Varhaiskasvatuksen Tiedelehti
Journal of Early Childhood Education Research
Volume 7 Issue 1 2018, 100–126

jecer.

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Preschool Children are More Physically Active and Less Sedentary on Weekdays Compared with Weekends

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ABSTRACT: Physical activity (PA) is necessary for young children. The new recommendations for physical activity in early childhood in Finland suggest that daily activity consists of at least 3 hours of light-to-vigorous physical activity (LMVPA). In this article, we report preschool children's compliance with the recommendations, PA amounts at different intensity levels, the variation between genders, and the effect of weekend on PA. The data were collected from 172 children, aged 3 to 7 years, using accelerometers during January–March 2015 for 7 days, 24 hours per day. Results revealed that compliance with the recommendations is low: 43% of the boys and 32% of the girls engaged in LMVPA for at least 3 hours per day. The variation was remarkable. Moderate-to-vigorous physical activity (MVPA) averages ranged from 16 to 154 minutes in boys, and from 4 to 98 minutes in girls. The weekend decreased PA at all intensity levels and increased sedentary behavior by approximately 60 minutes ($p < .001$, $\eta_p^2 = .39$) in both genders. Interventions should focus on girls as a group, on boys with minimal amounts of MVPA, on reducing sedentary behavior, and on increasing weekend activity.

Keywords: *Accelerometer, early childhood, physical activity, recommendations*

Introduction

Research has revealed that physical activity (PA) has great potential for well-being of the individual starting from early childhood (Poitras et al., 2016)—a period very important for developing a physically active lifestyle (Telama et al., 2014). For example, research has

 Peer-review under responsibility of the editorial board of the journal ISSN 2323-7414; ISSN-L 2323-7414 online

found evidence of short-term and long-term associations of PA on physical and psychosocial health and well-being (Poitras et al., 2016; Timmons et al., 2012). In addition, PA may have positive associations on brain functioning, cognitive development, and academic achievement in young children (Diamond, 2015; Fedewa & Ahn, 2011; Krafft et al., 2014; Pesce et al., 2016).

Earlier research has focused on and emphasized at least moderate physical activity (MPA), especially in health promotion (Janssen & LeBlanc, 2010; Timmons et al., 2012), but recently, interest has also increased in light physical activity (LPA) and its possible favorable associations with children's health and well-being (Poitras et al., 2016).

On the other hand, researchers have reported that children spend most of their waking time in sedentary behavior (SB) or very light physical activity (VLPA), (Spittaels et al., 2012), which has negative association on children's health (Biddle & Asare, 2011; LeBlanc et al., 2012). Multiple international studies have investigated the prevalence of VLPA in older children and adolescents, but fewer studies have concentrated on preschool age children (Pate et al., 2013). This paper reports the results obtained in a cross-sectional study designed to examine and better understand preschool children's PA at different intensity levels, and VLPA in the Finnish (Helsinki) metropolitan area.

Preschool children's physical activity

Physical activity is often defined as any bodily movement generated by skeletal muscles that raises energy expenditure above resting values. PA is a complicated phenomenon, which may be meaningfully divided into different categories and different intensity levels. PA can be categorized, for example, based on identifiable portions of daily life (e.g., leisure, work/daycare, sleep) during which the activity occurs. (Caspersen et al., 1985; Malina et al., 2004; World Health Organization, 2010.) It appears in many forms throughout a life span and in the early years it is mostly play with short bursts of intense PA followed by brief but variable intervals of lower intensity activities or resting (Bailey et al., 1995; Burdette & Whitaker, 2005; Dwyer et al., 2009; Truelove et al., 2016).

Young children's PA is usually categorized into three to five basic intensity levels and reported as time spent at these levels in minutes: SB or VLPA, LPA, moderate (or brisk) physical activity (MPA), and vigorous physical activity (VPA). The two highest levels (MPA and VPA) are often combined into moderate-to-vigorous physical activity (MVPA). (e.g., Cardon & De Bourdeaudhuij, 2008; Pate et al., 2010; Puhl, et al., 1990.)

The abbreviation LMVPA in turn denotes PA intensities ≥ LPA, and indicates the amount of TPA per day in minutes. In most studies, the amount of TPA has been expressed as total

accelerometer counts divided by daily registered time in activity (counts/minute). (Evenson et al., 2008; Puhl et al., 1990; Van Cauwenberghe et al., 2011.) Some accelerometers, for example the Polar Active® (PAC) accelerometer (Polar Electro Ltd, Finland) used in the present study, express LMVPA as absolute time spent at least the LPA level during the whole day. In short, reporting formats for total physical activity in the research literature are as follows: TPA, amount of PA, and LMVPA (Ruiz et al., 2006; Soini et al., 2014; Van Cauwenberghe et al., 2012). LMVPA is used in this study.

Researchers have indicated that SB or VLPA is separate and distinct from a lack of MVPA, because of independent and qualitatively different effects on health (LeBlanc et al., 2012; Sedentary Behaviour Research Network, 2012). VLPA can be defined as any waking behavior associated with energy expenditure ≤ 1.5 metabolic equivalent (MET) and a sitting or reclining posture. One MET is the amount of oxygen consumed at rest while sitting and is equal to 3.5 ml O_2/kg/minute. (Jette et al., 1990.) In this study, we use the abbreviation VLPA, which is programmed in PAC accelerometer and refers to energy expenditure between 1–2 METs. Table 1 presents the intensity levels and corresponding MET values in this study.

TABLE 1 Physical activity intensity levels, corresponding MET values and activity types (MET = metabolic equivalent; PA = physical activity; SB = sedentary behavior)*

INTENSITY LEVEL	*ABBREVIATION*	*MET*	*ACTIVITY TYPES*
Sleeping	–	<1	Sleeping
Very light	VLPA/SB	1–2	Sitting, watching television, playing video games, reading, drawing, etc.
Light	LPA	>2–3.5	Slow walk, stretching, swinging, throwing, easy physical exercise, etc.
Moderate	MPA	>3.5–5	Walking, cycling, skating, playground games, etc.
Vigorous and very vigorous	VPA	>5	Running, jogging, rope jumping, soccer, stair walking, fast running, etc.
Moderate to vigorous	MVPA	≥3.5	The two highest levels together; walking, rope jumping, fast running…
Light to vigorous	LMVPA	≥2	All PA ≥ LPA

*Adapted from https://www.polar.com/sites/default/files/b2b/pe/lessons_for_life_e-version.pdf

The importance of different physical activity intensity levels

Of all intensity levels, MVPA has been the most studied. Overall, MVPA has been proposed as being essential for health promotion and for disease prevention (Carson et al., 2017; Janssen & LeBlanc, 2010; Poitras et al., 2016; Timmons et al., 2012). Poitras et al. (2016) supported the view that at least 60 minutes of MVPA per day was important for health benefits and to reduce the risk of some diseases. For example, engaging in at least 60 minutes of MVPA has been suggested to decrease the risk of metabolic and cardiovascular disease (L. B. Andersen et al., 2006; Janssen et al., 2013; Sääkslahti et al., 2004). In addition, MVPA and especially vigorous PA, are considered to have favorable associations with bone health in children (Cardadeiro et al., 2012; Hasselstrøm et al., 2007) and in young adults (Pettersson et al., 2009).

