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Title page:**Child physical activity levels and associations with modifiable characteristics in centre based child care**

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Keywords

Preschool children, pedometer, observation, physical activity, child care

Abstract

Objective. To describe children's physical activity levels during childcare and associations with modifiable characteristics.

Methods. A cross-sectional study of 328 preschool children (43% girls; age 3-5 years) and 145 staff from 20 long day care centres in the Hunter Region of NSW, Australia. Pedometers assessed child physical activity levels. Centre characteristics and staff attitudes and behaviours towards children's physical activity were assessed using surveys, interviews and observational audit. Results were analysed using descriptive statistics and linear regression.

Results. Over the measurement period, average step count of children was 15.8 (SD= 6.8) steps/minute. Four-year olds had the highest step counts (16.4, SD= 7.1, $p=0.03$) with no differences by sex. Step counts were significantly higher in centres that had a written physical activity policy (+3.8 steps/minute, $p=0.03$) and where staff led structured physical activity (+3.7 steps/minute, $p<0.001$) and joined in active play (+2.9 steps/minute, $p=0.06$).

Conclusions. Written physical activity policy, structured staff-led physical activity and staff joining in active play were associated with higher levels of physical activity.

Implications. Future childcare physical activity interventions should consider including strategies to encourage written physical activity policies and support structured staff led physical activities.

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Introduction

Health benefits of physical activity for children include improved blood lipids and blood pressure, greater bone mineral density, less depression, and lower risk of overweight and obesity [1]. Preschool-aged children (3- 5 years) require opportunities to participate in physical activity to establish healthy behaviours at an early age and avoid the health consequences of inactivity that are known to track into adulthood [2, 3].

There is growing evidence that preschool age children are not sufficiently physically active [4, 5]. In Australia two studies have compared the physical activity levels of preschool aged children with government guidelines that recommend a minimum of three hours of active play daily [6]. Based on parent report, the first study found that only 56% of a sample of 266 children met this guideline [7]. The second, found that, only 32% of a sample of 220 children met the guideline based on a mix of parent reports and accelerometry data [8]. These findings are consistent with a review of physical activity levels in preschool children that reported low levels of vigorous physical activity and high levels of inactivity [9].

Centre based childcare is a key setting in which to promote child physical activity [10,11,12,13], as they are accessed by large numbers of preschool age children [14].

However, evidence indicates that children's physical activity levels during childcare are low

and little is known about specific characteristics that may be contributing factors across the childcare day. International evidence is currently at a formative stage [15] and, to our knowledge, objective measures of physical activity (such as step counts) have not previously been used to describe and determine environmental associations with physical activity levels of children in centre-based care in an Australian context [16].

The aims of this study were to describe children's levels of physical activity in centre based childcare as assessed by step counts and secondly to describe associations between physical activity levels and modifiable characteristics of the childcare environment.

Methods

Ethical approval for this study was obtained from the Hunter New England Area Human Research Ethics Committee (approval No.06/07/26/4.04) and University of Newcastle Human Research Ethics Committee (approval No.20100038).

Design and setting

The study involved an examination of baseline data collected as part of a randomised controlled trial, for which a detailed protocol has been described elsewhere [17]. The study was set in three local government areas of the Hunter Region of New South Wales, Australia. These areas encompass non-metropolitan 'major cities' and 'inner regional' areas as described by the Australian Standard Geographic Classification system and have lower socio-economic status than the New South Wales stage average [18]. There are approximately 14,061 children aged 3 to 5 years in this region [14].

Long day care centres (referred to as centre based childcare centres) in NSW provide care for eight or more hours per day for five days per week and enrol children from six weeks old to six years [14]. There were a total of 85 centres in the study region. We approached randomly selected centres to invite participation in the study until 20 centres with at least 25 enrolled

children aged three to five years agreed. Children were eligible to participate in the study if they were enrolled to attend the centre on the day of the week nominated by the Authorised Supervisor (managers) for data collection. Written consent was obtained at centres from parents of all eligible children who participated.

