Physical Activity in Children Attending Preschools

WHAT'S KNOWN ON THIS SUBJECT: Physical activity (PA) levels in preschool children vary considerably between preschools, and are positively associated with the overall quality of the preschool. However, knowledge regarding specific characteristics of the preschool environment hypothesized to promote PA is inconsistent and lacking.

WHAT THIS STUDY ADDS: This study tested multiple potential correlates of preschool children's objectively measured moderate and vigorous PA level during preschool attendance, identifying size of indoor area per child and location of preschool building on the playground as new potentially modifiable correlates.

abstract

OBJECTIVE: To identify correlates of objectively measured moderate and vigorous physical activity (MVPA) in children during preschool attendance.

METHODS: This cross-sectional study included data from 426 apparently healthy Danish children (49.5% boys), 5 to 6 years of age enrolled in 42 randomly selected preschools. The percentage of time spent in MVPA (≥574 counts/15 second) during preschool attendance was measured using ActiGraph accelerometers over 4.3 preschool days in May and June in 2009. Thirty-seven potential correlates across the child, preschool staff, and preschool environment domains were tested for associations with MVPA.

RESULTS: The final multivariate model identified 9 significant correlates of MVPA. Preterm birth, vegetation on the playground, and rainy days were negatively associated with MVPA, whereas child motor coordination, location of preschool building on the playground, gender (boys), percentage afternoon hours, and size of indoor area per child were positively associated with MVPA. The direction of the significant association with the parental mean education level was unclear.

CONCLUSIONS: We identified a number of new modifiable correlates of MVPA during preschool attendance. The positive association with size of indoor area per child and location of the preschool building on the playground seem important correlates to be targeted in future studies.

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KEY WORDS

motor activity, preschool child, environment design, play, playthings

ABBREVIATIONS

CI—confidence interval
DUN—Danish educational nomenclature
ICC—Intraclass correlation
MVPA—moderate and vigorous physical activity
PA—physical activity

Ms Olesen carried out the data collection and design of methods used in the study, prepared the data set for analysis, including choice of correlates and confounding factors, and drafted the descriptive statistics and initial manuscript; Dr Kristensen designed the study and methods used, supervised data collection and article writing, and critically reviewed the manuscript; Dr Korsholm designed the study, carried out the statistical analysis after receiving the proposed correlates, and critically reviewed the manuscript; Mr Froberg conceptualized the idea of the study, designed the study and supervised data collection, and critically reviewed the manuscript; and all authors approved the final manuscript as submitted.

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It is recommended that children progress toward at least 60 min of daily time spent in moderate and vigorous physical activity (MVPA) by 5 years of age.[1,2] Furthermore, evidence suggests that preschool attendance influences a preschool child's level of MVPA, explaining 11% to 43.2%[3–6] of the total variance in MVPA.

Correlates of children's MVPA behavior specifically during preschool attendance have been identified in relation to a child's total MVPA,[7–10] but also in relation to the outdoor[5,11–15] and indoor[5] MVPA level, specifically. Whereas the overall quality of the preschool seems to be a consistent potential correlate of preschool children's MVPA level during preschool time,[7,8,16] inconsistent results are reported for other preschool correlates, such as the size of the playground, regardless of testing the association in relation to the children's total[7,9,10] or playground-specific MVPA level.[5,15,17]

Few large-cluster, randomized, controlled intervention studies have targeted potential correlates of physical activity (PA) at the preschool level, and so far for those that have, there has not yet been any effect.[12,18] Thus, well-designed cross-sectional studies still seem important in identifying potential modifiable preschool characteristics associated with MVPA, which can be targeted for change in future intervention studies. The combination of a relatively new research area[19] and inconsistent results emphasizes that more research is needed. Furthermore, little research has been conducted outside the United States,[3,5,9,15,17] highlighting the need to study cultural differences within this area.[19]

The objective of this study was to investigate multiple potential correlates expected to be associated with preschool children's daily MVPA behavior during preschool attendance. Specifically, correlates across the individual, environmental, and preschool staff domains were tested.

