

1-1-2017

## Relationship between children's physical activity, sedentary behavior, and childcare environments: A cross sectional study

Michele Peden

*University of Wollongong*, [mep948@uowmail.edu.au](mailto:mep948@uowmail.edu.au)

Rachel A. Jones

*University of Wollongong*, [rachelj@uow.edu.au](mailto:rachelj@uow.edu.au)

Silvia Costa

*University of Cambridge*

Yvonne Ellis

*University of Wollongong*, [yge019@uowmail.edu.au](mailto:yge019@uowmail.edu.au)

Anthony D. Okely

*University of Wollongong*, [tokely@uow.edu.au](mailto:tokely@uow.edu.au)

Follow this and additional works at: <https://ro.uow.edu.au/sspapers>



Part of the [Education Commons](#), and the [Social and Behavioral Sciences Commons](#)

---

### Recommended Citation

Peden, Michele; Jones, Rachel A.; Costa, Silvia; Ellis, Yvonne; and Okely, Anthony D., "Relationship between children's physical activity, sedentary behavior, and childcare environments: A cross sectional study" (2017). *Faculty of Social Sciences - Papers*. 2924.  
<https://ro.uow.edu.au/sspapers/2924>

---

## Relationship between children's physical activity, sedentary behavior, and childcare environments: A cross sectional study

### Abstract

The purpose of this study was to investigate the relationship between the childcare environment and physical activity and sedentary behavior of toddlers and preschoolers. A total of 68 toddlers (1.0–2.9 years) and 233 preschoolers (3.0–5.9 years) were recruited from 11 childcare services in 2013 within the Illawarra and Shoalhaven region of NSW, Australia. For this study analysis was conducted in 2016. The childcare environment was assessed using the Environment and Policy Assessment Observation (EPAO) instrument, and childcare services categorized as low, medium, or high based on their scores. Time spent in physical activity and sitting was assessed over one week using activPAL accelerometers. Relationship between EPAO and children's physical activity and sedentary behavior was assessed using multilevel mixed-effects linear regression. Toddlers who attended high EPAO services sat more (8.73 min [-10.26, 27.73]) and stood less (-13.64 min [-29.27, 2.00]) than those who attended low EPAO services. Preschoolers who attended high EPAO services sat less than those in low and medium services (mean [95%CI] = -7.81 min [-26.64, 11.02]). Sub-categories of the EPAO that were associated with less time sitting were: sedentary environments for toddlers and portable play equipment for preschoolers. This study extends previous research by identifying differences between toddlers and preschooler's physical activity and sedentary behaviors in relation to childcare environments. A greater understanding of how the childcare environment relates to sitting time for both toddlers and preschool aged children is needed.

### Disciplines

Education | Social and Behavioral Sciences

### Publication Details

Peden, M. E., Jones, R., Costa, S., Ellis, Y. & Okely, A. D. (2017). Relationship between children's physical activity, sedentary behavior, and childcare environments: A cross sectional study. *Preventive Medicine Reports*, 6 171-176.



## Relationship between children's physical activity, sedentary behavior, and childcare environments: A cross sectional study

Michele E. Peden<sup>a,\*</sup>, Rachel Jones<sup>a</sup>, Silvia Costa<sup>b</sup>, Yvonne Ellis<sup>a</sup>, Anthony D. Okely<sup>a</sup>

<sup>a</sup> Early Start Research Institute, Faculty of Social Sciences, University of Wollongong, New South Wales, Australia

<sup>b</sup> UKCRC Centre for Diet and Activity Research (CEDAR), MRC Epidemiology Unit, University of Cambridge, United Kingdom

### ARTICLE INFO

#### Article history:

Received 11 October 2016  
Received in revised form 15 February 2017  
Accepted 18 February 2017  
Available online 21 February 2017

#### Keywords:

Child care  
Physical activity  
Preschool  
Intervention

### ABSTRACT

The purpose of this study was to investigate the relationship between the childcare environment and physical activity and sedentary behavior of toddlers and preschoolers.

A total of 68 toddlers (1.0–2.9 years) and 233 preschoolers (3.0–5.9 years) were recruited from 11 childcare services in 2013 within the Illawarra and Shoalhaven region of NSW, Australia. For this study analysis was conducted in 2016. The childcare environment was assessed using the Environment and Policy Assessment Observation (EPAO) instrument, and childcare services categorized as low, medium, or high based on their scores. Time spent in physical activity and sitting was assessed over one week using activPAL accelerometers. Relationship between EPAO and children's physical activity and sedentary behavior was assessed using multilevel mixed-effects linear regression.

