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**Directly Observed Physical Activity among 3-Year-Olds in Finnish Childcare**

### 3-YEAR-OLDS' PHYSICAL ACTIVITY IN CHILDCARE

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#### Abstract

10 The main purpose of the study was to determine 3-year-olds' physical activity (PA) levels and how these vary across  
11 season, gender, time of day, location, and the physical and social environment in childcare settings in Finland. A  
12 modified version of the Observational System for Recording Physical Activity in Children-Preschool (OSRAC-P) was  
13 used to measure PA levels and contextual variables (e.g., group composition, prompts) of children attending childcare  
14 centres. In total, 81 children (42 boys and 39 girls) were observed in autumn and in winter. Three-level linear regression  
15 analyses were used to assess differences between the seasons in the association between the context variables and PA.  
16 During the observations, the present sample of children was mostly sedentary in nature, engaging in MVPA in only 2%  
17 of all observations. The results further showed a significant difference between season and the children's PA levels: in  
18 winter, the children spent significantly more time in sedentary-level activities and less time in MVPA than in autumn.  
19 The present sample of children was physically more active outdoors than indoors. Boys showed significantly higher PA  
20 levels than girls. The majority of the observations did not include any oral prompting. We conclude that childcare  
21 centres offer good opportunities to increase children's PA. Interventions should focus on enhancing children's outdoor  
22 time, free play, and positive prompting and encouragement by teachers.

23 *Key words:* childcare; direct observation; physical activity; preschool children

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#### Résumé

26 L'objectif principal de l'étude était de déterminer les niveaux d'activité physique (PA) chez les enfants de trois ans, et  
27 la façon dont ils varient selon la saison, le sexe, le moment de la journée, le lieu et l'environnement physique et social  
28 dans les garderies en Finlande. Une version modifiée de l'OSRAC-P (Observational System for Recording Physical  
29 Activity in Children-Preschool) a été utilisée pour mesurer les niveaux d'activité physique et les variables contextuelles  
30 (notamment la composition du groupe, les incitations) des enfants fréquentant les garderies. Un total de 81 enfants (42  
31 garçons et 39 filles) ont été observés en automne et en hiver. Des analyses de régression ont permis d'étudier les  
32 variables liées à l'activité physique des enfants à différentes saisons. Au cours des observations, l'échantillon des  
33 enfants était principalement de nature sédentaire avec une activité physique d'intensité modérée à élevée (MVPA) dans  
34 seulement 2 % des observations. Les résultats ont révélé une différence significative entre la saison et les niveaux  
35 d'activité physique. En hiver, les enfants ont passé sensiblement plus de temps dans des activités de niveau sédentaire et  
36 moins de temps dans des activités d'intensité modérée à élevée qu'en automne. L'échantillon des enfants était  
37 physiquement plus actif à l'extérieur qu'à l'intérieur. Les garçons ont manifesté des niveaux d'activité nettement plus  
38 élevés que les filles. La majorité des observations ne présentait aucune incitation verbale. Nous en concluons que les

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39 garderies offrent de bonnes possibilités pour augmenter l'activité physique des enfants. Les interventions devraient se  
40 concentrer sur l'augmentation du temps passé à l'extérieur et consacré aux jeux libres ainsi que sur les incitations et les  
41 encouragements positifs de la part du personnel chargé de la petite enfance.