METHODS

Selection of Preschools

The sampling frame for this cross-sectional study was all traditionally public preschools in the municipality of Odense, Funen, Denmark. Based on information from the municipality, all preschools ($n = 117$) were stratified for location (urban or rural), socioeconomic status in the school district, and preschool size. In total, 43 preschools were randomly selected, of which 23 preschools also cared for toddlers.

Selection of Children

All apparently healthy children ($n = 627$) 5 to 6 years of age (born in the year 2003) and their parents were invited to participate in the study. Exclusion criteria was that the child was no longer enrolled in the preschool by the start of data collection.

Ethics

The Regional Scientific Ethical Committee in Southern Denmark approved this study.

PA

Children's PA levels were assessed by using GT1M and GT3×ActiGraph accelerometer (Pensacola, FL). The activity monitor was worn at the right hip, close to the skin for 1 week. PA data collection occurred during a period of 4 weeks. Each day the preschool staff kept a record of each child's arrival and departure times, and preschool staff supervised trips. The weather was recorded each day.

Data Reduction

PA inclusion criteria were 3 valid preschool days, with at least 3 hours of measurement during preschool time. Periods of non-wear time of 60 consecutive minutes during which a "0" was recorded were interpreted as "activity monitor not worn," and removed from the summation of activity.[7,20,21] Weekdays on which the child did not attend preschool and weekend days were excluded. PA data from a European study indicated that during preschool attendance the children were more physically active during the afternoon hours.[21] To adjust for this, the percentage of monitored hours during the afternoon was calculated as the number of hours (after 12 PM) divided by the total number of monitored hours. Custom-made software was used for data reduction.

MVPA

MVPA was defined as the percentage of the daily monitored time during preschool attendance[22] spent in MVPA (≥574 counts/15 second).[23]

Potential Correlates of MVPA

The potential correlates were prespecified and categorized into the following domains: child, preschool staff, preschool environment, and confounding factors. With the exception of anthropometrics, all measures and observations were carried out by the same trained researcher in 2009.

Table 1 describes the name, source, definition, scale, and psychometrics of the correlates. Selected correlates needing further explanation are described below.

Child and Staff Correlates

From March to July, anthropometrics and motor coordination of the child were measured simultaneously at the preschool. Motor coordination was measured by using the Kiphard-Schilling body coordination test,[24] measuring mainly dynamic balance. During the week of PA data collection in May or June, the parents, the preschool staff, and the educational leader answered a questionnaire. The Danish Physical Activity Scale questionnaire[25] was used to collect information on the staff's average daily percentage of time spent in

TABLE 1 Potential Predictors of MVPA During Preschool Time to be Tested in Univariate Analyses

