Accelerometer Measured Level of Physical Activity Indoors and Outdoors During Preschool Time in Sweden and the United States

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Background: It is important to understand the correlates of physical activity (PA) to influence policy and create environments that promote PA among preschool children. We compared preschoolers’ PA in Swedish and in US settings and objectively examined differences boys’ and girls’ indoor and outdoor PA regarding different intensity levels and sedentary behavior. Methods: Accelerometer determined PA in 50 children with mean age 52 months, (range 40–67) was recorded during preschool time for 5 consecutive weekdays at 4 sites. The children wore an Actigraph GTIM Monitor. Results: Raleigh preschool children, opposite to Malmö preschoolers spent significantly more time indoors than outdoors ($P < .001$). Significantly more moderate-to-vigorous intensity physical activity (MVPA) was observed outdoors ($P < .001$) in both settings. Malmö children accumulated significantly more counts/min indoors ($P < .001$). The percent of MVPA during outdoor time did not differ between children at Raleigh and Malmö. Conclusion: Physical activity counts/minutes was significantly higher outdoors vs. indoors in both Malmö and Raleigh. Malmö preschoolers spent 47% of attendance time outdoors compared with 18% for Raleigh preschoolers which could have influenced the difference in preschool activity between the 2 countries. Time spent in MVPA at preschool was very limited and predominantly adopted outdoors.

Keywords: accelerometry, country comparison, physical activity level, preschool children

The rise in childhood obesity during the past decade has been dramatic. In 2010, worldwide 43 million children under age 5 were estimated be overweight. More than 25% of the preschool-aged children in the United States are considered overweight or obese. Research in Sweden reports an increase of overweight/obese 4 year-olds over the past 2 decades with a tendency to remain at a high level of 20%. Decreased physical activity (PA) and increased sedentary behaviors during preschool years are likely to contribute to this trend. The Framingham Children’s Study showed that less active preschoolers gained more fat than more active children, and that higher levels of PA in early childhood decreased the amount of fat gained in early adolescence. Comparing activity levels of overweight and nonoverweight preschoolers, Trost et al. demonstrated that overweight boys were significantly less active than nonoverweight boys. Expert panels have among others emphasized the importance of promoting PA and limiting sedentary behavior in preschool.

In Sweden, 96% of all 3- to 5-year-old children attend preschool and 82% of preschools are public. In the US, approximately 76% of preschool children with employed parents attend some form of child care, which is the dominant early childhood environment for over 8 million children who are away from their families for 35 hours a week or more.

According to the NASPE guidelines preschoolers should not be sedentary for more than 60 min at a time, but engage in at least 60 min and up to several hours per day of daily, unstructured PA and in addition accumulate > 60 min daily of structured PA. More recent Australian recommendations recommend 3 hours or more of daily light, moderate, or vigorous physical activity (ie, total PA or nonsedentary behavior) for preschoolers. Available data on PA among preschool children are scanty. The intermittent pattern of preschool children’s PA is difficult to measure and highlights the need of measures of
different activity levels. Tucker et al\textsuperscript{15} reviewed 39 studies of preschoolers’ PA level and reported that nearly half of the children do not achieve the minimum recommendation and that boys are more active than girls.

In a recent review of preschool children’s correlates of PA, Hinkley et al\textsuperscript{16} use an ecological-framework across 5 domains: 1) demographic and biological; 2) a psychological, cognitive, and emotional; 3) behavioral and skills; 4) social and cultural; and 5) physical environment. In the physical environment domain, which includes measures of the neighborhood and the measures of the preschool physical environment, time spent outdoors, and the specific preschool attended were correlates positively associated with PA\textsuperscript{16} as well as the quality of the outdoor environment.\textsuperscript{17}

Besides the total amount of PA and different intensity levels of activity, research has especially pointed out the association between amount of sedentary behavior and increased overweight and obesity in preschoolers.\textsuperscript{18} A review of 6 accelerometer studies in the US, Scotland, and Belgium reports that levels of estimated MVPA were low and the authors comment the result stating that “even when child care time was extrapolated during a full day it would not have provided 60 min MVPA”.\textsuperscript{13} These findings underscore the importance of understanding the specific aspects of PA to impact preschool children’s PA and the child care environmental settings\textsuperscript{19} as PA is a powerful preventive factor for early childhood overweight and obesity.\textsuperscript{6} The majority of the studies conducted to date were undertaken in the US and a need for comparative studies between the US and other countries is therefore apparent.