Recently, the importance of LPA has been proposed. Poitras et al. (2016) reported in their review, that several researchers considered broadening the health promotion focus beyond MVPA. For example, Haapala et al. (2017) proposed 3.5 hours of PA exceeding 2 METs per day being critical in identifying overweight and normal weight children. In addition to health promotion, Laukkanen et al. (2014) added that increasing the amount of LPA might improve preschool children's gross motor skills. Later in adolescence, gross motor skills can be associated with better bone strength (Ireland, Sayers, Deere, Emond, & Tobias, 2016). Additionally, improvements in motor development, motor competence, and motor creativity (Timmons et al., 2012; Robinson et al., 2015; Ourda et al., 2017) may result in better physical self-perception and positive self-esteem (Biddle & Asare, 2011).

Several instances have found positive correlation between VLPA and health factors like adiposity, decreased psychosocial health, and decreased cognitive development (Biddle & Asare, 2011; Haapala et al., 2017; LeBlanc et al., 2012; Sedentary Behaviour Research Network, 2012). Furthermore, VLPA may track or be an even better indicator of children's future activity than physical activities (Epstein & Roemmich, 2001; Janz, Burns, Levy, & Iowa Bone Development Study, 2005).

Preschool children's physical activity volumes at different intensity levels

The Ministry of Education and Culture in Finland has recently launched a new publication entitled "Joy, play and doing together. Recommendations for physical activity in early childhood" (Ministry of Education and Culture, 2016). The recommended daily minimum of 3 hours of varied PA indoors or outdoors consists of light-to-vigorous intensity activities, i.e., LMVPA including one hour of MVPA and 2 hours of LPA. In contrast to the

previous recommendations, the new recommendations take a position on VLPA also. Sedentary periods should not last longer than an hour and all inactive periods—even shorter ones—should include breaks (Ministry of Education and Culture, 2016).

Research has indicated that compliance with the recommendations is low and the level of preschool children's MVPA is also low (E. Andersen et al., 2017; Reilly, 2010; Soini et al., 2014; Tucker, 2008). For example, in a systematic review of preschool-aged children from seven countries and 39 primary studies (published 1986–2007), only just over half of the preschoolers, aged 2–6 years, engaged in MVPA for at least 60 minutes per day (Tucker, 2008), and in a recent Norwegian study by E. Andersen et al. (2017) the proportion was 60% (in three and four-year-old children). In a large observational study by Reunamo et al. (2014) completed in 50 daycare centers and with 823 participants in Finland, the mean time spent in high PA for children between 1 and 7 years was 24 minutes between 8:00 and 12:00, which is 10% of the time.

Additionally, the volume of LPA appears to be low, varying from less than an hour to a little over an hour (Byun et al., 2013; Soini et al., 2014). However, the research targeting LPA and LMVPA is scarce, since most previous studies have focused on MVPA.

Furthermore, the amount of VLPA does not follow the PA recommendations in different countries but rises close to or even exceeds 10 hours per day (Byun et al., 2013; Cardon & De Bourdeaudhuij, 2008; Reilly, 2010; Vanderloo et al., 2015). Now that the Ministry of Education and Culture in Finland has launched the new recommendations for physical activity in early childhood (2016) there is a need to know the current state of preschool children's PA and VLPA to better determine where to best aim the interventions.

In addition to MVPA volumes, the less observed LPA and LMVPA volumes should also be examined among preschool children (Haapala et al., 2017; Laukkanen et al., 2014; Ministry of Education and Culture, 2016; Poitras et al., 2016). In addition, little is known about the extreme values. How low are the lowest volumes at different PA levels and how high are the highest volumes? And furthermore, are there children who do not engage in PA at all?

Factors associated with preschool children's physical activity

The importance of PA in young children has been stated, and there has been a growing interest in identifying the factors that predict or affect children's PA behaviors. Many recent studies have focused on gender. Samples have mostly demonstrated that male gender appears to have a positive association with PA. For example, in the Finnish studies of Soini et al. (2014; focus on 3-year-olds) and Jämsen et al. (2013; focus on 3- to 4-year-

olds), boys spent more time in MVPA and in LMVPA than girls did. Similarly, the reviews of Hinkley et al. (2008; focus on 2- to 5-year-olds), Spittaels et al. (2012; focus on 3- to 6-year-olds), Finn et al. (2002; focus on 3- to 5-year-olds), and Tucker (2008; focus on 2- to 6-year-olds) considered preschool-aged boys significantly more physically active than girls, but the review of De Craemer et al. (2012; focus on 4- to 6-year-olds) provided strong evidence against differences between the genders.

In the same way, researchers have presented contradictory findings about children's weekend and weekday PA. The day of the week was a significant determinant of VLPA as young children were more sedentary (De Craemer et al., 2012; Wong et al., 2015) (the latter for 6- to 8-year-olds) and more physically active on weekdays (De Craemer et al., 2012). Brooke et al. (2014) reported in their meta-analysis that children (4–18 years) engaged more in MVPA and LMVPA on weekdays than on weekends. Nupponen, et al. (2010; focus on 3- to 12-year-olds) and Hinkley et al. (2012) indicated that children were more often physically active on weekend days than on weekdays, while Soini et al. (2014) found children more sedentary on weekend days compared with weekdays, but other differences in PA levels were not found. In another Finnish study, the LATE research project (focus on 0.5-, 1-, 3-, 5-, and 7-year-olds) found that boys engaged in sedentary activities, spending a lot of time on screen-based activities (Mäki et al., 2010) at the weekend.