Toddlers who attended high EPAO services sat more (8.73 min [−10.26, 27.73]) and stood less (−13.64 min [−29.27, 2.00]) than those who attended low EPAO services. Preschoolers who attended high EPAO services sat less than those in low and medium services (mean [95%CI] = −7.81 min [−26.64, 11.02]). Sub-categories of the EPAO that were associated with less time sitting were: sedentary environments for toddlers and portable play equipment for preschoolers.

This study extends previous research by identifying differences between toddlers and preschooler's physical activity and sedentary behaviors in relation to childcare environments. A greater understanding of how the childcare environment relates to sitting time for both toddlers and preschool aged children is needed.

© 2017 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

### 1. Introduction

The early years (0–5 years) is a critical time in establishing healthy levels of physical activity and sedentary behavior (Reilly et al., 2004). Optimal levels of these behaviors at this age are associated with more favorable health outcomes in childhood and adolescence (Bower et al., 2008; Vanderloo et al., 2014). Of concern is that a high proportion of young children currently do not meet physical activity and sedentary behavior recommendations (Hinkley et al., 2012; Pujadas Botey et al., 2016; Ellis et al., n.d.), thereby potentially impacting long-term health outcomes.

In recent years, the number of children attending childcare services has escalated with the majority of children in developed countries now attending some sort of formal childcare each week (OECD, 2016). This makes childcare services ideal environments to promote healthy levels

of physical activity and sedentary behavior. Healthy lifestyles (including physical activity and sedentary behaviors) is also a mandated part of most early childhood curricula (Stegelin, 2005; Australian Children's Education and Care Quality Authority (ACECQA), 2011) and childcare services offer environments, both indoors and outdoors, for active play opportunities (ERIC Digest, 2001).

A number of studies have investigated the relationship between the childcare environment and young children's physical activity. (Hesketh Kvan Sluijs, 2016; Vanderloo and Tucker, 2015; Henderson et al., 2015) Such studies have reported positive relationships with physical activity and the availability of portable or fixed equipment, teacher-led physical activity lessons, and staff behaviors (such as staff intentionally engaging with children in active play or providing positive or negative comments in relation to physical activity) (Bower et al., 2008; Kreichauf et al., 2012; Goldfield et al., 2012; Trost et al., 2009). Staff involvement in the promotion of active play, the use of positive statements and prompts about physical activity have been associated with increased child activity within childcare environments (Vanderloo et al., 2014; Gubbels et al., 2011). In contrast, other studies have identified negative

\* Corresponding author at: Early Start Research Institute, Faculty of Social Sciences, University of Wollongong, Wollongong, NSW 2522, Australia.  
E-mail address: [mep948@uowmail.edu.au](mailto:mep948@uowmail.edu.au) (M.E. Peden).

relationships between staff participation during indoor play (Brown et al., 2009; Henderson et al., 2015) and larger peer group size with physical activity (Gubbels et al., 2011). Staff participation refers to the levels of staff engagement with children in active play and how staff initiate play experiences with children (Brown et al., 2009). Whilst peer group size refers to the number of children assigned to a group that is supervised by a staff member (Gubbels et al., 2011). Previous studies have reported an association between social environmental factors and physical activity. Understanding these relationships is important as it helps to identify specific factors that could be targeted within childcare environments to improve children's physical activity and reduce children's sedentary time. However, a number of limitations have been identified with these studies including: the number and type of environmental factors investigated, the instruments used to measure physical activity and/or sedentary behavior and age range of participants. To date, few studies have reported on such relationships among younger children (i.e. children aged <2.5 years) and limited studies have investigated the relationship between childcare environments and objectively measured sedentary behavior. Therefore, the aim of this study was to investigate the relationship between childcare environments and objectively measured physical activity and sedentary behavior among toddlers and preschoolers.

## 2. Methods

### 2.1. Setting and participants

Cross sectional data was collected between August and November 2013 from 11 childcare services that were part of an overarching administering organization, operating within the Illawarra and Shoalhaven region of NSW, Australia (population 0.5 M) (Australian Bureau of Statistics, 2014). Parent consent was obtained prior to data collection. The Human Research Ethics Committee at the University of Wollongong approved the study (HE12/443).

### 2.2. Assessment of the childcare environment

The childcare environment was objectively assessed using the validated Environment Policy and Observation instrument (EPAO) (Ward, 2008; Gubbels et al., 2011). Prior to data collection, four data collectors participated in an intensive full day workshop, inclusive of general observational techniques, a review of the EPAO and its uses, description of indoor and outdoor space, lessons on interview techniques and procedures, instructions and demonstration of record keeping and the completion of a mock assessment alongside an experienced observer. An inter-observer agreement was completed with inter-observer agreement averaging 84.5% (Ward, 2008). Following the workshop, the trained data collectors unobtrusively completed observations within childcare services over two full days. One day was spent observing the preschool-aged children and the other day observing the toddler-aged children.