Correlate	Source	Definition	Correlate Type	Test-Retest
Child				
Age	Database	Child's age	Continuous: 5.3–6.5 y	NA
BMI	Measure	BMI	Continuous: 13–22	NA
Motor coordination	Measure	Motor quotient (mean 100 ± 15)	Continuous: 49–135	0.89[a]
Ethnicity	Question	Mother's country of birth	Categorical: Denmark, Western, other country	NA
Born preterm	Question	Born <37 wk gestational age	Categorical: no, yes, none-response	NA
Supervised trips	Question	*N* total trips on PA monitored days	Interval: 0–3	NA
Preschool staff				
Educational leader				
PA enjoyment	Question	Leader enjoyment of PA	Ordinal (1–5; 1 not enjoyable, 5 very enjoyable)	0.87[b]
PA education level	Question	Leader with PA education	Categorical: no or yes	NA
PA guideline	Question	Leader spent ≥30 min of MVPA per day	Categorical: no or yes	NA
Staff				
PA enjoyment	Question	Average staff enjoyment of PA	Ordinal (1–5; 1 not enjoyable, 5 very enjoyable)	0.87[b]
PA education level	Question	% Staff with PA education	Continuous: 0%–80%	NA
MVPA	Question	Average % daily MVPA at work	Continuous: 0%–12.5%	NA
Men	Database	% Men at each preschool	Continuous: 0%–67%	NA
Young assistants	Database	% Assistants ≤25 y	Continuous: 0%–33%	NA
Initiate activities	Question	Average staff initiating PA outdoors daily	Ordinal (1–5; 1 never, 5 several times daily)	NA
Preschool environment				
Playground outside				
Location preschool building	Observe	*N* of sides around the preschool building that are accessible when playing outside	Ordinal (0, 1 side; 1, 2 sides; 2, 3 sides, 3, 4 sides; 4, all sides of the preschool building)	0.90[c]
Natural environment				
1 Surrounding environment	Observe	Surrounding environment of the preschool yard	Ordinal (0, apartment houses; 1, residential area; 2, wooded area)	0.89[c]
2 Vegetation along perimeter	Observe	Primary vegetation along playground perimeter	Ordinal (0, little/nonexistent; 1, green hedge; 2, wild shrubbery/wooded area)	0.85[c]
3 Vegetation on ground	Observe	Primary vegetation on playground (not included in the perimeter categorization)	Ordinal (0, little/nonexistent; 1, few areas; 2, more areas with increased shrubbery/wooded area)	0.68[c]
4 Hilly landscape	Observe	Degree of hilly landscape on playground (area of fixed equipment, around preschool, and soccer field not included)	Ordinal (0, little/nonexistent; 1, one/few areas; 2, overall the ground can be characterized as hilly or elevated landscape)	0.89[c]
5 Open space	Observe	Open green space on the playground	Categorical no or yes	0.74
Sum (1–5)		Sum score of the above 1–5 correlates	Continuous: 0–10	0.94[c]
Play opportunities per child (age: 3–6 y)				
Balance	Observe	*N* portable per child	Continuous: 0.00–0.31	NA
Swing/slide	Observe	*N* portable per child	Continuous: 0.00–0.09	NA
Role play	Observe	*N* portable per child	Continuous: 0.03–0.28	NA
Sport	Observe	*N* portable per child	Continuous: 0.00–0.60	NA
Transportation	Observe	*N* portable per child	Continuous: 0.05–0.75	NA
Total portable	Observe	*N* total portable per child	Continuous: 0.53–5.69	NA
Balance	Observe	*N* fixed per child	Continuous: 0.00–0.31	NA
Swing/slide	Observe	*N* fixed per child	Continuous: 0.02–0.33	NA
Role play	Observe	*N* fixed per child	Continuous: 0.03–0.28	NA
Sport	Observe	*N* fixed per child	Continuous: 0.00–0.09	NA
Climb/crawl	Observe	*N* fixed per child	Continuous: 0.02–0.39	NA

TABLE 1 Continued

Correlate	Source	Definition	Correlate Type	Test-Retest
Total fixed	Observe	*N* total fixed per child	Continuous: 0.12–0.93	NA
Sandbox	Measure	Size of sandbox area per child	Continuous: 0.2–2.1 m^2	NA
Preschool indoor				
Rooms for PA	Interview	*N* rooms for children to be active daily	Interval: 0–5	NA
Computer	Question	Child computer access daily	Categorical: no or yes	NA
Confounding				
Gender	Measure	Gender child	Categorical: girl, boy	NA
Rain	Observe	Rain during preschool hours (per day)	Categorical: no or yes	NA
Preschool type	Database	Age integrated preschools (age: 0–6 y)	Categorical: no or yes	NA
Afternoon hours	Measure	Afternoon hours in % of total hours	Continuous: 20% to 67%	NA
Location	Database	Preschool location	Categorical: urban, rural area	NA
Area indoor	Database	Size of preschool area per child (age: 0–6 y)	Continuous: 4–13 m^2	NA
Area playground	Measure	Size of accessible playground	Continuous: 567–5175 m^2	NA
Playground time	Question	Average daily hours on playground	Ordinal (1.5–6.5) (1.5 h; 6.5 h)	NA
Parent education	Question	Parents mean educational level (1–9)	Ordinal (0, low [DUN 1 to <4]; 1, middle [DUN 4 to <6]; 2, high [DUN 6 to 9]; 3, none-response)	NA

