

Nielsen, G., Bugge, A., Hermansen, B., Svensson, J., Andersen, L. B. (2012). School playground facilities as a determinant of children's daily activity: a cross-sectional study of Danish primary school children. *Journal of Physical Activity and Health*, 9, 104-114.

School Playground Facilities as a Determinant of Children's Daily Activity: A Cross-Sectional Study of Danish Primary School Children

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Background: This study investigates the influence of school playground facilities on children's daily physical activity. **Methods:** Participants were 594 school children measured at preschool (age 6 to 7 years) and 3 years later in third grade (518 children age 9 to 10 years) from 18 schools in 2 suburban municipalities in Denmark. Physical activity data were obtained using accelerometers. These were related to the number of permanent play facilities in school grounds and the school playground area (m²). **Results:** The number of play facilities in the school grounds was positively associated with all measures of children's activity. In preschool every 10 additional play facilities the children had access to was associated with an increase in the average accelerometer counts of 14% ($r = .273, P < .001$) in school time and 6.9% ($r = .195, P < .001$) overall. For the children in third grade, access to 10 additional play facilities was associated with an increase in school time activity level of 26% ($r = .364, P < .001$) and an increase in overall activity level of 9.4% ($r = .211, P < .001$). School playground area did not affect activity levels independently of the number of permanent play facilities. **Conclusion:** Increasing the number of play facilities in primary school playgrounds may increase the level of children's daily physical activity.

Keywords: physical activity, child, physical environment, accelerometers, schools, school activity

Physical activity (PA) is important to children's health and development. Daily activity level during childhood has been established as an important factor in preventing childhood obesity,^{1,2} improving bone density,³ and in positively influencing academic performance,⁴ social development,^{5,6} psychological welfare,⁷ and eventual adult activity level.^{8,9} Furthermore, insufficient daily PA in children has been linked to an increase in health-risk factors.^{1,10,11}

Children's daily PA levels have become polarized over the last 20 years resulting in increasing numbers of children being insufficiently active.¹²⁻¹⁵ To address the problem of inactivity in children, a thorough understanding of the factors that influence children's PA is required. However, many of the recognized determinants and mediators of childhood PA level (such as socioeconomic position, gender, ethnicity, perceived self-efficacy, and

parent's activity levels^{16,17}), are characteristics that are difficult to alter through public-health interventions, presenting challenges to the design and implementation of intervention projects.

Recent studies and reviews have highlighted the influence of physical environments on daily PA levels in children.^{16,18-20} School grounds are an example of a physical environment that all children encounter that could be targeted by public-health initiatives. Children spend a large proportion of their time at school (for the children in this study 25 hours per week in preschool and 30 hours per week in third grade, including a large amount of free-play time among other children during breaks (approximately 5 hours per week) (ie, in an environment abundant with the necessary social resources for stimulating play and sports activities).⁶

Several studies have demonstrated that the temporary provision of equipment in school play areas during breaks can influence activity in children.²¹⁻²⁵ However, while such initiatives may offer a cost-effective approach to increasing activity, they require staff to distribute and/or monitor equipment, which may limit their use due to the busy schedules of school staff.²⁶ In contrast, the potential for more permanent structures to influence PA in school children has not been as well studied. While permanent school facilities have been found to be related to the percentage of time children were moderately to vigorously active,²⁵ and children have been found to be

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more likely to be active in better equipped areas of a single school playground,²⁷ these studies have all used self-reporting or observations as the measure of PA.²⁸ To our knowledge, only 1 study²⁹ has used accelerometry to provide an objective measure^{30–32} of children's daily PA and assess the impact of playground structures on total daily activity. This work was limited to only 7 schools in rural New Zealand communities, but was able to show a strong association between the number of school ground play facilities and the amount of directly measured PA of the children.

To test whether this effect can be found in other contexts, this study uses similar methods to test the association between the number of available school ground play facilities and the daily PA of 6- and 10-year-old children at 18 schools in 2 suburban Copenhagen municipalities. It is hypothesized that if the physical resources for play, sports, and games are available and plentiful in school breaks, these will allow, inspire, and help children to be more active.

Methods

Participants

The study collected longitudinal data from the same children in preschool and 3 years later in third-grade to monitor age changes in children's PA and other health parameters and to minimize bias from factors on the personal level affecting PA.

