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Permanent play facility provision is associated with children's time spent sedentary and in light physical activity during school hours: A cross-sectional study

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ABSTRACT

Objective: To study the associations between: 1) number of permanent outdoor play facilities per pupil and 2) the size of the outdoor play area per pupil with sedentary time and physical activity (PA) during school hours in six-, nine-, and 15-year olds. We conducted a cross-sectional study of nationally representative samples of Norwegian six- (n = 1071), nine- (n = 1421) and 15-year-olds (n = 1106) in 2011 (the Physical Activity Among Norwegian Children Study). The participation rates were 56.4%, 73.1% and 57.8% for six-, nine- and 15-year olds, respectively. We assessed PA objectively for seven consecutive days using accelerometers, the size of a school's outdoor play area (SOPA) using an online map service and the permanent play facility (PPF) provision using a standardized form during school site visits. We successfully measured SOPA and PPF in 99 schools, from which 3040 participants provided valid accelerometer data. We used generalized least-squares random-effects models with robust variance estimation to assess associations. Our results indicate that better provision of permanent play facilities may reduce sedentary time and increase time spent in light PA among six-year-olds. Permanent play facility provision was not associated with sedentary time or PA among nine- and 15-year-olds. Associations found between outdoor play area size, physical activity and sedentary time were negligible. Future research should investigate what types of permanent play facilities may be associated with physical activity in both children and adolescents.

1. Introduction

Since almost all children spend a large proportion of their awake time in school, this arena provides a unique setting for physical activity (PA) promotion. During and adjacent to the school day, children may have several opportunities to be physically active, e.g. through active travel, physical education (PE) and recess. Intervention studies aimed at promoting PA in all these settings have shown promising results (Lonsdale et al., 2013; Larouche et al., 2014; Ickes et al., 2013). However, because it is already compulsory in most schools and does not compete with academic interests (Ickes et al., 2013), recess might be a particularly attractive arena for PA promotion. Children also seem to be more physically active in school free play than during PE lessons (Sleap and Warburton, 1996), and more physically active outdoors compared with indoors (Gray et al., 2015). Unstructured free play during recess has been shown to contribute 5–40% of recommended daily PA (Ridgers et al., 2006), indicating that some schools might have a large PA promoting potential through simple, low-cost strategies.

Designing outdoor play areas that stimulate as many pupils as possible to be physically active is, however, a multifaceted process. For example, studies indicate that girls and boys use different areas of their school's outdoor play area (SOPA) when being physically active (Fjørtoft et al., 2009; Anthamatten et al., 2014), that PA levels are higher in areas with a naturalistic feel (Fjørtoft, 2004) and that colorful playground markings can increase recess PA (Blaes et al., 2013). Both the size of SOPA and the availability of permanent play facilities (PPF) are basic components of a schoolyard design, and studies indicate that both factors may be important to stimulate PA (D'Haese et al., 2013; Escalante et al., 2012; Nielsen et al., 2010). However, previous research is limited by the use of subjective measures of PA and small sample sizes (Haug et al., 2010; Ridgers et al., 2010b). Furthermore, studies investigating the association between the size and PPF content of SOPA with time spent sedentary among children and adolescents are limited. Even though debated, studies have indicated that sedentary time

Abbreviations: PA, Physical activity; PE, Physical education; CPM, Counts per minute; LPA, Light physical activity; MVPA, Moderate-to-vigorous physical activity; SES, Socioeconomic status; CI, Confidence interval; BMI, Body mass index; SOPA, School's outdoor play area(s); PPFs, Permanent play facilities.

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might pose a negative effect on cardiovascular risk factors already at a young age (Healy and Owen, 2010). Therefore, further research is necessary to identify the importance of the size and PPF content of SOPA for both PA and sedentary time.

Therefore, the aim of this study was to assess the associations between: 1) number of permanent play facilities and 2) the size of the outdoor play area with objectively measured sedentary time and physical activity during school hours in a representative sample of pupils from Norwegian schools.