The new recommendations for physical activity in early childhood are intended for all individuals and organizations involved in promoting the PA, health, and well-being of children under 8 years of age. Children's PA is every adult's responsibility. The recommendations are intended to support, for example, children's parents, educators, and professionals of other communities working with children. (Ministry of Education and Culture, 2016.) The present study sought to elucidate the current situation by providing information about the gender differences in preschool children's PA on weekends and on weekdays. For example, parents and educators probably benefit from questions like: are children less active or less sedentary on weekends or weekdays, or, do the genders differ from each other?

Method

The variable name "weekend-or-not" defines the idea of whether it is the *weekend (i.e., Saturday, Sunday)* or *not the weekend (i.e., a weekday) and it refers to one variable.* The main purpose of this study was to explore preschool children's PA. In this paper, we report the volume and variation of preschool children's different PA intensity levels against the independent variables of gender and weekend-or-not. We also analyze and report the results of whether there is interaction between gender and weekend-or-not.

Another purpose was to explore how children meet the new physical activity recommendations: what percentage of children engages in the daily minimum of 3 hours of LMVPA? In addition, since the recommendations propose that sedentary periods lasting over one hour are avoided, we also explore how much children engage in VLPA.

Instruments

Direct observation and accelerometers are appropriate and valid measures of physical activity and sedentary behavior in very young children. Accelerometers measure the frequency, intensity, and time spent at different intensity levels and TPA or LMVPA (Chen & Bassett, 2005; Pate et al., 2010; Van Cauwenberghe et al., 2011). In this study, children's PA was measured by the uniaxial Polar Active® (PAC) accelerometer (Polar Electro Ltd, Finland). The PAC captures the frequency and regularity of wrist movements in 30-second epochs or intervals and describes PA as time spent at different intensity levels. Describing PA as time spent at different levels instead of accelerometer counts divided by daily registered time in activity provides more meaningful and interpretable data (Van Cauwenberghe et al., 2012). Epochs vary generally between 5 and 60 seconds in preschool age children (Cliff et al., 2009). Due to the sporadic nature of very young children's PA (Bailey et al., 1995), researchers have started to use shorter epochs of 5 and 15 seconds, since epochs of longer durations may result in misclassification of VPA and VVPA as moderate (Obeid, 2011; Reilly et al., 2008). Nevertheless, the epoch of 30 seconds has been found sufficient and reliable in measuring the intensity and time spent in PA in very young children (Reilly et al., 2008; Virtanen et al., 2011). To avoid misclassification, Reilly et al. (2008) suggested combining the MPA and VPA intensities together and reporting the time engaged in MVPA. Following Reilly et al. (2008), MVPA is used in the present study.

The wrist-worn PAC has mostly been used in studies involving youths and adults. It has been found valid and reliable for assessing physical activity levels and total energy expenditure. Validation tests with adults, adolescents, and children aged 7 to 10 years suggest that PAC strongly relates with indirect calorimetry (Cosmed K4b). PAC also estimated the intensities accurately in various activities when compared with Actigraph GT3X. (Brugniaux et al., 2010; Kinnunen et al., 2012; Virtanen et al., 2011.) Schaefer et al. (2015) used PAC when assessing PA of children aged 4 to 7 and reported that good compliance in their study might be due to the device. It was found comfortable to wear, and unlike most accelerometers PAC captures data during water-based activities as well (Schaefer et al., 2014).

Researchers in previous studies suggest different amounts of accelerometer monitoring to be sufficient for reliable results when assessing children's PA. Hislop et al. (2014) and

Basterfield et al. (2011) indicated that 3 days of accelerometer monitoring for at least 7 hours per day offers sufficient reliability to estimate the habitual physical activity of preschool children. When estimating group-level means, Wolff-Hughes et al. (2016) suggest that as few as one randomly selected monitoring day from a sampled week may be reliable enough. Cliff et al. (2009) proposed that the monitoring required to represent a typical day might be less in the early years than after formal schooling has started due to daytime sleeping patterns and similarity of days in the early years. Based on previous studies, the acceptable collection of data in this research was considered to include at least three monitored days including one weekend day. A valid day to estimate physical activity in this study was defined as at least 7 hours of waking activity per day. The sleep periods were not included in the activity data.

In accordance with Ozdoba (2004), the accelerometers were sealed to avoid data loss. Schaefer et al. (2015) observed that children were excited about the animated figure on the PAC face and that that might have aided better compliance with the device in their study of 4 to 7-year-old children. Following these findings, we did not cover the animated figure on the PAC face since we thought that it would diminish interruptions. Also, Ozdoba (2004) found no significant evidence for reactive behaviors in step counts among elementary school children using pedometers when the children could see the results on the indicator. Instead, Dössegger et al. (2014) suggested that if PA is measured by accelerometers, reactivity is present on the first two measurement days in preschoolers, generating better results in PA. To avoid the bias of the first measurement days, we changed the starting day every week.

Participants and procedures

This study was operated in one municipality in the metropolitan area. After research approval was granted by the Education and Early Education Committee of the Municipality, the staff or principals of 13 daycare centers were invited to a briefing. Two family daycare groups with children under 3 years withdrew from the research after the briefing. A total of 11 daycare centers decided to participate in the study. Written informed consent was obtained from parents or guardians of 179 children from 3 to 7 years prior to data collection. The anthropometric measurements were collected in preschools using a form completed by the parents. This was done to simplify the methodology following the research of Reilly et al. (2008), who found only a little age/body size related systematic variation in accelerometry output (in 3 to 10-year-old children) with the ActiGraph accelerometer.

The researcher synced children's anthropometric measurements—height, body weight—and the birth month on the Polar GoFit web service (https://polargofit.com) and took the

sealed accelerometers to preschools on the first morning of the data collection week. In two preschools, the distribution of the accelerometers to the children happened in the afternoon. The children (and their educators or child-minders) were advised how to use the accelerometer on the non-dominant wrist, which was chosen to prevent the bias caused by writing, drawing, and other things that children do with their dominant hand. The researcher also neutrally told the children what the figure on the face of the device means and asked them to behave as they normally do.

The parents of children who were going to participate were given a letter outlining—following good research practices—that the child could withdraw from the research and interrupt the measurement whenever he or she wanted (Allea, 2011; Tenk, 2009). They were also provided with the PAC's User Manual. Children were not exposed to strong stimulus and the research took place as a part of everyday practices. Children's names, birthdays, or any information that could identify the children were not collected, nor was any register of names developed from the data.

