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## ORIGINAL PUBLICATIONS

### I

#### SEASONAL AND DAILY VARIATION IN PHYSICAL ACTIVITY AMONG THREE-YEAR-OLD FINNISH PRESCHOOL CHILDREN

by

Soini, A., Tammelin, T., Sääkolahti, A., Watt, A., Villberg, J., Kettunen, T., Mehtälä, A., & Poskiparta, M. (2014).

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7 **Seasonal and daily variation in physical activity among 3-year-old Finnish preschool**

8 **children**

9

## 10 Abstract

11 The purposes of this study were to assess seasonal, daily, and gender variations in children's  
12 physical activity (PA). ActiGraph GT3X accelerometers were used to record the 3 year-old  
13 children's PA levels for five consecutive days in autumn and winter. Complete data for both  
14 seasons were obtained for 47 children. Despite a significant difference in seasonal  
15 temperatures ( $p < .001$ ), differences were only found for weekdays light PA ( $p = .021$ ). No  
16 difference in PA was observed between weekdays and weekend days. Only 20% of the  
17 sample had  $\geq 120$  minutes light-to-vigorous PA (LMVPA), and 46% of children had  $\geq 60$   
18 minutes moderate-to-vigorous PA (MVPA). Boys spent more minutes in LMVPA ( $p = .001$ )  
19 and MVPA ( $p = .004$ ) than girls. The current findings indicated that season and day of the  
20 week only minimally influence children's PA levels, whereas gender continues to be a  
21 significant factor.

22 **Keywords:** accelerometer; childcare; early childhood; physical activity

23

## 24 **Introduction**

25 Early childhood has been identified as an important time for the development of healthy  
26 behaviours such as physical activity (PA) (Timmons, Naylor, & Pfeiffer, 2007). Children's  
27 engagement in PA plays a key role in their physical growth and biological maturation (Strong  
28 et al., 2005) and exerts a positive influence on their cognitive, social, and psychological  
29 development (Timmons et al., 2007). Previous studies have demonstrated that PA not only  
30 appears to track reasonably well over time (Strong et al., 2005), but that physical inactivity  
31 (Telama, 2009) and obesity (Moore et al., 2003) demonstrate even stronger consistency in the  
32 transition from childhood to adulthood. In light of this trend, the enhancement of PA and  
33 reduction in sedentary behaviour in children are genuinely important from a public health  
34 perspective (Tremblay et al., 2011).

35         Preschool children's (3–5 years) PA may be described as "play" and occurs at various  
36 levels of intensity (Timmons et al., 2007). The assessment of young children's PA is  
37 demanding, primarily because their behaviour is intermittent and sporadic. Objective  
38 measures such as accelerometers can detect these short spurts of activity and determine  
39 frequencies, intensities, and duration of PA (Cliff, Reilly, & Okely, 2009; Oliver, Schofield,  
40 & Kolt, 2007; Pate, O'Neill, & Mitchell, 2010). Accelerometers have become one of the most  
41 widely used methods for assessing preschool-aged children's PA (Pate et al., 2010). Although  
42 the use of accelerometers to assess PA in preschool children has increased over the past  
43 decade (Bornstein, Beets, Byun, & McIver, 2011), Carson and Spence (2010) reported that  
44 there was only a small set of studies where preschool-aged children's PA levels have been  
45 determined with accelerometers across different seasons. Carson and Spence found that 29  
46 out of a total of 35 studies assessed seasonal variations in PA among children and/or  
47 adolescents, but that only six exclusively examined preschool-aged groups, in which the  
48 pattern of findings were less clear. For example, in Scotland (Fisher et al., 2005), Canada

49 (Carson, Spence, Cutumisu, Boule, & Edwards, 2010) and the United States (Poest, Williams,  
50 Witt, & Atwood, 1989) children were less physically active in wintertime compared to  
51 summertime, whereas Finn, Johannsen, & Specker (2002) found no seasonal variations in  
52 their US study. Burdette, Whitaker, and Daniels (2004) reported that the highest levels of  
53 outdoor playtime occurred in the summer and the lowest in the winter and that seasonal  
54 differences in children's PA levels, as measured by accelerometers, were less pronounced  
55 compared to children's parents' proxy reports. Differences in children's PA have related  
56 more to time spent outdoors than to season or weather conditions (Baranowski, Thompson,  
57 DuRant, Baranowski, & Puhl, 1993). Seasonality merits study in young preschool children,  
58 as lifelong patterns of PA participation throughout the year are adopted in the early years of  
59 life (Poest et al., 1989). Because so few of these earlier studies were conducted in locations  
60 characterized by very cold winter temperatures, such as experienced in Finland, more  
61 knowledge is needed about seasonal variation in young children's PA in environmental  
62 conditions of this kind.