NA, not applicable.
[a] Test-retest reliability (range, 0.25–4 d) was estimated by ICC in 50 children (46% boys) during the test period.
[b] ICC reported by Sallis et al (2002).[39]
[c] Test-retest reliability based on retest in 23 randomly selected preschools of the 43 participating preschools (κ or ICC).

MVPA during work, and the educational leader's average daily leisure time spent in MVPA.

The physical education variable expressed the percentage of staff with extra physical education and training (eg, university, college, pedagogical physical educational courses). Parent mean education level was based on the Danish educational nomenclature (DUN) from 2006.[26]

Environmental Correlates

From September to November the same trained researcher collected the environmental and preschool equipment correlates at the playground; this was accompanied by a structured interview with the educational leader to collect information on any environmental changes since the PA data collection.

The outdoor environment was estimated by a direct observational method. Location of the preschool building was a measure of the number of sides of the preschool building that were accessible for the children when playing on the playground.

The specific elements of the natural environment were observation of the surrounding environment of the preschool, and vegetation expressing the degree of shrubbery and trees along the perimeter and on the rest of the playground, respectively. Finally, the degree of hilly landscape and the presence of open space at the playground were observed. Table 1 presents the definitions of the correlates. The sum of the obtained score for each of the 5 correlates (0–2), except for the open space correlate (0–1), expressed the natural environment score.

On the playground the number of accessible fixed (eg, playhouse) and portable (eg, balls) play opportunities per child was counted. Sandpit toys, branches, and nursery school equipment were excluded. Based on direct observation studies showing that type

of equipment seems to be important in promoting MVPA,[13,14,27] the fixed and portable play opportunities were categorized according to their primary intended function: balance, climb/crawl, swing/slide, sport, role-play, and transportation (not balance). In the balance category we included secondary balance opportunities, such as tree trunks or groups of stumps intended as seating capacity. The fixed and composite play structures (eg, swing set) were split into single structures (eg, number of swings). Finally, the size of the freely accessible playground area was calculated by using a geographic information-based system.

Statistics

Data were analyzed in Stata 12 (Stata Corp, College Station, TX), with the level of significance $P < .05$.

Inverse probability weighting was used in all descriptive and statistical analyses to adjust for a slight oversampling in the rural areas.

Descriptive statistics for preschool and participant characteristics are displayed as weighted means (SD)/median (range). Pearson's χ^2 test was used to compare proportions of groups. Test-retest reliability was calculated by using κ (with linear weights) for the ordinal categorical variables and intraclass correlation coefficient (ICC) with 1-way analysis of variance for the continuous variables (Table 1). The ICC measures the proportion of variability in the outcome that is accounted for by the groups or clusters.[28]

Multilevel mixed modeling with the preschool and individual child included as random effects was used to investigate the association between correlates and the percentage of children's preschool-time spent in MVPA. The confidence interval (CI) calculation was based on the cluster-robust Hubert-White estimation. We included a "none-response" category in 2 categorical variables, increasing the number of eligible children with complete data in the final analyses from 367 (62%) to 426 children.

A test for possible selection bias showed that eligible children not included in the final model were older ($P < .001$), had a higher proportion of mothers born outside Denmark ($P < .001$), and performed poorer in the motor skills test ($P < .05$), compared with the group of children included in the final model. No difference between groups was found for gender, BMI, height, parental mean education level, location (urban or rural), and measures of preschool size.

Initially we tested all the confounding variables against the outcome. No variables were excluded, although not all the variables reached statistical significance. Second, a univariate analysis testing each potential covariate adjusted for all confounding factors was run. Third, all covariates with $P < .10$ and all the confounding variables were included in the final model. Finally, the effect of preschool clustering represented by the ICC was calculated without any independent variables.