The complete EPAO instrument assesses the physical activity, sedentary behavior, and nutrition environments, policies, and practices. However, for this study only the physical activity and sedentary behavior component of the EPAO was used. This component comprised eight subscales (Ward et al., 2008; Lyn et al., 2013), however, only six subscales were reported in this study. The document review subscale pertaining to policy on physical activity and training and curriculum review were omitted due to all services belonging to the same overarching organization (thus having identical written policies). The six subscales included in this study were: 1) Active Opportunities (frequency and total minutes of indoor and outdoor active play, structured-educator led physical activity opportunities and unstructured physical activity opportunities); 2) Sedentary opportunities (time spent seated beyond 30 min period (excluding nap and meal times), use of small screen devices (computers, DVD, iPads); 3) Sedentary Environments;

4) Portable Play Equipment (e.g. ball play, climbing structures, floor and jumping play equipment, parachute, push/pull toys, riding toys, rocking/twisting toys, sandpit, water play, slides, balancing surfaces, hoops and tricycle tracks); 5) Fixed Play Equipment (e.g. climbing structures and balancing equipment); and 6) Staff Behaviors (educators restricting play as punishment, engaging in physical activity with children, providing positive or negative prompts relating to physical activity, and providing formal physical activity lessons). Observations also identified the presence of small or large outdoor running spaces (obstructed and unobstructed), suitable indoor space for gross motor activities, and displays, books, and posters relating to physical activity and sedentary behavior.

Each subscale was scored using recommendations from Bower et al. (2008) and Vanderloo et al. (2014) Initially, all item responses were converted to a three-point scale (ranging from 0 to 2). Sedentary Opportunities and Sedentary Environment subscales were reversed scored; thus, lower levels of sedentary behavior signified higher values (Bower et al., 2008). For each of the six subscales, the converted responses were then tallied and divided by the number items in each subscale. To standardize each score, the average was then multiplied by 10, which provided an overall score out of 20 for each subscale (Bower et al., 2008). A total EPAO score was calculated by averaging all of the subscale scores, with a more supportive environment equating to a higher score and a less supportive environment equating to a lower score (Vanderloo et al., 2014; Ward et al., 2008). Childcare services were then stratified based on their total EPAO score: centres that scored <70 were classified as low EPAO centres, those scoring 70–79 were classified as medium EPAO centres, and those scoring >80 were classified as high EPAO centres.

### 2.3. Physical activity and sedentary behavior

ActivPAL accelerometers were used to assess physical activity and sedentary behavior. The activPAL accelerometer has proven to be a practical, reliable and valid instrument that objectively and successfully captures data on children's sitting, standing and stepping activities (Davies et al., 2012; De Decker et al., 2013; Dowd et al., 2012). The small activPAL device (53x35x7mm) was secured to a child's upper thigh within a pouch using a Velcro garter. The activPAL was fitted upon arrival and removed prior to the children leaving the childcare service in the afternoon. Toddlers (1.0–2.9 years) fitted with an activPAL were all mobile and able to demonstrate competent walking skills. The Centre for Physical Activity and Health Research (CPAHR) MATLAB program with fifteen-second epoch files were used to calculate sitting/lying, standing, physical activity and non-wear time for each participant per day (Hamilton et al., 2004). Children needed to wear the activPAL  $\geq$  180 min/day for a day to be considered valid (Ellis et al., n.d.). Sitting breaks and bouts were determined from activPAL outputs. Data were collected between 1 and 5 days depending on the number of days the children attended the service. All the childcare services included in this study scheduled a nap during each day ( $\pm$  1 h), this period was excluded from the total wear time (Ellis et al., n.d.).

### 2.4. Statistical methods

All analyses were performed using STATA version 13. ActivPAL-specific software (v 5.9.1.1) was used to download activPAL data (Ellis et al., n.d.). This program was used to calculate for each participant the sitting, standing, stepping and non-wear time for each day. This time was recorded in epochs of 15 s. After the program calculated non-wear time for each participant, data were imported into Microsoft Excel 2011 for Mac (Microsoft Corporation, 2010) to calculate the total minutes of wear time, sitting, standing, and stepping. Non-wear time was identified and removed if the activPAL recorded series of 0 counts for over 30 min (120 consecutive counts). These non-wear bouts were manually removed from the total minutes monitored, and Excel files were

transferred into STATA files. Finally, multilevel mixed-effects linear regression was used to calculate mean stepping, standing, and sitting time adjusted for mean wear time.