42 *Mots-clés* : garderie, observation directe, activité physique, enfants d'âge préscolaire

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#### Resumen

45 El objetivo de este estudio fue determinar la intensidad de la actividad física de niños finlandeses de tres años en la  
46 guardería en tiempos diferentes del día y del año. Además, fue investigada la relación del sexo, de entornos diferentes y  
47 de factores sociales y físicos con la actividad física de los niños. Durante el día en la guardería, los niveles de actividad  
48 física y las variables contextuales (como la composición del grupo o incentivación) fueron determinados con un método  
49 de observación modificado de OSRAC-P (Observational System for Recording Physical Activity in Children –  
50 Preschool Version). En total 81 niños (42 chicos, 39 chicas) participaron en las observaciones en el otoño e invierno. La  
51 relación de las variables elegidas con la actividad física de los niños entre las estaciones del año fue investigada con el  
52 análisis de regresión. La mayoría de la actividad física de los niños fue de intensidad muy ligera; solo el dos por ciento  
53 del tiempo fue como mínimo semipesada. Los resultados evidenciaron que en el invierno los niños tuvieron más  
54 actividad física muy ligera y menos actividad como mínimo semipesada que en el otoño. Los niños que participaron en  
55 la investigación fueron físicamente más activos fuera que dentro de la guardería. La actividad física de los chicos fue  
56 más cargante que la de las chicas. La mayoría de las observaciones no incluyeron persuasión relacionada con la  
57 actividad física. En base a los resultados podemos concluir que las guarderías ofrecen buenas oportunidades para  
58 aumentar la actividad física de los niños. Las intervenciones tendrían que centrarse en el aumento de actividades al aire  
59 libre, de juego espontáneo y de consejos positivos e incentivación por educadores preescolares.

60 Palabras clave: guardería infantil; observación directa; actividad física; niños de la edad preescolar

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### 3-YEAR-OLDS' PHYSICAL ACTIVITY IN CHILDCARE

62 Behavioural habits, such as physical activity (PA) and sedentary behaviours (SB), are formed in early childhood (Janz  
63 et al. 2005; Timmons et al. 2007; Ward et al. 2010). PA in preschool children (age 3–5 years) may be described as  
64 “play”, and occurs at various levels of intensity (Timmons et al. 2007). Play, like learning, is a natural component of a  
65 child’s everyday life and assists the child to make sense of his or her world (Pramling Samuelsson & Asplund Carlsson  
66 2008). Further, PA has been found to have a positive effect on children’s physical, cognitive, emotional and social  
67 development (Timmons et al. 2007, Ward 2010). An active lifestyle in childhood serves as the foundation for an active  
68 lifestyle later in life (Janz et al. 2005; Singh et al. 2008). Therefore, the enhancement of PA and reduction in SB in early  
69 childhood are important from a public health perspective (Strong et al. 2005; Tremblay et al. 2011).

70 Various studies have shown that the childcare centres children attend influence their levels of PA (Bower et al.  
71 2008; Finn et al. 2002; Pate et al. 2004; Pate et al. 2008; Ward 2010). Typically, very low PA levels and very high SB  
72 have been reported among preschool children during attendance at childcare settings (Brown et al. 2009; Gubbels et al.  
73 2011; Oliver et al. 2007; Pate et al. 2008; Reilly 2010). Features of the physical environment of the childcare setting,  
74 such as the ground surface, playground markings, open space, and the availability of play equipment, have previously  
75 been linked to higher levels of PA (Bower et al. 2008; Cardon et al. 2008; Cosco et al. 2010; Hannon & Brown 2008;  
76 Gubbels et al. 2012; Nicaise et al. 2011; Ridgers et al. 2007). Children have been shown to be more active when they  
77 spend more time outdoors (Boldeman et al. 2006; Finn et al. 2002; Hinkley, Crawford et al. 2008; Pate et al. 2004) and  
78 when recess is shorter in duration (Cardon et al. 2008; Dowda et al. 2004). Furthermore, children’s PA has been  
79 observed to increase in warm seasons and decrease in colder seasons (Carson & Spence 2010; Fisher et al. 2005; Poest  
80 et al. 1989). Factors related to the social environment, such as positive prompts by teachers or peers, have also been  
81 associated with increased PA (Brown et al. 2009; Gubbels et al. 2011). Despite this positive association, Brown et al.  
82 (2009) reported that teachers and peers rarely prompt children to raise their level of PA. Finally, child-initiated instead  
83 of teacher-initiated play (Brown et al., 2009), smaller group size (Brown et al. 2009; Cardon et al. 2008) and higher  
84 educational level of teachers (Dowda et al. 2004) have been linked to increased levels of children’s PA.