The aims of this study were to compare preschoolers’ PA in a Swedish and in a US setting and to objectively examine the differences in preschool boys’ and girls’ indoor and outdoor PA regarding different intensity levels and sedentary behavior.

**Methods**

In this convenience sample the participants were recruited from 4 preschools: 2 in Raleigh, NC, US, and 2 in Malmö, Sweden.

**Preschools**

Raleigh is situated in a lush humid subtropical climate zone dominated by deciduous forests (lat. 36N); Malmö in a humid maritime climate zone, an area dominated by agricultural land (lat. 55N). The Raleigh preschools were located in woodland areas outside the city and the Malmö preschools in the city. Preschool outdoor environment, such as space, greenery, and topography, were overall similar. One Malmö preschool was hillier than the others. The daily structure of the US preschool was scheduled with lessons interrupted by shorter indoor or outdoor play sessions. In Sweden, school-like lessons are not the routine and longer durations of outdoor activities are common am and pm. In Raleigh, the children napped between 1–3 PM which was not the case in Malmö. During the week of measurement, the preschool staffs were informed to go about their duties as usual and did not participate in data collection.

**Participants**

All of the 58 children’s parents were invited by an informational letter to sign up their children in the study. After omitting 8 participants with incomplete data, the current study sample consisted of 50 children (26 boys, 24 girls) with a mean age 52 months (range 40–67 months). Measurements were carried out during 5 consecutive days March 30–April 3 (Raleigh) and May 4–8 (Malmö). Permission for the study was obtained from the Internal Revision Board at North Carolina State University (NCSU) and the Stockholm Regional Ethics Committee, the involved local authorities (Malmö) and preschools, and by parental written informed consent.

**Accelerometry**

This study is a secondary analysis of accelerometer data. Data collection methods have been described previously in detail\textsuperscript{20} and are summarized here. The participants wore an elastic belt with an accelerometer during all 5 weekdays. The belt was attached by trained researchers upon children’s arrival to the preschool and removed at departure. During the preschool day the researchers clocked and recorded all outdoor and indoor episodes.

The time-stamped Actigraph GT1M accelerometer (Pensacola Fl. United States), a uni-axial accelerometer registering volume and pattern of PA, was used. The GT1M is a developed version of Actigraph model 7164 which has established utility, validity, and reliability in 3–5 year old children.\textsuperscript{21,22} Accelerometers enable the exploration of activity patterns by discrimination between intensities of PA and of the total volume of activity over a period of time. Activity is measured in epochs (number of seconds), and for each epoch movement data (ie, activity counts) are summed and stored for processing and analysis. Accumulated activity counts of each epoch are then classified into intensity categories (eg, light, moderate, vigorous PA), applying validated threshold values (cut points) for the observed age group. Epoch was set at 15 seconds as recommended by Cliff et al\textsuperscript{21} as the maximum epoch length due to children’s intermittent PA pattern.\textsuperscript{21,22} Activity counts for epochs spent indoors and outdoors were separated. Cut points were used according to Sirard et al.\textsuperscript{24}

**Anthropometry**

The children’s height and weight (mean of 2 values on digital scale) were measured by the same researcher at all 4 sites. The body mass index (BMI) was calculated and classified as normal or overweight/obese according to Cole et al.\textsuperscript{25}
Statistical Analysis

Data were analyzed using SPSS for Windows (18.0). The 5 days of activity count data were reviewed to check for missing scores. If 4 days (as in 7 children) of activity counts were recorded, the missing days were replaced with each subject’s mean scores. Independent t tests were applied to identify differences in mean activity counts between sexes and countries. Mann Whitney U tests were applied to identify the difference in intensity categories MVPA and sedentary behavior between sexes and countries. Paired t test was performed to evaluate the differences between indoor and outdoor activities. The alpha level was set at .01 for all analyses.

Results

Descriptives

Mean time spent at preschool was 471 min/day (± 74 min). Mean age was 52 months (± 6), mean weight was 18.4 kg (± 2.4), mean height was 107.4 cm (± 5.7), and 9% were classified as overweight/obese (boys 0%, girls 22%). Descriptive data of mean and standard deviation (SD) of the participating children are presented by sex and country in Table 1.

