



## Objectively measured physical activity level and sedentary behavior in Norwegian children during a week in preschool☆

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### ABSTRACT

Although many studies have reported on physical activity (PA) levels using accelerometers, a thorough description of the PA pattern in preschool children during their stay in the preschool, is lacking in the current literature. Furthermore, there remains a lack of understanding of the PA level and pattern in children in the lower end of the PA continuum.

The first aim of this study was therefore to describe the PA pattern during a week-long stay in a preschool in all children born in 2011 (either three or four-year-olds) attending public preschools in a municipality in Norway. The second aim was to describe the PA level and pattern of the children who are the least physically active.

This cross-sectional study included baseline data from 95% of children ( $N = 111$ ) participating in a randomized controlled physical activity intervention (Active Kindergarten – Active Children study). The participants wore an Actigraph accelerometer, in week 39 in 2015, from when they arrived at the preschool on Monday morning and throughout their stay of five consecutive days.

The amount of moderate- to vigorous-intensity PA (MVPA) per day ranged from 16 min to 116 min, and sedentary time ranged from 2.7 h to 6.5 h per day in the least and most sedentary child, respectively. The least physically active 25% of children were less active throughout the entire day, and only a few of them managed to achieve the recommended level of MVPA on any weekday.

The physical activity levels and patterns among the least active children described in this study may help to inform interventions targeting this group.

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### 1. Introduction

There is a common societal belief that preschool children, aged three to five, are physically active and in constant motion (Adamo et al., 2010). However, most evidence indicates that a substantial proportion of preschool aged children do not meet the widely accepted World Health Organization (WHO) guidelines (WHO, 2010) of at least 60 min of moderate- to vigorous-intensity physical activity (MVPA) per day (Hnatiuk et al., 2014), but rather spend most of their waking hours engaged in sedentary behavior (Kelly et al., 2007; Reilly et al., 2004). Insufficient MVPA levels and high amounts of sedentary time are associated with high systolic blood pressure (Vale et al., 2015), poor motor skills (Iivonen et al., 2013) and low cardiorespiratory fitness

(Burgi et al., 2011) in preschool children. Moreover, both lack of MVPA and high sedentary time are implicated in the etiology of childhood obesity (Troiano and Flegal, 1998; Reilly et al., 1999) and children tend to carry this excessive adiposity into adulthood (Jimenez-Pavon et al., 2010; Rey-Lopez et al., 2008). In addition to health outcomes, physical activity (PA) level is related to academic and cognitive function later in life (Sibley and J.L., 2003).

Although many children have healthy and active lifestyles, there seems to be a group of children with a very low PA level, low fitness level, and obesity: factors which influence one another, leading to a vicious cycle (Pietilainen et al., 2008). This is especially worrying because it is known that, as with being overweight, PA level often tracks from childhood into adulthood (Jones et al., 2013; Biddle et al., 2010). The Framingham Children's Study showed that less physically active children gained more body fat mass than more active children, and that higher levels of PA in early childhood decreased the amount of body fat mass gained in early adolescence (Moore et al., 2003). Given that children's PA levels track from early childhood into adulthood and that overweight is difficult to treat once it has developed, increasing

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these children's PA levels and reducing sedentary time early on may alter their activity trajectory. Thereby increasing the likelihood that they will be physically active and physically fit during the rest of their childhood and into youth and adulthood (Hallal et al., 2006).

Preschool age might be a critical period to intervene because PA and sedentary behavior seems to be established at this age (Janz et al., 2005). Many studies have reported on PA levels using accelerometers, but a thorough description of the PA pattern using the full range of the accelerometer, that is PA level hour by hour, sedentary bouts and breaks in sedentary time, in this age group is lacking in the current literature (Trost, 2007; Mattocks et al., 2008). This information may facilitate the identification of intervention opportunities and potentially highlight critical windows through which to intervene. Furthermore, sound knowledge on modifiable PA correlates in young children (Hinkley et al., 2008; Duch et al., 2013) and correlates related to preschool have been gained. These include the size of indoor areas, vegetation on playgrounds, and number of staff per child (Olesen et al., 2013). Focusing on the above-mentioned and other modifiable correlates, would be recommended in order to develop effective interventions. However, these studies cannot fully explain why the PA level varies between children within the same preschool and, hence, exposed to the same environment. Therefore, in addition to identifying modifiable correlates of PA in preschool children, it is imperative to examine the PA level and pattern of those who are least active, and thereby at the highest risk of future health problems, in order to develop interventions which are tailor-made for this important target group. Lastly, there are no large-scale studies in Norway which objectively measure the PA level and pattern in children during their stay at the preschool, where these children spend most of the week (Statistics Norway, 2015).