Data collection procedures and measures

Physical activity was assessed using pedometers (model Yamax SW200 and SW7000) [19,20,21], worn over a six-hour measurement period from 9 am to 3 pm (the period over which most children were in attendance) in March 2010. Pedometers have been demonstrated to be a valid and reliable method of measuring physical activity levels in preschool aged children [15,21,22]. The measurement period was one day to minimise respondent burden and based on evidence that one day of monitoring yields a valid representation of steps per day [23]. Data collection was rescheduled in three instances where weather conditions disrupted usual centre routines and prevented children from using outdoor space. The procedures for fitting participants with pedometers followed protocols utilised in previous studies of young children [20,24].

Parents reported demographic and physical activity measures on the participant consent forms including child age, Aboriginal and/or Torres Strait Islander status, sex, postcode of residence and parental education. Parents were also reported the usual number of days their child spends at long day care each week and the usual amount of time their child spends being physically active (≤ 30 mins, 31-60 mins, 61- 120 mins, 121-180 mins, > 3 hours) and participating in small screen recreation during weekdays outside of care hours (≤ 30 mins, 31-60 mins, 61- 120 mins, 121-180 mins, > 3 hours). All demographic and physical activity measures were

based on those used in other population-based surveys of preschool age Australian children [18].

On the day of pedometer testing, information on long day care centre characteristics was collected via an Environment and Policy Assessment Observation (EPAO) instrument [25]. The EPAO included: (1) observation of children's physical activity and interaction with staff, (2) an audit of service documents, and (3) an Authorised Supervisor interview. All other Centre staff self-completed a staff questionnaire.

The EPAO and Authorised Supervisor interview included data on the number of children enrolled to attend on the day of collection; number of staff; presence of a written policy on physical activity (yes/no); outdoor play area (m²); number of types of fixed (from a list of 11 different types) outdoor equipment; portable (from a list of 17 different types) indoor or outdoor play equipment; television observed (yes/no); computer/video game system available for use by children (yes/no); time available for playing computer/video games, time for seated activities (minutes), outdoor play or staff led structured physical activity (minutes); long day care provision of physical activity training for staff (yes/no); observation of staff leading structured physical activity for children (yes/no); number of times staff prompted children to be active divided into two groups at the median or joined in active play divided into two groups at the median.

The staff questionnaire collected data on educational attainment (University or Australian Technical and Further Education (TAFE) qualifications or no formal training), whether or not staff were confident in encouraging children to meet physical activity guidelines or saw a role for themselves in ensuring children meet physical activity recommendations while in care (strongly disagree/disagree/agree/strongly agree), and frequency of joining in with children in

free active play or prompting children to increase physical activity (rarely/some of the time/most of the time/all of the time).

Analysis.

Step counts per minute were used for all association analyses to control for different wear times over the observation period [26]. Participants with step counts < 5 steps/min were excluded from the analysis as step counts this low were deemed not feasible [27].

Descriptive statistics were used to describe daily step counts and centre-characteristics.

Bivariate associations (one way ANOVA) between steps/minute and child characteristics, characteristics of the long day care centre environment and staff training, attitudes and behaviours were tested using ANOVA. Independent associations of significant ($p < 0.05$)

correlates of step counts were tested by fitting a linear regression model within a GEE framework to adjust for the clustering of children within long day care centres. Variables

were entered simultaneously and the number of types fixed and portable equipment were divided into two groups at the median to make a clear distinction between centres with low

and high equipment availability. All statistical analyses were performed using SAS software Version 9.2 (SAS Institute Inc., Cary, NC, USA).

Results

Twenty childcare services agreed to participate in the study representing a 54% response rate from 37 invited eligible services. A total of 328 children participated in the study out of 537

eligible participants from the 20 centres, representing a response rate of 61%. Most children were 4 years old (58%, $n=191$), and 57% were boys ($n=186$). Almost 4% ($n=12$) were

Aboriginal or Torres Strait Islander. Three-quarters of the parents surveyed had either a

Tertiary and Further Education (TAFE) (24%) or University (51%) education and 73% lived in locations that fell within the upper half of the state of NSW with respect to socio-economic

status. Based on parent-proxy report, most children obtained less than two-hours (75%) of physical activity outside of care. Twenty-seven percent of children watched more than one hour of television or used other forms of electronic media outside of care. An additional 42% spent between 31 and 60 minutes in these sedentary activities.