Time Spent Indoors vs. Outdoors During Preschool Time

The Raleigh children’s total mean stay at preschool per day was significantly longer than that of the Malmö children (497 min, ± 26 min vs. 445 min, ± 113 min; P < .001). At the Raleigh sites, 18% of preschool time was spent outdoors vs. 47% at the Malmö sites (92 vs. 211 min, P < .001). The Malmö sites spent significantly less time indoors than their peers at the Raleigh sites (235 vs. 406 min, P < .001). This also applied to Raleigh vs. Malmö girls and Raleigh vs. Malmö boys, with indoor times of 399 vs. 268 min (girls; P < .001) and 413 vs. 199 min (boys; P < .001), respectively (Table 2 and Table 3). Outdoor time did not differ much in Raleigh (girls 19%, boys 17%), but it did in Malmö, with boys being outdoors significantly more than girls (56 vs. 38%, P < .001).

PA Indoors vs. Outdoors During Preschool Time

Counts-per-minute of total activity were significantly higher for outdoor than indoor activity (1098 vs. 493 counts/min, P < .001) in both boys (1134 vs. 530 counts/min, P < .001) and girls (1064 vs. 459 counts/min, P < .001) and in both locations (Raleigh, 1114 vs. 406 counts/min, Malmö, 1081 vs. 586 counts/min). In total, the Malmö children accumulated significantly more counts/min indoors than their peers in Raleigh (586 vs. 406 counts/min, P < .001) (Tables 2 and Table 3).

Total PA During Preschool Time

Regarding total PA, approximately 25% of outdoor and 10% of indoor time was spent in non-sedentary behavior, which equals 65 min and 75 min of total PA, respectively, in Raleigh and Malmö preschoolers (ie, 25% of outdoor min + 10% of indoor min) (Table 2).

Intensity of PA at Preschool

Moderate-to-Vigorous Physical Activity. The fraction of MVPA was significantly higher outdoors than indoors (7.3 vs. 2.3%, P < .001) in both boys (7.5 vs. 2.0%, P < .001) and girls (7.0 vs. 2.7%, P < .001). Indoors, a significantly higher percentage of MVPA was observed in Malmö than in Raleigh (2.9 vs 1.8%, P < .001). No significant difference between Raleigh and Malmö was seen in the percent of time spent in MVPA intensity outdoors. In minutes of preschool time, the Malmö children spent 19 min out of 445 total mins (range 3–38) in MVPA, whereas the corresponding figures for the Raleigh children was 14 min out of 498 total mins (range 0–35) (Table 2).

Sedentary Behavior. Significantly more sedentary behavior was accumulated indoors than outdoors (89.1% vs. 75.2%) in Raleigh (91% vs. 74%, P < .001), in Malmö (87.4% vs. 76.3%, P < .001), in boys (89.2% vs. 73.8%, P < .001), and in girls (89.1% vs. 76.8%, P < .001). The Raleigh children had a significantly higher recorded percent of time in sedentary behavior indoors compared with the Malmö children (91% vs. 87.4%, P < .001). The differences between Raleigh girls and boys vs. Malmö girls and boys were all insignificant (91.0% vs. 87.0%, and 91.2% vs. 87.6%, respectively). Data of preschool sites (as total, boys, and girls) sorted by indoor and outdoor time, counts/min, percent spent in sedentary behavior, light PA, and MVPA, and standard deviations are shown in Table 2. The differences between the Raleigh and Malmö sites are shown in Table 3.

Discussion

The main finding was that in terms of counts/min, PA was significantly higher outdoors than indoors during preschool time in both locations. Malmö preschoolers spent 47% outdoors compared to 18% for the Raleigh children which could have impacted the difference in preschool activity. Once outdoors, no significant difference in percent of time spent in MVPA was observed. In line with the review study16 reporting outdoor time as a correlate associated to PA, we found the same in both Raleigh and Malmö. Time spent outdoors seems to be a supportive aspect of objectively measured MVPA for preschool children, and more outdoor time might be one route to increased PA in the Raleigh preschoolers during preschool time.