Based on the above-mentioned considerations, the first aim of this study was to describe the PA pattern during a week-long stay in a preschool in all children born in 2011 (either three or four-year-olds) attending public preschools in a municipality in Norway. The second aim was to describe the PA level and pattern of the children who are the least physically active.

## 2. Methods

The data presented in this paper are the baseline results from the "Active Kindergarten – Active Children" (AK-AC) study. The AK-AC study was designed as a two-arm, randomized by preschool (kindergarten in Norway), evaluative controlled trial with the overarching aim of increasing the children's PA level.

### 2.1. Participants

All children attending Sandefjord municipality public preschools and born in 2011 ( $N = 130$ ) were invited to participate in the study. Participants were then asked to wear an accelerometer upon arrival at their preschool on Monday morning, until the end of the preschool day, for five consecutive days. Three to four year old children were chosen in order to target the oldest children still in preschool, for the purposes of facilitating one-year follow-up measurements. Parents of a total of 116 children (89%) signed the informed consent form. The Regional Committee for Medical & Health Research Ethics found the research project to be outside the remit of the Act on Medical and Health Research; therefore, the study could be implemented without its approval. Approval from the Norwegian centre for research data was not needed because we did not collect personal information.

### 2.2. Measurements

The measurements were conducted in the autumn of 2015. Free-living PA was assessed using ActiGraph GT1M and GT3X+ accelerometers (ActiGraph, LLC, Pensacola, FL, USA). These are seismic instruments which continuously measure acceleration. Raw data from these

instruments are referred to as "counts", which are the sum of acceleration in a given time period. Accelerometers are small and non-invasive and provide a valid estimate of overall PA, which includes frequency, intensity and duration of PA, and steps (Tudor-Locke and Myers, 2001). The participants were instructed to wear the accelerometer on the left hip during their stay at the preschool for five consecutive days (Monday morning to Friday afternoon in week 39). The staff attached the named monitors to the children every morning when they arrived at the preschool and removed it at the end of each day. In order to ensure compliance with wearing the monitor, the staff were also instructed to make sure the monitor was fastened properly at all times and in the right position. The epoch length (sample interval) was set to 15 s (Cliff et al., 2009). In the analysis of accelerometer data, epoch periods with a value of zero for 60 min (with allowance for two exceptions above zero) or longer were interpreted as "accelerometer not worn" and removed from the analyses (Cooper et al., 2015). PA data were included if the participant had accumulated a minimum of 6 h of activity data per day for at least two days. Accelerometer data were processed and analyzed using ActiLife version 6 from Actigraph. The minutes spent in various levels of PA intensity were calculated according to the cut-offs set by Butte et al. (2014), in which sedentary behavior (sedentary time) was defined as  $\leq 239$  counts, light intensity PA was defined as 240 to 2119 counts, moderate intensity PA was defined as 2120 to 4449 counts, and any amount above 4450 was considered vigorous or very vigorous intensity PA (Butte et al., 2014). A sedentary bout was defined as a registration period during which the child had no more than 239 counts/15 s for 10 consecutive min or more, and a sedentary break as an activity registration of above 239 counts following a sedentary bout. One hundred and eleven participants had valid accelerometer recordings (95.7%); five children had fewer than two valid days of recordings. Of the 111 participants with valid recordings, five had two days of recordings, 12 had three days, and 94 wore the monitor for four or five days. The mean ( $\pm$  standard deviation (SD)) wearing time was  $8.1 \pm 0.1 \text{ h} \cdot \text{day}^{-1}$ .

The staff in each unit completed a written log for every clock hour documenting the children's location, applying a four-level scale denoting 0–25%, 26–50%, 51–75%, and 76–100% regarding indoor- and outdoor-time (a child can be inside or outside for a full clock hour, but can also be, to a various degree, inside and outside in one clock hour). The staff also wrote down the time spent for each meal and registered temperature and weather conditions during the five measurement days. These variables, which included indoor- and outdoor-time, meals, temperature and weather conditions, were logged because they could potentially, to various degrees, influence and explain variations in PA level throughout the day and week in general, and between children.