RESULTS

All selected preschools participated in the study ($n = 43$). In accordance with the exclusion criteria, children leaving preschool before data collection ($n = 20$) were excluded from the study. Furthermore, children from 1 preschool were excluded ($n = 16$), because our target group on a daily basis unexpectedly moved by bus to a forest setting.

In total 591 (100%) invited children and parents were eligible to participate in the study. The final model included data from 426 eligible children (49.5% boys, mean age [SD], 5.8 years [0.3]), who had been enrolled in 1 of the 42 preschools for 2.6 years on average. Reasons for non-participation were families deciding not to participate in the study ($n = 10$), missing data in individual variables ($n = 15$), PA data not meeting inclusion criteria because of casual absences such as holiday and sick leave ($n = 31$), excluded because of extremely high PA values ($n = 1$), other reasons determined by staff and researchers ($n = 40$), or reason not stated ($n = 68$).

The median (5th–95th percentile) percentage of eligible children with complete data from each preschool was 74% (31%–100%).

Out of 267 ($n = 40$ men) eligible preschool staff, 90% ($n = 241$) completed the questionnaire. The median number of total children (age 0–6 years) and preschool children (age 3–6 years) enrolled in the participating preschools was 59 (range, 28–139) and 46 (range, 26–88), respectively.

In the final sample ($n = 426$), the median accepted activity monitor wear-time was 4 weekdays, 7.15 hours per day, and 30 hours per week. No differences were observed between genders with respect to eligible data.

A gender difference in MVPA was observed in favor of the boys (2.8% [95% CI, 1.9–3.8]). The mean (SD) daily percentage of preschool time spent in MVPA was 15% (5.0) and 12.2% (3.9) for boys and girls, respectively.

The univariate analysis presented in Table 2 shows that the daily percentage of MVPA was significantly associated with child motor coordination, preterm birth, educational leader's PA education level, vegetation and hilly landscape on the playground, the natural environment score, gender, rainy days, percentage afternoon hours, and mean parental educational level. Associations between location of the preschool building on the playground and fixed sport equipment approached significance ($P < .10$).

The final multilevel analysis presented in Table 3 shows that the daily percentage of MVPA was significantly negatively

associated with preterm birth, vegetation on the playground, rainy days, and significantly positively associated with child motor coordination, location of preschool building on the playground, gender (boys), percentage afternoon hours, and size of indoor area per child. However, the direction of the association with parental mean education level was unclear. The association with fixed sport equipment, location (rural), and size of accessible playground area approached significance ($P < .10$). Gender-interaction on fixed sport equipment was non-significant.

The ICC was 0.05 ($P < .001$), thus the proportion of the total variance in MVPA explained by the preschools was 5%.

DISCUSSION

We investigated the influence of individual and selected preschool characteristics on the daily percentage of time spent in MVPA during preschool attendance in 5- to 6-year-old Danish preschool children, who had been exposed to the environment of the same preschool for 2 to 3 years. The final model identified preschool and child but not preschool staff characteristics to be related to children's MVPA level.

In Denmark the average number of days with precipitation ≥1 mm is 121 days per year.[29] Thus, the finding of a negative effect of precipitation (−2.2 percentage point) on MVPA, corresponding to a reduction of ∼9 minutes in MVPA (−0.022 × 420 minutes) on an average 7-hour preschool day with precipitation, could have a significant impact on the total amount of MVPA in Danish preschools. Initiatives to ensure indoor PA on rainy days could be an important area of focus for Danish preschools.