The data were collected for seven consecutive days in every preschool. Because of the limited number of available devices, the measurements had to be accomplished for five consecutive weeks between January and March, which in Finland is the winter season.

TABLE 2 Data description

CHARACTERISTICS	*FREQUENCY*	*PERCENTAGE (%)*
Total sample/days	1165	100
weekend	319	27
weekday	846	73
Preschools	11	
	172	100
Total number of children	82	48
Boys		
Girls	90	52
3–5 years	84	49
6–7 years	88	51

The results of six children were discarded from the final analysis because of insufficient data. On the other hand, we did not remove the data if the child was sick, because we wanted to get an overall picture of children's PA. Minor illnesses are also part of children's life. Only one child left the study. This was a 3-year-old who found the monitor unpleasant to wear. Most of the children had data for at least 6 days (mean = 6.6 days). Acceptable data were obtained from 82 boys and 90 girls: 84 children of 3 to 5 years of age, and 88 children of 6 to 7 years. The mean age of the children was 4.2 years. Altogether, the data

were collected from 11 daycare centers resulting in 1165 recorded and valid days from 172 children (Table 2).

Statistical analyses

After normality checking, the recorded data were analyzed by the statistical package for the social sciences (SPSS) for Windows (IBM, version 24). The mean, standard deviation (*SD*), range, extreme values, and coefficient of variation (*V*) were calculated for intensity levels to show the differences in independent variables of gender and day of the week. The coefficient of variation was used to better compare the actual variance at different intensity levels and is presented as the percentage of the mean. The independent-samples t-test was performed to compare the means in time spent at different intensity levels for both genders. In addition, repeated measures multivariate analysis of variance (MANOVA) was conducted to indicate whether there is interaction between gender and weekend-or-not. To measure the magnitude of the independent variables, effect sizes (Cohen's d (*d)* and partial eta squared (η_p^2) were calculated using the original *SD*s. Statistical significance for all analyses was alpha level .05.

Results

Volume and variation at different physical activity intensity levels between genders

The mean MVPA per day was 54 minutes for all children, *SD* = 24, 95% confidence interval (*CI*) = [50.65, 57.88], sample size (*N*) = 172, ranging from 4 to 154 minutes. In Figure 1, the ascending curves demonstrate the variances in mean MVPA minutes in boys and in girls. A lot of variance was found in both groups and between groups, but it was substantial within the boys' group. At other intensity levels, the variations were smaller than in MVPA. The least variance was found in VLPA, in which the mean was 697 minutes for the whole sample (*SD* = 65.6, CI = [687, 707], *N* = 172).

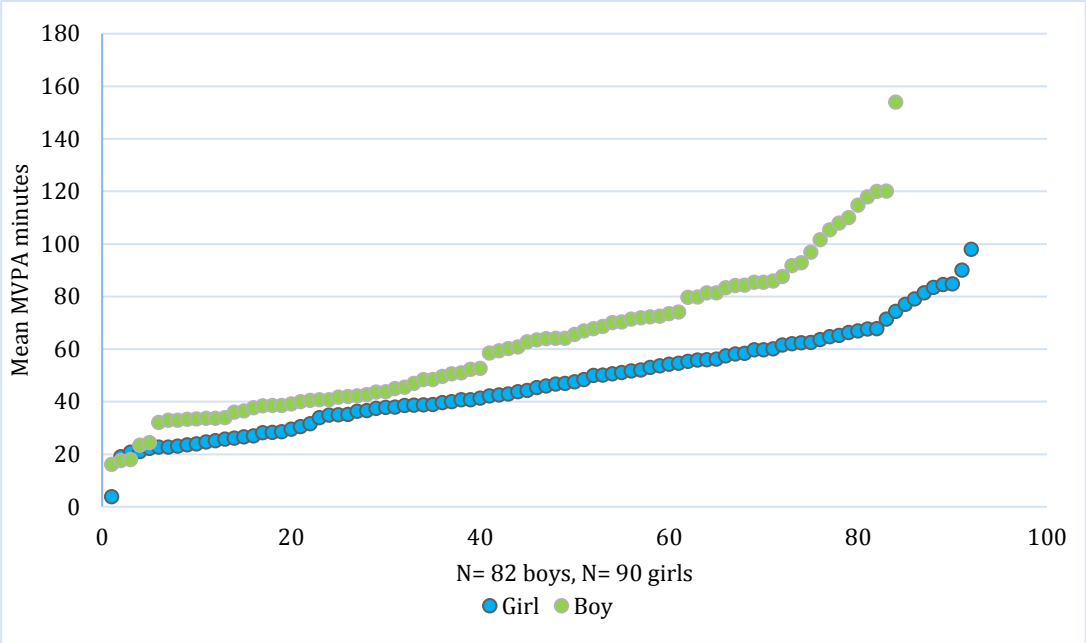

FIGURE 1 Distribution of mean moderate-to-vigorous physical activity (MVPA) minutes per day for boys and girls

Table 3 shows that boys engaged on average 14 minutes (29%) more than girls per day in MVPA. The independent-samples t-test revealed that the differences in MVPA means between genders were statistically significant, t (141.9) = 3.869, p = .000, Cohen's d (d) = 0.7 (large effect). Instead boys engaged less in VLPA, but the effect of gender was low, t (170) = −2.313, p = .022, d = −0.4. No significant difference was found between genders in time spent either in LPA or LMVPA for the measurement week.

The results revealed substantial variation between individuals in both genders. The range in MVPA means (for all measured days) was 138 minutes in boys and 94 minutes in girls. The highest extreme values during the measurement week (154, 120, 118, 115, and 110 minutes) in the boys' group were notably higher than in the girls' group (98, 90, 85, 85, and 84 minutes). The lowest extreme values in MVPA for girls were (4, 19, 21, 22, and 23 minutes) and they differed minimally from the values in the boys' group (16, 18, 18, 24, and 24 minutes). Differences between genders were minimal in LPA and LMVPA.

Even though girls had a higher VLPA mean, boys had the highest extreme values (between 825 and 785 minutes). The VLPA range varied between 495 and 808 minutes in girls and between 426 and 825 minutes in boys, which confirms the bigger variation in the boys' group. The descriptive statistics, coefficient of variation, p value, t value, and degrees of freedom for both genders at different intensity levels are presented in Table 3.