85 Although studies assessing PA and SB in preschool children have increased over the past decade (Bornstein et  
86 al. 2011), observational research yielding contextual information to promote PA is still lacking, especially in Europe  
87 (Bower et al. 2008; Brown et al. 2009; Gubbels et al. 2011). Additionally, only a small set of studies exists where  
88 preschool children’s PA levels have been determined during different seasons (Carson & Spence 2010). An improved  
89 understanding of the determinants of PA in the childcare setting could support the development of interventions aimed  
90 at promoting PA levels of younger preschool children throughout the year. Therefore, the purpose of this study was to

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91 examine Finnish 3-year-olds' PA levels and SB during attendance at childcare, and their seasonal variation, related  
92 demographic and biological characteristics, and physical and social contexts.

#### 93 **Methods**

##### 94 *Sample and data collection*

95 Participants were recruited in a city in central Finland. Principals of childcare centres were provided with  
96 information regarding the study at a regional administrative meeting. A total of 14 childcare centres volunteered their  
97 involvement in the study. The childcare centres were situated in different environmental and socioeconomic  
98 neighbourhoods in the city. All the families of the 3-year-old children (year of birth 2007) attending the participating  
99 childcare centres were invited to join the study. The parents of 102 (57%) of the 179 families provided informed  
100 consent.

101 The children's PA data were collected in two phases using a repeated-measure design. The first data collection  
102 phase was between August and October 2010 (autumn), and the second between January and February 2011 (winter). A  
103 total of 96 children (48 boys and 48 girls) participated in the autumn data collection and 94 children (50 boys and 44  
104 girls) in the corresponding winter collection. Data from both collection phases were gathered for 81 children (42 boys  
105 and 39 girls).

##### 106 *Instruments*

107 A modified version of the Observational System for Recording Physical Activity in Children-Preschool  
108 Version (OSRAC-P; Brown et al. 2006) was used to measure children's PA intensity, type of activity, location, contexts,  
109 prompts and interactions. Two trained researchers observed the children's PA and contextual factors using a procedure  
110 in which 15 seconds of observation were followed by 30 seconds of recorded observation. The observation sheets were  
111 completed manually and the procedure was repeated eight times over six minutes for each child. Each child was  
112 observed at least twice per day, in the morning (between 8 a.m. and 12 p.m.) and in the afternoon (between 2 p.m. and 5  
113 p.m.), including indoor and outdoor observations, during three consecutive days (from Wednesday to Friday). Children  
114 were randomly selected for observation and were not observed during the scheduled meal or rest times. The data  
115 collection was conducted without disturbing the daily routines of the childcare centres and without undue influence on  
116 the children or teachers.

117 Children's PA intensity levels were measured on a five-point scale (1 = stationary or motionless, 2 = stationary  
118 with limb or trunk movements, 3 = slow or easy movements, 4 = moderate movements, and 5 = fast movements) and  
119 reflected the highest intensity level reached by the child during each 15-second observation interval. For the purpose of  
120 this study and further comparison, activity levels 1–2 were regarded as SB, activity level 3 as light PA and levels 4–5 as

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121 moderate-to-vigorous physical activity (MVPA) (Bower et al. 2008; Brown et al. 2009; Gubbels et al. 2011; Nicaise et  
122 al. 2011; Pate et al. 2008).