### 2.3. Statistical analysis

All statistical analyses were performed using SPSS (Statistical Package for the Social Sciences for Windows, version 21, IBM, Inc., Chicago, USA). Within and between differences of interval data were evaluated by *t*-tests (independent *t*-tests and paired *t*-tests). A univariate general linear model was used when adjusting for wear time, gender, age, and preschool in relevant analysis. The least physically active 25% of children and the most physically active 25% were defined by 25% lowest and highest total counts per min (CPM), respectively. When analyzing differences between the least and most active, adjustments were made for gender and age. The results are presented as mean differences between the two groups  $\pm$  confidence intervals (CI).

## 3. Results

The children were, on average, 3.7 years old ( $SD \pm 0.4$ ). Fifty-seven percent of the children were girls. During their time in preschool, the children spent 54% in sedentary, 33% in light, 9% in moderate, and 2%

in vigorous intensity activity. Sixty percent of the children had at least 60 min of MVPA on Monday and Friday, while only 26% of the children reached this level on Tuesday. Boys had a higher total PA level (mean difference 93 CPM, CI = 10 to 176;  $p = 0.02$ ), spent more time in light and MVPA (mean difference 12 min, CI 5 to 19;  $p < 0.01$ ), took more steps per day (mean difference 571, CI 0 to 1143;  $p = 0.050$ ), and spent less time sedentary (mean difference -20 min, CI -3 to -37;  $p = 0.02$ ) than girls. There were no differences in time spent in vigorous activity between genders. Thirty-two percent of the girls and 67% of the boys reached the recommended level of 60 min of MVPA per day.

The children had an average of 58 min (SD  $\pm$  20) of MVPA per day, ranging from 16 min to 116 min (Fig. 1, left). Diversity was also seen in time spent sedentary among the children, ranging from 163 min to 387 min per day (2.7 h to 6.5 h) in the least and most sedentary child, respectively (Fig. 1, right). Time spent sedentary was negatively correlated with MVPA ( $r = 0.57$ ,  $p < 0.01$ ), meaning that children with high amounts of sedentary time also achieved significantly less physical activity of moderate to vigorous intensity than the children with high MVPA and low sedentary time.

The children's PA level varied throughout their stay at the preschool, with peak levels being reached at around 10 o'clock, noon, and at the end of the preschool day. This pattern of three peaks and two drops is seen on all five of the measured weekdays, reflecting playtime and food breaks, respectively. Fig. 2 visualizes this pattern of PA level for the four activity quartiles, except that the least active 25% of children were more active for the first hour instead of later in the morning as the other groups were. The least active children were consistently less physically active on all time points compared to the other three quartiles, except for in the first hour (Fig. 2). The peak PA level between 1 and 2 o'clock in the afternoon corresponds to the time when most of the children were outdoors.

The least physically active 25% of children took 2975 fewer steps per day (CI = 3614 to 2337;  $p < 0.01$ ), spent significantly more time sedentary (mean difference = 76 min; CI = 99 to 52;  $p < 0.01$ ), and spent less time engaging in light intensity activity (mean difference = 31 min; CI = 44 to 17;  $p < 0.01$ ) and MVPA (mean difference = 50 min; CI = 57 to 43;  $p < 0.01$ ) than the most active 25% of the children. When wear time had been adjusted for, it was found that within the 80 min in which the least active group had spent sedentary, the most active quartile were engaged in either light intensity activity or MVPA. The children in the lowest activity quartile engaged in less MVPA and spent more time sedentary on all weekdays compared to the most active