63 In Europe, the average enrolment rate of children aged 3 years in childcare and early  
64 education services is 69% (OECD Family Database, 2008). During weekdays, children attend  
65 childcare approximately 6–9 hours/day, while on weekend days they spend the whole day  
66 typically engaged in activities based within the home setting. There is evidence that  
67 children's attendance at childcare influences their levels of PA (Finn et al., 2002; Pate,  
68 McIver, Dowda, Brown, & Addy, 2008; Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004),  
69 thereby underlining the importance of examining and comparing children's PA levels during  
70 weekdays and weekend days.

71 To date, studies of objectively measured PA and sedentary behaviour in preschool-  
72 aged children have drawn attention to the fact that levels of PA are typically low and  
73 sedentary behaviour high (Oliver et al., 2007; Reilly, 2010). On the basis of their

74 accelerometer-derived meta-analysis, Bornstein et al. (2011), concluded that preschool  
75 children accumulate anywhere from 40 to 100 minutes of MVPA daily. Previous early  
76 childhood studies have investigated whether preschoolers are meeting PA guidelines,  
77 meaning at least 60 minutes of MVPA (Beets, Bornstein, Dowda, & Pate, 2011; Cardon &  
78 De Bourdeaudhuij, 2008; Reilly, 2010; Tucker, 2008). Despite the recommendations to  
79 engage in PA and its indisputable benefits, many young people do not achieve the guidelines  
80 for daily PA (Reilly, 2010; Tucker, 2008). For example, a review of studies from seven  
81 different countries found that nearly half of preschool-aged children did not engage in  
82 sufficient PA, and only 54% achieved the minimum of 60 minutes of PA daily (Tucker,  
83 2008). Few earlier PA studies have focused exclusively on 3-year-olds, and therefore more  
84 research is needed to reach a comprehensive understanding of PA levels and sedentary  
85 behaviour during the very early preschool years.

86         The main purposes of this study were to assess the PA levels and sedentary time of 3-  
87 year-old children, paying special attention to the variation in PA and sedentary behaviour  
88 between boys and girls, weekdays and weekend days, and the autumn and winter seasons. A  
89 secondary purpose was to ascertain whether preschool children achieve the recommended  
90 levels of PA proposed within national and international current guidelines (Australian  
91 Government, Department of Health and Ageing, 2010; Canadian Society for Exercise  
92 Physiology, 2012; Department of Health. UK physical activity guidelines, 2011; Institute of  
93 Medicine [IOM], 2011; The National Association for Sport and Physical Education [NASPE],  
94 2009; Recommendations for Physical Activity in Early Childhood Education, 2005; World  
95 Health Organization [WHO], 2010).

## 96 **Method**

### 97 *Participants*

98 Principals of childcare centres in Jyväskylä were provided with information regarding the  
99 study at a regional administrative meeting. A total of 14 childcare centres volunteered to be  
100 involved in the study. All the families of the 3-year-old children (year of birth 2007)  
101 attending the participating childcare centres were invited to participate. One hundred and two  
102 (57%) parents of 179 families provided informed consents. The PA data on the children were  
103 collected in two phases. The first data collection was in autumn (August to October) and the  
104 second during the winter (January to February).