123 OSRAC-P scales assessing contextual variables such as time of day and primary location were used. In  
124 addition, the following social OSRAC-P scales were assessed: group composition, initiator of activity and prompts. In  
125 the present study, Brown and colleagues' (2006) original 18 activity-type codes (e.g., *sitting, standing, running*) were  
126 complemented with four typical Finnish types of activity (i.e., *balancing, sliding, skiing, ice-skating*) and used as  
127 descriptive categories. Finally, the indoor contexts were complemented with i.e., *toys* (e.g., playing with cars, dolls),  
128 *household chores* (e.g., baking, cleaning), *rage* (crying scene), *pool activities* and *small-group* variables, and the  
129 outdoor contexts with i.e., *rage, forest, sport field* and *transition* variables.

#### 130 *Background information*

131 Weather conditions and outdoor temperatures were recorded per observation day. Body weight and height of  
132 the children were measured between the two observation phases at the time of the PA data collection, and body mass  
133 index (BMI:  $\text{kg/m}^2$ ) was calculated for each child. The BMI results indicated, in accordance with the International  
134 Obesity Task Force BMI definition, that nine children (12%) during the autumn assessments and six children (8%)  
135 during the winter assessments were overweight. All the other children were in the normal BMI range (Cole et al. 2000).  
136 Background information on children's attendance times was recorded in diaries kept by the children's parents. Outdoor  
137 times were recorded by the researchers during the observation days. In general, Finnish childcare centre hours are from  
138 6.30 a.m. to 5 p.m. Meal (i.e., breakfast at 8 a.m., lunch 11.30 a.m. and snacks at 2 p.m.) and rest times give a rhythm to  
139 the childcare centre's daily schedule. Typically, a childcare day includes two outdoor recess periods, one in the morning  
140 and one in the afternoon. The ethics committee of the local university, and the city's social affairs and health officer  
141 approved the study.

#### 142 **Statistical analyses**

143 The observers' scores for the dichotomous variables (e.g., prompt by teacher, yes/no) were combined by  
144 coding the variable as present (1) when one or both observers rated that variable as present, and coding it as absent (0)  
145 when both rated it as absent. For continuous variables (e.g., activity intensity), the mean of the scores of both observers  
146 was calculated. Cohen's kappa was used to determine the inter-rater reliability (IRR) of the two observers during the  
147 observations of the OSRAC-P variables (i.e., activity intensity, activity types, group composition, contexts, initiator of  
148 activity, prompts). Mean IRR of the variables assessed was .70 (SD = 0.2;  $p < .001$ ).

149 Various background characteristics were explored using descriptive statistics. General Linear Models (GLM)  
150 for repeated measures (MANOVA) were used to analyse differences between autumn and winter. Differences in the

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151 observed contextual variables between observations and seasons were examined using Chi-square tests. The association  
152 between the mean level of PA intensity as the dependent variable and independent variables such as, gender (girl vs.  
153 boy), BMI (linear), primary location (outdoor vs. indoor), time of day (afternoon vs. morning), group composition  
154 (solitary vs. non-solitary), initiator of activity (adult vs. child), prompts (no prompts vs. negative or positive prompts),  
155 temperature (linear) and weather condition (rain vs. sunny, with clear sky or cloudy but dry), was examined using three-  
156 level linear regression. All analyses were performed using SPSS 18.0 and STATA 12. In all analyses,  $P$ -values  $< .05$   
157 were considered statistically significant.

#### 158 **Results**

##### 159 *Childcare and outdoor times, temperature and weather conditions*

160 During the data collection periods, the participants attended their childcare settings for approximately 7.7  
161 hours/day in the autumn and 7.5 h/day in the winter. A total of 1 978 observations and 15 824 single observation  
162 intervals (1 978 x 8 times) were analysed; 966 observations (an average 5.96 ( $SD = 2.49$ ) observations/child) were  
163 observed in the autumn and 1012 observations (an average 6.25 ( $SD = 2.96$ ) observations/child) in the winter. The  
164 results indicated a significant difference between autumn and winter in mean outdoor time during childcare attendance  
165 (minutes per day 179 vs. 120, respectively;  $p = .002$ ). The mean outdoor temperature was 11.6°C during the autumn  
166 observations (range: -2°C to 20°C) and -9.9°C during the winter observations (range: -30°C to 2°C). The differences  
167 between the autumn and winter mean temperatures were significant ( $p < .001$ ). Most of the time, the weather was  
168 cloudy but dry (49% autumn; 51% winter) or sunny with a clear sky (27% autumn; 36% winter); the least prevalent  
169 weather type was precipitation of rain (23% autumn) or snow (13% winter). The differences between the seasons in the  
170 percentages of intervals observed in the different temperature categories and weather conditions, and in engagement in  
171 SB, light PA and MVPA associated with these categories, are described in Table 1.