The median observational period was six hours (range 3 to 6 hours). Average step count was 5,466 (SD 2,383) and the average number of steps/minute was 15.8 (SD 6.8). Mean step counts and step/minute by age were: 5298 (SD 2248), and, 15.4 (SD 6.4) for three year olds; 5670 (SD 2509) and 16.4 (SD 7.1) for four year olds; and 4862 (SD 2901) and 14.3 (SD 8.5) for five year olds. Four year olds took significantly more steps/min than three year olds ($p=0.03$) and this difference was also reflected in total step counts ($p=0.04$). There were no significant differences in total step count or steps/min by gender with males at 5684 (SD 2610) and 16.5 (SD 7.4), and females at 5248 (SD 2156) and 15.2 (SD 6.2). Likewise for Aboriginal or Torres Strait Islander status with a mean total count of 5467 (SD 2448) and step/minute of 16.8 (SD 6.6).

Of the 20 centres participating, 15 (75%) had no written policy on physical activity. The average size of long day care outdoor play areas was 389m². The mean number of fixed pieces of outdoor play equipment was three and of types of portable playground equipment was eight. Only one long day care centre had a TV present and viewing time on the survey day was less than five minutes so this variable was excluded from further analysis. Three centres had computer/video games and average total playing time observed was 65 minutes. Children were observed in seated activities for an average of 35 minutes and spent an average of 95.7 minutes (1 hour 35 minutes) in outdoor play. Of this time, 21.3 minutes was observed to be structured staff-led physical activity. Only, half (50%) of the centres had staff with

physical activity training. Staff were observed leading structured physical activity in 19/20 centres. There was an average of nine prompts from staff to children to increase their physical activity at each centre and staff were observed to join in active play an average of five times during the observation period.

Most staff (84%) had University or TAFE qualifications. Most staff (98%) agreed or strongly agreed with the statement 'I am confident in my ability to encourage children to meet physical activity recommendations while in care' and all staff agreed with the statement 'I have a role to play in ensuring children meet physical activity recommendations while in care'. Most (97%) also reported joining in free active play with the children and, of these staff, 60% reported joining in most or all of the time. Almost all staff (99%) reported providing verbal prompts to increase children's physical activity, with 76% reporting providing prompts most or all of the time.

Results of bivariate analysis of associations between child, long day care and staff characteristics with children's step counts while in care can be seen in table 1. No significant associations were observed with the size of the outdoor play area; number of types of fixed or portable play equipment; total minutes of outdoor play; total minutes children were seated; physical activity training for staff; or frequency of staff prompting physical activity. With respect to staff characteristics, if staff at the centre reported prompting children to increase their physical activity most or all of the time, this was significantly associated with a higher step count ($p = 0.0019$). The presence of a written physical activity policy ($p = 0.034$); structured staff-led physical activity at the centre ($p < 0.0001$); and staff joining children in active play more than 3 times per day ($p = 0.0576$) were significant, independent correlates of

higher step counts while children were in care, after adjusting for clustering by centre using the GEE analysis framework.

Discussion

The aim of this study was to describe children's levels of physical activity in childcare and associations with modifiable characteristics of the childcare environment. Step counts were significantly higher in long day care centres that had a written policy on physical activity and where staff led children in structured physical activity and joined children in active play at least three times during the day.

There are no current recommendations for the number of steps preschool children should take per day, or while in care, although for maintaining a healthy weight, optimal cut points have been reported as 12,000 steps/day for Australian boys aged 5 to 12 years and 10,000 steps/day for Australian girls in the same age range [28]. Two other studies have reported step counts in preschool settings. In a study of four preschools in North Carolina, U.S.A. and Sweden [29], children aged 3-5 years (n=58) took an average of 16.1 (SD=6.8) steps/min, comparable to the 15.8 (SD=6.8) steps/min observed in our study. Similar to our study (excluding our small sample of 5-year olds), they also observed that older children had higher step counts, with an average steps/min of 12.3 (SD=3.0) in 3-year-olds, 15.8 (SD=6.0) in 4-year-olds and 20.9 (SD=8.8) in 5-year-olds. Interestingly, the US/Sweden study observed a significant 4.7 steps/min difference ($p < 0.004$) between boys 18.5 (SD=7.6) and girls 13.8 (SD=5.0) that was not observed in our study (1.3 steps/min difference).

