement of the body, such as cycling. However, hip was probably the best  
21  
22  
23 259 placement to capture whole-body movements and on the side of the hip was also the  
24  
25 260 most often site by various studies.<sup>48</sup> Third, the accelerometer-based PA collection  
26  
27  
28 261 process spans different seasons that may have an impact on the result, although the  
29  
30  
31 262 seasonal variation in accelerometer-determined PA was not always observed in  
32  
33 263 different region's studies.<sup>49</sup>  
34

35 264

## 37 265 **CONCLUSIONS**

39  
40 266 At least 27% of preschool children in Shanghai did not meet current age-specific  
41  
42  
43 267 PA recommendations and preschool children in Shanghai were less active than most  
44  
45  
46 268 of the populations assessed in comparable studies. Findings of this study implication  
47  
48  
49 269 that there remains a lot of room for improvement in PA behaviors among preschool  
50  
51  
52 270 children in Shanghai, suggesting that public health interventions and policies  
53  
54  
55 271 regarding PA should be explored to promote PA levels in Shanghai preschoolers  
56  
57  
58 272 given that the development of active lifestyle behaviors early in life are believed to  
59  
60 273 yield health benefits that extend into adulthood.

## **Acknowledgements**

We thank all the participants and kindergarten very much for their collaboration.

## **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.

## **Funding**

This work was supported by grants from the Science and Technology Commission of Shanghai Municipality, China (12XD1404500), the Humanity and Social Science Youth Foundation of the Ministry of Education of China (15YJC890029, 17YJC890036), National Natural Science Foundation of China (81703252), and a grant from the China Postdoctoral Science Foundation funded project (2017M620160).

## **Potential conflicts of interest**

The authors declare that they have no conflicts to report.

1  
2  
3  
4 **Data sharing statement**  
5

6 No additional data are available.  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For peer review only

**REFERENCES**

1. Poitras VJ, Gray CE, Borghese MM, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab* 2016;41(6 Suppl 3):S197-239.
2. Telama R, Yang X, Leskinen E, et al. Tracking of physical activity from early childhood through youth into adulthood. *Med Sci Sports Exerc* 2014;46(5):955-62.
3. Booth FW, Laye MJ, Lees SJ, et al. Reduced physical activity and risk of chronic disease: the biology behind the consequences. *Eur J Appl Physiol* 2008;102(4):381-90.
4. Durstine JL, Gordon B, Wang Z, et al. Chronic disease and the link to physical activity. *J Sport Health Sci* 2013;2(1):3-11.
5. Tremblay MS, Chaput JP, Adamo KB, et al. Canadian 24-Hour Movement Guidelines for the Early Years (0–4 years): An Integration of Physical Activity, Sedentary Behaviour, and Sleep. *BMC Public Health* 2017;17(Suppl 5):874.
6. Pate RR, Almeida MJ, McIver KL, et al. Validation and calibration of an accelerometer in preschool children. *Obesity (Silver Spring)* 2006;14(11):2000-6.
7. Bjornson KF. Physical activity monitoring in children and youths. *Pediatric Physical Therapy* 2005;17(1):37-45.
8. Hnatiuk JA, Salmon J, Hinkley T, et al. A review of preschool children's physical activity and sedentary time using objective measures. *Am J Prev Med* 2014;47(4):487-97.
9. Troiano RP, Berrigan D, Dodd KW, et al. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc* 2008;40(6):181-88.



