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Schoolyard upgrade in a randomized controlled study design—how are school interventions associated with adolescents' perception of opportunities and recess physical activity

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Abstract

School recess physical activity is important for adolescent s health and development, and several studies have established evidence based on cross-sectional studies that it is influenced by the environment in the schoolyard. The aim of this study was to investigate the effect and variation across schools of a school-based intervention on students perceived opportunities for physical activity in the schoolyard, and to evaluate if an improved collective perception of opportunities was followed by an increase in PA during recess for the 13–15 year-old students. The intervention components included schoolyard renovation; mandatory outdoor recess; and increased adult supervision and support. Students collective perceptions were evaluated by a newly developed Schoolyard index (SYi) with seven items, and physical activity was objectively measured with accelerometer. We found variations in the change of student perceptions across the intervention schools, and that a one unit increase in the Schoolyard index (SYi) led to a 12% increase in recess PA. This study shows that adolescent PA during recess can be increased through a multicomponent intervention. The prospect for making an impact is low and according to the process analysis dependent on direct involvement; active and supportive adults; and varied, connected and well located facilities.

Introduction

Scientific evidence supports the overall conclusion that regular physical activity (PA) provides fundamental health benefits for adolescents [1]. Despite the benefits of PA, 80% of adolescents do not meet the recommended 60 min of daily moderate to vigorous PA (MVPA), with significant consequences for current and future health [2–4]. Schools represent a suitable setting for intervention programs aiming to promote PA due to (i) an almost all-embracing reach to all adolescents, (ii) the large proportion of time they spent at school and (iii) the school staff's subject knowledge of physical (PE) and health education curriculum [5, 6].

In Denmark, the primary and lower secondary education are combined and include classes from Year 0 to Year 9 (6–16 years). All year levels have usually the same school recess, but duration varies between schools. Typically students have at least a 15- to 30-min morning break and a 15- to 30-min break after lunch. Recess is supervised by teachers, but generally, the content is characterized by

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student's self-imposed activities. School recess provides an important contribution to the overall level of PA among students [7, 8], but the activity level decreases as the students grow older [8, 9]. Internationally, school recess has been found to contribute between 5 and 40% of student's (6–12 years) daily recommended MVPA [10], and evidence based on cross-sectional studies suggests that provision of facilities, access to unfixed equipment and social support can enhance PA during recess [11]. However, the evidence from intervention studies on recess PA is limited [12], and more causal evidence would strengthen the impact of research to promote recess PA. This is particularly relevant to adolescents due to the lack of school recess research in relation to this population [12, 13].

The majority of school-based PA intervention studies have focused on overall intervention effects, but few studies have use process evaluation to examine the mechanism of change and differential effects for subgroups [14, 15]. In this perspective, we find it important to explore how a structural intervention impacts students' perceived possibilities for PA; and whether a given impact leads to relative increase in recess PA for all children.

The aim of this study was therefore 4-fold: to investigate the effect of a school-based intervention on students' perceived opportunities for PA in the schoolyard; to quantify the variation of this perception across schools; to evaluate if an improved perception was followed by an increase in PA during recess for the 13- to 15-year-old students; and finally if a given increase was moderated by students characteristic.

Materials and methods

Study design, setting and participants

We used data from the Danish *SPACE for physical activity* study, a multicomponent school-based intervention study aimed at improving PA levels among adolescents [9, 16]. The SPACE study used a randomized controlled study design, with seven intervention schools and seven comparison schools. A total of 1348 adolescents from fifth and sixth grade (aged 11–14 years) were enrolled. Further information on the enrolment procedure and the study design has been described in detail elsewhere [16]. The Danish National Committee on Health Research Ethics reviewed the study protocol and concluded that formal ethical approval was not required. The study was registered and listed in the Danish Data Protection Agency (reference number: 2009-41-3628) and registered in The Current Controlled Trials (ISRCTN79122411, http://www.controlled-trials.com/ISRCTN79122411, Accessed: 3 January 2017). Students and parents were informed of the nature and procedure of the study before data collection. It was emphasized that participation was voluntary, that participants could withdraw consent at any time and that all data were confidential and treated anonymous.