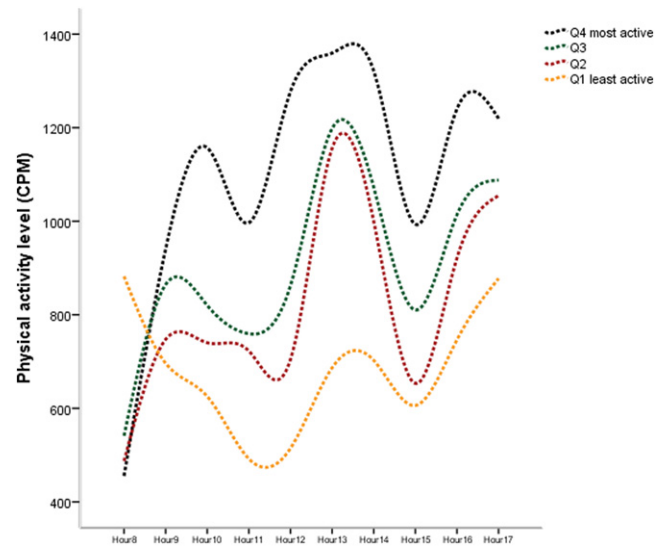


Fig. 2. Physical activity level hour by hour by quartiles ( $N = 24-29$ ), in which Q1 is the least physically active 25% of children, and Q4 are the most physically active 25% of children.

quartile (Fig. 3). Children in the most active quartile achieved  $\geq 60$  min of MVPA on 82% of the measured weekdays (SD  $\pm$  20) compared to 8% (SD  $\pm$  15) in the least active quartile (mean difference = 74%; CI = 84 to 63;  $p < 0.01$ ). There were no differences in how much time the least active and most active groups spent in a single sedentary bout (21  $\pm$  4.5 min and 22  $\pm$  5.3 min, respectively). However, the least active group had a greater number of sedentary bouts during the day, and therefore, the accumulated time spent in a sedentary bout was higher in this group (83  $\pm$  28 min) compared to the most active group (42  $\pm$  25 min, mean difference = 40.5 min; CI 22 to 58;  $p < 0.01$ ). With more sedentary bouts, the least active group naturally had more sedentary breaks during the week (mean difference = 8.0; CI = 5.0 to 10.9;  $p < 0.01$ ).

The children were significantly more physically active outdoors than they were indoors (mean difference = 259 CPM; CI = 180 to 339;  $p < 0.01$ ). The three most active quartiles were all more active outdoors compared to when they were indoors; however, for the least active 25% of children, there was no difference in the PA levels between being outdoors and indoors (Fig. 4). Furthermore, girls were found to