The choice of instrument is essential when it comes to objective measurement the intermittent pattern of
### Table 1 Descriptive Data of the Participating Preschool Children Presented by Sex and Country; Raleigh, US, and Malmö, Sweden

<table>
<thead>
<tr>
<th></th>
<th>All (n = 50)</th>
<th>Boys (n = 26)</th>
<th>Girls (n = 24)</th>
<th>Diff boy girl</th>
<th>US (n = 26)</th>
<th>US boys (n = 14)</th>
<th>US girls (n = 12)</th>
<th>Swe (n = 24)</th>
<th>Swe boys (n = 12)</th>
<th>Swe girls (n = 12)</th>
<th>Difference Swe US</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (month) SD</strong></td>
<td>52 ± 4.3</td>
<td>50 ± 4.2</td>
<td>54 ± 4.5</td>
<td>ns</td>
<td>52 ± 4.3</td>
<td>46 ± 4.0</td>
<td>58 ± 4.6</td>
<td>52 ± 4.4</td>
<td>54 ± 4.4</td>
<td>50 ± 4.4</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Height (cm) SD</strong></td>
<td>107.5 ± 5.7</td>
<td>108.6 ± 5.1</td>
<td>106.5 ± 6.0</td>
<td>ns</td>
<td>107.8 ± 5.3</td>
<td>108.0 ± 5.1</td>
<td>107 ± 5.7</td>
<td>107.1 ± 6.1</td>
<td>109.0 ± 5.1</td>
<td>105.3 ± 6.9</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Weight (kg) SD</strong></td>
<td>18.5 ± 2.4</td>
<td>18.6 ± 1.8</td>
<td>18.9 ± 2.9</td>
<td>ns</td>
<td>18.6 ± 2.6</td>
<td>18.3 ± 2.0</td>
<td>19.0 ± 2.9</td>
<td>18.6 ± 2.2</td>
<td>18.6 ± 1.6</td>
<td>17.8 ± 2.9</td>
<td>ns</td>
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<tr>
<td><strong>Body mass index</strong></td>
<td>16.0 ± 1.3</td>
<td>15.7 ± 1.7</td>
<td>16.2 ± 0.9</td>
<td>ns</td>
<td>16.1 ± 1.3</td>
<td>15.7 ± 1.7</td>
<td>16.4 ± 1.0</td>
<td>15.8 ± 1.2</td>
<td>15.5 ± 1.7</td>
<td>16.0 ± 0.8</td>
<td>ns</td>
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</tbody>
</table>

*Note.* Data are given as mean and standard deviation (SD). Abbreviations: US, United States; Swe, Sweden; Diff, difference; ns, non significant.

### Table 2 Data of Preschool Sites (as Total, Boys, and Girls) Sorted by Indoor and Outdoor Time, Participants, Counts/Minute, Percent Spent in Moderate-to-Vigorous Physical Activity (MVPA), Light Physical Activity, Sedentary Behavior, and Standard Deviation; Raleigh, US, and Malmö, Sweden

