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Twelve-Month Effects of a Playground Intervention on Children's Morning and Lunchtime Recess Physical Activity Levels

Nicola D. Ridgers, Stuart J. Fairclough, and Gareth Stratton

Background: Recess is an opportunity for children to engage in daily physical activity. The aim of this study was to investigate the 12-month effects of a playground intervention on children's moderate-to-vigorous (MVPA) and vigorous physical activity (VPA) during morning and lunchtime recess. ***Methods:*** Four hundred and seventy children (232 boys, 238 girls) from 26 elementary schools participated in the study. Fifteen schools redesigned the playground environment using playground markings and physical structures. Eleven schools served as socioeconomic matched controls. Physical activity levels were quantified using heart rate and accelerometry at baseline, 6 months, and 12 months post-intervention. A 3-level (time, pupil, and school) multilevel analysis was used to determine the effects of the intervention across time on MVPA and VPA. ***Results:*** Positive yet nonsignificant intervention effects were found for MVPA and VPA during morning and lunchtime recess. Intervention children were more active during recess than control children. Interactions revealed that the intervention effect was stronger at 6 months than 12 months post-intervention. ***Conclusions:*** A playground markings and physical structures intervention had a positive effect on intervention children's morning and lunchtime MVPA and VPA when assessed using heart rate and accelerometry, but this effect is strongest 6-months post-intervention and decreased between 6 months and 12 months.

Keywords: school, heart rate, accelerometry, multilevel analysis

The promotion of physical activity to youth is a public health priority. There is concern that children are insufficiently active to benefit health,[1,2] with research highlighting that children's fitness levels are decreasing while their BMI is increasing.[3] It is logical therefore that age and developmentally appropriate interventions are needed for children to stimulate greater participation in physical activity, as moderate-to-vigorous physical activity (MVPA) benefits children's cardiovascular risk profiles[4] while vigorous physical activity (VPA) can have positive outcomes on body composition, cardiovascular function and bone health.[5,6]

Environmental interventions may hold potential as a method for promoting physical activity to children.[7] A systematic review of the literature[7] identified 4 school-based studies that had changed the recess environment using games equipment[8] and playground markings.[9,10] All studies reported that the respective interventions had a positive and significant effect on recess physical activity levels, though these studies generally employed a short-term follow-up, small sample sizes, and did not account for potential confounding variables in the analyses. More long-term data on recess intervention effects are needed,[11–13] as such data could provide further information concerning the effectiveness and feasibility of school-based interventions in a commonly occurring ubiquitous context.

Playground environment interventions are of interest as they represent a sustainable physical activity context. The presence of activity promoting equipment and playground markings may facilitate active behaviors, as children are provided opportunities and cues concerning their behavior in that environment. However, it has been argued that adopting an interventionist approach may have limited effects on physical activity and play behavior,[14] where prescriptive spaces for specific activities are adult attempts to constrain and control children's play during recess.[15] Imposing new structures on playgrounds may not be maintained for long, as they do not originate from the existing playground culture and the playground could revert back to its former structure; this structure being an established hierarchy of power based around age.[14] There is therefore a need to determine whether playground interventions have a sustained impact on recess physical activity levels over time.

Recess research has generally examined the effect of environment interventions on physical activity levels across all recess periods on a typical school day.[9,10,12] It is possible however that the intervention may have

Ridgers and Stratton are with the Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, United Kingdom. Fairclough is with Centre for Physical and Outdoor Education, Liverpool John Moores University, Liverpool, United Kingdom.

differential effects on activity levels during different recess periods. One study has reported data concerning this, and it was found that MVPA and VPA decreased during morning recess, while increases were observed during lunch recess.[8] The aim of this study therefore was to build on previous research and examine the effects of a school-based playground markings and physical structures intervention on children's MVPA and VPA during morning and lunch recess periods at 6-months and 12-months post-intervention, using a larger sample while accounting for confounding variables using multilevel analyses.