Intervention and implementation

The intervention consisted of 11 components targeting the physical and organizational environment at the schools in three main areas: (i) after school fitness program, (ii) active school transport and (iii) recess PA. The intervention components targeting

Fig. 1. Examples of the physical environment changes and the provision of unfixed equipment from three of the seven intervention schools.

after school fitness and active transport were limited in implementation, but all schools implemented the components targeting recess PA. The physical environment changes targeting recess PA included two components: a general upgrade of existing outdoor areas at the school for PA, including establishing access to unfixed equipment, making playground markings, establishing areas for ballgames and possibilities for outdoor loudspeakers (costing €10 000–30 000) and a specially designed playground for adolescents—named 'Playspot' (costing €50 000–250 000) (Fig. 1). While the general upgrade was managed by the schools with direct student involvement, the 'Playspots' were managed by architects, who incorporated expert knowledge and indirect student involvement (representatives of students) [17]. The functionalities varied between schools and included climbing, parkour, fitness and skate facilities. There were also enclosed ball game pitches, table tennis tables, large swings and loudspeakers at some schools. The organizational environment changes included education of teachers as 'recess kick-starters', to facilitate and motivate PA during recess, and a mandatory outdoor recess and/or access to gym/sports hall. Further details of the intervention components are described in the study design protocol [16]. The implementation of the intervention began in autumn 2010 and was finished in autumn 2011 (at least 6-month before follow-up).

Data collection

Baseline measurements were obtained in spring (April to June) 2010 among all students in grades 5 and 6, with follow-up measurements in spring 2012 (grade 7 and 8). PA was objectively measured among all students using accelerometers (Actigraph GT3X). The adolescents were instructed to wear the accelerometers all waking hours for seven consecutive days except when doing water activities. The accelerometers were downloaded using Actilife (Actigraph) and analysed by the software program Propero (University of Southern Denmark). Data were analysed using 30 s of epoch, and activity for all 24 h was included. Strings of 60 min or more of consecutive zeroes, allowing for two epoch periods of non-zero interruptions, were interpreted to represent non-wear time and were excluded from each individual recording [18].

Information on school timetables and periods of recess with exact bell times was obtained from each of the participating schools and merged with the accelerometer data in Propero. The absolute minutes that the participants wore the accelerometer during recess and PA intensity using mean counts per minute (MCPM) were calculated. Adolescents with valid accelerometer data i.e. 60 min/week of activity recorded at both baseline and follow-up were included in this study ($n = 875$). Daily PA was defined by minutes of MVPA using the Evenson activity cut points (MVPA $\geq$ 2296 cpm) [19, 20].

Sex and age were obtained through school records. The adolescent's height and weight were objectively measured using standard anthropometric procedures. Overweight was defined using sex and age-specific body mass index cut points relative to 25 kg/m^2 for adults [21]. The student's perception of schoolyard opportunities for PA was obtained by seven questions presented in Table I. The means of the seven items for all students were aggregated at school level and constituted the Schoolyard index (SYi). These questions were developed specifically for the intervention study based on the programme theory and on prior research [22–25]. Furthermore, information about school well-being, and socioeconomic position using the Danish Occupational Social Class [26] was obtained in the student questionnaire. School well-being was based on the question: 'What do you think of your school at the moment?' and dichotomized into adolescents with the most positive category ('I really like it') and adolescents with the lesser positive statements ('It's ok; I don't like it; I don't like it at all; Don't know').

Process evaluation of the intervention was conducted by an external research partner consisting of an organizational, economic and user-perspective evaluation. The data collection for the process evaluation included interviews with selected leaders, teachers and students; observations of recess; and documentation of cost at all schools [27]. The

Table I. *Questions and answer options for the perception of schoolyard opportunities included in the SYi*

	What do you think of the outdoor areas at your school, which you have access to during recess?	Answer options and coding for each question (Likert scale)	
1	There are opportunities for many different activities		
2	They are fun and challenging/exiting	Totally agree	5
3	They are good for ballgames	Agree	2
4	There are plenty of space	Neither	3
5	There are many different places to hang out	Disagree	4
6	There is plenty of greenery, lawns, trees etc.	Totally disagree	5
7	There are good access to unfixed equipment, e.g. balls		

findings from the process evaluation are used to qualify the discussion.