<table>
<thead>
<tr>
<th>Preschool site</th>
<th>Indoor time min SD</th>
<th>Outdoor time min SD</th>
<th>Diff</th>
<th>Count/min (range) SD</th>
<th>Count/min, outdoor (range) SD</th>
<th>Diff</th>
<th>MVPA % indoor SD</th>
<th>MVPA % outdoor SD</th>
<th>Diff</th>
<th>Light PA % indoor SD</th>
<th>Light PA % outdoor SD</th>
<th>Diff</th>
<th>Sedent % indoor SD</th>
<th>Sedent % outdoor SD</th>
<th>Diff</th>
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<tbody>
<tr>
<td>Raleigh, US</td>
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</tr>
<tr>
<td>Total</td>
<td>323 ± 114</td>
<td>149 ± 115</td>
<td>P &lt; .001</td>
<td>493 ± 202</td>
<td>1098 ± 571</td>
<td>P &lt; .001</td>
<td>2.3 ± 1.7</td>
<td>7.3 ± 5.7</td>
<td>P &lt; .001</td>
<td>8.5 ± 2.6</td>
<td>17.6 ± 6.1</td>
<td>P &lt; .001</td>
<td>89.1 ± 3.2</td>
<td>75.2 ± 9.5</td>
<td>P &lt; .001</td>
</tr>
<tr>
<td>Boys</td>
<td>306 ± 133</td>
<td>170 ± 130</td>
<td>ns</td>
<td>530 ± 264</td>
<td>1134 ± 586</td>
<td>P &lt; .001</td>
<td>2.0 ± 1.5</td>
<td>7.5 ± 6.3</td>
<td>P &lt; .001</td>
<td>8.5 ± 3.0</td>
<td>18.6 ± 6.5</td>
<td>P &lt; .001</td>
<td>89.5 ± 3.8</td>
<td>73.6 ± 10.3</td>
<td>P &lt; .001</td>
</tr>
<tr>
<td>Girls</td>
<td>339 ± 94</td>
<td>130 ± 100</td>
<td>P &lt; .001</td>
<td>459 ± 117</td>
<td>1064 ± 566</td>
<td>P &lt; .001</td>
<td>2.7 ± 1.8</td>
<td>7.0 ± 5.3</td>
<td>P &lt; .001</td>
<td>8.4 ± 3.0</td>
<td>16.1 ± 5.9</td>
<td>P &lt; .001</td>
<td>89.1 ± 3.8</td>
<td>76.8 ± 10.1</td>
<td>P &lt; .001</td>
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<tr>
<td>Malmö, Sweden</td>
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<tr>
<td>Total</td>
<td>234 ± 105</td>
<td>211 ± 141</td>
<td>ns</td>
<td>586 ± 232</td>
<td>1081 ± 566</td>
<td>P &lt; .001</td>
<td>2.9 ± 1.8</td>
<td>6.7 ± 5.3</td>
<td>ns</td>
<td>9.7 ± 2.2</td>
<td>16.5 ± 4.4</td>
<td>P &lt; .001</td>
<td>87.4 ± 2.9</td>
<td>76.8 ± 7.1</td>
<td>P &lt; .001</td>
</tr>
<tr>
<td>Boys</td>
<td>199 ± 108</td>
<td>254 ± 139</td>
<td>ns</td>
<td>647 ± 317</td>
<td>1054 ± 575</td>
<td>P &lt; .001</td>
<td>2.5 ± 1.7</td>
<td>6.4 ± 6.0</td>
<td>ns</td>
<td>9.7 ± 2.9</td>
<td>16.7 ± 3.4</td>
<td>P &lt; .001</td>
<td>87.6 ± 3.5</td>
<td>76.8 ± 7.0</td>
<td>ns</td>
</tr>
<tr>
<td>Girls</td>
<td>268 ± 93</td>
<td>169 ± 136</td>
<td>ns</td>
<td>527 ± 70</td>
<td>1107 ± 581</td>
<td>ns</td>
<td>3.3 ± 1.9</td>
<td>7.0 ± 4.8</td>
<td>ns</td>
<td>9.7 ± 1.4</td>
<td>16.3 ± 5.4</td>
<td>P &lt; .001</td>
<td>87.0 ± 2.3</td>
<td>76.7 ± 7.2</td>
<td>P &lt; .001</td>
</tr>
</tbody>
</table>

Abbreviations: Sedent, sedentary; SD, standard deviation; Diff, difference.
Table 3 Differences Between Raleigh, US and Malmö, Sweden Preschoolers’ Indoors and Outdoors Physical Activity

<table>
<thead>
<tr>
<th>Preschool site</th>
<th>Indoor time min</th>
<th>Outdoor time min</th>
<th>Count/min, indoor (range)</th>
<th>Count/min, outdoor (range)</th>
<th>MVPA % indoor</th>
<th>MVPA % outdoor</th>
<th>Light PA % indoor</th>
<th>Light PA % outdoor SD</th>
<th>Sedent % indoor</th>
<th>Sedent % outdoor</th>
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<tbody>
<tr>
<td>Difference US vs. Swedish total</td>
<td>$P &lt; .001$</td>
<td>$P &lt; .001$</td>
<td>$P &lt; .001$</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>$P &lt; .001$</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>US vs Swedish boys</td>
<td>$P &lt; .001$</td>
<td>$P &lt; .001$</td>
<td>ns</td>
<td>ns</td>
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<tr>
<td>US vs Swedish girls</td>
<td>$P &lt; .001$</td>
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Abbreviations: US, United States; PA, physical activity; Sedent, sedentary; ns = non significant.
preschool PA. We used the Actigraph model GT1M with epoch lengths set at 15 s as recommended by Cliff et al.\textsuperscript{21} The cut points used to identify light PA, MVPA, and sedentary behavior need to be scientifically validated. In the absence of comparative analysis indicating superiority of any particular set of cut points, we used the age specific cut points for 3, 4, and 5 years-old by Sirard et al.\textsuperscript{24}

In this study, we found a difference in objectively measured PA among preschoolers aged 3–5 between a US and Swedish setting. Higher levels of objectively measured PA (pedometers) in Swedish children compared to US children (age 7 to 14 years) has been previously reported.\textsuperscript{26} This difference, that seems to prevail at least to the age of 18,\textsuperscript{27} thus seems to start out as early as preschool age.