Although the daily expected effect is small, the positive association with the size of the total indoor area per child is an interesting finding, because no association was found in previous studies

TABLE 2 Predictors of Children's Time Spent in MVPA During Preschool Time Tested in Univariate Analyses

	N	*n*	Obs.	MVPA%	95% CI	*P* Value
Child						
Age	42	441	1903	1.1	(−0.5 to 2.6)	.18
BMI	42	427	1844	−0.0	(−0.3 to 0.3)	.78
Motor coordination	42	426	1839	0.1	(0.0 to 0.1)	<.001
Ethnicity	42	441	1903			.11
Denmark				0.0		
Western country				1.8	(0.1 to 3.4)	
Other country				0.6	(−1.0 to 2.1)	
Born preterm (<37 wk gestation)	42	441	1903			<.001
No				0.0		
Yes				−2.8	(−3.9 to −1.6)	
None-response				1.4	(−0.3 to 3.1)	
Supervised trips, *n*	42	441	1903	0.7	(−0.4 to 1.9)	.20
Preschool staff						
Educational leader						
PA enjoyment	42	441	1903	−0.2	(−0.8 to 0.3)	.38
PA education level	42	441	1903	−1.2	(−2.2 to −0.3)	.01
PA guideline	42	441	1903	−0.1	(−1.5 to 1.3)	.92
Staff						
PA enjoyment, average	42	441	1903	−0.6	(−1.6 to 0.4)	.26
PA education, %	42	441	1903	0.0	(−0.0 to 0.0)	.65
MVPA preschool, average %	42	441	1903	−0.0	(−0.2 to 0.1)	.51
Men, %	42	441	1903	−0.0	(−0.0 to 0.0)	.84
Young assistants, %	42	441	1903	0.0	(−0.0 to 0.0)	.51
Initiate activities, average	42	441	1903	0.5	(−1.4 to 2.3)	.63
Preschool environment						
Playground outside						
Location preschool building	42	441	1903	0.3	(−0.0 to 0.7)	.06
Natural environment						
1 Surrounding environment	42	441	1903	0.2	(−0.4 to 0.7)	.56
2 Vegetation along perimeter	42	441	1903	−0.4	(−1.1 to 0.3)	.30
3 Vegetation on ground	42	441	1903	−1.0	(−1.7 to −0.2)	.01
4 Hilly landscape	42	441	1903	−0.9	(−1.5 to −0.3)	.003
5 Open space	42	441	1903	−1.3	(−3.1 to 0.5)	.16
Sum (1–5)	42	441	1903	−0.3	(−0.6 to −0.0)	.03
Play opportunities per child (age: 3–6 y)						
Portable						
Balance	42	441	1903	−1.2	(−5.7 to 3.4)	.62
Swing	42	441	1903	3.8	(−18.2 to 25.7)	.74
Role play	42	441	1903	0.2	(−0.2 to 0.6)	.39
Sport	42	441	1903	1.1	(−2.0 to 4.3)	.48
Transport	42	441	1903	−1.3	(−5.1 to 2.4)	.49
Total portable	42	441	1903	0.2	(−0.2 to 0.5)	.42
Fixed						
Balance	42	441	1903	4.6	(−2.4 to 11.5)	.20
Swing	42	441	1903	3.3	(−6.1 to 12.6)	.49
Role play	42	441	1903	−0.6	(−8.1 to 6.9)	.88
Sport	42	441	1903	17.8	(−0.4 to 36.1)	.06
Climb	42	441	1903	−1.4	(−6.2 to 3.3)	.55
Total fixed	42	441	1903	1.4	(−1.8 to 4.7)	.39
Sandbox, m^2	42	441	1903	−0.6	(−1.6 to 0.5)	.29
Preschool indoor						
Rooms for PA	42	441	1903	0.3	(−0.2 to 0.7)	.22
Computer	42	441	1903	−0.5	(−1.6 to 0.7)	.42
Confounding						
Gender (boys)	42	441	1903	2.8	(1.8 to 3.8)	<.001
Rain, days	42	441	1903	−2.2	(−3.1 to −1.3)	<.001
Preschool type (0–6 y)	42	441	1903	0.2	(−1.0 to 1.5)	.70
Afternoon hours, %	42	441	1903	0.0	(0.0 to 0.1)	<.001
Location (rural)	42	441	1903	0.6	(−0.8 to 1.9)	.40
Area indoor per child, m^2	42	441	1903	0.3	(−0.1 to 0.6)	.11
Area playground, m^2	42	441	1903	0.0	(−0.0 to 0.0)	.70