Multilevel mixed-effects linear regression models were used to investigate the relationship between EPAO and 1) sitting, 2) standing, and 3) stepping. Models were run firstly using overall EPAO, and afterwards with each EPAO subscale as predictor variables. All models were adjusted for clustering at childcare centre level, activPAL wear time and sex. As initial analyses with toddlers and preschoolers combined revealed differences in these relationships between the two age groups, all analyses were subsequently conducted separately for toddlers and preschoolers. As the variability in scores was smaller for the EPAO subscales, it was decided to only use the high and low category scores for these predicted variables. Alpha was set at 0.05.

### 3. Results

Data from 68 toddlers (1.0–2.9 years, mean age ( $M_{age}$ ) 2.2 years) and 233 preschoolers (3.0–5.9 years,  $M_{age}$  4.12 years) were collected (Table 1). The 11 childcare services combined catered for an average of 35 per day. On average, there were 6 toddlers and 18 preschoolers per child care service who participated in this study. There were no statistical significant differences between high, medium and low EPAO scoring services in time spent sitting, standing and stepping among toddlers (Table 1). Toddlers who attended high EPAO scoring services sat more (mean [95% CI] = 8.783 min [−3.02, 37.30] and stood less (−13.64 min [−29.27, 1.99]) than those who attended low EPAO scoring services (Table 1). Toddlers in high EPAO scoring services spent more time stepping (4.86 min [−7.30, 17.02]) compared to those attending low and medium EPAO scoring services (Table 2).

Similarly, for preschoolers, there were no statistical significant differences between high, medium and low EPAO scoring services and time spent sitting, standing and stepping (Table 3). Preschoolers attending high EPAO scoring services sat marginally less (mean [95%CI] = −7.81 min [−26.64, 11.02]) than those attending low or medium EPAO scoring services and preschoolers from high EPAO scoring services stepped slightly more than those from medium and low scoring services (7.28 min [−1.39, 15.96]) (Table 3).

Given that no statistical significant differences were identified between the three EPAO levels and time spent sitting, standing and stepping, subsequent analyses were conducted comparing between only the high and low EPAO scoring services for the six subscales. A significant difference in time spent stepping was found in toddlers attending EPAO scoring services with a high sedentary environment and those attending at EPAO scoring services with a low sedentary environment (11.43 min [−0.18, 23.03]). Although not statistically

significant, toddlers in services where sedentary environments support high EPAO scores sat approximately 16 min per day less than toddlers who attended services with sedentary environments that supported low EPAO scores (Table 2).

### 4. Discussion

This is one of the first known studies to explore the relationships between toddlers and preschoolers' objectively measured physical activity and sitting time and their childcare environment. No statistically significant differences were found between EPAO categories (high, medium and low) and physical activity/sedentary behavior (time spent sitting, standing and stepping) for either toddlers or preschool aged children. However, several relationships were close to significant. For example, toddlers attending high EPAO scoring services stood 13 min less than toddlers attending low EPAO scoring services ( $p = 0.09$ ) and preschoolers attending high scoring EPAO services stepped an additional 7 min per day compared to those in attending low EPAO scoring services ( $p = 0.1$ ). These findings are consistent with other studies that report positive associations between more supportive childcare environments and physical activity levels of young children (Bower et al., 2008; Vanderloo et al., 2014). More supportive environments are characterized by, in part, structured and unstructured physical activity opportunities, accessibility to a variety of portable play equipment and high levels of intentionality from staff. It is not surprising that when these environmental factors are optimized, physical activity levels increase.

A significant relationship was found between sedentary environments and time spent stepping for toddlers from high EPAO scoring services compared with those from low EPAO scoring services: a difference of 11 min per day was reported (Table 2). Additionally, whilst not statistically significant, sedentary environment also had a more meaningful association with toddlers sitting behaviors, as children in the high EPAO environments sat 16 min less per day than those in the low EPAO environments (Table 2). The Sedentary Environment subscale focused on the presence of televisions and computers, as well as the presence of displays, posters and books relating to physical activity. However, in this study very few (<36%) childcare services had televisions or computers present in the learning environment, suggesting that these relationships identified maybe attributed to the presence of displays, posters and books in the childcare environment. Thus, the differences in stepping and sitting observed in this study could be related to the toddler's increased observational abilities and levels of curiosity as they engage with their surrounds (Fees et al., 2015). Children at this age are developing new schemas as they organize and interpret new information available in their learning environment (Kaplan, 1991). Therefore, the use of visual stimuli within a toddler-learning environment, such as posters, pictures and display books could positively impact physical activity (stepping) levels and sedentary behaviors (sitting time). Given that this is the first known study to report on these relationships among toddlers, additional studies in this area will be needed to confirm this assumption. Furthermore, additional studies will need to consider how aspects of the sedentary environment should be targeted in interventions to reduce sitting in toddlers.