In the elementary school comparison,\textsuperscript{26} structure of the school day (ie, schedule) with shorter recess time was discussed as one of many reasons for the difference. Likewise the structure of the preschool day (ie, schedule) seems to play a part in the difference in PA.

In our study, the overall intensity of PA as counts/min was higher outdoors than indoors in both locations and both sexes. In line with the recent review reporting outdoor time as a correlate associated to PA,\textsuperscript{15} we found the same in both locations. To our knowledge, comparison of objectively measured indoor and outdoor PA during preschool time has not been reported. However, a recent study on school children’s after-school time reports a 2.5 fold increase in outdoor activity vs. indoor activity.\textsuperscript{28} The difference in time spent outdoors, as now observed in Raleigh vs. Malmö, and consequently the children’s opportunities for MVPA, is a reason for concern. Outdoor education preschools have gained popularity in Sweden and higher levels of pedometer-determined PA in comparison with ordinary preschools have been observed.\textsuperscript{17} Future research is needed regarding difference in available equipment, space, environmental characteristics, and the differences in the teaching modes by which activities indoors and outdoors are prompted.

The special characteristic of children’s PA is its intermittent pattern of long durations of low activity mixed with very short bursts of vigorous activity,\textsuperscript{14,29} such as jumping and running, which is suggested to be important for bone mineralization. A recent longitudinal study showed that the most active boys and girls at age 5 (ie, highest proportion of MVPA approximately 45 min/day) had a 4%–14% increase in bone mineral content at age 11, compared to others.\textsuperscript{30} The short time spent in MVPA has previously been reported in preschoolers.\textsuperscript{18} The current study is no exception with 2.3% and 7.3% reported MVPA indoors and outdoors, respectively (ie, an average of 16 min of MVPA during preschool time, which is not likely to be sufficient for bone mineralization benefits even if extrapolated to a whole day). The amount of MVPA is not explicitly expressed in preschool recommendations. However, school-age recommendations are 60 minutes of MVPA. For the preschoolers in the current study with a mean of 16 minutes of MVPA, the chances for fulfillment of school-age recommendations would be slim even with an extrapolation to a full day. Cardon et al.\textsuperscript{21} report that preschoolers’ PA during preschool time is higher than outside preschool. If preschoolers’ active time during a whole day is 12 hours of waking hours (ie, 720 minutes out of which 16 minutes of MVPA are adopted during preschool time of almost 8 hours), an extrapolated 2 minutes of MVPA per hour outside preschool would result in 24 minutes during a full day (2 min of MVPA × 4 remaining waking hours = 8 min + 16 min = 24 min). It seems that at least twice as much accumulated MVPA is needed to give the abovementioned positive effect on preschoolers’ bone mineralization, and even more if we presuppose the same level of PA outside preschool (32 min of MVPA during 8 hours of preschool time + 4 min of MVPA × 4 remaining waking hours will lead to 48 min of MVPA per day). Obviously, further research is needed to explore the optimal amount of MVPA for preschool PA guidelines.

Recent Australian recommendations\textsuperscript{12} communicate 3 hours (180 min) of daily total PA (ie, nonsedentary behavior). In our study, 65 min and 75 min in Raleigh and Malmö, respectively, was spent in nonsedentary behavior during 8 hours of preschool time. Presuming 12 hours of waking time, this level of PA extrapolated to a full day will mean 97 and 112 min in Raleigh and Malmö, respectively. Again this is not enough to fulfill these recent recommendations.

Sedentary behavior seems to be described as the dominant state of preschool children’s PA during the preschool day. A recent review study\textsuperscript{13} concludes that “a body of high quality evidence is consistent in suggesting that PA levels within child care centers are typically low and levels of sedentary behavior are typically high.” In our study approximately 90% of indoor time and 75% of outdoor time is spent in sedentary behavior.