2. Materials and methods

2.1. Participants

The participants in this cross-sectional study, the Physical Activity Among Norwegian Children Study, were nationally representative samples of six-, nine- and 15-year-olds. Statistics Norway randomly selected the cohort using cluster sampling, with school as the primary unit. When a school agreed to participate, we invited all pupils in first, fourth or tenth grade to participate. In total, 5757 pupils from 107 schools were invited. We obtained written informed consent from 3598 participants and their primary guardians, yielding participation rates of 56.4%, 73.1% and 57.8% for six-, nine- and 15-year-olds, respectively. The Regional Committee for Medical Research Ethics and the Norwegian Social Science Data Services reviewed and approved the study. We conducted the study according to the Helsinki declaration.

2.2. Anthropometrics

We measured weight and height to the nearest 0.1 kg (Seca 877, SECA GmbH, Hamburg, Germany) and 0.1 cm (wall-mounted measuring tape), respectively, while the participants wore light clothing and no shoes. Body mass index (BMI) was calculated as kg/m^2.

2.3. Physical activity

We measured PA using ActiGraph accelerometers (models GT1M and GT3X+; ActiGraph, LLC, Pensacola, Florida, USA). Children's free-living PA measured with ActiGraph accelerometers has previously been shown to correlate moderately well with activity energy expenditure measured by doubly labeled water ($r = 0.66$, $p < 0.001$) (Ekelund et al., 2001). The participants were fitted with the accelerometers on their right hip during school visits, and instructed to wear the monitor during all waking hours for seven consecutive days, except during showering and bathing. Using the Actilife software (ActiGraph, LLC, Pensacola, Florida, USA), we initialized the accelerometers to sample vertical accelerations (30 Hz), and to start recording at 06:00 on the day after the monitors were attached in order to eliminate reactivity-bias (Dossegger et al., 2014). We used KineSoft (KineSoft Software, Rothesay, New Brunswick, Canada) to analyze the accelerometer files.

An epoch length of 10 s was used, which has been deemed suitable for children (McClain et al., 2008). We defined non-wear as intervals ≥20 consecutive minutes with no activity recordings, and wear time by subtracting non-wear from school hours. In Norway, school normally starts between 8:00 and 9:00 and ends between 13:00 and 14:45, depending on school and grade. To ensure that we only included school hours, we defined schooldays as 9:00–13:00 for six- and nine-year-olds and 9:00–14:00 for 15-year-olds. These periods include morning-, lunch- and afternoon recess for all grades. We excluded all schooldays with ≥60 min of non-wear and included participants if they had accumulated ≥2 valid schooldays of accelerometer data. We collected all data from March to December in 2011 (no measures in July due to summer holidays). Measurements were evenly distributed across the school year, with the exception of August and December during which only 82 and 95 pupils were measured, respectively.

We used counts$\cdot$min^{-1} (CPM) as a measure of overall school PA. We calculated CPM by dividing the total number of school day counts by the total number of school day wear minutes. To investigate time spent sedentary, in PA of light intensity (LPA) and of moderate-to-vigorous intensity (MVPA), we used cut-points of <100 CPM (1–1.5 METs), 100–1999 CPM (1.6–2.9 METs) and ≥2000 CPM (≥3 METs), respectively (Andersen et al., 2006).

2.4. Play facilities/area size

During school visits, the research team registered the number of PPFs using a standardized form. Subsequently, we calculated the number of PPFs per pupil. To measure the size of SOPA we used a polygon measurement tool and updated electronic maps from the Norwegian Mapping Authority (finn.no, 2011). We calculated SOPA by subtracting areas of buildings, car parks and other areas with car traffic from the school's total outdoor area, and then calculated the SOPA per pupil. Others have used similar methods (Pagels et al., 2014; Ridgers et al., 2010a; Nilsen, 2014).

Through interviews with teachers, we received information on recess period organization potentially influencing the availability of space and play facilities (e.g. access to areas outside school property and sectioning of SOPA during recess).

2.5. Socioeconomic status

We used the highest education level of the participant's parents (data from Statistics Norway) as a proxy for socioeconomic status (SES) and computed four SES groups: low (primary school, lower secondary school, vocational high school), middle low (secondary school/high school), middle high (undergraduate degree) and high (graduate degree).