TABLE 3 Differences in means between boys and girls at different physical activity (PA) levels.

PA LEVEL	*GENDER*	*N*	*MIN*	*MAX*	*MEAN*	*SD*	*V*	*t*	*p*	*df*
MVPA	boy	82	16	154	62	27	44	3.869	.000	170
	girl	90	4	98	48	19	40			
LPA	boy	82	56	199	113	30	27	–.340	.734	170
	girl	90	40	176	115	29	25			
LMVPA	boy	82	73	304	175	46	26	1.816	.072	170
	girl	90	44	265	162	43	27			
VLPA	boy	82	426	825	685	72	11	−2.313	.022	170
	girl	90	495	808	708	57	8			

LMVPA = light-to-vigorous physical activity; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity; VLPA = very light physical activity

Volume and variation at different physical activity intensity levels between weekdays and weekends for boys and girls

Table 4 displays the descriptive statistics and coefficient of variation for weekdays and weekends for boys and girls. As a rule, there was more variation in PA on weekends than on weekdays. Overall, the lowest values were found on weekends and the highest were found on weekdays at other/all levels except for VLPA, which was the opposite. Four of the boys had one day without a single minute of MVPA, and several boys had only 2 minutes of MVPA (all on weekends) Girls had no zero-days, but some of the girls had days with only one minute of MVPA (on weekends and weekdays). The variation between genders in terms of the extreme values, coefficients of variation, and ranges was lowest for LPA and LMVPA.

The coefficient of variation was highest in MVPA and lowest in VLPA. Compared with girls, boys had more variation and highest coefficient of variation in MVPA, especially at the weekend, but at other levels, the variation was almost similar between genders. The coefficients of variation for weekday and weekend were the smallest in VLPA, varying between 8 (girl, weekday) and 12 (boy, weekday), indicating the similarity of children's sedentary activities for both genders.

TABLE 4 Gender differences in mean time spent at physical activity (PA) levels on weekdays and weekend days.

PA LEVEL	*WEEKEND-OR-NOT*	*GENDER*	*N*	*MIN*	*MAX*	*MEAN*	*SD*	*V*	*t*	*p*	*df*	*d*
MVPA	weekday	boy	82	14	154	66	31	47	5.28	.000	171	0.8
		girl	90	4	118	50	22	44				
	weekend	boy	82	2	129	49	28	57				
		girl	90	2	112	42	20	48				
LPA	weekday	boy	82	53	209	115	31	27	2.81	.006	171	0.4
		girl	90	31	206	117	32	27				
	weekend	boy	82	16	188	108	36	31				
		girl	90	15	195	110	35	32				
LMVPA	weekday	boy	82	67	304	181	51	28	4.64	.000	171	0.4
		girl	90	35	286	167	48	29				
	weekend	boy	82	18	260	158	54	34				
		girl	90	17	248	152	47	31				
VLPA	weekday	boy	82	399	813	666	78	12	-10.2	.000	171	-1.5
		girl	90	269	818	697	57	8				
	weekend	boy	82	480	884	739	83	9				
		girl	90	386	885	742	74	10				

LMVPA = light-to-vigorous physical activity; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity; VLPA = very light physical activity

Effect of weekend-or-not on different physical activity intensity levels for boys and girls

Repeated measures MANOVA was used to analyze the effect of weekend-or-not on different intensity levels between boys and girls. Firstly, gender appeared to have a medium effect on PA as boys spent more time in MVPA on weekdays and weekends than girls, F (1,170) = 13.09, p < .001, partial eta squared (η_p^2)= .071. On the other hand, MVPA also diminished more in boys on weekends. On weekdays, the average MVPA was 17 minutes higher in boys, and 8 minutes higher in girls, compared with weekends, but weekend-or-not seemed to have a large effect on both genders, F (1,170) = 30.000, p < .001, η_p^2 = .15 (Figures 2 and 3).

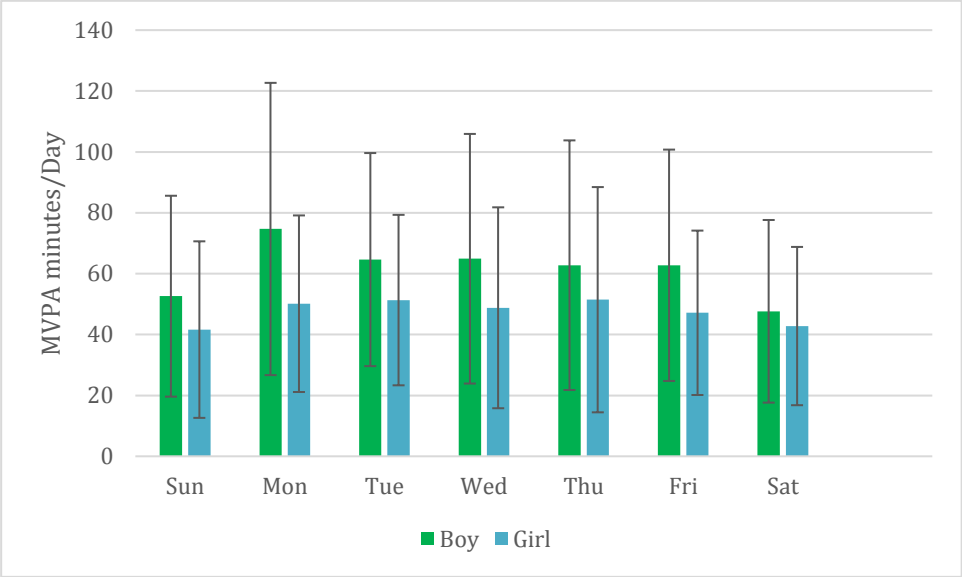

FIGURE 2 Moderate-to-vigorous physical activity (MVPA) columns: means and standard deviations for boys and girls during the week. $p < .001$ (between genders), $p < .001$ (between weekends and weekdays)

FIGURE 3 Effects of gender and weekend-or not on moderate-to-vigorous physical activity (MVPA) (transferred from SPSS)

Additionally, repeated measures MANOVA revealed the interaction between gender and day of the week, $F(1,170) = 4.7$, $p = .032$. Although the effect was low ($\eta_p^2 = .027$), weekend appeared to diminish MVPA more in boys than in girls (Figures 2 and 3).