Given that our study had a larger number of participants, a possible explanation for the similarity in step counts between boys and girls in our study may be that there was little difference in the type of activities boys and girls engaged in while in care. In a study comparing various measures of physical activity in preschool children (n=129 children aged

4-5 years), Cardon et al [13] also found no difference in daily step counts between boys (10,121 SD=2,836) and girls (9,867 SD = 2,422). Based on the step counts observed in our study we believe both boys and girls may need to be more active while in care [30]. Physical activity guidelines for children 3-5 years in Australia recommend at least three hours of physical activity each day and no more than one hour of watching television or using other electronic media (DVDs, computer and other electronic games) [6]. We found that most children obtained less than two hours of physical activity outside of care implying that most children need to obtain at least an hour of physical activity while in care to meet the current recommendations.

Child-care environments are known to exert a substantial influence on children's physical activity behaviour [30], and previous studies have identified various policy, space, equipment, time-structuring and staff characteristics that may account for this influence [13]. In our study, having a written physical activity policy yielded the highest effect size, suggesting that policy may be particularly important for children's physical activity in the centre based childcare. In a previous study [31], we found that only 48% of childcare centres had a written physical activity policy and in this study, only 25% had such a policy. A study conducted in 20 child care centres in North Carolina, [11] found physical activity policy to be weakly related to mean activity levels and the time children were observed to spend sedentary or engaged in moderate to vigorous physical activity (MVPA). This may, however, reflect differences in policy implementation and enforcement.

We found that structured staff-led physical activity was an important correlate predictor of children's step counts suggesting that teacher involvement is an important stimulus of children's activity. Our additional finding that children had higher step counts in centres where staff joined in physical activity experiences with children supports this. However,

unlike the Bower et al study we did not find a significant association with time available for activity. This may have been because children may not have been active in the time available for activity (i.e. they may have sat and played in a sandbox).

No significant association was observed between the size of the outdoor play area and step counts. This may have been because the size and suitability of the outdoor play space did not vary as widely (from 78m² to 806m²) between centres as was observed in a Swedish study (from 280m² to 11, 871m²) [32].

Two studies [11,12] found that portable (positively) and fixed (negatively) equipment were significantly related to the proportion of time children spent in moderate to vigorous physical activity. While the number of types of fixed and portable equipment was not significantly associated with step counts in our study, the same differential association was observed. In our study the negative association between types of fixed equipment and step counts may be because some equipment did not encourage steps (eg sitting and playing in a sandbox) as has been observed in other studies [33]. It could also be because the equipment 'crowded' the space available for physical activity [34], or that the activity they encouraged was not picked up by the spring-levered pedometers used to measure physical activity (eg slow walking, or possibly sliding or swinging) [35]. Certain types of portable equipment (eg riding toys where children are pulled along) may also be associated with decreased physical activity [36], explaining the lack of association with portable play equipment in our study. The lack of association may also be because all centres had sufficient equipment to promote physical activity with median number of types of portable equipment at eight compared to a median of one piece in the Dowda et al study [12].

In terms of staff characteristics and behaviour, Dowda et al in a 2004 study found that children were more active on the playground in preschools where teachers were college educated [37]. In our study 84% of staff had a college education (University and TAFE) perhaps accounting for the lack of such an association. Interestingly, physical education training for staff was not associated with higher step counts for children in our study or higher MVPA in Dowda's 2009 study [12]. It may be that training is necessary but not sufficient for promoting physical activity for children in care, as has been observed in primary school-based research [38]. As a composite variable, Bower et al [11] found that staff behaviour (interactions between staff and children that may promote or discourage physical activity behaviour; includes restricting active play, joining in activity, positive statements about physical activity) was correlated with children's MVPA. Our study adds to this finding by showing that of these components, staff joining in with children is particularly important.