This study identified portable play equipment as having a more meaningful relationship to sitting and stepping for preschoolers when compared to toddlers. Although relationships between Portable Play Equipment and stepping was not significant, preschool children stepped 10 min more per day in high scoring EPAO services compared to low scoring EPAO services. An additional 10 min of physical activity is meaningful in childcare settings given that preschool children spend >50% of their time sitting in these settings (Ellis et al., n.d.). These results are consistent with previous studies, which also report positive associations between availability of portable play equipment and higher levels of physical activity in preschool aged children (Bower et al., 2008; Dowda et al., 2009; Vanderloo et al., 2014; Henderson et al., 2015). As previously reported, physical activity is likely to increase when portable

**Table 1**  
Descriptive characteristics.\*

Characteristics	Toddlers (1–2.9) (n = 68)	Preschoolers (3–5.9) (n = 233)
Age (y), mean (SD)	2.2 (0.5)	4.1 (0.6)
Boys, (n = 145), mean (SD)	2.2 (0.6)	4.2 (0.6)
Girls (n = 156), mean(SD)	2.3 (0.4)	4.1 (0.6)
Total EPAO score, mean (SD)	13.17 (3.40)	12.35 (1.74)
Active Opportunities, mean (SD)	11.48 (5.0)	14.85 (3.12)
Sedentary opportunities, mean (SD)	17.78 (3.14)	13.03 (1.00)
Sedentary environment, mean (SD)	12.59 (4.91)	10.91 (3.36)
Portable play equipment, mean (SD)	12.22 (4.6)	13.45 (3.70)
Fixed play equipment, mean, (SD)	8.52 (2.67)	10.20 (2.76)
Staff behaviors, mean (SD)	16.44 (3.98)	11.64 (4.88)
Sitting, mins/day), (SD) % of time*	112 (44), 40%	160 (50), 51%
Standing, mins/day, (SD) % of time*	107 (42), 37%	98 (36), 31%
Stepping, mins/day, (SD) % of time*	62 (25), 22%	58 (23), 18%

\* % = proportion of time.

**Table 2**  
Multi-level mixed effects linear regression.

Toddlers									
EPAO Category	Sit min/d			Stand min/d			Step min/d		
	Coeff	P	95% CI	Coeff.	P	95% CI	Coeff.	P	95% CI
Low	Ref			Ref			Ref		
Medium*	17.14	0.10	−3.022,37.30	−8.74	0.30	−25.33,7.86	−8.44	0.20	−21.35,4.46
High*	8.73	0.90	−10.26,27.73	−13.64	0.09	−29.27,1.99	4.86	0.43	−7.30,17.02
Active Opportunities									
Low	Ref			Ref			Ref		
High	−5.95	0.48	−22.53,10.63	0.36	0.96	−12.57,13.30	5.47	0.34	−5.81,16.76
Sedentary opportunities									
Low	Ref			Ref			Ref		
High	3.75	0.67	−13.54,21.05	−7.84	0.24	−21.02,5.34	3.85	0.52	−7.82,15.52
Sedentary environment									
Low	Ref			Ref			Ref		
High	−16.09	0.08	−34.02,1.84	4.65	0.55	−10.41,19.72	11.43	<b>0.05</b>	−0.18,23.03
Portable play equipment									
Low	Ref			Ref			Ref		
High	8.20	0.31	−7.69,24.08	−3.47	0.60	−16.26,9.32	−4.38	0.44	−15.54,6.78
Fixed play equipment									
Low	Ref			Ref			Ref		
High	8.04	0.37	−9.53,25.61	−8.92	0.21	−22.99,5.15	0.85	0.88	−10.14,11.84
Staff behaviors									
Low	Ref			Ref			Ref		
High	0.85	0.93	−18.32,20.02	−2.19	0.77	−16.91,12.52	1.61	0.81	−11.36,14.58

Legend: CI – confidence interval; Coeff – coefficient; min/day – minutes per day; ref. – reference group.  
Boldface indicates statistical significance (\* $p < 0.05$ ).

play equipment is provided because children are moving whilst engaging with the various types of transportable materials (e.g., bikes, balls) (Vanderloo et al., 2015).