Participants were primary-school children attending preschool classes in 2001 (6–7 years of age, mean age = 6.3, SD = 0.35) and third grade classes in 2004 (9–10 years of age, mean age = 9.5, SD = 0.83) from 18 schools in 2 suburban municipalities in the Copenhagen area participating in the COSCIS study.^{33,34} Written informed consent was obtained from the parent/guardian of each child. In the preschool classes, 704 of 1024 children agreed to participate in the study with 594 returning accelerometer data with the required number of days of valid measurements for inclusion in the analysis. Three years later when measurements were taken from the same children in third grade, 536 of the initial 704 children participated in the study, with 518 returning accelerometers with the required days of measurements for inclusion in the analysis. The children were attending the same schools at preschool and in third grade.

As the main focus of this study is the relationship between school play facilities and PA (and not changes in PA with age), the measurements taken in preschool classes and those taken 3 years later in third grade were statistically analyzed as 2 independent cross-sectional datasets.

The 31% of the children that did not participate in the preschool measurements in this study were later measured as part of the systematic medical examination of children in Denmark (about 1 year after the preschool measurements were taken). There were no significant differences between the groups of children that did and did

not participate in the current study with respect to age, height, weight, and body mass index (BMI) for either sex³³ indicating that the sample population did not differ from the target population in these characteristics.

Measurements of Physical Activity (PA)

The children's daily amount of PA was measured using MTI 7164 accelerometers (Actigraph, Fort Walton Beach, Florida, USA). Accelerometers are PA monitors that provide precise, valid, and reliable measurement of children's daily activity levels, which overcome children's lack of ability to recall and quantify their physical activities in detail.^{35–38} Due to children's PA often consisting of short bursts of activity, we chose an epoch of 10 seconds, which limited the registration period to 4 days as a result of the limited memory of the accelerometers. The monitors were worn by the children secured at the lower back using an elastic belt. The children were instructed to wear the monitor for 5 days continuously except during water-based activity and when sleeping. To minimize any biasing effect from the novelty of wearing an activity monitor, the MTI monitors were worn by the children for 1 day before recording. To best reflect the distribution of school days and school-free days (weekends and holidays) in school children's lives, both school days and weekend days were included in the measuring period. The 4 days of recording included 1 to 2 weekend days (preschool mean = 1.84, third grade mean = 1.68).

Due to variation in sleeping patterns in children, accelerometer data were analyzed for each child from 7 AM to 11 PM. To further ensure that the accelerometer measures of daily PA were not corrupted by including data from periods when the accelerometers were not being worn, a program was used to automatically delete missing data (defined as continuous sequences of zeros longer than 10 min, which could only be caused by the accelerometer not being worn). This technique has been recommended as an important part of ensuring the reliability of accelerometer data.^{33,39}

Data were included in the dataset if the monitor had recorded more than 8 hours of valid recordings a day for at least 3 days, given the above mentioned criteria. At preschool age this resulted in 594 children being included in the analysis, of which 466 had 4 valid days and 128 had 3 valid days of measurements. Fifty-eight children had less than 3 valid days of measurements and were therefore excluded from the analysis.

At third grade age, 518 children returned accelerometers with the required days of measurements for inclusion in the analysis, of which 379 had 4 and 139 had 3 valid days of measurements.

Data Transformation to PA Variables

To obtain information on how school play facilities were associated with the activity levels of children at school and to assess whether the possible effect was large enough to influence the total activity level of children,

or influenced their activity outside school, data were analyzed for school time (classified by the time tables of the schools as 8 AM to 1 PM or 2 PM on schooldays), outside school time (7 AM to 8 AM and 1 PM or 2 PM to 11 PM on school days + 7 AM to 11 PM on weekend days), and total time (7 AM to 11 PM on all the measured days; ie, a combination of school time and outside school time).

As a measure of the children's general or habitual amount of PA in their everyday lives, the mean counts per valid minutes of recording (counts per minute) were calculated producing the variable "total activity average counts" describing the children's average PA level over the 4 days measured in accelerometer counts/min. The time spent in moderate PA (4–6 METS or 2500 to 5000 counts per minute reflecting medium exertion in a standing position; eg, walking approximately 5.2 km/h) and vigorous PA (>6 METS or >5000 counts per minute reflecting a high level of exertion in the standing position; eg, running faster than 6.4 km/h) was calculated. The selection of the counts/min cut-off points identifying moderate and vigorous PA was based on a combination of 5 different validation studies of accelerometer measures of PA in children.^{40–44} The percentage of time spent at these activity levels was calculated by dividing the minutes of each measure by the minutes of recording.