This study has two main strengths. Firstly, our models exploring correlates of physical activity in care included estimates of children's physical activity behaviour and sedentary activity outside of care allowing adjustment for potential confounding. Secondly, we used an objective measure of physical activity. The study also has several limitations. Because weight and height were not measured, we were unable to adjust for children's weight status, which is known to influence children's physical activity levels [39]. Secondly, child step counts were assessed on one day, which while shown to give a valid representation of steps per day relative to a whole week in population studies of children [23], represent the minimum standard for reliability. Craig et al as part of a large nationally representative survey of pedometer-determined physical activity in youth including children aged from 5-19 years, reported that one day of pedometer monitoring yielded a valid representation of steps per day relative to the whole week in terms of both reliability (ICC = 0.79) and validity (relative

absolute percent error [APE] = <10%) [23]. This information in combination with strong findings of non-reactivity [23], evidence that younger children demonstrate smaller variation in physical activity levels [40] and that variability is less during week days [41] suggest that one day of data collection was sufficient to reliably assess young children's physical activity during a weekday in centre based care setting. None-the-less, the internal validity of the findings would have been improved with the addition of multiple days [42]. Thirdly, pedometers do not measure type or intensity of physical activity and it is possible that some of the centre and staff characteristics we looked at influenced the type of activity children engaged in or intensity. Fourthly, it is possible that authorised supervisors selected a day for the evaluation when children were particularly active or staff promoted physical activity more than usual. Finally, the cross-sectional nature of the data means conclusions cannot be reached about causality.

Internationally, there is a clear need in centre based childcare centres for interventions that promote physical activity [31]. To implement effective interventions however, those aspects of the childcare environment that have the biggest influence on children's activity levels need to be targeted. We found that written physical activity policy, structured staff-led physical activity and staff joining in active play were associated with higher levels of physical activity. Also, coupled with the lack of association with space and play equipment we think space and equipment are probably more than adequate for promoting physical activity in Australian childcare centres and that what really matters is having an adult join with the children in physical activity. Based on these findings we recommend further trials on these influences and that interventions support long day care centres to develop and implement written physical activity policies and encourage staff to lead structured physical activity and join in with active play.

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Table

Table 1: Results of bivariate and generalized estimating equation (GEE) analysis of associations between child, long day care and staff characteristics with children's step counts while in care

Independent variable	Class	Bivariate (n=328)		GEE (n=324)	
		Effect size (steps/min)	p-value	Effect size (steps/min)	p-value
<i>Child characteristics</i>					
Gender	Female	-			
	Male	0.8493			
Age, years	3	-			
	4	1.552	0.0307	1.573	0.0274
	5	-0.238		-0.201	
Aboriginal or Torres Strait Islander origin	Yes*	1.794			
Low physical activity at home (≤ 60 minutes)	Yes*	0.0349			
High small screen recreation at home (≥ 60 minutes)	Yes*	1.307			
<i>Long day care characteristics</i>					
Written policy	Yes*	4.5333	0.0090	3.8544	0.0339
Large outdoor play area ($> 400 \text{ m}^2$)	Yes*	1.536			
At least three types of fixed play equipment available	Yes*	-0.1296			
At least eight types of portable play equipment available	Yes*	0.835			
Total outdoor play (mins)		0.017			
Total minutes children were seated (mins)		-0.0516			
Centre provides physical activity training for staff	Yes*	-1.515			
Staff leadership of structured physical activity	Yes*	5.609	<0.0001	3.6838	<0.0001
Staff join children in active play (> 3 times)	Yes*	3.2932	0.0200	2.480	0.0576
Staff prompt children to increase physical activity (> 7 times)	Yes*	-1.0510			
<i>Staff characteristics</i>					
Number of staff confident in ability to encourage children to meet physical activity recommendations while in care (mean)		1.5680			
Any staff report joining children in active play most or all of the time	Yes*	-0.1974			
Any staff report prompting children to increase physical activity most or all of the time	Yes*	2.7288	0.0019		

- Referent category, * No was the referent category for all yes/no questions