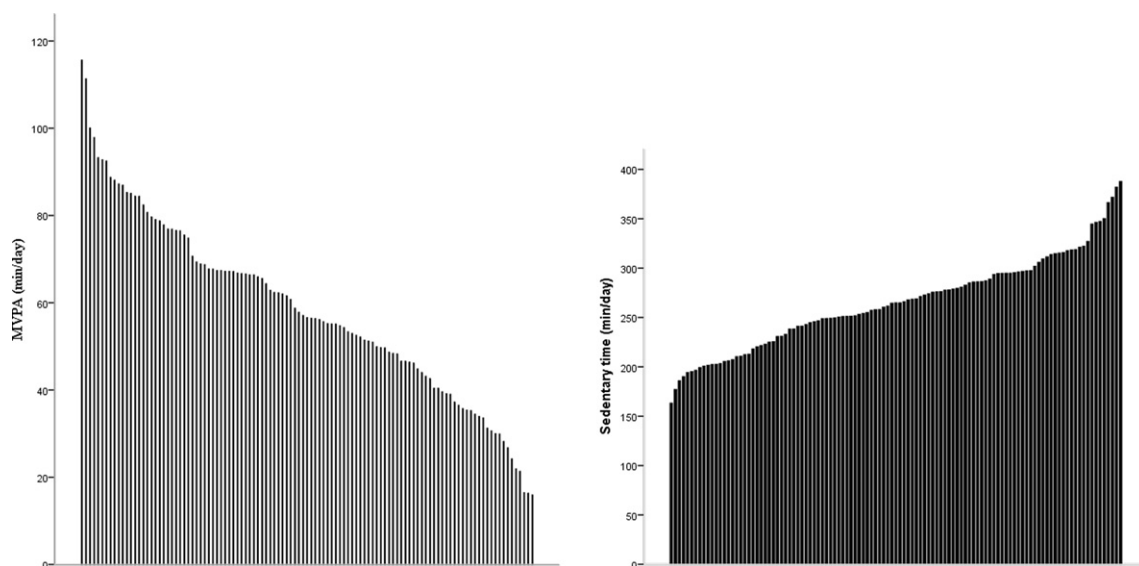
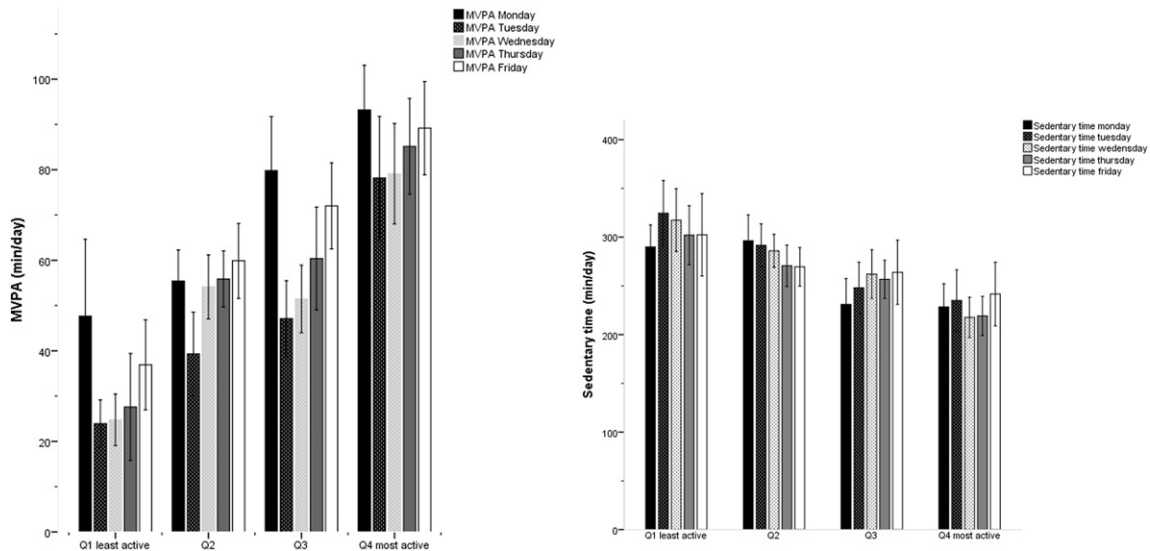


Fig. 1. Amount of MVPA (left) and sedentary time (right) per day for each of the 111 children (Rank order). MVPA; moderate- to vigorous physical activity.



**Fig. 3.** Amount of MVPA (left) and sedentary time (right) on each of the five measured weekdays for the least physically active 25% (Q1) of children through to the most physically active (Q4) 25% of the children.

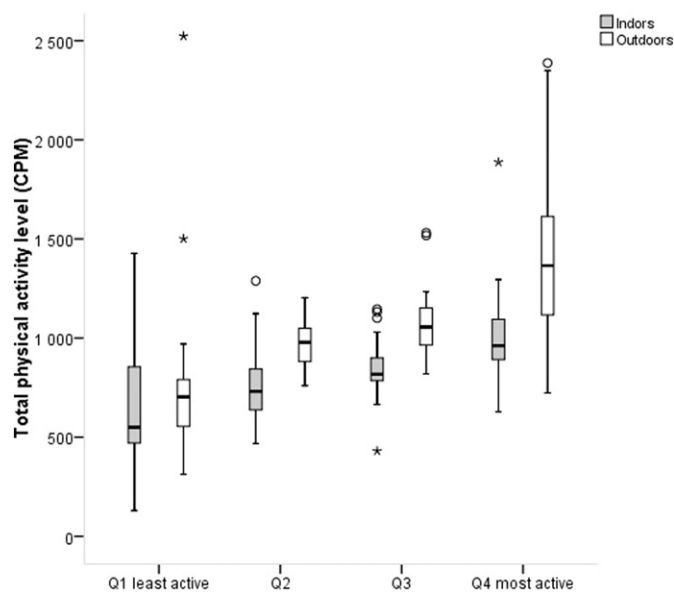
be less active than boys indoors (mean difference = 151 CPM; CI = 57 to 246;  $p < 0.01$ ), but just as active outdoors. On an individual level, the children's PA level indoors correlated with their PA level outdoors ( $r = 0.35$ ;  $p < 0.01$ ).