- 1  
2  
3  
4 10. Colley RC, Garriguet D, Janssen I, et al. Physical activity of Canadian children and  
5  
6 youth: accelerometer results from the 2007 to 2009 Canadian Health Measures  
7  
8 Survey. *Health Rep* 2011;22(1):15-23.  
9  
10  
11 11. Hesketh KD, Hinkley T, Campbell KJ. Children's physical activity and screen time:  
12  
13 qualitative comparison of views of parents of infants and preschool children. *Int J*  
14  
15 *Behav Nutr Phys Act* 2012;9(1):152.  
16  
17  
18 12. Colley RC, Garriguet D, Adamo KB, et al. Physical activity and sedentary behavior  
19  
20 during the early years in Canada: a cross-sectional study. *Int J Behav Nutr Phys*  
21  
22 *Act* 2013;10:54.  
23  
24  
25 13. Hinkley T, Salmon J, Okely AD, et al. Preschoolers' physical activity, screen time,  
26  
27 and compliance with recommendations. *Med Sci Sports Exerc* 2012;44(3):458-65.  
28  
29  
30 14. Bornstein DB, Beets MW, Byun W, et al. Accelerometer-derived physical activity  
31  
32 levels of preschoolers: a meta-analysis. *J Sci Med Sport* 2011;14(6):504-11.  
33  
34  
35 15. Fan X, Cao ZB. Physical activity among Chinese school-aged children: National  
36  
37 prevalence estimates from the 2016 Physical Activity and Fitness in China-The  
38  
39 Youth Study. *J Sport Health Sci* 2017;6(4):388-94.  
40  
41  
42 16. Chen ST, Liu Y, Hong JT, et al. Co-existence of physical activity and sedentary  
43  
44 behavior among children and adolescents in Shanghai, China: do gender and age  
45  
46 matter? *BMC Public Health* 2018;18(1):1287.  
47  
48  
49  
50  
51  
52 17. Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for child  
53  
54 overweight and obesity worldwide: international survey. *BMJ*  
55  
56 2000;320(7244):1240-3.  
57  
58  
59  
60

- 1  
2  
3  
4 18. Choi L, Liu Z, Matthews CE, et al. Validation of accelerometer wear and nonwear  
5  
6 time classification algorithm. *Med Sci Sports Exerc* 2011;43(2):357-64.  
7  
8  
9 19. Hislop JF, Bulley C, Mercer TH, et al. Comparison of epoch and uniaxial versus  
10  
11 triaxial accelerometers in the measurement of physical activity in preschool  
12  
13 children: a validation study. *Pediatr Exerc Sci* 2012;24(3):450-60.  
14  
15  
16 20. Moller NC, Christensen LB, Molgaard C, et al. Descriptive analysis of preschool  
17  
18 physical activity and sedentary behaviors - a cross sectional study of 3-year-olds  
19  
20 nested in the SKOT cohort. *BMC Public Health* 2017;17(1):613.  
21  
22  
23 21. Vale S, Santos R, Silva P, et al. Preschool children physical activity measurement:  
24  
25 importance of epoch length choice. *Pediatric Exercise Science* 2009;21(4):413-20.  
26  
27  
28 22. Obeid J, Nguyen T, Gabel L, et al. Physical activity in Ontario preschoolers:  
29  
30 prevalence and measurement issues. *Applied physiology, nutrition, and metabolism*  
31  
32 2011;36(2):291-97.  
33  
34  
35 23. Trost SG, Pate RR, Sallis JF, et al. Age and gender differences in objectively  
36  
37 measured physical activity in youth. *Med Sci Sports Exerc* 2002;34(2):350-5.  
38  
39  
40 24. Crespo NC, Corder K, Marshall S, et al. An examination of multilevel factors that  
41  
42 may explain gender differences in children's physical activity. *J Phys Act Health*  
43  
44 2013;10(7):982-92.  
45  
46  
47 25. Niederer I, Kriemler S, Zahner L, et al. BMI group-related differences in physical  
48  
49 fitness and physical activity in preschool-age children: a cross-sectional analysis.  
50  
51 *Res Q Exerc Sport* 2012;83(1):12-19.  
52  
53  
54 26. Tanaka C, Tanaka S. Objectively-measured physical activity and body weight in  
55  
56  
57  
58  
59  
60