2.6. Sample size calculations

We based the sample size calculations on the ability to detect subgroup differences in CPM. With respect to this, 516 individuals in each age and sex group allowed us to detect subgroup differences of 7% using a two-tailed test ($1 - \beta = 0.90$; two-tailed $\alpha = 0.05$). Because of cluster sampling, we incorporated a design effect of 1.1, yielding a final target sample size of 567 individuals in each age and sex group.

2.7. Statistical analysis

We performed all statistical analyses using Stata 13.1 (StataCorp. 2013. Stata Statistical Software: TX: StataCorp LP.). We used independent samples *t*-test to investigate sex differences, and one-way ANOVA with Bonferroni corrections to assess differences between the three age groups. For our main analyses, we ran all the models separately for the different age groups. To account for cluster sampling, we used GLS-re models with robust variance estimation. Initially, we entered the interaction terms *sex ∗ number of PPFs* and *sex ∗ play area size*. The interaction terms were not statistically significant. Consequently, we did not stratify the main analyses by sex but rather included sex as a covariate.

We adjusted all analyses for accelerometer wear time (except analyses of CPM), measurement month, sex, and SES, and the dummy variables “access to areas outside school property”, “sectioning of play areas”, “recess at different time points for different classes” and “allowed to spend recess indoors”. We also adjusted for number of PPFs in analyses with the size of SOPA as the independent variable.

3. Results

Of the 3598 participants, 3040 from 99 schools met the inclusion criteria. Because of construction work, we did not get valid measurements in three schools ($n = 212$). The remainder of the excluded participants did not provide valid PA measurements (n = 346). Table 1 displays descriptive characteristics of the study sample. Participants meeting the inclusion criteria were similar to those who did not in terms of age and BMI. However, a higher proportion of the excluded six- and nine-year-old participants were categorized in the two lowest SES categories. In general, there were only small differences in BMI and SES between boys and girls within the age groups.

3.1. Physical activity

The participants provided 4.2 ± 0.9 valid school days of PA measurements (mean ± SD). Table 2 displays the participants' school day PA and sedentary time. School day PA and sedentary time were significantly different between all the age groups ($p < 0.001$) and significantly different between girls and boys within the age groups ($p < 0.001$). For the six-, nine- and 15-year-olds, the mean ± SD proportions of weekday time spent sedentary accumulated during school hours were 31 ± 5%, 31 ± 5% and 38 ± 7%, respectively. The mean ± SD proportions of weekday MVPA accumulated during school hours were 36 ± 8%, 35 ± 10% and 36 ± 15%, respectively.

3.2. Permanent play facilities

We registered >50 unique PPFs across the participating schools. Swings (94.5%), climbing frames (87.9%), soccer goals (85.5%) and sand boxes (79.5%) were the most common permanent play facilities in primary schools. The most common permanent play facilities in lower secondary schools were basketball hoops (85.3%), soccer goals (79.0%) and beach volleyball nets (33.5%). The absolute number of PPFs and the number of PPFs per pupil in primary schools were significantly higher than in lower secondary schools ($p < 0.001$) (Table 3).

The participants' overall PA and time spent in MVPA were not associated with the number of PPFs per pupil. Among six-year-olds, however, there was a significant negative association between the number of PPFs per pupil and time spent sedentary and a significant positive association between the number of PPFs per pupil and time spent in LPA. These associations translate to daily changes in time spent sedentary and in LPA of −3.8 and 2.2 min, respectively, if the number of PPFs per pupil increased from 0.1 to 0.2 (Table 4).

3.3. Outdoor play area size

The size of SOPA per pupil in primary schools was significantly larger than in lower secondary schools ($p < 0.001$) (Table 3). For the six- and nine-year-olds, we did not find an association between the size of SOPA per pupil and overall PA, LPA, MVPA or time spent sedentary. Among the 15-year-olds, we found the size of SOPA per pupil to be positively associated with LPA and negatively associated with MVPA (Table 5). These associations translate to an increase in LPA of 0.9 min/d and a decrease in MVPA of 0.4 min/d if the size of SOPA increased by 10m^2 per pupil.