105         A total of 96 children (48 boys and 48 girls) participated in the data collection in  
106 autumn and 94 children (50 boys and 44 girls) took part in winter. Before analysis, the data  
107 on 16 children from the autumn sub-sample, and 34 children from winter sub-sample were  
108 discarded, as 6 children (autumn) and 14 children (winter) were in homecare, and the  
109 remaining 30 participants did not have sufficient complete data. The minimum requirement  
110 for valid PA data was at least 8 hours of monitored PA per day (from 7 am to 9 pm) for at  
111 least 2 weekdays and 1 weekend day. Complete data were obtained for 81 children (41 boys  
112 and 40 girls) during autumn and for 60 children (33 boys and 27 girls) during winter.  
113 Complete data for both seasons were obtained for 47 children (26 boys and 21 girls). Body  
114 weight and height were measured at the time of each PA data collection and body mass index  
115 (BMI: kg/m<sup>2</sup>) was calculated for each child. Demographic characteristics of the sample by  
116 gender and season are shown in Table 1. Results for BMI indicated, in accordance with the  
117 International Obesity Task Force BMI definition, four children (9%) during the autumn  
118 assessments and three children (7%) during the winter assessments were evaluated as  
119 overweight. All other children were in the normal BMI range (Cole, Bellizzi, Flegal, & Dietz,  
120 2000). [Table 1 near here]

121 *Instruments*



122 PA was quantified with ActiGraph GT3X accelerometers on five consecutive days (from  
123 Wednesday to Sunday), which were programmed to save data in 5-s intervals (epochs) as  
124 proposed for children this age (Cliff et al., 2009). In the present study, total physical activity  
125 (TPA) was expressed as mean counts per minute (cpm). To analyse the amount of the time  
126 children spent at different intensity levels, the separate count cut points for preschool-aged  
127 children established recently by Van Cauwenberghe, Labarque, Trost, De Bourdeaudhuij, and  
128 Cardon, (2011) were adapted for this study. The following cut-points were used: sedentary ( $\leq$   
129 1491 cpm); light (1492-2339 cpm); moderate (2340-3523 cpm); vigorous ( $\geq$  3524 cpm); light-  
130 to-vigorous physical activity (LMVPA) ( $\geq$  1492 cpm); and moderate-to-vigorous physical  
131 activity (MVPA) ( $\geq$  2340 cpm) (Van Cauwenberghe et al., 2011).

### 132 *Procedures*

133 Before the data collection, all the participants were familiarized with the accelerometer. The  
134 children received an accelerometer on the first morning of the study, and all the children,  
135 together with their parents, were instructed to wear the accelerometer on an adjustable elastic  
136 belt over their right hip for as long as possible during all waking hours, removing it only for  
137 water-based activities and sleeping. Parents and early educators were informed about the  
138 correct procedures and proper accelerometer use via an information letter.

139 Parents were asked to record the times at which children woke up, went to bed, and  
140 their childcare attendance times. Additionally, parents were asked to report any abnormalities  
141 in daily routines, for example, long periods spent sitting (e.g., in a car), swimming, bathing  
142 and if the child falls ill during the measurement time. Receptivity to wearing the instrument  
143 was rated by the parent on a five-point scale (from very pleasant to very unpleasant). Outdoor  
144 times were recorded by the researchers during attendance at childcare. The ethics committee  
145 of the University of Jyväskylä, and the Social Affairs and Health officer in city of Jyväskylä  
146 approved the study.

**147 Environmental conditions**

148 The city of Jyväskylä is located in central Finland (62° 15' 36"N, 25° 45'E). The suburbs of  
149 the city of Jyväskylä are in close proximity to forests, hills and lakes, with good opportunities  
150 for active commuting and leisure time activities. The region experiences four distinct seasons.  
151 The average maximum air temperature in autumn (August to October) is around 13.0°C,  
152 average precipitation 66 mm/month and duration of sunshine approximately 255 hours/month.  
153 During the winter months (January and February) the average air temperature is around -  
154 8.4°C, average precipitation of 39 mm/month, duration of sunshine approximately 51  
155 hours/month and average snow depth 36 cm (Climatological Statistics of Finland, 1981–  
156 2010). In this study, the findings showed significant seasonal variation in mean daily  
157 temperature (9.4°C in autumn vs. -13.1°C in winter;  $p < .001$ ). These temperatures were  
158 lower than normally recorded for these seasons.

**159 Statistical analyses**

160 All data were checked for normality before statistical analysis. Periods of non-wear time  
161 (defined as 20 consecutive minutes of '0' counts) and an upper range of biological  
162 plausibility (defined as no more than 15 000 cpm) were removed from the data (Cliff et al.  
163 2009). The data reduction was done with using self-customized software.