- 1  
2  
3  
4 Japanese pre-schoolers. *Ann Hum Biol* 2013;40(6):541-46.  
5  
6  
7 27. Tucker P, Maltby AM, Burke SM, et al. Comparing physical activity and sedentary  
8  
9 time among overweight and nonoverweight preschoolers enrolled in early learning  
10  
11 programs: a cross-sectional study. *Appl Physiol Nutr Metab* 2016;41(9):971-6.  
12  
13  
14 28. Bornstein DB, Beets MW, Byun W, et al. Accelerometer-derived physical activity  
15  
16 levels of preschoolers: a meta-analysis. *Journal of Science & Medicine in Sport*  
17  
18 2011;14(6):504-11.  
19  
20  
21 29. Kahan D, Nicaise V, Reuben K. Convergent validity of four accelerometer cutpoints  
22  
23 with direct observation of preschool children's outdoor physical activity. *Research*  
24  
25 *Quarterly for Exercise & Sport* 2013;84(1):59-67.  
26  
27  
28  
29 30. Pfeiffer KA, Dowda M, McIver KL, et al. Factors related to objectively measured  
30  
31 physical activity in preschool children. *Pediatr Exerc Sci* 2009;21(2):196.  
32  
33  
34 31. Pate RR, O'Neill JR, Byun W, et al. Physical activity in preschool children:  
35  
36 comparison between Montessori and traditional preschools. *J Sch Health*  
37  
38 2014;84(11):716-21.  
39  
40  
41  
42 32. Caldwell HA, Proudfoot NA, King-Dowling S, et al. Tracking of physical activity  
43  
44 and fitness during the early years. *Appl Physiol Nutr Metab* 2016;41(5):504-10.  
45  
46  
47 33. Pate RR, Brown WH, Pfeiffer KA, et al. An Intervention to Increase Physical  
48  
49 Activity in Children: A Randomized Controlled Trial With 4-Year-Olds in  
50  
51 Preschools. *Am J Prev Med* 2016;51(1):12-22.  
52  
53  
54  
55 34. Barkin SL, Lamichhane AP, Banda JA, et al. Parent's Physical Activity Associated  
56  
57 With Preschooler Activity in Underserved Populations. *Am J Prev Med*  
58  
59  
60

- 2017;52(4):424-32.
35. French SA, Sherwood NE, Mitchell NR, et al. Park use is associated with less sedentary time among low-income parents and their preschool child: The NET-Works study. *Preventive medicine reports* 2017;5:7-12.
36. Leeger-Aschmann CS, Schmutz EA, Radtke T, et al. Regional sociocultural differences as important correlate of physical activity and sedentary behaviour in Swiss preschool children. *Swiss Med Wkly* 2016;146:w14377.
37. Vale S, Silva P, Santos R, et al. Compliance with physical activity guidelines in preschool children. *J Sports Sci* 2010;28(6):603-08.
38. Website SPE. Shanghai Preschool Education Curriculum Guide 2004 [Available from: <http://www.age06.com/Age06.web/Detail.aspx?CategoryID=e4b37c4b-499b-4cdc-bb5e-e76d24ba0701&InfoGuid=c098a514-b66e-45a4-9457-a9676fa19bee2009>].
39. Ward DS, Vaughn A, McWilliams C, et al. Interventions for increasing physical activity at child care. *Med Sci Sports Exerc* 2010;42(3):526-34.
40. Reilly JJ, Kelly L, Montgomery C, et al. Physical activity to prevent obesity in young children: cluster randomised controlled trial. *BMJ* 2006;333(7577):1041.
41. Trost SG, Fees B, Dzewaltowski D. Feasibility and efficacy of a "move and learn" physical activity curriculum in preschool children. *J Phys Act Health* 2008;5(1):88-103.
42. Fitzgibbon ML, Stolley MR, Schiffer LA, et al. Hip-Hop to Health Jr. Obesity Prevention Effectiveness Trial: postintervention results. *Obesity (Silver Spring)*