4. Discussion

The results from the present study suggest a weak association between outdoor PPF availability, time spent sedentary and time spent in LPA among six-year-olds. An increase in the number of PPFs from 0.1 to 0.2 per pupil, which equates to a doubling of PPF in an average Norwegian primary school, was associated with 3.1% less sedentary time and 2.5% more time spent in LPA during school hours. However, since the influence of PPF on sedentary time and PA is mainly restricted to recess, these weak, although statistically significant, associations may not be negligible. Primary and lower secondary schools in Norway provide approximately 60 min/day of recess (10–15 min of morning recess, 30–40 min of lunch recess and 10–15 min of afternoon recess). Although speculative, if the observed associations were in fact restricted to recess, they would translate to ~6.3% less sedentary time and ~3.6% more LPA. However, we did not observe any associations between sedentary time and PA with PPF in nine-year-olds. This may be explained by differences between age groups in time spent outdoors during school hours. In the Norwegian school system part of the taught classes in the first grade are outdoor classes, possibly contributing differences in observed associations.

Studies investigating the isolated association between PPF provision and objectively measured sedentary time in children are limited. Results from Ridgers et al. (2010a, 2010b) support our finding that PPF provision is negatively associated with sedentary time during school hours (Ridgers et al., 2010a). In their study, children without access to fixed equipment during recess engaged in 8.2% more sedentary activity than children provided with fixed equipment.

We did not find PPF provision to be associated with overall PA or MVPA in children. This is supported by two studies conducted in Australia, where no association between equipment availability (other than balls) and MVPA (Zask et al., 2001) or energy expenditure (Harten et al., 2008) was observed. In contrast, Ridgers et al. (2010a, 2010b) suggested a positive association between PPF provision and MVPA (Ridgers et al., 2010a). The latter is also supported by three other cross-sectional studies that used accelerometers to assess PA (Nielsen et al., 2010, 2012; Taylor et al., 2011). However, the strength of the associations reported in these studies varied considerably (Nielsen et al., 2010; Taylor et al., 2011). Consequently, studies differ in their conclusions with regard to the actual importance of PPF provision for children's PA during school hours.

Contradictory results may reflect actual differences in the everyday life of children in different study populations, e.g. due to different school policies regarding PA. However, in three of the studies reporting an

Table 1
Characteristics of the study sample in the Physical Activity Among Norwegian Children Study (2011) by age and sex (n = 3040).

	6-year-olds		9-year-olds		15-year-olds	
	Girls	Boys	Girls	Boys	Girls	Boys
n	489	479	663	625	393	391
Age (yrs.)[a]	6.6 (0.4)	6.6 (0.4)	9.6 (0.4)	9.6 (0.4)	15.1 (0.6)	15.1 (0.6)
Height (cm)[a]	121.0 (5.5)[c]	122.2 (5.8)	138.0 (6.5)	138.7 (6.8)	164.7 (6.4)[c]	172.9 (8.0)
Weight (kg)[a,b]	23.8 (4.2)	24.0 (3.8)	33.7 (6.8)	33.9 (6.9)	57.1 (9.4)[c]	62.0 (12.0)
BMI (kg/m^2)[a]	16.2 (1.9)	16.0 (1.6)	17.6 (2.7)	17.5 (2.7)	21.1 (3.1)	20.7 (3.3)
Parents' educ. level (%)						
Low	7.5	6.8	10.8	9.0	10.9	12.7
Middle low	30.8	31.7	31.1	36.3	33.1	35.4
Middle high	45.8	45.7	43.0	40.7	39.1	37.7
High	15.8	15.9	15.0	14.0	16.9	14.3

BMI = body mass index; educ. = education.
[a] Mean (standard deviation).
[b] The weight was corrected by −0.3 kg for all participants to account for clothes.
[c] Significantly different from boys within age group (all p-values ≤ 0.001).