To reduce the bias from some children not wearing their monitors for the total measuring period, the data were transformed when calculating the minutes per day of moderate or vigorous activity for each child. Each child's daily minutes of activity were calculated by multiplying the defined daily measuring period for all children (960 minutes) with the percentage time for which each child was active during their individual total measuring period. The proportion of children who did not meet current health-related PA recommendations⁴⁵ was calculated based on the recommendations of 1 hour a day of activity of at least a moderate level recommended by many health organizations (including the Danish Ministry of Health and the Danish Heart Foundation).⁴⁶ In addition, since it is recommended that children engage in a combination of both moderate and vigorous PA,^{47,48} the proportion of children who did not reach more than 90 minutes of vigorous activity per week (a secondary health recommendation in some countries)⁴⁵ was also calculated.

Measurements of School-Ground Characteristics

The playgrounds in the schools in this study were split so that only particular age groups were allowed access to certain parts of the playgrounds (a common practice in Denmark). School ground characteristics were therefore measured separately for the preschool and for the third grade playground areas.

The quality of the school playgrounds was quantified using 2 measures: the surface area of each school playground (m²) and the number of permanent play facilities. The area of the school playgrounds was calculated using

trundle wheel measurements of surface area, excluding buildings but not play facilities.

Quantification of the number of permanent play facilities on school grounds (stationary and fixed objects or equipment in school playgrounds that provide active-play options for children) was based on similar methods to a previous study in New Zealand.²⁹ This method involved observational pilot studies of children's play activities in school breaks (44 observations at 22 schools), followed by counts of the number of permanent play facilities in each school-ground. Based on the observation that children play physically active games in groups of 2 to 10 children, permanent play facilities were defined as permanent school ground physical structures (excluding buildings) shown during the observations to be used by such groups of children when constructing and playing a game, play-, or sports-activity.

All the schools in this study of Danish schools have an adventure playground on their grounds (similar to those seen in public parks, for example Figure 1). These adventure playgrounds often have a design based on a fort structure and comprise several main towers interlinked with structures such as monkey bars, bridges, and ropes. During playtime, it was common to observe small groups of children structuring their games and play activities around one of the towers and its accompanying structures (eg, a slide or climbing wall). Each tower in an adventure playground was therefore counted as 1 individual play facility. This method resulted in adventure playgrounds being counted as composed of up to 12 play facilities (when they provided sufficient physical structures for up to 12 different groups of children to play at any one time). Other examples of items that were counted as a play facility are: goals and hoops for ball activities, such as soccer and basketball; line marked pitches for self-invented or established games, such as hopscotch and 4-square; clusters of trees or bushes that were big and close enough to enable games such as hide-and-seek; small hills, cavities, and sand pits; and walls useful and designated for playing ball against.

Because these quantifications of the number of school ground play facilities rely on a great deal of subjective judgment, school ground facilities were counted twice on different occasions. There were only discrepancies in the number of permanent play facilities counted in 4 of 36 school grounds counted (with the counts differing by 1 to 3). When discrepancies occurred, additional observations of children's play were undertaken and a third recounting of facilities was carried out to assure that all relevant facilities were counted.

Data on Potentially Confounding Background Variables

To adjust statistical models for the influence of general weather and amount of daylight on PA, the time of measurement was categorized in 2 seasons: winter (November-February); and nonwinter (August-October and March-June). Winter months differ markedly from



Figure 1 — An example of an adventure playground.

autumn and spring months in the amounts of sunlight, rain, and in the temperature. Preschool PA measures were taken during winter and spring while third grade measures were taken during autumn and winter. No measures were taken during summer months as children were on holiday.

At third grade age the children's school timetables were used to get data on whether the children had their weekly 1 hour PE classes while their PA was measured and this factor (yes/no) was included in the models. At preschool children did not have formal PE-classes.

As an indicator of the socioeconomic position of the children's family, questionnaire data about the parent's occupation and education were used to classify the parents into the 5 groups of socioeconomic position most commonly used in Danish research on social relations and inequality in health and education.⁴⁹ The highest position/status of the 2 parents was used as indicator of the socioeconomic family background of the child.