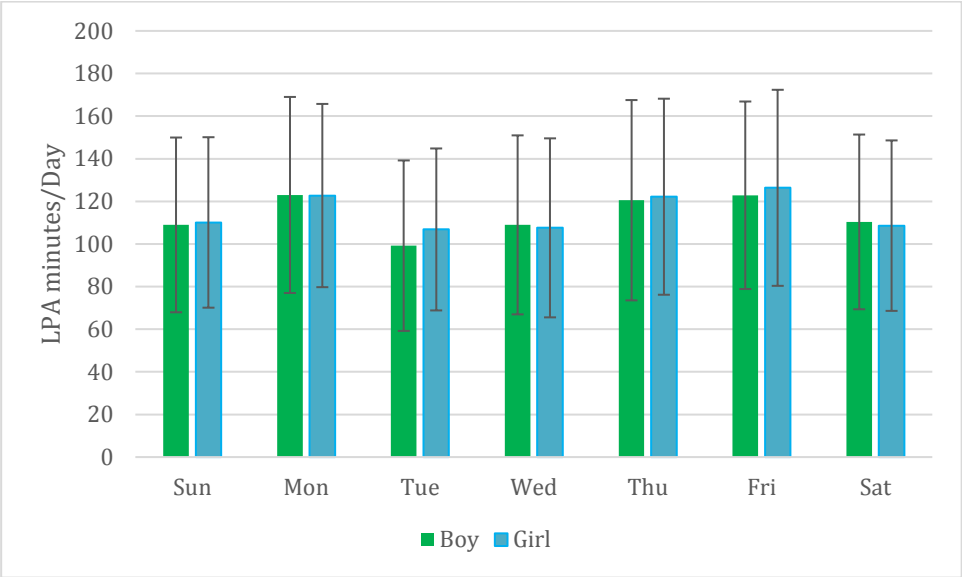

FIGURE 4 Light physical activity (LPA) columns: means and standard deviations for boys and girls during the week. $p = .740$ (between genders), $p < .05$ (between weekends and weekdays)

LPA tended to increase after and before the weekend and to decrease in the middle of the week. In LPA, the main effect of weekend-or-not was observed. Both sexes engaged 7 minutes more in LPA on weekdays than on weekends, $F(1,170) = 7.805$, $p = .006$, $\eta_p^2 = .04$ (small effect). The genders exhibited almost identical curves and the differences between boys and girls were not statistically significant (Figure 4).

The amount of LMVPA followed the trend of MVPA, decreasing at the weekend and increasing after the weekend. Repeated measures MANOVA found a medium effect of weekend-or-not on children's LMVPA, $F(1,170) = 22$, $p < .001$, $\eta_p^2 = .13$, but as in LPA, the curves for boys and girls were very similar to each other. Gender was revealed to have no significant effect on children's LMVPA behavior during the week (Figure 5).

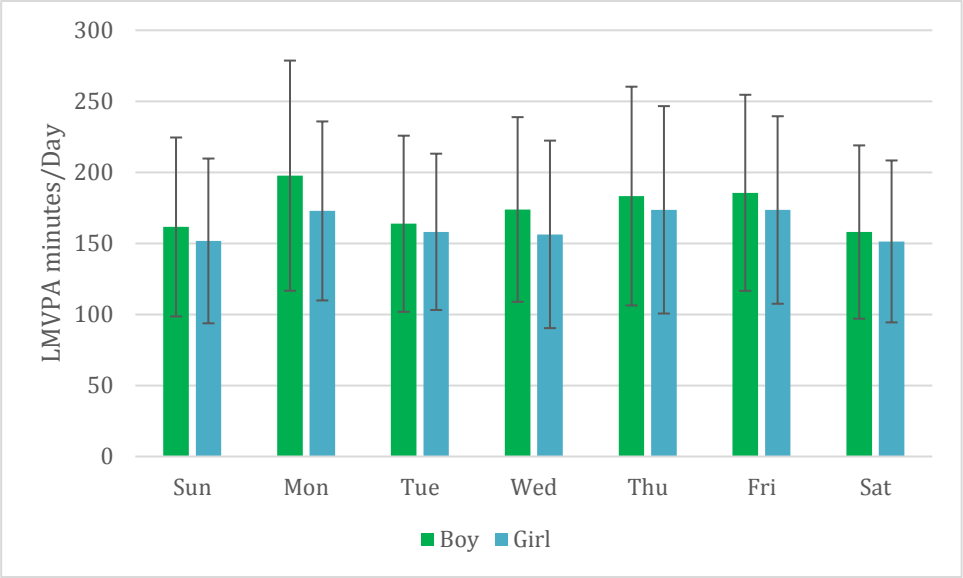

FIGURE 5 Light-to-vigorous physical activity (LMVPA) columns: means and standard deviations for boys and girls during the week. $p = .122$ (between genders), $p < .001$ (between weekends and weekdays)

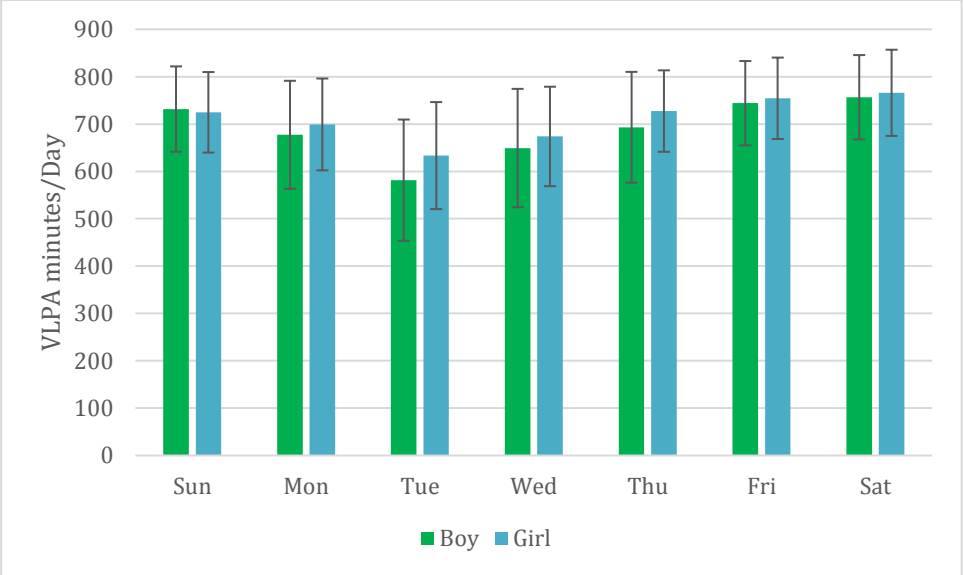

FIGURE 6 Very light physical activity (VLPA) columns: means and standard deviations for boys and girls during the week. $p = .072$ (between genders), $p < .001$ (between weekends and weekdays)

In contrast to other intensity levels, the weekend was revealed to arouse VLPA. The difference between weekends and weekdays was more than 60 minutes and the effect of

the weekend was large, $F(1,170) = 109$, $p < .001$, $\eta_p^2 = .39$. Additionally, repeated measures MANOVA found low interaction between gender and the weekend-or-not (VLPA, $F(1,170) = 5.94$, $p = .016$, $\eta_p^2 = .03$). VLPA increased in boys by 71 minutes on weekends compared with 67 minutes in girls (Figure 6).