Table 2
Mean (SD) physical activity and minutes of time spent sedentary among Norwegian children and adolescents during school hours.[a]

	6-year-olds		9-year-olds		15-year-olds	
	Girls	Boys	Girls	Boys	Girls	Boys
n	489	479	663	625	393	391
Overall PA (CPM)[b]	765 ± 211[c,e]	845 ± 227[c]	607 ± 183[d,e]	750 ± 206[d]	358 ± 138[e]	475 ± 173
Sedentary (min/d)[b]	127 ± 18[c,e]	118 ± 20[c]	150 ± 23[d,e]	137 ± 23[d]	237 ± 36[e]	214 ± 29
LPA (min/d)[b]	85 ± 14[c,e]	88 ± 13[c]	71 ± 14[d,e]	76 ± 15[d]	56 ± 16[e]	69 ± 18
MVPA (min/d)[b]	31 ± 9[c,e]	37 ± 11[c]	26 ± 9[d,e]	34 ± 11[d]	20 ± 10[e]	26 ± 11

PA = physical activity; CPM = counts per minute; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity.
[a] 9 AM to 1 PM for six- and nine-year-olds, 9 AM to 2 PM for 15-year-olds.
[b] Mean ± standard deviation.
[c] Significantly different from nine- and 15-year-olds ($p < 0.001$).
[d] Significantly different from 15-year-olds ($p < 0.001$).
[e] Significantly different from boys in the same age group ($p \leq 0.045$).

association, only PPFs that had previously been observed to be used for play and/or sports activities during break-time were counted. In addition, PPFs that facilitated active play for several small groups of children at the same time were counted as more than one item (Nielsen et al., 2010, 2012; Taylor et al., 2011). This might have given a more detailed and realistic picture on PPF accessibility than in the present study, where we counted all individual play structures as one item. It is therefore possible that the associations between PPF provision, sedentary time and LPA found in the present study are underestimated. One could argue that a doubling of the sheer number of PPF (from ~22 to ~44 in an average Norwegian primary school) is neither realistic nor practical when we consider the relatively modest associations observed in the present study. However, investing in PPFs that promote PA for many children at the same time might both be realistic and practical. Further research is therefore needed to identify what sort of PPF increases PA-levels the most.

Although a few experimental studies have investigated the isolated effect of altering PPF availability (Ickes et al., 2013; Parrish et al., 2013; van Sluijs et al., 2007; Ridgers et al., 2010b), we are only aware of one such study with a long term follow-up. In this study, Ridgers et al. (2007) investigated the effect of redesigning the playground environment in elementary schools on MVPA and vigorous PA (VPA) during recess (Ridgers et al., 2007). Results demonstrated significant intervention effects after 6 weeks and 6 months (Ridgers et al., 2007), but at 12 months, the only significant intervention effect that remained was higher VPA during lunch recess (Ridgers et al., 2010b). This might indicate a novelty effect of the intervention and, furthermore, that regular changes in the outdoor playing environment might be necessary in future interventions to increase PA in the long term.

Using questionnaires to assess PA, Haug et al. (2010) investigated the association between characteristics of the outdoor school environment and PA in a nationally representative sample of Norwegian 13–15 year olds. They found that adolescents with access to the maximum number of play facilities had almost three times higher odds of being physically active during recess than adolescents attending schools not providing play facilities. Although comparability is limited because of the different methods used to assess both PA and play facilities, this is in contrast to our findings. We are not aware of studies that have investigated the association between objectively measured PA or sedentary time and PPF availability in adolescents.

Few cross-sectional studies have investigated the association between the size of SOPA and objectively measured PA in children, and the results are equivocal. Two studies conducted by Nielsen et al. (2010, 2012) support our findings of no association. On the other hand, five studies report positive associations between the size of SOPA and MVPA during recess (Sallis et al., 2001; Harten et al., 2008; Ridgers et al., 2010a; D'Haese et al., 2013; Escalante et al., 2012). Furthermore, interventional studies indicate a positive effect of increasing the size of SOPA per pupil on PA during recess (Loucaides et al., 2009; D'Haese et al., 2013; Harten et al., 2008). Although small sample sizes and short follow-up limit the generalizability of these studies, they contrast with our findings.

One possible reason for the differing results might be due to the actual size of SOPA. In the present study, and in the studies by Nielsen et al., the size of SOPA per pupil was much larger than in the other studies. In PANCS2, only four of the 60 participating primary schools provided < 15 m^2 of outdoor play space per pupil, while none of the 18 schools in the study by Nielsen et al. (2012) conducted on Danish children provided <77 m^2 per pupil. In comparison, none of the 11 participating schools in the two studies by Ridgers et al. (2010a) and D'Haese et al. (2013) provided >16.9 m^2 per pupil. It is therefore likely that smaller

Table 3
Permanent play facility provision and the size school's outdoor play area in schools participating in the Physical Activity Among Norwegian Children Study in 2011 (n = 99).