The main strength of this study is the inclusion of both toddlers and preschool aged children physical activity data. Most previous studies investigating the relationships between childcare environments and physical activity/sedentary behavior include only preschool children

(Bower et al., 2008; Gubbels et al., 2011; Vanderloo et al., 2014; Copeland et al., 2016). Identifying relationships for both toddlers and preschool children is important because developmentally toddlers and preschool children are considerably different (Fees et al., 2015), which may mean that the childcare environmental factors relating to physical activity and sedentary behavior may also be different. This is important in light of the development and implementation of interventions that

**Table 3**  
Multi-level mixed effects linear regression.

Preschoolers									
EPAO Category	Sit min/d			Stand min/d			Step min/d		
	Coeff.	P	95% CI	Coeff.	P	95% CI	Coeff.	P	95% CI
Low	Ref			Ref			Ref		
Medium	1.48	0.88	−17.80, 20.76	−2.75	0.64	−14.28, 8.78	1.05	0.82	−7.85, 9.95
High	−7.81	0.42	−26.64, 11.02	0.50	0.93	−10.51, 11.51	7.28	0.10	−1.39, 15.96
Active opportunities									
Low	Ref			Ref			Ref		
High	0.55	0.94	−12.92, 14.02	−0.90	0.88	−12.18, 10.38	0.24	0.96	−8.39, 8.88
Sedentary opportunities									
Low	Ref			Ref			Ref		
High	−14.94	0.27	−41.50, 11.62	5.35	0.50	−10.20, 20.90	9.64	0.14	−3.14, 22.42
Sedentary environment									
Low	Ref			Ref			Ref		
High	5.87	0.49	−10.66, 22.40	−5.88	0.20	−14.81, 3.05	0.29	0.95	−8.75, 8.16
Portable play equipment									
Low	Ref			Ref			Ref		
High	−6.69	0.23	−43.77, 10.63	6.10	0.48	−10.66, 22.86	10.58	0.11	−2.44, 23.60
Fixed play equipment.									
Low	Ref			Ref			Ref		
High	−2.81	0.74	−19.68, 14.05	0.75	0.88	−8.97, 10.48	2.26	0.60	−6.08, 10.61
Staff behavior									
Low	Ref			Ref			Ref		
High	−0.55	0.95	−17.81, 16.70	−0.82	0.87	−10.88, 9.24	1.10	0.80	−7.48, 9.96

Legend: CI – confidence interval; Coeff – coefficient; min/day – minutes per day; ref. – reference group.

focus on physical activity and sedentary behavior within childcare environments. It is plausible to suggest that interventions may need to be tailored for toddlers and preschool-aged children. Another strength of this study is the objective measure of sitting and standing time.

## 5. Limitations

The results of this study should be considered in light of the following limitations. First, the moderate sample size may have underpowered potential statistically significant relationships that may have been more apparent in a larger sample. In this sample, the preschool group was adequately powered to detect significant differences however the toddler groups were not adequately powered. The number of toddlers recruited was small as all children involved in the study had to be competent walkers for accurate measurements by the activPALS. This meant that some toddlers were excluded from the study. However, given that there are no other studies that have investigated these relationships among toddlers, we suggest that the results from this study are meaningful. In order to confirm the results from this study, larger studies will be needed. Second, the EPAO assesses 'structural characteristics' of childcare environments and does not account for indicators of 'process quality' (i.e. interactions between educators and children and interactions among children themselves) (Vandell and Wolfe, 2000; Gordon et al., 2013). Such interactions may also be important in physical activity/sedentary levels of toddlers and preschool children.

## 6. Conclusions

This study extends previous research by identifying differences between toddlers and preschoolers' physical activity and sedentary behaviors in relation to childcare environments. Childcare environmental factors seem to differ between toddlers and preschool children. These differing environmental factors are important in the development and facilitation of interventions that focus on physical activity and sedentary behavior opportunities within childcare environments. More tailored interventions are needed. Furthermore, interactions between staff and children are another important environmental factor that need to be considered in future studies. Similarly, research should also investigate the quality and accessibility of staff training in the promotion of physical activity. Given no one environmental attribute was significantly related to an increase in physical activity in each age group, a contextualized and holistic approach in professional learning should be used to equip educators with the knowledge and skills needed to improve the physical activity levels of toddlers and preschool children in childcare settings.

## Funding source

This study was supported by a faculty research grant by The University of Wollongong. It was partly funded an Australian Research Council (ARC) Discovery Early Career Researcher Award (DE140101588) and a National Heart Foundation of Australia Career Development Fellowship (CR11S 6099).

## Financial disclosure

Michele Peden has no financial disclosures. Rachel Jones has no financial disclosures. Silvia Costa has no financial disclosures. Yvonne Ellis has no financial disclosures. Anthony Okely has no financial disclosures.

## Conflict of interest

The authors declare no conflict of interest.