Measurements of Physical Characteristics

The children's height was measured to the nearest 0.1cm using a portable stadiometer and weight to the nearest 0.1 kg using electronic scales. Both were measured in duplicate. Body mass index (BMI) was calculated (height

in meters divided by weight in kilograms squared) and global reference data were used to define children as overweight.⁵⁰

Statistical Analysis

All data were analyzed using the software program SPSS 17.0. The associations between the number of available play facilities in the school grounds (as an independent variable) and children's amounts of PA during school time, and in total (as dependent variables) were found to be linear, and were therefore investigated using multiple linear regression. Variables that were not normally distributed and did not show homogeneity of variance were log-transformed before analysis. The associations between the number of school ground play facilities and children's individual likelihood of meeting recommended levels of daily activity was analyzed using multiple logistic regression models. In the regression analysis, adjustments were made for weather (season), socioeconomic position, gender, and participation in PE during the days of measurement by adding these as independent variables in the regression models. It was tested whether interaction terms between gender and play facilities, and play facilities and participation in PE were associated to PA. As none of these interaction terms were significantly

associated to the measures of PA, they were not included in the final models.

Results

Characteristics of the Participants

At preschool age 704 of 1024 children agreed to participate in the study with 594 returning accelerometer data with the required number of days of valid measurements for inclusion in the analysis. For these 594 children the average proportion of missing data (calculated as the 3840 minutes of planned measuring time minus children's actual measuring time divided by the 3840 minutes of planned measuring time) was 28.8%. Three years later when measurements were taken in third grade, 536 of the initial 704 participants participated in the study, with 518 returning accelerometers with the required days of measurements for inclusion in the analysis. For these 518 children, the average proportion of missing data was 28.0%. Both at preschool- and at third grade-age, children's proportion of missing data were equally distributed among the schools and were not associated to any of the measures of PA or the number of play facilities at the schools.

Table 1 shows the distribution of the children at preschool and in third grade included in the analysis. At preschool mean age was 6.3 years, mean BMI was 16.3 and 11.5% had non-Danish ethnic background. At third grade mean age was 9.5 years, mean BMI was 17.3 and 11.4% had non-Danish ethnic backgrounds.

No significant differences were found between the 2 genders regarding age, height, weight, BMI, overweight status, and ethnic background. No significant differences were found between schools regarding compliance rate to the study, days of measurements or gender distribution.

Description of School Grounds

In the school playgrounds used by the preschool children, the number of play facilities ranged from 6 to 32 (mean = 16.1, SD = 6.9) and the area from 378 m² to 13475 m² (mean = 3769.3, SD = 3087.57). In the playgrounds used by the third graders, the number of play facilities ranged from 10 to 30 (mean = 18.7, SD = 6.13) and area size ranged from 1308 m² to 21501 m² (mean = 8491.3, SD = 6614.27).

General Activity Levels of the Children

Table 2 shows the PA levels of the children in total and while at school. In preschool the children were on average spending 64.8 minutes per day in moderate activity and an additional 19.7 minutes in vigorous activity. However, 20.3% of the children did not meet the recommended amount of 1 hour per day of activity above moderate level. By third grade a decrease was observed in the children's total activity level (5.2% $P < .001$) and amount of moderate activity (10.8%, $P < .001$) and a higher proportion of children (23.2%, $P = .034$) were inactive. This was due to activity levels during free time having decreased, although their school-time activity level and school-time minutes of vigorous activity had increased.

Table 1 Characteristics of the Study Population

	Male	Female	All
Preschool			
n	310	284	594
Age (in years)	6.4 (0.36)	6.2 (0.33)	6.3 (0.35)
Height (in cm)	129.7 (5.44)	128.3 (5.06)	129.0 (5.31)
Weight (in kg)	27.4 (4.57)	26.9 (4.51)	27.2 (4.54)
BMI	16.3 (1.77)	16.3 (2.14)	16.3 (1.96)
Overweight (age specific cut point at BMI > 17.6 ⁵⁰)	15.1%	20.0%	17.5%
Non-Danish ethnic background ^a	9.9%	13.2%	11.5%
Third grade			
n	266	252	518
Age (in years)	9.5 (1.10)	9.4 (0.36)	9.5 (0.83)
Height (in cm)	140.1 (5.70)	138.9 (5.99)	139.5 (5.87)
Weight (in kg)	34.1 (6.00)	33.4 (6.44)	33.8 (6.22)
BMI	17.3 (2.30)	17.2 (2.59)	17.3 (2.44)
Overweight (age specific cut point at BMI > 19.5 ⁵⁰)	14.0%	15.5%	14.7%
Non-Danish ethnic background	10.3%	12.4%	11.4%

Note. Data are presented as mean (SD) except for overweight and Non-Danish ethnic background, which are expressed as % (of n). There are no significant differences between groups.