##### 172 *Prevalence of contextual variables and physical activity levels*

173 During the observations, the children's PA levels were mostly sedentary: 69% (indoors 86%; outdoors 46%) of  
174 total intervals were recorded as SB, and only 2% (indoors 1%; outdoors 2%) as MVPA. The initiators of activities were  
175 most frequently children (77%), and the children's play was most frequently non-solitary (74%). Teachers or peers  
176 rarely prompted children to increase or decrease their PA: no prompts were recorded in 92% of all observations. In  
177 prevalence (%) of observations, significant seasonal differences were found in all the variables, except gender and time  
178 of day (see Table 1).

179 In winter, the children engaged in MVPA outdoors significantly less in than in autumn. Seasonal variations  
180 were observed in boys' but not in girls' PA levels. The percentages of PA in the categories SB, light and MVPA



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181 observed during autumn and winter are shown in Table 1.

182 *Activity types, indoor and outdoor contexts and physical activity levels*

183 In both seasons, the three most frequently observed physical activity types were: 1) *sitting/squatting/kneeling*,  
184 2) *walking/marching* and 3) *standing*. In the autumn, the most frequently observed *indoor activity variables* were 1)  
185 *toys* (25%) 2) *other* (25%; e.g., being in some other indoor context or engaging in some activity other than the option  
186 listed, and 3) *sociodramatic* (8%), whereas in the winter these were 1) *toys* (36%), 2) *other* (26%), 3) *art* (9%) and  
187 *transition* (9%; both lining up or moving from one activity context to another area). When examined more closely for  
188 seasonal variations, several differences in the activity variables were found; in the autumn, the children were engaged  
189 significantly more frequently in the variables *large blocks* ( $p = .007$ ), *manipulative* ( $p = .017$ ), *music* ( $p = .035$ ), *snacks*  
190 ( $p < .001$ ) and *self-care* ( $p = .013$ ) than in the winter, during which the children more often played with *toys* ( $p < .001$ )  
191 and engaged in *art* activities ( $p = .009$ ) than in the autumn. The three most frequently observed *outdoor context*  
192 variables were 1) *open space* (30%), 2) *sandbox* (20%) and 3) *fixed equipment* (16%) in the autumn, and 1) *open space*  
193 (26%), 2) *portable equipment* (14%), and 3) *fixed equipment* (13%) in the winter. In the autumn, the children more  
194 frequently played in an *open outdoor area* ( $p = .016$ ), touched, ride or pushed *wheeled toys* ( $p < .001$ ), used *sandbox*  
195 materials or played in the *sandbox* ( $p < .001$ ), played using *sociodramatic props* ( $p = .003$ ), and engaged in *other*  
196 activities ( $p < .001$ ) than in the winter. Finally, during the winter, the children more often made use of *portable*  
197 *equipment* (other than balls or wheeled toys) brought into the playground ( $p < .001$ ) than in the autumn. The most  
198 common activity types, physical and social environments at the different levels of PA are shown in Table 2.