Statistical analyses

Descriptive analyses at student-level of sociodemographic, physical and schoolyard variables were performed reporting mean and SD for quantitative variables and number of students (*N*) and percentage (%) for categorical variables. The descriptive variables were tested for difference using *t-test* and χ^2 test. At school level, the minimum and maximum school-level average was reported.

To examine the effect of the intervention on the seven schoolyard variables at each school, two analyses were conducted. The first analysis tested the difference between baseline and follow-up at each school using a two-sided *t-test*. Furthermore, the difference between baseline and follow-up was tested for the seven intervention schools and for the comparison schools, respectively. The second analysis tested the difference at follow-up between each intervention school and the seven comparison schools using *t-test*.

The reliability of the SYi was evaluated using Cronbach's alpha. The overall Cronbach's alpha was 0.909 and the average inter-item correlation for the each of the seven variables in the SYi at baseline ranged from 0.560 to 0.650. The effect of the change in SYi on recess PA was evaluated using multilevel linear regression, which accounted for clustering of students within schools. Recess MCPM at follow-up was used as the dependent variable and SYi at follow-up as independent variable (school level). Analyses were adjusted for differences in age, sex, minutes of recess measured, SYi at baseline and recess MCPM at baseline. Residual plots were conducted to evaluate the normal distribution of the model's residuals. Effect modification of the association between SYi and PA was explored by sex, parental social class, daily MVPA, school well-being and weight status. The interaction terms were evaluated individually in the multilevel model using a likelihood ratio test to determine significant improvement of model fit. Data were analysed by Stata/IC, version 14. A 5% significance level was used.

Results

Participants

A total of 1,348 students entered the study. Two years later, at follow-up, 13% ($n = 162$) had moved to another school, and 2% ($n = 27$) withdrew consent. A total of 875 adolescents (75%) were included in the analyses if they had at least 60 min/week of valid accelerometer data during recess at follow-up and filled out the questionnaire. Average time of accumulated accelerometer data during recess was 259.5 min in the intervention group (I) and 229.4 min in the comparison group (C) (Table II). There were no significant differences between any of the psychosocial or demographic variables. The average age at follow-up was 14.5 years; approximately half of the students (I: 52.5% and C: 48.4%; $P = 0.23$) were girls and one-third (I: 38.6% and C: 36.6%; $P = 0.39$) had highest rating of five categories on school well-being. A total of 11.0% and 13.3% of the students were defined as

Table II. *Descriptive analysis of variables at follow-up for intervention and comparison schools at student-level [mean and SD for quantitative variables and number of students (n) and percentage (%) for categorical variables] and at school level [range of school-level averages (minimum–maximum values)]*

	Student-level, mean (SD) or *n* (%)			School-level Min–max[a]	
	Type of school			Type of school	
	Intervention $n = 427$ students	Comparison $n = 448$ students	*P* value	Intervention $n = 7$ schools	Comparison $n = 7$ schools
Sociodemographic					
Age (years)	14.5 (0.6)	14.6 (0.6)	0.45	14.4–14.7	14.4–14.8
Gender (% girls)	52.5%	48.4%	0.23	41.8–61.7	39.8–58.2
School well-being (% in best category)	38.6%	36.6%	0.39	20.0–65.6	16.7–53.0
Social class (% in low social class)	23.2%	18.8%	0.11	15.6–31.4	7.3–50.0
Overweight (% overweight)	11.0%	13.3%	0.30	6.8–15.2	7.2–47.1
Physical activity					
Total PA (MVPA min/day)	44.8 (23.5)	49.9 (27.6)	0.003	34.5–54.6	40.5–74.0
Recess PA (MCPM)	714 (427)	642 (417)	0.01[b]	578–939	432–808
Recess time measured (minutes)	259.5 (113.9)	229.4 (77.9)	<0.001	173.8–333.7	201.8–254.1
Schoolyard					
Different activities (Likert scale)	3.85 (0.32)	3.52 (0.19)	<0.001	3.42–4.34	3.28–3.76
Fun and challenging (Likert scale)	3.24 (0.32)	3.07 (0.12)	<0.001	2.84–3.64	2.80–3.20
Good for ballgames (Likert scale)	3.97 (0.28)	3.98 (0.20)	0.53	3.63–4.42	3.30–4.22
Plenty of space (Likert scale)	3.97 (0.26)	4.00 (0.19)	0.02	3.66–4.41	3.56–4.23
Hang-out places (Likert scale)	3.93 (0.16)	3.86 (0.18)	<0.001	3.70–4.16	3.50–4.07
Greenery (Likert scale)	3.90 (0.23)	3.99 (0.36)	<0.001	3.58–4.26	3.59–4.32
Unfixed equipment (Likert scale)	3.45 (0.53)	2.83 (0.32)	<0.001	2.70–4.18	2.54–3.43