TABLE 2 Continued

	N	*n*	Obs.	MVPA%	95% CI	*P* Value
Playground time, h/day	42	441	1903	0.3	(−0.2 to 0.7)	.24
Parent education	42	441	1903			.04
Low				0.0		
Medium				−0.3	(−1.6 to 1.0)	
High				0.9	(−1.1 to 2.9)	
None-response				−0.7	(−2.6 to 1.3)	

MVPA%, moderate and vigorous PA in percentage points; *N*, number of preschools; *n*, number of children; Obs, observations (days).

using indirect measures of indoor area.[5,7,9]

Although we used stratification to ensure selection of preschools of different sizes, there was an unexpected borderline significant association with playground size; this might be attributable to a lack of variance in the low end of playground area (median, 2700 m^2; range, 567–5175 m^2). Previous studies including playgrounds of similar[10] or larger sizes[9] compared with this study confirmed our finding of no association. On smaller playgrounds (median, <386 m^2), the daily MVPA level is reported to be reduced.[7]

Similarly, the inconsistent findings of the relationship between playground time MVPA and the size of playground area might be related to differences in the reported playground sizes.[5,15,17]

The positive association with the location of the preschool building on the playground might be related to the findings that circular pathways on the playground[13,27] might inspire activities such as running, biking,[27] or "risky play" while avoiding supervision from adults.[30]

The negative association with more vegetation areas on the playground was unexpected. However, in retrospect, the vegetation areas might have inspired more symbolic play, such as playhouse or construction play rather than running.[31] Furthermore, areas with hard surfaces (eg, asphalt or synthetic material) are often reported to be associated with higher intensity.[5,13,14,17,27,32] The association with hilly terrain might have been underestimated by the activity monitor.[33] In comparison, previous studies found no association with playground time MVPA and the specific elements of the natural environment.[5,17]

An explanation for the negative association with the natural environment score (tested in univariate analyses) might be that we were interested in the association with the specific natural elements, and did not directly measure the integration measured by the Outdoor Play Environment Categories,[9,34] which have been found to be positively associated with step counts.[9,10]

The lack of association with the total number of fixed or portable play possibilities per child is not consistent with other studies observing the presence of certain types[8] or quantity of equipment.[7] Measuring the association during outdoor stay alone also shows

TABLE 3 Predictors of Children's Time Spent in MVPA During Preschool Time Tested in a Multilevel Model

	N	*n*	Obs.	MVPA%	95% CI	*P* Value
Child						
Motor coordination	42	426	1839	0.1	(0.0 to 0.1)	.001
Born preterm (<37 gestation wk)	42	426	1839			<.001
No				0.0		
Yes				−2.7	(−3.9 to −1.6)	
None-response				1.5	(−0.1 to 3.1)	
Preschool staff						
Educational leader						
PA education level	42	426	1839	−0.8	(−1.7 to 0.2)	.10
Preschool environment						
Playground outside						
Location preschool building	42	426	1839	0.3	(0.0 to 0.5)	.04
Natural environment						
3 Vegetation on ground	42	426	1839	−0.7	(−1.3 to −0.0)	.04
4 Hilly landscape	42	426	1839	−0.4	(−1.1 to 0.2)	.18
Play opportunities per child (age: 3–6 y)						
Fixed						
Sport[a]	42	426	1839	14.5	(−1.5 to 30.5)	.07
Confounding						
Gender (boys)	42	426	1839	2.6	(1.5 to 3.7)	<.001
Rain, days	42	426	1839	−2.1	(−2.9 to −1.2)	<.001
Preschool type (0–6 y)	42	426	1839	−0.1	(−1.1 to 0.9)	.80
Afternoon hours, %	42	426	1839	0.0	(0.0 to 0.1)	.001
Location (rural)	42	426	1839	1.1	(−0.0 to 2.3)	.06
Area indoor per child, m^2	42	426	1839	0.3	(0.0 to 0.6)	.03
Area playground, m^2	42	426	1839	0.0	(−0.0 to 0.0)	.06
Playground time, h/day	42	426	1839	0.2	(−0.2 to 0.6)	.28
Parent education	42	426	1839			.002
Low				0.0		
Medium				−0.5	(−1.8 to 0.8)	
High				0.7	(−1.2 to 2.7)	
None-response				−1.6	(−4.2 to 1.1)	
Constant	42	426	1839	0.6	(−3.8 to 5.0)	.79