Proportion of children engaging in different physical activity intensity levels and achieving of the recommendations

In boys, the proportions engaging in MVPA were 6% (under 30 minutes/day), 43% (30–59 minutes/day), 38% (60–89 minutes/day), and 13% (over 90 minutes/day). Fifty-nine percent of boys engaged in LPA for 60–120 minutes per day and 35% for 121–180 minutes per day. Four percent engaged in LPA under 60 minutes per day. The proportion of boys engaging in less than 120 minutes of LMVPA was 12%, for those engaging between 120–179 minutes the proportion was 45%, and 43% of boys engaged in LMVPA for at least 180 minutes. Only two boys (3 to 5-year-olds) engaged in VLPA for less than 9 hours, 13% of boys engaged in VLPA for less than 10 hours, and the rest of the boys were sedentary for at least 10 hours per day. Thus 43% of the boys achieved the new recommendations daily minimum of 3 hours of LMVPA, and half of the boys engaged in MVPA for at least one hour.

In girls, the proportions engaging in MVPA were approximately 20% (under 30 minutes/day), 53% (30–59 minutes/day), 24% (60–89 minutes/day), and 2% (over 90 minutes/day). Fifty-nine percent of girls engaged in LPA for 60–120 minutes/day and 40% for 121–180 minutes per day. Only one percent of girls engaged in LPA for less than an hour and none for more than 3 hours. The proportion of girls engaging in less than 120 minutes of LMVPA was 20%, for those engaging between 120–179 minutes the proportion was 48%, and 32% of girls engaged in LMVPA for at least 180 minutes. Only 3% of girls engaged in VLPA for less than 10 hours per day, and 97% of girls were sedentary for at least 10 hours per day. Thus 32% of the girls achieved the new recommendations daily minimum of 3 hours of LMVPA and 26% of the girls engaged in MVPA for at least one hour.

Discussion

The main objectives of this study were to explore the volume and variation of preschool children's PA at different intensity levels (dependent variables) for boys and girls and to inspect the effect of the independent variable weekend-or-not on PA. Another purpose was to ascertain whether children achieve the new recommendations.

The results revealed that the average time spent in MVPA was in line with the previous results of Soini et al. (2014), E. Andersen et al. (2017), Spittaels et al. (2012), and Tucker (2008), being 54 minutes in the whole sample. The difference between genders was considerable. According for most of the previous studies, boys engaged more in MVPA than girls (Hinkley et al., 2008; Jämsen et al., 2013; Schaefer et al., 2015; Soini et al., 2014; Spittaels et al., 2012; Tucker, 2008). On average, boys engaged 14 minutes more in MVPA per day than girls did. Additionally, 51% of boys and 26% of girls engaged in MVPA for at least 60 minutes per day. By comparison, Soini et al. (2014) found that 46% of children spent 60 minutes in MVPA and E. Andersen et al. (2017) found that 60% of 3 and 4-year-olds spent 60 minutes in MVPA. Overall, the present findings indicate that children do not meet the PA recommendations of one hour of the higher intensity activities.

The volumes of LPA and LMVPA were almost equal in boys and girls and were approximately 60 minutes higher than in the studies of Byun et al. (2013) and Soini et al. (2014). The equal amounts of LPA in both genders differed from the results of Soini et al. (2014), who studied 3-year-old children, and showed boys engaging more in LPA than girls. In contrast, for Jämsen et al. (2013), Reilly (2010), Soini et al. (2014), and Tucker (2008), boys and girls spent similar amounts of time as each other in LMVPA. On the other hand, in this study the time engaged in LMVPA in boys and girls was bigger than in the formerly mentioned studies. For example, Soini et al. (2014) reported that only 20% of 3-year-old children engaged in 120 minutes or more of LMVPA. In the present study children engaged in LMVPA on average for almost 3 hours of their day. Nevertheless, only 32% of girls and 43% of boys engaged in at least 3 hours of LMVPA and thus achieved the recommendations.

Since this study was completed in the metropolitan area of Finland it is possible that the environment provokes more less intense activities and fewer more intense activities. For example, the weather may have affected the results, since the present study was implemented in winter, and the conditions for outdoor activities are very varied in the wintertime in the metropolitan area. In the study of Soini et al. (2014), children spent significantly less time in outdoor activities and in LPA on winter weekdays compared with autumn. Another reason for the greater amounts of LMVPA in this study might be the different age distributions of the studies. In the study of Soini et al. (2014), the sample consisted of 3-year-olds, and in the present study, in turn, the age distribution was 3- to 7-year-olds (mean = 4.2 years). Furthermore, since older children engaged in more LMVPA than younger children it probably heightened the overall prevalence of recommended levels of LMVPA in the present study. Another reason may be differences between the programmed intensity level boundaries and MET thresholds in the accelerometers.

An interesting but alarming finding in this study is that the amount of VLPA was so high, and does not follow the recommendations, as it was approximately 11 hours per day. This is noticeably more than in earlier studies of Byun et al. (2013), Cardon and De Bourdeaudhuij (2008), Soini et al. (2014), Spittaels et al. (2012), and Vanderloo et al. (2015). It is possible that the metropolitan area provokes sedentary activities. Another reason may be that in this study accelerometer wear time was 24 hours per day. The average sleep time for the whole sample was 10 hours, which leaves 14 hours for other actions. If the amount of LMVPA was approximately 3 hours and sleeping time was 10 hours, there would remain 11 hours for VLPA. Before falling asleep the accelerometers recorded long periods of VLPA, which probably consists of, for example, calming down, talking, and bedtime stories with parents. It is possible that in the previous studies the relative share of sedentary behavior would have been greater if the recording times had been longer. Additionally, it is possible that the VLPA volumes in the PAC outputs are too high, since the accelerometer appeared to react too sensitively to children's nightly movements. Accelerometer recorded intensities of 1.250 MET at night in most participants, which is within the limits of VLPA.