## Acknowledgements

This study was funded by a faculty research grant by The University of Wollongong. Many thanks to the participating parents and children, the childcare services located in the Illawarra and Shoalhaven regions of New South Wales Australia, Tamara Raso for managing the project and Penny Cross for data management.

## References

- Australian Bureau of Statistics, 2014. *Childhood Education and Care (Cat. No. 4402.0)*. ABS, Canberra, Australia.
- Australian Children's Education and Care Quality Authority (ACECQA), 2011. *Guide to the National Quality Standard*. Retrieved 16/1/2016. [www.acecqa.gov.au/storage/THREE\\_Guide\\_to\\_the\\_National\\_Quality\\_Standard.pdf](http://www.acecqa.gov.au/storage/THREE_Guide_to_the_National_Quality_Standard.pdf).
- Bower, J., Hales, D., Tate, D., Rubin, D., Benjamin, S., Ward, D., 2008. The childcare environment and children's physical activity. *Am. J. Prev. Med.* 34 (1):23–29. <http://dx.doi.org/10.1016/j.amepre.2007.09.022>.
- Brown, W., Pfeiffer, K., McIver, K., Dowda, M., Addy, C., Pate, R., 2009. Social and environmental factors associated with preschoolers' non-sedentary physical activity. *Child Dev.* 80 (1):45–58. <http://dx.doi.org/10.1111/j.1467-8624.2008.01245.x>.
- Copeland, K., Khoury, J., Kalkwarf, H., 2016. Child care center characteristics associated with preschoolers' physical activity. *Am. J. Prev. Med.* 50 (4):470–479. <http://dx.doi.org/10.1016/j.amepre.2015.08.028>.
- Davies, G., Reilly, J., McGowan, A., Dall, P., Granat, M., Paton, J., 2012. Validity, practical utility, and reliability of the activPAL™ in preschool children. *Med. Sci. Sports Exerc.* 44 (4):761–768. <http://dx.doi.org/10.1249/mss.0b013e31823b1dc7>.
- De Decker, E., De Craemer, M., Santos-Lozano, A., Van Cauwenbergh, E., De Bourdeaudhuij, I., Cardon, G., 2013. Validity of the ActivPAL™ and the ActiGraph monitors in preschoolers. *Med. Sci. Sports Exerc.* 45 (10):2002–2011. <http://dx.doi.org/10.1249/mss.0b013e318292c575>.
- Dowd, K., Harrington, D., Bourke, A., Nelson, J., Donnelly, A., 2012. The measurement of sedentary patterns and behaviors using the activPAL™ professional physical activity monitor. *Physiol. Meas.* 33 (11):1887–1899. <http://dx.doi.org/10.1088/0967-3334/33/11/1887>.
- Dowd, M., Brown, W., McIver, K., et al., 2009. Policies and characteristics of the preschool environment and physical activity of young children. *Paediatrics.* 123 (2):e261–e266. <http://dx.doi.org/10.1542/peds.2008-2498>.
- Ellis Y, Cliff D, Janssen X, Jones R, Reilly J, Okely A Sedentary time, physical activity and compliance with IOM recommendations in children at childcare. *Prev. Med.* (in press)
- ERIC Digest, 2001. *Outdoor Experiences for Young Children*. (Accessed May 17, 2016). <http://www.ericdigests.org/2001-3/children.htm>.
- Fees, B., Fischer, E., Haar, S., Crowe, L., 2015. Toddler activity intensity during indoor free-play: stand and watch. *J. Nutr. Educ. Behav.* 47 (2):170–175. <http://dx.doi.org/10.1016/j.jneb.2014.08.015>.
- Goldfield, G., Harvey, A., Grattan, K., Adamo, K., 2012. Physical activity promotion in the preschool years: a critical period to intervene. *Int. J. Environ. Res. Public Health* 9 (12):1326–1342. <http://dx.doi.org/10.3390/ijerph9041326>.
- Gordon, R., Fujimoto, K., Kaestner, R., Korenman, S., Abner, K., 2013. An assessment of the validity of the ECERS-R with implications for measures of child care quality and relations to child development. *Dev. Psychol.* 49 (1):146–160. <http://dx.doi.org/10.1037/a0027899>.
- Gubbels, J., Kremers, S., van Kann, D., et al., 2011. Interaction between physical environment, social environment, and child characteristics in determining physical activity at child care. *Health Psychol.* 30 (1):84–90. <http://dx.doi.org/10.1037/a0021586>.
- Hamilton, M., Hamilton, D., Zderic, T., 2004. Exercise physiology versus inactivity physiology: an essential concept for understanding lipoprotein lipase regulation. *Exerc. Sport Sci. Rev.* 161–166. <http://dx.doi.org/10.1097/00003677-200410000-00007>.
- Henderson K, Grode G, O'Connell M, Schwartz M. Environmental factors associated with physical activity in childcare centers. *Int. J. Behav. Nutr. Phys. Act.* 2015;12(1). doi:10.1186/s12966-015-0198-0.
- Hesketh Kvan Sluijs, E., 2016. Features of the UK childcare environment and associations with preschooler's in-care physical activity. *Prev Med Rep.* 3:53–57. <http://dx.doi.org/10.1016/j.pmedr.2015.12.004>.
- Hinkley, T., Salmon, J., Okely, A., Crawford, D., Hesketh, K., 2012. Preschoolers' physical activity, screen time, and compliance with recommendations. *Med. Sci. Sports Exerc.* 44 (3):458–465. <http://dx.doi.org/10.1249/mss.0b013e318233763b>.
- Kaplan, P., 1991. *A Child's Odyssey*. West, St. Paul, Minn.
- Kreichauf, S., Wildgruber, A., Krombholz, H., et al., 2012. Critical narrative review to identify educational strategies promoting physical activity in preschool. *Obes. Rev.* 13: 96–105. <http://dx.doi.org/10.1111/j.1467-789x.2011.00973.x>.
- Lyn, R., Maaouf, J., Evers, S., Davis, J., Griffin, M., 2013. Nutrition and physical activity in child care centers: the impact of a wellness policy initiative on environment and policy assessment and observation outcomes, 2011. *Prev. Chronic Dis.* 10. <http://dx.doi.org/10.5888/pcd10.120232>.
- OECD, 2016. *Family Data Base 2013 PF3.2: Enrolment in Childcare and Preschools*. (ed. OECD- Social Policy Division- Directorate of Employment Labour and Social Affairs). OECD-Social policy Directorate of Employment Labour and Social Affairs.
- Pujadas Botey, A., Bayrampour, H., Carson, V., Vinturache, A., Tough, S., 2016. Adherence to Canadian physical activity and sedentary behaviour guidelines among children 2 to 13 years of age. *Prev Med Rep.* 3:14–20. <http://dx.doi.org/10.1016/j.pmedr.2015.11.012>.