^a Non-Danish ethnic background is defined as having parents who have immigrated to Denmark.

Table 2 Physical Activity in Total and at School

Period		Boys	Girls	All
Preschool				
Total ^a	Average counts (counts/min)*	778.8 (219.2)	703.2 (164.8)	743.2 (198.6)
	Moderate activity (min/day) ^{c*}	69.5 (22.5)	59.6 (17.6)	64.8 (20.9)
	Vigorous activity (min/day) ^{c*}	21.5 (12.3)	17.7(8.7)	19.7 (10.9)
	Active ^d <1 hour/day*	16.6%	24.4%	20.3%
	Vigorously active < 1.5hours/week	24.3%	30.8%	27.3%
School ^b	Average counts (counts/min)*	733.8 (275.2)	637.1 (228.7)	688.4 (258.3)
	Moderate activity (min/day) ^c *	19.5 (9.9)	15.7 (7.9)	17.7 (9.2)
	Vigorous activity (min/day) ^{c*}	6.3 (5.2)	5.2 (4.3)	5.8(4.8)
Third grade				
Total ^a	Average counts (counts/min)*	746.4 (201.4)	665.2 (173.8)	706.7 (193.2)
	Moderate activity (min/day) ^{c*}	62.4 (18.1)	54.3 (16.4)	58.5 (17.8)
	Vigorous activity (min/day) ^{c*}	24.8 (13.1)	21.1 (12.6)	22.3 (13.0)
	Active ^d <1 hour/day*	17.2%	29.7%	23.2%
	Vigorously active < 1hour/week	15.7%	26.5%	20.9%
School ^b	Average counts (counts/min)*	865.0 (331.4)	681.0 (273.8)	775.6 (319.2)
	Moderate activity (mins/day) ^{c*}	23.6 (9.4)	18.4(8.1)	21.1 (9.2)
	Vigorous activity (mins/day) ^{c*}	12.1 (8.3)	9.2 (7.2)	10.7 (7.9)

Note. Data are presented as mean (SD) except from % being inactive.

^a Total time is defined as 7 AM to 11 PM on all days.

^b School time is defined as 8 AM to 1 PM (preschool) and 2 PM (third grade) on weekdays.

^c Each child's daily minutes of activity were calculated by multiplying the defined daily measuring period for all children (960 minutes) with the percentage of time for which each child was active during their individual total measuring period.

^d Activity of at least moderate intensity.

* Gender difference is statistically significant at $P < .05$.

At preschool-age, the average activity level (counts/min) was significantly lower during school time compared with the total activity level (8.0%, $P < .001$), while the opposite was the case at third grade age where children had a higher level of activity at school than in total (9.7%, $P < .001$). Both at preschool and in third grade the mean activity level of boys was 11% higher than that of the girls ($P < .001$ at both ages), resulting in more girls than boys being physically inactive ($P < .001$ at both ages).

Associations Between School Playground Physical Characteristics and Children's PA

Tables 3 and 4 show the relationships between the number of play facilities and different measures of the children's daily PA. The number of play facilities in the school playgrounds was significantly associated to all measures of activity during school time and total time, after adjusting for season, gender, socioeconomic position and whether the children have had their weekly PE class during measuring. No associations were found between the number of school grounds' play facilities and children's PA during their time outside school.

The data on the children in preschool showed that for each 10 additional play facilities that children had access to, there was an associated increase in the average accelerometer counts of 14% ($r = .273$, $P < .001$) during school-time and a 6.9% ($r = .195$, $P < .001$) increase overall. Furthermore, access to 10 additional play facilities was associated with an additional 6.7% or 5.7 minutes of activity (moderate/vigorous) ($P < .001$), and 10.9% or 2.2 minutes of vigorous activity ($P = .002$) over the course of the day for this age group. School-time PA was also significantly associated to season ($r = .116$, $P = .013$), gender ($r = .160$, $P = .001$) and socioeconomic position ($r = .098$, $P = .038$), whereas total PA was only associated to season ($r = .309$, $P = .000$) and gender ($r = .177$, $P < .001$).