P values for test of unadjusted significant differences between intervention and comparison schools using the *t-test* or the χ^2-test.
[a]Minimum and maximum school-level average.
[b]The difference in recess PA was also detected at baseline.

overweight for intervention and comparison groups, respectively (Table II). The students at the comparison schools accumulated significant more minutes of daily MVPA (I: 49.9 min and C: 44.8 min, $P = 0.003$), but the students at the intervention schools were significant more physically active during recess in the crude analysis (I: 714 MCPM and C: 642 MCPM, $P < 0.001$) (Table II). The difference in recess PA between intervention and comparison schools was however also present at baseline, and the decrease in recess PA after 2 years was 331 MCPM in average for all schools (data not shown).

School-level differences

For the seven variables assessing schoolyard opportunities for PA aggregated to school level, the highest overall ratings at follow-up were observed for *plenty of space*, *greenery* and *good for ballgames* (3.90–4.00). The lowest rating was observed for *unfixed equipment* at the comparison schools at 2.83. There was a significantly higher rating for four variables at the intervention schools: *different activities, fun and challenging, hang-out places* and *unfixed equipment* and a significantly higher rating for two variables at the comparison schools: *greenery and plenty of space.* Furthermore, there were large differences between schools especially between the intervention schools. The largest range between school ratings was observed for *access to unfixed equipment* at the intervention schools (range from 2.70 to 4.18) (Table II).

To further investigate the effect of the intervention on students' perception of schoolyard opportunities, we compared the results from baseline and follow-up

Table III. *Differences between baseline (T1) and follow-up (T2) for the individual intervention schools (S1–S7), for all intervention schools (Int) and for all comparison schools (Com). Furthermore, differences between each individual intervention school and the seven comparison schools at follow-up (Ix-Com). T1–T2: test for difference between baseline and follow-up*

	Intervention schools															
	S1 (n = 67)		S2 (n = 88)		S3 (n = 50)		S4 (n = 72)		S5 (n = 34)		S6 (n = 51)		S7 (n = 64)		{c1}T1–T2	
Schoolyard variables	T1-T2	Ix-Com	T1-T2	Ix-Com	T1-T2	Ix-Com	T1-T2	Ix-Com	T1-T2	Ix-Com	T1-T2	Ix-Com	T1-T2	Ix-Com	Int	Com
Different activities	NS	NS	NS	NS	+	+	NS	NS	NS	NS	+	+	NS	+	+	÷
Fun and challenging	NS	NS	÷	÷	NS	+	NS	NS	NS	NS	+	+	÷	+	÷	÷
Good for ballgames	÷	÷	÷	÷	NS	NS	NS	NS	NS	NS	NS	+	NS	+	÷	÷
Plenty of space	÷	÷	÷	NS	NS	NS	÷	÷	NS	NS	NS	+	NS	+	÷	÷
Hang-out places	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	+	NS	+	NS	÷
Greenery	÷	÷	NS	NS	÷	÷	NS	NS	NS	÷	NS	+	NS	NS	÷	÷
Unfixed equipment	+	+	NS	NS	+	+	NS	NS	+	+	+	+	+	+	+	÷
SYi	−0.42		−0.74		0.94		−0.40		−0.06		1.41		1.47		−0.19	0.20
Construction cost(1000 ?)	150 + 10		130 + 15		240 + 30		50 + 15		250 + 10		170 + 20		50 + 25			