**4. Discussion**

On average, the 111 children accumulated almost 60 min of MVPA per day during the measured week at the preschool, however the PA level varied significantly among the children, and between weekdays. Except for the first hour, the 25% least physically active children were less active throughout the whole day compared to the other children, and only a small number achieved the recommended level of daily MVPA on any of the weekdays. Furthermore, the least active cohort took significantly fewer steps per day and spent considerably more time pursuing sedentary behaviors. Sedentary bouts, defined as physical

inactivity periods lasting for >10 min, were not longer for the 25% least active than for the other children, but they did have more of these bouts during the day. The most active quartile had 80 min more of light-, moderate- and vigorous-intensity PA each day compared to the least active children. Finally, the least active children differed from the pattern of children in the other three activity-quartiles as they were not more physically active outdoors than indoors. As previously reported in several other studies (Cooper et al., 2015; Brasholt et al., 2013; Dolinsky et al., 2011; Byun et al., 2011), boys had a higher PA level than girls and spent less time in a sedentary state. However, while girls were less active compared to the boys in total, they were just as active as boys when they were outside.

Almost 60% of the children reached the recommended level of 60 min of MVPA per day in the current study. The PA level was considerably lower on Tuesday, which can probably be explained by heavy rain that day. A study of 426 five and six year olds, enrolled in 42 randomly selected preschools in Denmark, found that rainy days were negatively associated with MVPA (−2.2 percentage points; 9 min in MVPA) (Olesen et al., 2013). In Sandefjord, the average number of days with precipitation  $\geq 1$  mm is 100–125 days (Tveito and Laursen, 2001) and is an unavoidable barrier for PA which should be planned for by staff; for example, by ensuring that children engage in indoor physical activities on these days. In the Copenhagen Prospective Studies on Asthma in Childhood, 39% of the 253 children included reached 60 min of MVPA per day (Brasholt et al., 2013), which is lower than that found in the current study, but higher than in other studies, which have reported prevalence from 3 to 14% (Fisher and Montgomery, 2005; Fisher et al., 2005; Specker and Binkley, 2003). In a review including 40 studies on preschool children aged 2–5 years, the percentage of time spent in MVPA ranged from 1.7 to 41.2% (from 13 min to 5.4 h per day) (Hnatiuk et al., 2014). Compared to the children in the current study, who spent 11% of the day in MVPA, most of the children studied in the review by Hnatiuk et al. (2014) were less active. The studies reporting high PA levels using accelerometers have set lower cut-off points for classifying MVPA and may, therefore, have overestimated the time spent in MVPA (Hnatiuk et al., 2014). Thus, the differences between studies may be real or may be merely a result of cut-off points for PA intensities not being uniformly established (Trost, 2007). In addition to intensity thresholds, length of EPOCH chosen (i.e. 15 s vs 1 min), type and placement of accelerometer could influence the results (Mattocks et al., 2008; Colley et al., 2014). Because of these methodological issues, comparing time spent in different intensities between studies should be conducted with great



**Fig. 4.** Indoor and outdoor physical activity level for the least physically active 25% of children (Q1) through to the 25% most physically active (Q4) 25% of children; CPM, counts per minute.

caution. Norwegian preschool children may, however, be truly more physically active during their stay at preschool compared to children in other countries because they spend most of their time outdoors (Moser and Martinsen, 2010).

When comparing results across studies, the same methodological issues apply to the sedentary variable. A review including 31 studies using accelerometers in preschool children found that the amount of sedentary time ranged from 23 to 95% of waking hours, and that results were largely dependent on the methods used (Hnatiuk et al., 2014). Over a 13-hour waking day, this would equate to between 2.9 and 12.4 h. The median amount of time spent sedentary in this review was 77% (approx. 10 h), which is much higher than that found in the current study (54%); however, the children in the AK-AC study removed the accelerometer when they left the preschool in the afternoon. They may have accumulated more sedentary time if they had worn the monitor for the whole day; however, this would not necessarily have affected the percentage of sedentary time.