For the 10 year olds, access to an additional 10 play facilities was associated with an increase in school-time activity level of 26% ($r = .364$, $P < .001$) and an increase in overall activity level of 9.4% ($r = .211$, $P < .001$). The daily minutes of activity (moderate and vigorous) were also increased by 9.3% (7.5 minutes) ($P < .001$), and the minutes of vigorous activity by 13.9% or 3.1 minutes ($P = .003$). School-time PA was associated to gender ($r = .284$, $P < .001$) and whether the children took part in PE

Table 3 Associations Between the Number of Permanent Play Facilities in Preschool School Grounds and Measures of Activity Levels in School Time and in Total Time for Preschool Children

	Partial <i>r</i>	Ratio	95% CI	<i>P</i> -value
School time activity ^a				
Average counts	0.273	1.0139	1.0093–1.0186	<0.001
Time in moderate activity (min./day)	0.309	1.0257	1.0186–1.0328	<0.001
Time in vigorous activity (min./day)	0.071	1.0116	1.0000–1.0209	0.042
Time in moderate/vigorous activity	0.299	1.0257	1.0186–1.0351	<0.001
Activity outside school time ^b				
Average counts	0.068	1.002	0.995–1.003	0.257
Time in moderate activity (min./day)	0.020	1.000	0.991–1.004	0.606
Time in vigorous activity (min./day)	–0.017	1.000	0.989–1.002	0.713
Time in moderate/vigorous activity	0.050	1.002	0.997–1.004	0.289
Total activity ^c				
Average counts	0.195	1.0069	1.0043–1.0106	<0.001
Time in moderate activity (min./day)	0.148	1.0067	1.0023–1.0116	<0.001
Time in vigorous activity (min./day)	0.143	1.0109	1.0048–1.0162	0.001
Time in moderate/vigorous activity	0.159	1.0077	1.0046–1.0116	<0.001

Note. Data are presented as ratios per unit increase in play facilities adjusted for season, gender, and socioeconomic position.

^a School time is defined as 8 AM to 1 PM on weekdays; ^b Outside school time is defined as all other time within.

^c Total time is defined as 7 AM to 11 PM on all days.

Table 4 Associations Between the Number of Permanent Play Facilities in School Grounds Used by Children in Third Grade and Measures of Their Activity Levels in School Time and in Total Time

	Partial <i>r</i>	Ratio	95% CI	<i>P</i> -value
School time activity ^a				
Average counts	0.364	1.0261	1.0199–1.0324	<0.001
Time in moderate activity (min./day)	0.242	1.0194	1.0124–1.0257	<0.001
Time in vigorous activity (min./day)	0.260	1.0373	1.0239–1.0513	<0.001
Time in moderate/vigorous activity	0.259	1.0238	1.0131–1.0295	<0.001
Activity outside school time ^b				
Average counts	0.015	1.000	0.998–1.004	0.683
Time in moderate activity (min./day)	–0.012	1.000	0.997–1.003	0.647
Time in vigorous activity (min./day)	–0.041	0.998	0.993–1.007	0.713
Time in moderate/vigorous activity	–0.030	0.999	0.997–1.002	0.450
Total activity ^c				
Average counts	0.211	1.0094	1.0054–1.0134	<0.001
Time in moderate activity (min./day)	0.163	1.0093	1.0035–1.0139	<0.001
Time in vigorous activity (min./day)	0.141	1.0139	1.0047–1.0230	0.003
Time in moderate/vigorous activity	0.167	1.0093	1.0041–1.0133	<0.001

Note. Data are presented as partial *r* for the association and ratios per unit increase in play facilities adjusted for season, gender, socioeconomic position, and whether the children had PE classes.

^a School time is defined as 8 AM to 2 PM on weekdays; ^b Outside school time is defined as all other time within.

^c Total time is defined as 7 AM to 11 PM on all days.

($r = .254, P < .001$), whereas total PA was also associated to gender ($r = .193, P < .001$).