Ix-Com: test for difference at follow-up between the individual intervention school and the seven comparison schools. Construction cost: the cost of the Playspot and of the general upgrade of the physical environment. NS: Non-significant difference. +: Significant increase or difference in favour of the intervention schools. ÷: Significant decrease or difference in favour of the comparison schools.

for each individual school (T1–T2, Table III). Out of the seven variables at the seven intervention schools (49 tests), eight tests showed a significant increase from baseline to follow-up and nine tests showed a significant decrease. Furthermore, we analysed whether the students at each intervention school assessed the schoolyard more positive compared with the seven comparison schools at follow-up (Ix-Com, Table III). In this analysis (49 tests), 17 tests showed significant higher values at the intervention schools compared with the comparison schools, and seven tests showed significant lower values at the intervention schools compared with the comparison schools.

For the total group of comparison schools, all seven variables decreased significantly at follow-up compared with baseline, and for the intervention schools, there was an increase in two variables (*different activities and access to unfixed equipment*) and a status quo for one variable (*hang-out places*) (Table III, right columns). This positive development was largely driven by the change at the three top rating schools, and for unfixed equipment it was additionally supported by two more schools (S1 and S5). The cumulative SYi was above average for only three of the schools at follow-up (S3, S6 and S7).The variation in construction cost is presented in the last row (Table III).

Schoolyard perception and PA

The results of the multivariable regression with recess PA as outcome at follow-up are shown in Table IV. The effect of sex (boys) was very strong at 335 MCPM ($P < 0.001$), and additionally there was a significant negative association with age (-47, $P = 0.012$). As the model was adjusted for baseline recess PA and baseline SYi, the effects of SYi can be interpreted as a causal effect. An one-unit increase in the SYi is associated with an increase in recess PA on 81 MCPM or 12% in relation to the crude average at 677 MCPM.

To investigate if an intervention effect on recess PA could be ascribed to the increase in SYi, we conducted two additional models. When the SYi variable was replaced by the intervention variable, the intervention schools had 73 MCPM higher

Table IV. *Multivariable regression between objectively measured PA during recess at follow-up and individual and school level variables*

	Physical activity mean counts per minute (MCPM)[a] ($n = 875$)		
	Coefficient	CI	Significance
Individual level			
Constant	312	216 to 409	<0.001
Gender (boys)	335	284 to 386	<0.001
Age (years)	−47	−83 to − 10	0.012
School level			
School Yard Index (SYi) (1 unit)	81	19 to 142	0.010

[a]Adjusted for age, gender, measured time, baseline recess PA, baseline SYi and school random effect.

recess PA. When both SYi and the intervention variable were in the model, the effect of the intervention diminished to -3 MCPM and the effect of the SYi was 82 MCPM (data not shown).

Finally, we investigated if there were differential effects of the SYi between five subgroups defined by sex (boys versus girls), social class (low social class versus higher social classes), weight status (overweight versus normal weight), school well-being (high school well-being versus lower school well-being) and total PA (25% least physically active versus the 75% most physically active). High levels of school well-being; being a boy and being in the group of the 75% most physically active was associated with more recess PA. For weight status and school well-being there was a tendency towards interaction effect with a *P* values in the likelihood-ratio test at 0.137 and 0.099, respectively. The linear predictions of the two models are presented in Figs 2 and 3, illustrating that the overweight students and the students with lower school well-being had a steeper inclination and thus were more affected by the environment, but the two curves have very large confidence intervals.

Discussion

This study investigated the intervention effect on students' perception of the opportunities for PA in the schoolyard, and whether an improved collective perception led to an increase in PA during recess. Two of the seven variables assessing schoolyard opportunities increased significantly after the intervention (*different activities and access to unfixed equipment)*, and the aggregated SYi increased on three out of seven schools. We found a profound diversity in student collective perceptions of the schoolyard across the seven intervention schools, and that an one-unit increase in the SYi led to a 12% increase in recess PA. We found no significant differential effects across the five subgroups (gender; social class; weight status; school well-being and total PA), but there was a tendency that the overweight students and students with lower school well-being had an additional positive effect of a higher SYi.