- Reilly, J., Jackson, D., Montgomery, C., et al., 2004. Total energy expenditure and physical activity in young Scottish children: mixed longitudinal study. *Lancet* 363 (9404): 211–212. [http://dx.doi.org/10.1016/s0140-6736\(03\)15331-7](http://dx.doi.org/10.1016/s0140-6736(03)15331-7).
- Stegelin, D., 2005. Making the case for play policy: research based reasons to support play based environments. *Young Child* 60 (2), 76–84.
- Trost, S., Fees, B., Dzwalowski, D., 2009. Feasibility and efficiency of a 'move and learn' physical activity curriculum in preschool children. *J. Phys. Act. Health* 5, 88–103.
- Vandell, D., Wolfe, B., 2000. Child Care Quality: Does it Matter and Does it Need to Be Improved? [www.purdue.edu/hhs/hdfs/fi/wp-content/uploads/2015/07/s\\_wifis17c01.pdf](http://www.purdue.edu/hhs/hdfs/fi/wp-content/uploads/2015/07/s_wifis17c01.pdf) (Accessed May 11, 2016)
- Vanderloo, L., Tucker, P., 2015. An objective assessment of toddlers' physical activity and sedentary levels: a cross-sectional study. *BMC Public Health* 15 (1). <http://dx.doi.org/10.1186/s12889-015-2335-13>.
- Vanderloo, L., Tucker, P., Johnson, A., van Zandvoort, M., Burke, S., Irwin, J., 2014. The influence of Centre-based childcare on preschoolers' physical activity levels: a cross-sectional study. *Int. J. Environ. Res. Public Health* 11 (2):1794–1802. <http://dx.doi.org/10.3390/ijerph110201794>.
- Vanderloo, L., Tucker, P., Johnson, A., Burke, S., Irwin, J., 2015. Environmental influences on Preschoolers' physical activity levels in various early-learning facilities. *Res. Q. Exerc. Sport* 86 (4):360–370. <http://dx.doi.org/10.1080/02701367.2015.1053105>.
- Ward, D., 2008. An instrument to assess the Obesogenic environment of child care centers. *Am. J. Health Behav.* 32 (4). <http://dx.doi.org/10.5993/ajhb.32.4.5>.
- Ward, D., Benjamin, S., Ammerman, A., Ball, S., Neelon, B., Bangdiwala, S., 2008. Nutrition and physical activity in child care. *Am. J. Prev. Med.* 35 (4), 352–356.