- 2011;19(5):994-1003.
43. Alhassan S, Sirard JR, Robinson TN. The effects of increasing outdoor play time on physical activity in Latino preschool children. *Int J Pediatr Obes* 2007;2(3):153-8.
44. Medicine Io. Early Childhood Obesity Prevention Policies. . Washington, DC: The National Academies Press 2011.
45. Gao Z, Huang C, Liu T, et al. Impact of interactive dance games on urban children's physical activity correlates and behavior. *Journal of Exercise Science & Fitness* 2012;10(2):107-12.
46. Gao Z, Xiang P. Effects of exergaming based exercise on urban children's physical activity participation and body composition. *J Phys Act Health* 2014;11(5):992-8.
47. Gao Z, Pope Z, Lee JE, et al. Impact of exergaming on young children's school day energy expenditure and moderate-to-vigorous physical activity levels. *Journal of Sport and Health Science* 2017;6(1):11-16.
48. Cliff DP, Reilly JJ, Okely AD. Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0-5 years. *Journal of Science & Medicine in Sport* 2010;12(5):557-67.
49. Rich C, Griffiths LJ, Dezateux C. Seasonal variation in accelerometer-determined sedentary behaviour and physical activity in children: a review. *Int J Behav Nutr Phys Act* 2012;9:49.

**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 <sup>2</sup>	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)	<b>498.3 ± 120.3*</b> (478.7–516.7)	<b>99.2 ± 18.4*</b> (96.8–102.0)	40.9 ± 9.7 (39.5–42.3)	<b>31.9 ± 10.7*</b> (30.4–33.4)	<b>72.8 ± 18.8*</b> (70.1–75.4)	<b>171.9 ± 34.0*</b> (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)	<b>471.0 ± 117.4†</b> (457.8–484.6)	96.4 ± 17.9 (94.5–98.3)	<b>39.3 ± 9.3†</b> (38.3–40.4)	30.9 ± 9.9 (29.9–32.1)	70.2 ± 17.5 (68.4–72.1)	<b>166.6 ± 32.3†</b> (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:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

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

1		<a href="#">#7</a>	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 /	<a href="#">#8</a>	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				
12				
13				
14	Bias	<a href="#">#9</a>	Describe any efforts to address potential sources of bias	6
15				
16				
17	Study size	<a href="#">#10</a>	Explain how the study size was arrived at	8
18				
19	Quantitative	<a href="#">#11</a>	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	<a href="#">#12a</a>	Describe all statistical methods, including those used to control	8
24	methods		for confounding	
25				
26				
27		<a href="#">#12b</a>	Describe any methods used to examine subgroups and	none
28			interactions	
29				
30				
31		<a href="#">#12c</a>	Explain how missing data were addressed	none
32				
33		<a href="#">#12d</a>	If applicable, describe analytical methods taking account of	8
34			sampling strategy	
35				
36				
37		<a href="#">#12e</a>	Describe any sensitivity analyses	none
38				
39	Participants	<a href="#">#13a</a>	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.	
44				
45				
46				
47		<a href="#">#13b</a>	Give reasons for non-participation at each stage	8
48				
49				
50		<a href="#">#13c</a>	Consider use of a flow diagram	none
51				
52	Descriptive data	<a href="#">#14a</a>	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.	
56				
57				
58				
59				
60				

1		<a href="#">#14b</a>	Indicate number of participants with missing data for each	9
2			variable of interest	
3				
4				
5	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give	9
6			information separately for exposed and unexposed groups if	
7			applicable.	
8				
9				
10	Main results	<a href="#">#16a</a>	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		<a href="#">#16b</a>	Report category boundaries when continuous variables were	10-11
18			categorized	
19				
20				
21		<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into	none
22			absolute risk for a meaningful time period	
23				
24	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and	none
25			interactions, and sensitivity analyses	
26				
27				
28	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	12-13
29				
30				
31	Limitations	<a href="#">#19</a>	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	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives,	10-13
37			limitations, multiplicity of analyses, results from similar studies,	
38			and other relevant evidence.	
39				
40				
41	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	14
42				
43				
44	Funding	<a href="#">#22</a>	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				

49 The STROBE checklist is distributed under the terms of the Creative Commons Attribution License  
 50 CC-BY. This checklist can be completed online using <https://www.goodreports.org/>, a tool made by  
 51 the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)  
 52  
 53  
 54  
 55  
 56  
 57  
 58  
 59