Implementation of intervention components

The intervention affected the students' perception of the possibilities for PA different across the seven intervention schools. Compared with the effort and cost of the intervention, it was surprising that only three out of seven schools obtained better perceptions of opportunities. From the externally conducted process evaluation, three elements seemed to be important for successful schoolyard renovation: (i) direct involvement of the students and careful consideration of their need and wishes; (ii) location of facilities in close proximity to the class room or existing activity spaces and (iii) number and diversity of facilities including opportunities that does not demand specialized movement skills [27].

Ad (1): The physical upgrade of the schoolyards was split in two as described in the Materials and methods section: a general upgrade of the existing facilities and a special designed playground for the adolescent target group. There were differences in economic cost of the seven schoolyard improvements, but neither the expert knowledge used to create the designed 'Playspot' nor the cost seems directly associated with the students' collective perceptions. There can exist an incongruence between adult conception of the optimal playscape and the

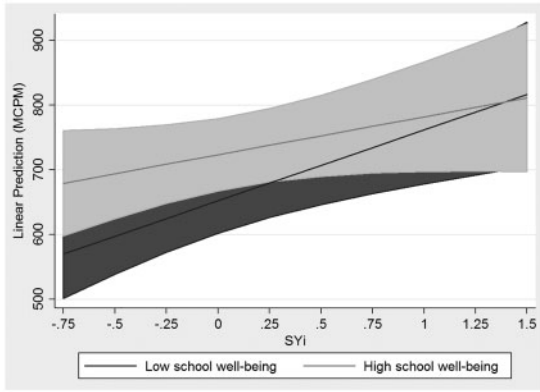

Fig. 2. Interaction plot for the estimated recess PA for different values of SYi and for students with highest and lower school well-being.

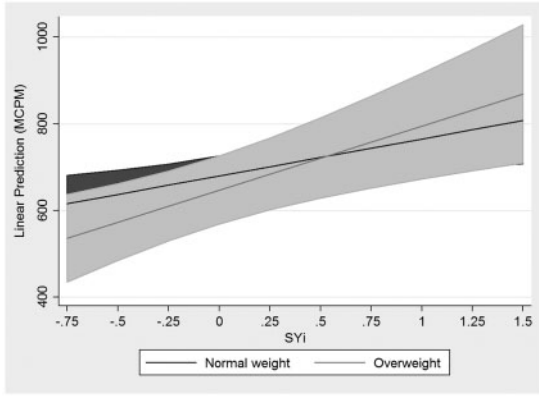

Fig. 3. Interaction plot for the estimated recess PA for different values of SYi and for normal weight and overweight students.

executed behaviour of children [28, 29], which has been found for adolescents in relation to recreational activity as well [30]. This stresses the need for direct involvement of the end-user [31], or at least a thorough background research in each individual setting, before designing a new playground.

Ad (2): The process evaluation pointed out that at some Playspots were located in areas where the targeted students did not naturally reside or passed by. Mårtensson et al.'s [32] extensive investigation of school environments in Sweden found that green areas near buildings, was more often used. Location of facilities near the student's normal activity space (class rooms and other facilities) is therefore important [28, 33, 34].

Ad (3): Both number and diversity of facilities (and landscape), can increase PA for more students [11]. Studies have found that the number of school ground play facilities was associated with the daily amount of PA [22, 33, 35–37]. Variation of facilities is also important and should target students with different physical competences [38, 39]. Mårtensson et al. [32] differentiate between settings programmed for sport and ball games, and settings programmed for open-ended play, games and socializing. In the process evaluation, new facilities programmed to more open-ended activities and placing lesser demands on the specific physical skills (e.g. football skills, parkour skills, climbing skills) were emphasized as attractive alternatives to the traditional activities for many students [27]. Another Danish study found, that lack of facilities for open-ended activities were associated with decreased motivation for PA and increased preference for staying indoors during recess for students not interested in playing football [40]. The finding from the current study, that overweight students and students with lower well-being was more affected by improvements in the environment, suggests that more opportunities can increase PA and social interaction for the students most in need.