164 The data were analysed using SPSS for Windows (version 18.0). Means and standard  
165 deviations (SD) were calculated for daily TPA expressed as cpm, and time spent (minutes per  
166 day) at different intensity levels (sedentary, light, moderate, vigorous, LMVPA and MVPA)  
167 to show the extent of activity behaviour for the independent variables of gender and season.  
168 Nonparametric tests (Wilcoxon and Mann-Whitney) and General Linear Models (GLM) for  
169 repeated measures (MANOVA) were used to analyse gender and seasonal differences in  
170 children's PA on weekdays and weekend days. To compare PA levels on weekdays and  
171 weekend days, paired-samples *t*-tests were conducted. Gender differences in TPA and in

172 engagement at different intensity levels were analysed using independent-samples *t*-test.  
173 Effect size was determined using the Cohen's *d* formula. Crosstabs utilizing Pearson Chi-  
174 square were used to determine the percentages of children who reached the current  
175 recommended levels of PA. Statistical significance was set at an alpha level of .05 for all  
176 analyses.

## 177 **Results**

178 The results showed a significant seasonal variation in mean outdoor time during childcare  
179 attendance (178 minutes in autumn vs. 116 minutes in winter;  $p = .002$ ). During the data  
180 collection periods, the participants attended childcare settings for an average of 7.6 hours/day.  
181 Accelerometers were worn for an average of 4.6 days and 692 minutes/day.

182 The results indicated that the children engaged in sedentary activity for 85% of the  
183 time, in light activity for 6% of the time, and in MVPA for 9% of the time monitored. Mean  
184 TPA for the whole sample was 632 cpm ( $SD = 145$ ), boys showing significantly higher TPA  
185 than girls (673 vs. 580 cpm;  $p = .001$ ,  $d = 0.70$ ). A paired-samples *t*-test indicated no  
186 significant differences in TPA or in PA levels between weekdays and weekend days, except  
187 in winter, when the children engaged significantly more in sedentary behaviour on weekdays  
188 compared to weekend days (596 vs. 570 min/day;  $p = .019$ ,  $d = 0.37$ ).

189 No seasonal difference was observed in children's PA levels, except for minor  
190 variation on weekdays light PA ( $p = .021$ ; see Table 2). Boys were more physically active  
191 than girls. Between-subjects comparisons in PA on weekdays and weekend days indicated  
192 significant gender differences for all the dependent variables, except for sedentary time on  
193 weekend days (see Table 2). Results of the independent-samples *t*-tests for the comparison of  
194 PA levels by gender revealed that especially during winter weekdays boys were physically  
195 more active than girls (see Table 3). Seasonal variations between boys and girls were also  
196 analysed with GLM for repeated measures. No significant differences were observed for any

197 of six variables. Due to small sample size, the power of the tests was minimal on all  
198 occasions, and therefore the results of the MANOVA are merely indicative. [Tables 2 and 3  
199 near here]

200 The proportions of children engaging in LMVPA were 1% (under 60 minutes/day),  
201 36% (6089 minutes/day), 43% (90119 minutes/day), 20% (120 minutes or more/day). The  
202 proportions of children engaging in MVPA were 53% (3059 minutes/day), 40% (6089  
203 minutes/day, and 6% (90119 minutes/day). None of the children engaged in MVPA 120  
204 minutes or more/day. Pearson Chi-Square tests confirmed the gender differences in the time  
205 spent in LMVPA ( $p = .010$ ) and MVPA ( $p = .002$ ). According to parents' reports of their  
206 children's receptivity to wearing the accelerometer, only 3% of the children reported the  
207 experience as "unpleasant" and none as "very unpleasant".

## 208 **Discussion**

209 The main purposes of this study were to assess seasonal, daily, and gender variations in 3-  
210 year-old preschool children's PA and sedentary behaviour. The results indicated only minor  
211 seasonal variations in the children's light PA on weekdays, and no difference was observed in  
212 PA levels between weekdays and weekend days, except in winter in the children's sedentary  
213 behaviour. Boys were more active than girls, particularly in winter and during weekdays. The  
214 findings indicated that the children's PA levels were very low and sedentary time very high.  
215 Overall, the children did not meet the recommendations of three hours of daily LMVPA  
216 (Australian Government, Department of Health and Ageing, 2010; Canadian Society for  
217 Exercise Physiology, 2012; Department of Health. UK physical activity guidelines, 2011;  
218 IOM, 2011), or two hours of daily brisk PA (Recommendations for Physical Activity in Early  
219 Childhood Education, 2005). Approximately 20% of the present sample engaged in at least  
220 two hours of daily LMVPA (NASPE, 2009) and 46% fulfilled the requirement of at least 60  
221 minutes of MVPA daily (WHO, 2010).