An interaction term for gender and amount of play facilities (gender*play facilities) was tried included in the models, but was not found to be significantly related to any of the PA measures. This indicates that the association between the number of play facilities and PA is independent of gender, (and the interaction term was therefore not included in the final models).

To assess whether school ground play facilities had an effect on those children at risk for being problematically inactive (active <1 hour/day), the number of play facilities was related to the chances of meeting recommended levels of physical activity (Table 5). After adjusting for the above mentioned confounding variables, the association between the number of school ground play facilities and the likelihood for reaching the recommended 1 hour of PA daily was found to be only weakly significant ($P = .060$) for the 6 to 7 year olds. However, the association to the chances for being vigorously active more than 1.5 hours per week was significant (odds ratio = 1.036, $P = .012$) at this age. For the 9 to 10 year olds, access to 10 additional play facilities increased the likelihood of the children being active more than 1 hour per day by 73% ($P < .001$) and the likelihood of being vigorously active more than 1.5 hours per week by 66% ($P = .001$).

Both in preschool and in third grade, school ground area and the number of children having access to the school grounds were both correlated to the number of play facilities ($r = .572$ and $r = .192$, in preschool and $r = .469$ and $r = .091$ in third grade, all $P < .05$), but showed no significant independent effects on PA when adjusting for the number of play facilities. Furthermore, adjusting the model of the association between play facilities and PA for school ground area and the number of children using the area did not significantly change the estimates of the associations between play facilities and PA. School playground area did not affect activity levels of either age group independently of the number of permanent play facilities.

The number of play facilities per child using the school grounds was found to be associated to all measurements of PA after adjusting for confounders. For the children in preschool, play facilities per child was associated to the level of PA during school time with a partial r for the association of 0.236 ($P < .001$). In third grade, the partial r for the association between play facilities per child and PA during school time was $r = .200$ ($P < .000$).

Discussion

This study lends further support to previous findings based on smaller datasets that the number of permanent play facilities in schools is positively related to physical activity in children.²⁹ Furthermore, the study suggests that for children aged 9 to 10 years, the higher the number of play facilities that children have access to, the greater the likelihood that they meet recommended levels of PA. This indicates that a high number of play facilities not only affects the average amount of activity among children at this age, which could potentially be an effect of increasing the PA levels of the most active and sports-interested children, but also has a specific effect on the children at risk for being problematically inactive.

The use of direct measurement of activity has shown to be crucial in generating reliable measures of children's daily PA levels and its determinants.^{30–32} The use of accelerometry in this study enabled objective measurements of children's PA, which could then be divided into different timeframes (life-settings), and intensity levels. This provided the means to show that the association between school ground play facilities and children's PA was strong enough during school time to result in a significant association with their total PA levels. It could also be seen that children from schools with more play facilities, who had a higher than average school-time PA level, did not compensate for this with a decreased activity level outside school hours. Furthermore, it enabled us to show that the number of play facilities was not only associated to the total amount of PA that the children

Table 5 Associations Between Play Facilities and Children's Individual Likelihood of Meeting Optimal Levels of Daily Activity

The odds ratio of meeting recommended levels of activity per unit increase in play facilities	Odds ratio		
	β	95% CI	P
Preschool			
Being active* > 60 min per day	1.030	0.999–1.073	0.060
Being vigorously active > 90 min. per week	1.036	1.008–1.064	0.012
Third grade			
Being active* > 60 min per day	1.073	1.031–1.120	<0.001
Being vigorously active > 90 min./week	1.066	1.025–1.109	0.001

Note. Data are presented as odds ratios (increased likelihoods) per unit increase in play facilities adjusted for weather, gender, socioeconomic position, and whether the children had PE.

* In physical activity of at least moderate intensity.

engaged in, but also to the amount of more vigorous PA, which is important for the development of VO_2 Max (a strong correlate of cardiovascular health),⁵¹⁻⁵³ motor skills,^{54,55} and bone density.³

The findings of this study are broadly in line with recent reviews of the literature that have concluded that access to recreational facilities, as well as safe sidewalks and bike lanes, may be positively associated to children's participation in recreational physical activities and physically active transport.^{16,56,57} The results are also consistent with a number of more school-ground-specific studies: Studies using observational methods have indicated an effect on children's PA from school ground improvements, such as distributing loose play gear, increasing the number of permanent play facilities (eg, basketball hoops) as well as providing adult supervision.^{25,27,58}