Building the social motivational climate

Besides the physical environment components, organizational components were implemented as well: teachers were educated as 'kick-starters', who motivated students to PA during recess and mandatory outdoor recess. The effect of these components was not directly assessed in this study, but the 'kick-starters' were to some degree responsible for the 'access to unfixed equipment', and the variation across schools of that variable could reflect the level of adult engagement. The importance of the teachers in establishing a social inclusive environment and motivating PA was emphasized in the process analysis, especially for the students who were less motivated for PA [27]. Implementation of

teacher supported play during recess to increase recess PA has been emphasized in other studies [36, 41], and it has been proposed that especially girls request and benefit from social support to engage in recess activities [23, 42, 43].

The Youth Physical Activity Promotion Model (YPAPM) posits that both enabling and reinforcing factors can affect adolescents with different predispositions for PA [44]. This intervention was especially targeted to provide enabling factors for recess PA, by installing and upgrading facilities and by establishing access to unfixed equipment. The teachers' role as 'recess kick-starters' reinforced the physical upgrade by suggesting new games and play activities, and by motivating the least active students. Some schools and teachers succeeded in this reinforcement, but other could have benefitted of an increased focus on the motivational climate for students with lowers capabilities, as some schools relied too much on the environmental changes. Huberty et al. conclude on the 'Ready for Recess' study that the 'Environmental modifications are only as strong as the staff that implements them' [43], which corresponds to the experiences from this study.

Perception of the environment

The SYi was designed to assess collective perceived physical environmental characteristics of the schoolyards. The seven questions of the index concerned both spaciousness, number of activities, attractiveness and possibility for equipment, which all previously have been found to be associated with recess PA [12]. The SYi was able to differentiate between schools, and one-unit increase in the SYi was associated with a 12% increase in recess PA. The changes in the student's perception of opportunities for PA can be influenced by other things than actual changes in the objective physical environment, e.g. changes in motivational climate created by the recess kick-starters or changes in personal attitude towards PA. Studies have found poor association between the perceived and objective measured environment for adults, and suggested to include both in future research [45, 46]. Regardless of the different interpretation of the perceived environment used in this and previous studies, the perception of the environment has proven to be a strong predictor for adolescent PA [47, 48].

Strengths and limitations

A strong aspect of this study is the randomized controlled design and the relatively large sample size in the SPACE study, from which the current study originates. PA was measured objectively, with the possibility to assess recess PA. Accelerometry is perceived as a valid way of measuring recess PA [49], but low-intensity activities, as recess activities, could be underestimated. Opportunities for PA during recess were assessed based on self-report from students using the SYi. To our knowledge, this is the first study to examine how a schoolyard renovation affects students' collective perceptions and recess PA. The SYi showed high internal consistency, was able to detect differences between schools and mediated the intervention effect of a schoolyard renovation on recess PA. The composite structure of the index entails, however, that some variables can change in different directions, which can make interpretations ambiguous. In the current study, there were a tendency to more space and more greenery at the comparison schools, which could have attenuated the total effect of the intervention.

The assessment of recess PA is based on information on schools' timetables and periods of recess with exact bell times. This information was obtained from each of the participating schools, and was not validated by direct observation or logging [50]. It is possible that the exact recess periods differ from the official bell times, and furthermore, lunch can be an integrated part of recess, resulting in some of the recess time actually being sedentary time.

Conclusion

The intervention was implemented with a varying degree of effect on schoolyard perceptions in the intervention schools. The student's perception of the opportunities for PA during recess, measured

with the SYi, was only higher at three out of seven intervention schools. The variation could not be explained by economic costs of the renovations, but direct involvement of the students, location near the target group's normal activity space and variation of facilities including access to equipment seemed more important. The SYi was associated with recess PA, and an one-unit increase in the index resulted in 12% increase in recess PA. The analyses of change in the different components of the SYi across the seven intervention schools gave interesting information on implementation, but there still exist a knowledge gap on how future schoolyard renovations should balance both demands from the students and general recommendations from evidence-based literature. This study increases the evidence that schoolyard environment is important for adolescent PA, and that investments herein could be effective if well executed.

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Conflict of interest statement

None declared.

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