In conclusion, since these nightly movements were included in VLPA (1–2 MET) volumes, the total volumes of VLPA might have increased too high. On the other hand, accelerometers can dismiss some activities depending on the accelerometer type and mounting position. A wrist-worn PAC dismisses activities like pulling, pushing, pedaling, and skating—activities in which the arms are not moving (Pate et al., 2010; Van Cauwenberghe et al., 2011). This might have caused the underestimation of activities with intensities higher than VLPA.

Another purpose was to examine the variation (range, extreme values, and coefficients of variation) in the independent variables of gender and weekend-or-not. Indeed, the most prevalent finding in this research was the large variation in PA in the whole sample: between boys and girls, and between weekends and weekdays. Boys showed more variation at the higher intensities than girls. They had the largest coefficients of variation, and the highest and for the most part the lowest extreme values too. Variation during the week was highest on weekends in LPA, MVPA, and LMVPA, which is in line with Soini et al. (2014). Most variation was found in MVPA and least in VLPA.

The third purpose was to examine whether the independent variable of weekend-or-not affects the differences in PA amounts between genders. The finding of more MVPA on weekdays was in line with Brooke et al., (2014). Overall, the weekend appeared to have a large effect on MVPA in both genders. Similarly, to Soini et al. (2014), the difference between boys and girls was most obvious on weekdays. An interesting finding revealed that MVPA decreased more in boys, compared with girls, on weekends, although the drop

was found in girls also. Equally, the amounts of LPA and LMVPA decreased on weekends in boys and girls, which is opposite to Hinkley et al. (2012), who found weekends more active, but in contrast to MVPA, no difference was found between genders in the present study. This is partly in line with Brooke et al., (2014), who indicated that amounts of LMVPA are lower on weekends, but they did not analyze the gender differences.

In contrast to the other PA intensity levels, an increase in VLPA was recorded during the weekend and the effect of weekend-or-not on VLPA was extremely high in both genders. Still, boys had more variation in their VLPA means, and their amount of VLPA increased more on weekends compared with girls. Studies of preschool children's PA and sedentary behavior on weekends and on weekdays are limited. The current samples' inactivity levels at weekends are in line with the results of Dössegger et al. (2014), who also found higher levels of inactivity at weekend, and opposite to Aguilar-Farias et al. (2015), and Cardon and De Bourdeaudhuij (2008), who found inactivity levels to be lower on weekends.

Conclusion

The present study conducted in the metropolitan area of Finland shows that preschoolers' compliance with the new PA recommendations is inconsistent. The average time spent in LMVPA was 3 hours, but only 32% of girls and 43% of boys engaged in 3 hours of LMVPA. The study discloses the large variation in children's PA. Most preschoolers do not meet the new recommendations' daily minimum of 3 hours of varied PA, while some children exceed the level. The new recommendations were launched soon after this research was carried out, and the findings underline the importance of future interventions. Similarly, to another Finnish study, by Soini et al. (2014), gender appears to be an important variable in children's PA, with girls less active and more sedentary than boys. The difference is most evident in MVPA. Boys move more at higher intensity levels than girls do. However, the variation is more remarkable in boys. Therefore, at the same time as paying attention to the girls as a group, attention should be paid to those boys who hardly engage in MVPA at all.

In addition, the present findings indicate that the weekend affects PA in both genders but more so in boys than in girls. The influence was notable in MVPA and VLPA. Following Finn et al., (2002) we propose that preschools are significant instigators of children's PA. Nevertheless, although some children are very active, a large proportion of children do not engage enough in PA. Therefore, parents and other adults should activate children on weekends to engage them more in physical activities and less in sedentary activities.

Because the amounts of VLPA appear to be high in preschool children, more attention should be paid to reducing sedentary activities. Educators, parents, and other adults

should guide children to engage in more physical activities and provide short active breaks in childcare settings, at home or during hobbies.

The present study was completed in the metropolitan area of Finland. We do not know what caused the differences, for instance, in the higher amounts of LMVPA and VLPA in this study compared with other studies completed in other parts of Finland. The results are tentative, but it is plausible that the location of residence may have an influence on preschool children's PA.

Strengths and limitations

The main strength of this study is the number of participants (N=172). On the other hand, the children's age ranged from 3 to 7 years, which makes it difficult to compare the results with some previous studies with more homogeneous age groups. Some additional information about the children's backgrounds would have enabled more analyses and conclusions about the results.

Accelerometers are considered reliable in studying children's PA. However, another limitation may be the PAC accelerometer, which is not much used in the research field, and thus the number of studies using the PAC accelerometer with which we can compare our results is limited. Difficulties may be caused by different cut points between the intensity levels and the epochs used in the PAC. For example, VLPA may be recorded too sensitively, as described in discussion. In addition, the volumes of MVPA recorded could have been higher with shorter epochs. However, since they are inexpensive and feasible, we propose additional validation tests for the PAC accelerometer to enhance the validity of the results and to increase the research use of the device in young children.

Another limitation is that we did not take the anthropometric measurements—height and body weight—clinically, since we wanted to simplify the methodology following the results of Reilly et al. (2008). In addition, we did not remove the data if the child was sick and the data were otherwise acceptable, since we wanted to get an overall picture of children's PA. This certainly reduces the activity volumes and increases VLPA. Additionally, we did not cover the feature on the PAC face, which might have influenced the results. On the other hand, this probably encouraged good compliance because only one of the children interrupted the measurements.

To our knowledge, the present study is the first one with objective methods completed in the metropolitan area of Finland that has examined preschool children's PA and the compliance with the new recommendations. It provides valuable information about how to target the interventions for the promotion of preschool children's PA. However, further research is warranted to examine how active children are during preschool hours

compared with time out of preschool, for example at home and during hobby activities. In addition, future research should investigate whether there is significant inter-preschool or between-preschool-center variability in children's PA and what are the possible sources. Also of interest would be to examine what children do in daycare centers or at home and how physically active they are in those actions.

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