Studies using direct measurements (accelerometry), have shown that providing loose games equipment in school breaks can increase the PA level of children during that time,²² that play area size can influence activity among boys, and that less athletic boys tend to be excluded from activity as space decreases.⁵⁹

Longitudinal intervention studies have shown increased PA in school children 4 weeks after creating additional playground markings.^{23,60} A study which investigated longer-term effects found that children in an intervention group participated in 4.5% more moderate/vigorous activity during school breaks 6 months after the introduction of playground markings, soccer goals, basketball hoops and fencing around designated play areas, and that these effects were stronger for those children who were less active at baseline.⁶¹

Using the same measures for quantifying the number of permanent play facilities in school grounds as in the current study, Nielsen et al²⁹ found a positive association between the number of play facilities and PA of 5- to 11-year-old children in 7 rural New Zealand schools.

Our study, based on a larger sample of schools in suburban Danish settings, supports these findings. Due to the use of different accelerometers, and therefore differing values to define moderate and vigorous activity, the reported measures of activity cannot be compared between the 2 studies. However, the parameter estimates for the associations between school ground play facilities and children's PA appear stronger in the New Zealand study, where access to 10 extra play facilities was associated with a 38% increase in school-time activity and a 27% increase in overall activity.²⁹ This study finds weaker yet still significant associations. The stronger association between school ground facilities and PA found in the New Zealand study is difficult to explain. It may be due to differences in the children's everyday lives, with New Zealand children spending more time in their school grounds as they have a 1-hour lunch break and often spend time on school grounds after school, whereas the Danish children have half-hour lunch breaks and go to afterschool daycare institutions straight after school.

In this study, as in the previous study by Nielsen et al, playground area was correlated with the number of

permanent facilities, but did not show any independent effects on activity levels once adjusted for the number of facilities. Furthermore, play facility per child was consistently associated with school time PA, indicating that children compete for access to play facilities during school recess in some schools, making a lack of available facilities to play with a limiting factor for children's PA.

This study is constrained by including PA measurements from children wearing the accelerometers for less than 4 days, thereby increasing the possibility that the measured PA was not representative of habitual PA.^{62,63} The use of relatively short measuring periods leads to increased error variation in PA measurements,^{62,63} weakening the strength of associations and making it likely that the observed associations in this study are underestimated. The possible effect of the novelty of wearing an accelerometer should also be considered, as this may in itself affect children's PA. This novelty effect would most likely affect children independently of the number of school-ground play facilities they have access to and should therefore only have a minimal effect on the associations investigated in this study.

The associations between 10 extra play facilities and PA reported in this paper was chosen as it is realistic that the number of play facilities in school grounds can vary by 10, as the difference between the least and the most equipped school ground in this study was 26 facilities (ranging from 6 to 32 in third grade). These numbers can also give an indication of the effect of potential intervention projects aiming to improve the school ground environment. An increase of 10 play facilities is feasible since many of the facilities included in this study are relatively inexpensive such as small soccer goals, basketball hoops, painted playground markings, trees, and bushes, and since many of the playground structures last several years with only small maintenance requirements (asking school principals at each school revealed that 78% of the counted facilities were more than 5 years old and had not been repaired during that time). However, we would like to stress that as this study is cross sectional, there is a need for longitudinal interventions studies to test the causal effects of increasing the number of school ground play facilities on children's PA levels. Furthermore, it is important to study the impact of different types of school play facilities, as these may affect various groups of children (active/inactive, boys/girls etc.) differently and also because increasing variety may have been part of the reason behind the association between number of play facilities and PA found in this study.

We find it likely that initiatives and interventions that aim at increasing children's PA by providing more permanent play facilities in school grounds may be attractive to both public-health agents and teachers since they require no staff after the initial outlay, can be sustained over several years and because PA has shown beneficial to physical health,¹⁰ learning,⁴ and social skills⁵ among school children. Furthermore it is expected that better opportunities for play will make school breaks more fun and attractive for children, which can be seen as an aim for schools in its own right.

Conclusion

Based on the consistent positive associations between the number of school ground play facilities and activity levels found in this study and a previous study using similar methods in New Zealand schools, and based on general good support in the research literature that environmental factors have strong influence on children's physical activity, we suggest that increasing the number of play facilities in primary school playgrounds could be a lasting way to increase children's daily physical activity, both in school and in general.

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