199 *Associations between observed contexts and physical activity in autumn and in winter*

200 Gender was significantly associated with children's activity levels in both seasons. Boys showed significantly  
201 higher mean PA intensity levels than girls (activity intensity 2.42 vs. 2.24, respectively  $p < .001$ ). When controlled for  
202 other variables (i.e., gender, location, time of day, group composition, initiator of activity, prompts and weather  
203 conditions), BMI was not associated with children's activity levels. An outdoor location associated positively with  
204 children's activity levels in both seasons ( $p < .001$ ). In the autumn, children were less active in the afternoon compared  
205 to morning, while in the winter, the children's PA levels were unaffected by time of day. Similarly, child-initiated play  
206 was positively associated with PA in the autumn but not in the winter. Solitary play had a stronger association with the  
207 higher activity levels in the autumn, although the influence was significant in both seasons. All prompts (both positive  
208 and negative) were associated with an increase in PA in both seasons in comparison to observations where no prompts  
209 were observed. Finally, temperature associated with children's PA levels in the winter but not autumn, whereas rain had  
210 no influence on PA during either season. (See Table 3.)

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#### **Discussion**

##### *Physical activity levels in childcare*

In line with earlier studies (Brown et al. 2009; Pate et al. 2008), the present study found that, for most of the childcare day, the children's PA levels and their PA types were sedentary in nature, with MVPA accounting for only 2% of all observations. The results further showed that, in the winter, the children spent significantly more time in sedentary-level activities than in the autumn. The seasonal variation in PA levels was more pronounced during the outdoor observations than indoor observations. The association on PA levels of the significant interaction between time of day and season showed that in the autumn the present sample of children were more physically active in the morning than afternoon, while in the winter their PA levels were unaffected by time of day.

##### *Indoor environment*

The most common activity types – sitting, standing, walking – and the indoor context were primarily sedentary in nature: 86% of indoor activities were observed as SB. This level of sedentariness is similar to that reported by Brown et al. (2009), and considerably more than found by Gubbels et al. (2011) in their Dutch study. Children were sedentary when engaged in art or in large group activities organized or led by a teacher. Although several activity types and contexts were associated with higher PA levels, children were rarely observed indoors in activities such as running, climbing, pulling or pushing. One potential explanation relate to the childcare facilities and behavioural rules. For safety reasons, running or climbing indoors is likely to be prohibited, while indoor spaces are often small rooms with narrow corridors. Nevertheless, a place in hallways and corridors for children's play and physical activities is commonly found. To enable children to move around freely and engage in physically active play indoors, childcare centres need to optimize their indoor space specifically for these purposes (Gubbels et al. 2012). Although Finnish childcare centres mostly have a large room or hall with gross motor equipment for physical activity and play, children, in groups, typically use them only once a week, during a structured physical education (PE) lesson, as laid down in the recommendations for physical activity in early childhood education (2005). Moreover, in its current format, PE plays a very small role in meeting the PA requirements of pre-schoolers (Van Cauwenberghe et al. 2012).

##### *Outdoor environment*

In line with previous studies (Boldeman et al. 2006; Brown et al. 2009; Hinkley et al. 2008; Pate et al. 2004), the present sample of children was physically more active outdoors than indoors. Outdoor locations had a strong positive association with higher PA levels in both seasons. However, even during outdoor play, nearly half of the children's activities were recorded as SB, and only 2% as MVPA, which is much lower than the 17% found by Brown et al. (2009), 21% by Gubbels et al. (2011), and 12% and 21% by Nicaise et al. (2011). Outdoor engagement at the