	6-year-olds	9-year-olds	15-year-olds
Permanent play facilities[a]	22.2 ± 7.5	21.7 ± 7.8	10.9 ± 7.1[b]
Per pupil[a]	0.095 ± 0.055	0.093 ± 0.058	0.037 ± 0.033[b]
SOPA (m^2)[a]	15,249 ± 7958	15,128 ± 8018	14,428 ± 7279
Per pupil (m^2)[a]	65.6 ± 45.2	62.9 ± 43.0	49.9 ± 35.7[b]

SOPA = school's outdoor play area.
[a] Mean ± standard deviation.
[b] Significantly different from 6- and 9-year-olds ($p < 0.001$).

Table 4
Associations between permanent play facility provision, physical activity and sedentary time among Norwegian children and adolescents in 2011 (n = 2588).[a]

	Age	n pupils (n schools)	B[b,c]	95% CI
Overall PA (CPM)	6	837 (55)	19.91	−26.09, 65.90
Sedentary (minutes)	6	837 (55)	−3.78*	−7.28, −0.28
LPA (minutes)	6	837 (55)	2.16**	0.53, 3.79
MVPA (minutes)	6	837 (55)	1.67	−0.55, 3.89
Overall PA (CPM)	9	1126 (55)	7.35	−36.65, 51.35
Sedentary (minutes)	9	1126 (55)	−1.92	−6.23, 2.39
LPA (minutes)	9	1126 (55)	1.93	−0.36, 4.22
MVPA (minutes)	9	1126 (55)	0.04	−2.52, 2.59
Overall PA (CPM)	15	625 (36)	−25.08	−94.74, 44.57
Sedentary (minutes)	15	625 (36)	0.17	−7.29, 7.64
LPA (minutes)	15	625 (55)	0.77	−4.08, 5.61
MVPA (minutes)	15	625 (36)	−0.90	−5.95, 4.14

PA = physical activity; CPM = counts per minute; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity.
* $p = 0.034$.
** $p = 0.009$.
[a] Data on one or more of the covariates in the statistical models were missing for 452 of the 3040 participants that met the inclusion criteria, therefor the results from the analyses are based on a total of 2588 participants.
[b] Beta values represent daily change associated with increasing the number of permanent play facilities per pupil by 0.1.
[c] Analyses adjusted for: accelerometer wear time (except analyses of CPM); measurement month; socioeconomic status; the dummy variables "access to areas outside school property during recess", "sectioning of the play area during recess", "recess at different time points for different classes" and "allowed to spend recess indoors".

Table 5
Associations between the size of school's outdoor play area, physical activity and sedentary time among Norwegian children and adolescents in 2011 (n = 2588)[a].

	Age	n pupils (n schools)	B[b,c]	95% CI
Overall PA (cpm)	6	837 (55)	3.43	−3.80, 10.67
Sedentary (minutes)	6	837 (55)	−0.01	−0.54, 0.52
LPA (minutes)	6	837 (55)	−0.02	−0.38, 0.33
MVPA (minutes)	6	837 (55)	0.03	−0.24, 0.29
Overall PA (minutes)	9	1126 (55)	2.40	−4.07, 8.88
Sedentary (minutes)	9	1126 (55)	0.08	−0.75, 0.59
LPA (minutes)	9	1126 (55)	0.06	−0.36, 0.47
MVPA (minutes)	9	1126 (55)	0.03	−0.32, 0.39
Overall PA (cpm)	15	625 (36)	−2.0	−3.39, 3.40
Sedentary (minutes)	15	625 (36)	−0.47	−1.26, 0.32
LPA (minutes)	15	625 (36)	0.86*	0.21, 1.50
MVPA (minutes)	15	625 (36)	−0.41**	−0.77, −0.05