222           The mean TPA scores for the children in the present study were slightly lower than  
223 those reported in earlier similar studies (Cardon & De Bourdeaudhuij, 2008; Fisher et al.,  
224 2005; Jackson et al., 2003). For example, Jackson et al. (2003) found total activity counts of  
225 669 cpm for 3-year-old Scottish children compared to the mean of 632 cpm found in this  
226 study. Cardon and De Bourdeaudhuij (2008) reported that a sample of 4- and 5-year-old  
227 Belgian children engaged in 9.6 hours per day of sedentary behaviour and in MVPA for only  
228 34 minutes per day. The present sample was similarly sedentary for 9.9 hours per day,  
229 although the children also engaged in MVPA for 61 minutes per day. Based on a meta-  
230 analysis of accelerometer based studies, Bornstein et al. (2011) indicated substantial  
231 variations in children's MVPA times, with no clear pattern emerging on the typical PA levels  
232 of preschool children. The pattern of low levels of PA and high levels of sedentary time  
233 reported for the present Finnish children as well as in comparable studies, underlines a  
234 worrying trend among preschool-aged children regarding their failure to engage in sufficient  
235 levels of PA.

236           Limited previous research has examined seasonal variations in younger age groups,  
237 and incorporated the use of accelerometers to evaluate PA (Carson & Spence, 2010). Several  
238 studies have shown seasonal variation in young children's PA, with PA levels typically  
239 higher and sedentary time lower in summertime (Carson et al., 2010; Fisher et al., 2005;  
240 Poest et al., 1989). The highest levels of outdoor playtime occurred in the summer and the  
241 lowest in the winter (Burdette et al., 2004). Baranowski et al. (1993) also found seasonal  
242 variation in outdoor activity, with all the children showing lower outdoor activity levels  
243 during the summer months. Finn et al. (2002) found no effect for season. Similarly, the  
244 present study found only minor seasonal variations in children's PA levels. The data revealed  
245 that on weekdays in autumn the children engaged significantly more in light PA than on  
246 weekdays in winter. Generally, childcare centres' daily schedules do not vary within seasons.

247 However, in cold weather, such as  $-20^{\circ}\text{C}$  or colder, it is possible, that children do not  
248 participate in outdoor activities, or recess periods are shorter than normally. Significant  
249 seasonal variations in mean temperatures could explain why the average outdoor time during  
250 childcare attendance in winter (116 min) was significantly less than in autumn (178 min).  
251 Furthermore, in winter, shorter outdoor activity times may explain children's lower  
252 engagement in light PA on weekdays. In addition, the amount of daylight hours during the  
253 winter months (51 hours/month) is much shorter than in autumn (255 hours/month), and  
254 might have an influence on children's outdoor times after childcare attendance. Given the  
255 considerable contrast in environmental conditions, such as temperature and the presence of  
256 snow, the results were surprisingly similar for the two seasons.

257         Aside from Finn et al. (2002), who concluded that attendance at the childcare centre  
258 was the strongest predictor of activity levels, with more than 50% of the daily activity counts  
259 performed during childcare hours, and Strong et al. (2005), who reported that preschools  
260 should provide opportunities for children to accumulate 60 minutes and more of MVPA each  
261 day, earlier studies have typically indicated that physical activity levels are very low among  
262 preschool children during their time in childcare settings (Pate et al., 2008; Reilly, 2010).  
263 Cardon and De Bourdeaudhuij (2008) reported higher levels of sedentary behaviour on  
264 weekdays compared to weekend days, although MVPA was as low during the weekend days  
265 as during the weekdays. In the present study, in wintertime, the children engaged more in  
266 sedentary behaviour on weekdays than weekend days. Childcare attendance and outdoor  
267 times may in part explain children's greater engagement in sedentary behaviours during  
268 weekdays compared to weekend days. The descriptive results revealed that the children  
269 tended to be more active on weekdays, although no significant difference in the time spent in  
270 different intensity levels was found between weekdays and weekend days. Similarly, Jackson  
271 et al. (2003) found no differences in activity levels between weekdays and weekend days.