The 25% least active children in the current study had half the PA level of the most active quartile and were less active than what was found in obese preschool children in Switzerland (Niederer et al., 2012). Furthermore, they took approximately 3000 fewer steps per day compared to the most active quartile, spent 80 more min pursuing sedentary behaviors each day, were consistently less active than the other children throughout the whole preschool day, and had longer sedentary bouts. Children are usually most active when they are outdoors (Raustorp et al., 2012), where there is more space for movement, a greater number of PA opportunities, and less rules, compared to indoors. Surprisingly, this was not the case for the least active children in the present study. The assumed qualities of the outdoor environment did not seem to affect these children's PA level for unknown reasons. To our knowledge, this is the first study to look at the difference between PA level indoors and outdoors in sedentary children.

The differences in PA level and pattern between the activity quartiles are probably not explained by gender or age, these variables were controlled in the analysis. Unfortunately, no data on the children or their parents were available which may have described potentially relevant background information about the children and their families. It is known from previous studies that children from low-income households and children who spend less time outdoors achieve lower MVPA (Dolinsky et al., 2011), and that children in the highest tertile of BMI are less active as compared with those in the lowest tertile (Brasholt et al., 2013). It is possible that the least active children in the current study were heavier and therefore not able to move as much, had a motoric delay, had fewer or no PA role models, or simply had more interest in activities which are more sedentary in nature. Factors within the preschool setting are most likely not the most relevant factor for explaining the different PA levels and patterns in this study because the activity levels of the children were equally distributed between the different preschools. Hence, both active and inactive children were attending the same preschool and most likely exposed to the same structural and environmental PA facilitators and barriers. However, Byun et al. (2011) found different correlates for PA among American preschool boys and girls (Byun et al., 2011); for example, athletic coordination was associated with sedentary behavior in girls but not in boys, and PA equipment was associated with sedentary behavior in boys but not in girls. This may also be the case for the "active" and "inactive" children in the current study. Another influencing factor may be that the built environment, available toys, and playground equipment did not stimulate and trigger these children to the same degree.

If a child's PA level is formed during preschool age, and PA level tracks from childhood to adulthood, then this needs to be taken seriously. It is probably more feasible to change behavior in childhood than in adulthood, and it is more economical to prevent lifestyle related diseases than to treat them. Many of these children are likely to become insufficiently active as adults and thereby increase the risk of developing cardiovascular disease (CVD) (Pearson et al., 2002), type 2 diabetes

(T2D) (Jeon et al., 2007) and increased mortality rates (Arem et al., 2015). The very low PA levels in many of these children may even be harmful and already have consequences at this young age. Even though hard endpoints, such as non-communicable diseases, are not present at such an early age, Jimenez-Pavon et al. (2013) found in a study on 1016 children between 2 and 6 years old that the odds ratio for CVD risk was elevated in the least active quintile of PA (OR: 2.58) compared with the most active quintile (Jimenez-Pavon et al., 2013).

A strength of the current study is that almost all of the children born in 2011 who were in the preschool on the first measurement day agreed to wear an accelerometer. This was especially important in this study because the least physically active individuals tend not to volunteer for studies of this nature. A limitation of this study is lack of additional data on the children or their parents to characterize these children (i.e. socio-economic status, ethnicity, weight). Furthermore, the reason for the low PA level and different PA pattern displayed by the least active children is not known. Some of these children could have been suffering from minor illnesses, had injuries, or other reasons which may have explained their low PA levels. Lastly, because the children removed the accelerometer at the end of the preschool day, comparing the results of this study with others is somewhat problematic. However, an average wear time of 8 h is comparable to most other studies.

## 5. Conclusion

In general, the children in the 11 public Norwegian preschools were quite physically active throughout the preschool week, but the large variation between the children with respect to both MVPA and sedentary time was a significant finding. The very low PA level and high amount of sedentary time of the least active quartile found in this study is a cause for concern, since this may influence both current and future health. Findings such as longer sedentary bouts, less activity throughout the entire day, and not being more active outdoors than indoors, may be useful information for tailoring interventions focused on this important target group of physically inactive children. The possibility that some children may prefer activities which are more sedentary in nature should be taken into account. However, to assist in combatting the obesity epidemic and contribute to avoiding the wide range of potentially negative cognitive and socio-emotional consequences which could be the consequences of a lack of PA, new and innovative interventions must be developed and proven. In order to develop and succeed with new and innovative interventions, more information also needs to be known about who the least active children are and what needs and interests these children might have with regard to physical activity.

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