Of special interest in the comparison of preschoolers’ PA in the 2 locations are the acknowledged differences in amount of sedentary behavior and MVPA indoors and fractions of indoor and outdoor time. The high proportion of sedentary behavior combined with little MVPA indoors, especially among the Raleigh children, is a reason for concern.

In the field notes, several observations were made of daily routines and of the way children’s behaviors were regulated at preschool which possibly could help to explain differences in activity pattern. Changes in the type of activity indoors at the Raleigh preschools were often associated with rules, routines, or adult leadership causing the children to slow down or interrupt their ongoing activity. The opportunity for a child to move into a new activity area could be dependent on explicit decisions that needed to be formulated by the child when indoors. In addition, at the Raleigh preschools many everyday routines were associated with the children being either instructed or encouraged to stay inactive, such as lining up before going outdoors or indoors. This was done for safety reasons but is a time-consuming procedure that is not routine in Sweden.
The children at the Raleigh sites also napped between 1–3 PM, a period during which the child was supposed to play calmly by their mattress if not asleep. Nonsleepers’ mandatory time in sedentary behavior could impact the results, and routines allowing nonsleepers to leave the room and play would probably increase PA levels. Recently published research concerning US preschoolers’ PA\textsuperscript{32} suggests guidelines that may need an additional item regarding this issue. In the Swedish preschool there are fewer and shorter periods of mandatory or encouraged sedentary behavior. Mainly there are 1 or 2 daily teacher-led assemblies involving all children in which they sit in a circle on the floor and are expected to stay calm.

Sex differences are well established by age 3.\textsuperscript{16} This was also seen in the current study in both Raleigh and Malmö. However, the combined effect of time spent outdoors and the fact that more PA was accumulated during time spent outdoors is probably an important reason why Malmö girls accumulated more PA during preschool time than the Raleigh boys. Possibly the Malmö children and especially the boys took advantage of the more liberal preschool management observed in Malmö, whereas in Raleigh the structured nature of day’s routine also structured their PA in a uniform pattern.

The higher relative intensity level indoors in the Malmö girls indicates that changes in the regulation of environmental indoors use could be especially advantageous for girls. Noticing that routines for longer periods of outdoor stay do exist at the Swedish sites, it should be considered to encourage girls to seize this opportunity as the boys already do. Open-ended play sequences in which children easily change between rapid and calm bouts of activity have been associated with preschool children’s mental health.\textsuperscript{33}

There are several limitations in this study. The convenience sample makes it difficult or even impossible to generalize the results to a national level. Thus, children of an eastern US state, for instance, may be different from children of a southwestern state. Similar differences apply to Sweden. Even if preschools showed similarities in environment and equipment (one school hillier, though) the existence of any common standard is unknown to us. Second, a small study population is vulnerable to subdivisions. For instance, the categories of overweight were collapsed as the number of participants fulfilling the criteria was too small both in Raleigh (n = 2) and in Malmö (n = 4). Third, the lack of whole-day data must be seen as a limitation as it complicates comparison with other studies.

The strength of the study is the controlled research setting within preschools. Indoor and outdoor times were accurately clocked and recorded. The use of accelerometers made it possible to determine the fractions of sedentary behavior and MVPA. As children’s PA levels vary depending on season,\textsuperscript{34} fieldwork was performed considering similar seasons (March–April in North Carolina and the first week of May in southern Sweden; ie, springtime at both sites). Even during similar seasons, weather conditions may vary as they did in our study, with the weather being predominantly sunny and calm in Raleigh and rough most of the time in Malmö.

Generalizable data requires national studies representing the variety of outdoor preschool settings in different parts of the countries during different seasons, including the investigation of differences in activity levels indoors vs. outdoors. Future research should also include studies in different contexts and settings to appropriately identify the association between time outdoors and PA in those settings. This would also allow the opportunity to investigate the contribution of different settings to PA in young children.

**Conclusion**

We conclude that PA expressed as counts/min was significantly higher outdoors than indoors in both Malmö and Raleigh. Time spent in MVPA at preschool was very short and predominantly adopted outside. The Malmö preschoolers spent 47% of their time outdoors compared to 18% for the Raleigh children, which could have influenced the difference in preschool activity between the 2 countries. So much time being spent indoors, where the fraction of MVPA is low, should be regarded as a risk of not fulfilling the daily amount of PA recommended for preschool children.

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