272 Interestingly, the present results showed that the variation in PA time (described by standard  
273 deviation and range) on weekend days was somewhat higher than on weekdays. In the  
274 present study, there were boys and girls who were physically very active, and others who  
275 were very inactive. This finding should encourage early educators and parents to make extra  
276 effort to promote a healthy lifestyle in their daily activities with children.

277 Previous preschool PA research has shown boys to be more active than girls (Finn et  
278 al., 2002; Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008; Jackson et al., 2003; Pate et  
279 al., 2004). In the present study, boys' TPA was significantly higher than girls', and boys also  
280 spent significantly more minutes in LMVPA and MVPA. On weekdays, girls spent  
281 significantly more minutes sedentary than boys. The gender differences were more  
282 pronounced on weekdays and during wintertime. It is possible that boys are more interested  
283 in rough and tumble play and winter-oriented physical activities (e.g., snow-based play) or  
284 enjoy more time in outdoor environments than girls. One potential explanation may be found  
285 in parents' and early educators' attitudes, which may affect children's PA. Boys are regularly  
286 encouraged to engage in more physically active play and games, whereas girls are exposed to  
287 stationary activities and expected to behave in a calmer manner (Pellegrini & Smith, 1998).  
288 Although it is not clear whether the gender difference in PA is biologically based or  
289 environmentally determined, it is most likely a combination of both (Timmons et al., 2007).  
290 The present findings provide further support for the recommendations that more attention and  
291 encouragement are needed to promote PA throughout the year for preschool-age girls (Pate et  
292 al., 2004).

293 Systematic reviews of previous population surveys have shown that many young  
294 children do not meet the international guidelines for PA (Bornstein et al., 2011; Reilly, 2010;  
295 Tucker, 2008); the results of the present study were in line with these findings.  
296 Approximately half of the children engaged in MVPA for at least 60 minutes per day. Only

297 20% of children reached the NASPE standard of at least 120 minutes of PA per day, when  
298 light PA was included. In addition, none of the present sample engaged in LMVPA for 180  
299 minutes or more (Australian Government, Department of Health and Ageing, 2010; Canadian  
300 Society for Exercise Physiology, 2012; Department of Health. UK physical activity  
301 guidelines, 2011; IOM, 2011), or achieved the Finnish Recommendations for Physical  
302 Activity in Early Childhood Education (2005) of at least 120 minutes of daily brisk PA  
303 (defined as MVPA ( $\geq 2340$  cpm)). The current sample of 3 year-olds was sedentary for  
304 nearly 10 hours per day. Finnish recommendations for preschool children's PA currently do  
305 not include limitations on sedentary time, whereas international guidelines (Australian  
306 Government, Department of Health and Ageing, 2010; Canadian Society for Exercise  
307 Physiology, 2012; Department of Health. UK physical activity guidelines, 2011; IOM, 2011;  
308 NASPE, 2009) specifically state that children should not be sedentary for more than one hour  
309 at a time except when sleeping. More research is needed to evaluate the effects of PA on  
310 children's health and wellness in the early years of life and what constitutes sufficient levels  
311 of health-enhancing PA (Beets et al., 2011). In particular, it would be very important to  
312 determine the quantity and quality of daily PA required to ensure children's optimal growth  
313 and maturation.

314 A major strength of this study was the repeated-measure design, where the same 3-  
315 year-old children were measured with accelerometers during two distinct seasons. However,  
316 caution should be exercised when comparing PA levels over short time periods (e.g., 3–6  
317 months) because children's normal growth and maturation may influence their physical  
318 abilities and motor skills in relation to their engagement in physically active play (Fisher et  
319 al., 2005). Children's PA was measured over five days in both the childcare and home  
320 settings, including weekdays and weekend days. Anecdotal evidence derived from the  
321 implementation of the study suggests that childcare centres are suitable places to reach



322 families with 3-year-old children. Moreover, the children were co-operative and eager to take  
323 part in this study. Proxy reports by parents of their child's receptivity to wearing the  
324 accelerometer clearly indicated that it was a positive experience for the majority of the  
325 children. Although previous data on the receptivity of preschoolers to wearing accelerometers  
326 is relatively limited and not well understood (Oliver et al., 2007), the present results are in  
327 line with those of earlier studies (Cardon & De Bourdeaudhuij, 2008; Pate et al., 2004).