PA = physical activity; CPM = counts per minute; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity.
* p = 0.009.
** p = 0.027.
[a] Data on one or more of the covariates in the statistical models were missing for 452 of the 3040 participants that met the inclusion criteria, therefor the results from the analyses are based on a total of 2588 participants.
[b] Beta values represent daily change associated with increasing outdoor play area size by 10 m^2.
[c] Analysis adjusted for: accelerometer wear time (except analyses of CPM); measurement month; socioeconomic status; number of permanent play facilities; the dummy variables "access to areas outside school property during recess", "sectioning of the play area during recess", "recess at different time points for different classes" and "allowed to spend recess indoors".

outdoor play areas might inhibit the PA level of children, but that most Norwegian schools provide children with sufficient outdoor play space to be physically active. Explorative analyses of the third of schools (n = 16) providing the least play space per pupil in the present study (4–40 m^2) did however indicate a positive association between play space and MVPA among nine-year-olds (data not shown). Further research on a larger sample of schools with smaller outdoor play areas (e.g. <40m^2) could be useful for developing general recommendations on the minimum outdoor play space per pupil that should be provided with regard to PA.

Discrepancy in results between studies could also be due to differences in methods used to measure PA. In our study, and in the studies by Nielsen et al. (2010, 2012), PA was measured objectively and continuously for several days. The other studies measured PA levels during recess only (D'Haese et al., 2013; Escalante et al., 2012; Harten et al., 2008; Ridgers et al., 2010a; Sallis et al., 2001). Isolating the PA measurements to recess could be more sensitive and therefore enable the detection of smaller differences in PA. However, if children are aware of the PA-monitoring, either as consequence of being observed (Ridgers et al., 2010a; Sallis et al., 2001) or being equipped with a PA monitor just before recess (D'Haese et al., 2013; Escalante et al., 2012; Harten et al., 2008), they might alter their normal recess behavior (Dossegger et al., 2014). Thus, a Hawthorne effect cannot be excluded (McCambridge et al., 2014).

Although the size of SOPA was negatively associated with MVPA and positively associated with LPA among 15-year-olds, these associations were weak and likely not clinically meaningful. When we also take into consideration that only five of the 44 included lower secondary schools provided ≤20 m^2 of outdoor play area per pupil, we could expect that the size of SOPA does not seem to be a limiting factor for PA among the 15-year-olds.

4.1. Study limitations and strengths

A major strength of the present study is the large, nationally representative sample of children and adolescents. Another strength is the objective and continuous measure of PA over multiple days. Because of known difficulties with accurately recalling details about PA, especially among children (Sallis and Saelens, 2000), objective measurement with accelerometers is considered the best option in large scale studies (Westerterp, 2009). Lastly, the high number of participants from a large number of schools allowed us to include several covariates in the statistical models.

This study also has some important limitations. First, this is a cross-sectional study, and we can therefore not make inferences about cause and effect. Second, because several schools did not provide us with class schedules, we were not able to use isolated recess PA/sedentary time in the analyses, or to control for PE. However, we used analyses that partly account for nesting effects within schools, and we do not have any indications that recess or PE durations were not randomly distributed between schools. Third, we did not consider the use and quality of the PPFs. Therefore, it is unknown how many pupils actually used the different play facilities, or how much PA they could potentially generate. Fourth, because we used vertical accelerations of the hip to assess PA, it is likely that the intensity (energy expenditure) of PA involving substantial upper-body movements, such as climbing, was underestimated (Lee and Shiroma, 2013). Lastly, we do acknowledge that landscape features, such as areas with a naturalistic feel and areas with different surfaces, may influence the PA level of children (Anthamatten et al., 2014; Fjørtoft, 2004). Because of the risk of overfitting the regression models, we chose not to adjust for this. Additional explorative analyses using soft surface area, asphalt area or treetop-covered area as the dependent variable in the model did not change the observed results.

5. Conclusions

Our results indicate that increasing the sheer number of PPFs in SOPA may be beneficial to reduce sedentary time and increase time spent in LPA among six-year-olds, but not among nine- and 15-year-olds. In order to recommend cost-effective changes to SOPA, there is a need to identify what types of PPFs that increase PA-levels the most, especially in adolescents. The size of SOPA did not seem to be a limiting factor for PA in the present study. This may be explained by the large outdoor areas generally observed in Norwegian schools.

Conflicts of interest statement

The authors declare that there are no conflicts of interest.

Transparency document

The Transparency document associated with this article can be found, in online version.

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