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241 sedentary level included children playing in a sandbox and/or playing with sandbox materials and activities with  
242 sociodramatic play props. Touching, riding, or pushing wheeled toys such as tricycles, scooters and wagons showed  
243 higher levels of PA. However, wheeled toys were used less frequently than fixed equipment such as the sandbox. This  
244 might be explained by the fact that the sandbox is available at all times, while scooters and wagons are held in storage.  
245 Children have to fetch these items and return them after use. Gubbels et al. (2012) showed that children were  
246 significantly more active when jumping equipment was continuously present, and when a fixed track was marked on the  
247 playground. Similarly, Nicaise et al. (2011) concluded that activity-genic portable equipment and riding vehicles  
248 appeared to foster MVPA. A playground redesign, which utilizes multicolour playground markings and physical  
249 structures, may be a suitable stimulus for increasing children's recess PA levels (Ridgers et al. 2007). Scheduling  
250 recesses to minimize the number of children sharing playground or play equipment (Cardon et al. 2008), and minimize  
251 the time spent in sedentary locations, such as the sandbox (Cosco et al. 2010), may also help to increase children's  
252 engagement in MVPA (Nicaise et al. 2011). In this study, in the autumn, the use of wheeled toys was more pronounced  
253 than in winter. In winter, snow, ice and cold weather do not present the same possibilities for their as in autumn. In the  
254 winter, children were more involved with portable equipment such as sleds. Finnish childcare centres have the  
255 possibility to utilize the natural environment, such as the forest, in their daily programme. During wintertime, children  
256 often play with snow or mounds of snow, and push and pull sleds. Furthermore, it is not rare to encounter young  
257 Finnish children in childcare skating or skiing. However, at the age of three, skiing and skating involve lower levels of  
258 PA, such as balancing and learning to slide, than vigorous PA.

#### 259 *Weather conditions*

260 In the present study, the differences between the autumn and winter mean temperatures were significant.  
261 Temperature was significantly associated with children PA in winter, but not in autumn. Baranowski and colleagues  
262 (1993) reported that differences in children's PA levels were related more to time spent outdoors than to season or  
263 weather conditions. In this study, significant seasonal variations in mean temperatures could explain why the average  
264 outdoor time during childcare attendance in winter (116 min) was significantly less than in autumn (178 min). In cold  
265 weather, -20°C or colder, children generally are not directed to play outdoors, or outdoor recesses are much shorter on  
266 such days. Shorter outdoor activity times in winter may also explain children's lower engagement in MVPA. However,  
267 in the autumn, engagement in sedentary level-activities outdoors was higher than in the winter. Although temperature  
268 was associated with PA, no association emerged between rain and children's PA levels.

#### 269 *Social contexts*

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270 The majority of the observations did not include any oral prompting. In line with previous observational  
271 studies (Brown et al. 2009; Gubbels et al. 2011), prompts (both negative and positive) positively associated with  
272 children's PA intensity in both seasons. Moreover, our results, like those of Brown et al. (2009), showed that even if  
273 teachers were present, they very rarely, if ever, implemented teacher-arranged activities and games to enhance  
274 children's PA or encouraged children to engage in PA. Teachers may assume that children are naturally very active and  
275 that they engage in sufficient activity, and therefore lay less emphasis on the importance for children of an active  
276 lifestyle (Pate et al. 2008). In general, children tended to be less physically active when more staff members were  
277 present or were involved in children's play (Brown et al. 2009; Cardon et al. 2008; Gubbels et al. 2011). Similarly, in  
278 this study, adult-initiated play had a negative association with the children's PA behaviour in the autumn, although not  
279 in the winter. In the winter, the children showed significantly more SB and engaged less frequently in MVPA during  
280 child-initiated activities, whereas adult-initiated play showed no seasonal variation in PA levels. Furthermore, in both  
281 seasons, children's solitary play was associated with increased PA levels, as also noted by Brown et al. (2009) and  
282 Nicaise et al. (2011). In contrast, in a Dutch study, non-solitary play was associated with higher activity levels (Gubbels  
283 et al. 2011).