328         The present study was limited by the relatively small sample size, although the sample  
329 was focused exclusively on 3-year-old children. Furthermore, the generalizability of the  
330 findings could be limited by the fact that all the participating childcare centres and children  
331 were located in the same city. It is noteworthy that a large number of children did not achieve  
332 the required 8 hours of daily data for at least two weekdays and one weekend day during the  
333 winter. This may partly have been due to the effect of the cold weather conditions on the  
334 functioning of the accelerometers.

335         A disadvantage of accelerometers is that they do not provide information on the type  
336 or context of PA (Pate et al., 2010). In addition, accelerometers are limited in their ability to  
337 measure non-weight-bearing activities, such as swimming, cycling, and skating or upper limb  
338 movements, (e.g., digging, carrying and pushing objects). They are not able to account for the  
339 increased energy cost associated with walking up stairs, on an incline or on soft surfaces  
340 (Oliver et al., 2007; Pate et al., 2010; Trost, 2007). Children playing outdoors in Finland  
341 during wintertime often climb up and slide down mounds of snow, pushing or pulling sleds,  
342 walking in soft snow, or skating on ice. Also, accelerometers do not detect movements, which  
343 are sedentary but need balance and/or concentration in order to develop motor skills or are  
344 integral to certain low intensity activities (e.g., singing, drawing and completing puzzles),  
345 which are particularly important for young preschool children (Cliff et al., 2009).

346           Although previous research has found that triaxial accelerometers generate data with a  
347 higher level of validity than uniaxial accelerometers (Rowlands, 2007), conjecture remains as  
348 to whether triaxial accelerometers detect PA better than uniaxial accelerometers in children  
349 (Oliver et al., 2007). In this study, we analysed acceleration in the vertical plane, which has  
350 been shown to provide the most important assessment of ambulatory movement (Oliver et al.,  
351 2007). The choice of cut points significantly influences the amount of PA reported across  
352 different intensity levels (Bornstein et al., 2011). Investigators in the field of PA need to  
353 resolve the issue of what accelerometer cut points are the most appropriate (Beets et al., 2011;  
354 Bornstein et al., 2011) and continue to focus on standardizing methods for the collection,  
355 cleaning, analysing and reporting of accelerometer data (De Vries et al., 2009). To date, the  
356 majority of validation and calibration studies have reported a strong positive correlation  
357 between ActiGraph accelerometer output and intensity of PA in children (Pate et al., 2010;  
358 Rowlands, 2007; Trost, 2007). Strong evidence also exists for good reproducibility of the  
359 data generated by ActiGraph accelerometers in samples of preschool-aged children (De Vries  
360 et al., 2009). Although the strengths and limitations of accelerometers are widely discussed in  
361 the literature, accelerometers remain a necessary tool for measuring PA and sedentary  
362 behaviour in free-living preschool children (Pate et al., 2010; Trost, 2007; Van  
363 Cauwenberghe et al., 2011).

#### 364 **Conclusion**

365 The present findings have valuable implications for developing interventions that could  
366 contribute to improvements in preschool children's PA both in the home and childcare setting.  
367 Based on the current results the influence of season and day of the week is minimal. However,  
368 consistent with previously reported research, gender is shown to be a critical variable in  
369 relation to children's PA levels. Finnish children appear to achieve recommended guidelines  
370 regarding PA levels and sedentary behaviour, in a similar distribution to other studies (e.g.,

371 Reilly, 2010; Tucker, 2008). The levels of sedentary behaviour observed in current sample  
372 may stimulate early educators and parents to work towards reducing the time children spend  
373 in sedentary behaviour and increase time and opportunity for engaging in the recommended  
374 levels of PA. This change in practice should particularly target girls. In future research, larger  
375 and more heterogeneous samples are required to determine key characteristics of children's  
376 PA such as type and context. This could be achieved through combining accelerometer  
377 information with other methods, such as direct observation, that describe where and how PA  
378 takes place among preschool-aged children.

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382

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**Table 1.** Demographic information for boys (n = 26) and girls (n = 21) by

season.