MVPA%, moderate and vigorous PA in percentage points; *N*, number of preschools; *n*, number of children; Obs, observations (days).

[a] The correlate "fixed sport play opportunities per child" expresses predominantly the number of soccer and basket goals per child, why the scaled effect of establishing a soccer field with the capacity to engage ∼10 preschool children would be more appropriate in the interpretation of the effect size being 1.45% point (14.5%/10 children).

inconsistent results.[5,17] Future studies should take into account the placement and design of the equipment on the playground, as this seems to affect the children's desire to use it.[13,27,35]

None of the staff correlates in the final model were associated with the children's daily MVPA level. Although a positive association between staff's physical education level and child indoor MVPA has been reported,[5] our finding of no association with the children's daily MVPA level is confirmed in some previous cross-sectional studies.[7,8]

The lack of association with the presence of male preschool staff often being more willing to engage in physical play might be attributable to the low prevalence of men or adoption of female norms.[36]

Finally, the generally low level of interaction between children and staff members during outdoor play often pointed out by other authors[8,12–14,17] might also offer an explanation for the finding of no associations with the staff variables.

In contrast to the findings of this study, outdoor play is reported to be an important correlate in relation to promoting PA in preschool children.[14,37] The Danish children were reported to play outdoors an average (SD) of 4.6 (1.0) hours per day during preschool attendance in the season studied. This might have diminished the assumed effect of the actual number of adult supervised trips outside the preschool area. In comparison, interview-based adult supervised trips have shown inconsistent associations with child MVPA.[7,16] Outdoor play might also have diminished the assumed effect of the number of freely accessible indoor rooms for physical active play used during the PA data collection period. Providing the possibility to perform indoor motor activities has been reported to be positively associated with indoor-specific MVPA.[5]

Although lower compared with a previous study,[5] the ICC of 0.05 confirms that MVPA is affected by the specific preschool's environment. However, the majority of the children's PA levels are still explained by the individual variance in preschool children's daily MVPA level within each preschool, highlighting the need to keep focusing on individual characteristics.

The positive association with motor coordination is supported by other studies.[20,38]

The strength of the current study is the sufficient number of randomly selected preschools ensuring power and heterogeneity for studying important potential correlates while avoiding the use of arbitrary cut points for categorizing variables. Furthermore, the PA measurements were simultaneously carried out in the preschools over the course of a few weeks, reducing season and weather effect.

The limitations of the study are the lack of completely validated parent and staff questionnaires, and that we only covered 1 dimension of preschool children's PA behavior. Unfortunately we could not account for the degree of prematurity, nor the possibility that daily rules or routines indoors or outdoors might have resulted in staff regulations of the children's movement and affected the results related to the physical environment.[9,17,37] The high number of correlates tested might have caused random findings.

Finally, because of the cross-sectional data, no conclusions about causality can be drawn, and the difference between children with and without complete data in some variables may limit generalizability.

CONCLUSIONS

This study added indoor area per child and location of preschool building on the playground as potentially new and modifiable preschool characteristics; this might have had a positive influence on the children's PA level during preschool attendance.

The finding of the high individual variation in the children's MVPA behavior and no association with the general staff correlates emphasizes the need to investigate more behavior-related aspects focusing on peer influence and also staff prompting or restricting the children's PA behavior during indoor and outdoor preschool stay.

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