#### 284 *Gender variations*

285 This study indicated a significant gender difference in PA levels, with boys showing significantly higher levels  
286 than girls. In line with the present findings, boys have generally been reported to be more active than girls (Hinkley et al.  
287 2008; Oliver et al. 2007; Pate et al. 2004, 2008). Currently, there is no definitive explanation why girls participate less  
288 in physical activity than boys (Pate et al. 2004). Observational studies have demonstrated that boys are more interested  
289 in playing rougher games, engage in more risk-taking behaviour and play in larger groups and in more open settings  
290 than girls (Pate et al. 2004). Also boys' activities may be more triggered by harder ground surfaces, which are mainly  
291 used for sports-related, competitive activities (Cardon et al. 2008). One potential explanation may found in teachers'  
292 attitudes, which may affect children's PA behaviour. It is possible that boys are regularly encouraged to engage in more  
293 physically active play and games, whereas girls are exposed to stationary activities and expected to behave in a calmer  
294 manner (Pellegrini & Smith 1998). Sandberg & Pramling Samuelsson (2005) found that despite emphasising the  
295 importance of creating inspiring environments for play and outdoor play, preschool teachers' participation in play  
296 differed by gender. For instance, male teachers had more play willingness and participated more in physically active  
297 play, whereas female teachers tended to prioritise calm play, which, for the most part, they also experienced in their  
298 own childhood (Sandberg & Pramling Samuelsson 2005). Cardon et al. (2008) also found that girls preferred to stay  
299 close to their supervising teachers, who commonly supervise sitting down or standing still, and that this might be one

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300 cause of the lower levels of PA in girls. It remains unclear whether the gender difference in PA is biologically based or  
301 environmentally determined, or a combination of both (Timmons et al. 2007).

#### 302 *Strengths and limitations*

303 The assessment of young children's PA is challenging, primarily because their behaviour is spontaneous,  
304 intermittent and sporadic. The benefit of the observation format used in the present study was that it recorded not only  
305 the intensity of activity, but also *where, how* and *in what kind of interaction* the activity was being performed. Moreover,  
306 the OSRAC-P has been shown to be a valid and reliable tool for measuring physical activity among preschool-aged  
307 children (Brown et al. 2006; Pate et al. 2010; Trost 2007). A major strength of this study was the use of a repeated-  
308 measure design, where the same 3-year-old children were measured using direct observation during two distinct seasons.  
309 However, one should be cautious when comparing PA levels over short time periods (e.g., 3–6 months), as children's  
310 normal growth and maturation may influence their physical abilities and motor skills in relation to their engagement in  
311 physically active play (Fisher et al. 2005). It should also be noted that the direct observations subjective, although, the  
312 interobserver reliabilities indicated substantial agreement and a validated observation protocol was deployed (Brown et  
313 al. 2006). Furthermore, the generalizability of the findings could be limited by the fact that all the participating  
314 childcare centres and children were located in the same city. Finally, the children's behaviour could have been  
315 influenced by other factors that were not taken into account in this study. For instance, fundamental motor skills  
316 (Stodden et al. 2008) and the educational level of teachers (Dowda et al. 2004) have been found to have an influence on  
317 children's PA behaviour, but these were not taken into account in this study. Therefore, the interaction between motor  
318 skills and/or educational levels of teachers and children's PA behaviour in different contexts merits further examination.

#### 319 **Conclusion**

320 The present findings have important implications for the development of PA interventions aimed at increasing  
321 preschool children's PA behaviour in the childcare centre setting. Our findings yield comprehensive behavioural and  
322 contextual information on a sample of 3-year-old preschool children. A notable proportion of the activities observed as  
323 sedentary in the sample may encourage teachers to work towards reducing the time children spend in SB and increasing  
324 time and opportunity for engaging in the higher levels of PA. Childcare centres offer good opportunities to increase  
325 children's PA and also support their learning. Childcare organizations in collaboration with families can use the  
326 findings of this study as a basis on which to promote children's PA. Interventions should focus on enhancing children's  
327 outdoor time, free play and positive prompting and encouragement by teachers. To enhance children's all-year-round  
328 PA, such changes should, in particular, target wintertime, given its consistently lower activity levels.

#### 329 **Conflict of interest**

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330 The Authors state that they have no conflicts of interest.

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