	Autumn				Winter			
	Boys		Girls		Boys		Girls	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age (years)	3.3	0.3	3.3	0.3	3.6	0.3	3.7	0.3
Height (cm)	100.0	5.4	98.4	3.3	102.5	5.5	101.2	3.4
Weight (kg)	16.1	2.0	15.6	1.4	17.0	2.0	16.4	1.6
BMI (kg/m <sup>2</sup> )	16.2	0.9	16.1	1.2	16.1	0.8	16.0	1.3

*Note.* *M* = mean, *SD* = standard deviation, BMI = body mass index

**Table 2.** Gender and seasonal differences in children's weekdays and weekend days' physical activity (PA)

(minutes/day).

Physical activity intensity	Total				Season							
	Boys (n = 26)		Girls (n = 21)		Autumn (n = 47)		Winter (n = 47)		<i>p</i>	<i>d</i> *		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>				
<b>Sedentary time</b>												
Weekdays	585	51	608	54	.047	0.44	595	48	596	58	.861	0.02
Weekend days	576	71	589	73	.310	0.18	594	58	570	82	.087	0.34
<b>Light PA</b>												
Weekdays	43	8	37	6	.001	0.85	41	7	39	8	.021	0.27
Weekend days	41	12	36	9	.030	0.47	39	10	38	11	.378	0.10
<b>Moderate PA</b>												
Weekdays	34	8	29	6	.001	0.71	32	7	31	8	.668	0.13
Weekend days	33	12	28	8	.028	0.50	30	10	31	11	.866	0.10
<b>Vigorous PA</b>												
Weekdays	32	12	27	9	.021	0.48	31	12	29	11	.331	0.17
Weekend days	33	16	26	12	.036	0.50	29	14	30	16	.767	0.07
<b>LMVPA</b>												
Weekdays	109	26	92	18	.001	0.77	104	24	100	24	.204	0.17
Weekend days	106	37	90	27	.021	0.50	99	32	99	36	.970	0.00
<b>MVPA</b>												
Weekdays	67	19	55	14	.005	0.73	62	18	61	18	.328	0.06
Weekend days	65	27	54	19	.029	0.48	60	23	61	26	.707	0.04

*Note.* \*Effect size (Cohen's *d*)

**Table 3.** Time (minutes/day) spent in different intensities of physical activity (PA) during weekdays and weekend days for each seasons in boys and girls.

Physical activity intensity	Autumn						Winter							
	Boys (n = 26)		Girls (n = 21)		<i>t</i>	<i>p</i>	<i>d</i> *	Boys (n = 26)		Girls (n = 21)		<i>t</i>	<i>p</i>	<i>d</i> *
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>				<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
<b>Sedentary time</b>														
Weekdays	587	48	604	48	1.22	.230	0.35	584	54	612	60	1.69	.097	0.49
Weekend days	594	56	594	62	0.01	.992	0.00	557	80	585	83	1.16	.252	0.34
<b>Light PA</b>														
Weekdays	44	8	39	6	2.36	.023	0.71	42	8	36	5	2.88	.006	0.92
Weekend days	41	11	37	8	1.66	.105	0.42	40	12	36	10	1.14	.260	0.36
<b>Moderate PA</b>														
Weekdays	34	7	30	6	2.00	.052	0.62	35	9	27	5	3.46	.001	1.14
Weekend days	33	11	28	7	1.91	.063	0.56	33	13	28	9	1.54	.131	0.46
<b>Vigorous PA</b>														
Weekdays	33	13	28	10	1.53	.133	0.44	32	12	26	8	2.14	.038	0.60
Weekend days	32	15	25	11	1.74	.088	0.54	33	17	27	14	1.32	.192	0.39
<b>LMVPA</b>														
Weekdays	110	25	96	20	2.11	.041	0.62	108	27	89	15	3.09	.004	0.91
Weekend days	106	36	89	23	1.94	.059	0.58	106	40	91	30	1.43	.160	0.43
<b>MVPA</b>														
Weekdays	66	19	57	16	1.80	.079	0.51	67	20	53	11	2.84	.007	0.90
Weekend days	65	26	53	17	1.93	.060	0.56	66	29	55	22	1.46	.152	0.43

*Note.* \*Effect size (Cohen's *d*)