Method

Participants and Settings

Two hundred and thirty-two boys and 238 girls from 26 elementary primary schools returned signed informed parental consent to participate in the study. Eighteen children (stratified by gender) were randomly selected from each school to participate in the project. The schools were located in 1 large city in the North West of England, which has high levels of social and economic deprivation. The study received ethical approval from the University Ethical Committee.

Intervention

All participating schools were located within 1 local authority that was involved in a national £10 million sporting playgrounds initiative, which was funded primarily by the Department for Education and Skills. Local eligibility criteria initially involved identifying schools that were included in a School Sport Partnership and located in the Sport Action Zone. These schools were then ranked on socioeconomic status (SES) and indices of deprivation, and 15 schools with low SES and high deprivation were selected to be intervention schools (Figure 1). The 15 schools (130 boys, 126 girls) each received £20,000 to change the playground environment through the use of playground markings and physical structures with the zonal sporting playgrounds design. The remaining 11 schools (102 boys, 112 girls) served as socioeconomic matched controls.

The sporting playgrounds design had 2 main aims, these being to increase the physical activity levels of young people and to tackle social exclusion and playground issues such as dominant games and bullying.[16] Each playground was divided in to 3 specific color-coded areas: (a) a red sports area, (b) a blue multiactivity and skills area, and (c) a yellow quiet play area. The areas were designed to contain dominant activities, provide safe play spaces for other activities, and to encourage children to engage in a number of activities, especially those children who are intimidated by the playground context or are excluded from games.[16] All playground markings were appropriate to the physical activity and social behaviors desired for each area.[17] In addition, the schools received physical structures that included soccer goal posts, basketball hoops and fencing around the red area, and seating in the yellow area.[17] The 11 control schools did not receive any funding for physical playground developments through this national initiative. Throughout the study, numerous pieces of manipulative sports equipment such as soccer balls, jump ropes and tennis balls were available in all schools during recess. Schoolteachers supervised morning and afternoon recess periods, while lunchtime assistants supervised lunch recess.

Measures

Anthropometry. Measurements of stature (to the nearest 0.1cm) and body mass (to the nearest 0.1kg) were recoded using the Leicester Height Measure (Seca Ltd, Birmingham, UK) and analog scales (Seca Ltd) at each stage of the project using standardized procedures. Body mass index (BMI) was calculated using (weight (kg)/height^2 (m)), and children were classified as normal weight or overweight using age-specific United Kingdom cut-points.[18]

Recess Duration. Recess duration was defined as the time the school bell rang to start recess to the time it rang to conclude recess. The principal researcher recorded these times for all recess periods at each participating school throughout the duration of the study. All schools had a morning recess (baseline mean = 19.5 ± 5.8 min) and lunch recess (58.9 ± 10.1 min; Table 1), while 11 schools (42%) had an afternoon recess (15.7 ± 3.7 min). As less than half the schools had an afternoon recess period, only the physical activity data from the morning and lunch recess periods were used in subsequent analyses.

Physical Activity. Children's physical activity levels were quantified during recess using heart rate (HR) telemetry and accelerometry. This enabled the assessment of mechanical and physiological strain, and to report against 2 aspects of health promotion respectively and independently in a field setting. The Polar Team System (Polar Electro Oy, Kempele, Finland) was used to measure the children's physiological responses during recess. Heart rate was recorded every 5 seconds, which was deemed short enough to detect random bouts of movement.[19] The Polar Precision Performance™ software was used to analyze recess physical activity, which was expressed as percentage heart rate reserve (HRR). Resting heart rate (RHR) was determined by averaging the 5 lowest heart rate values recorded during each daily school visit across the study.[19] Maximum heart rate was set at 200 beats·min^{-1}.[20] HRR threshold values of 50 (HRR_{50}) and 75 (HRR_{75}) per cent were used to represent moderate-to-vigorous physical activity (MVPA) and vigorous-physical activity (VPA) respectively,[20] and were calculated for every child on each day of measurement. The percentage absolute time each child spent at or above HRR_{50} and

HRR_{75} during morning and lunch recess periods was calculated by identifying the start and end time of the recess periods on the individual heart rate curves in the manufacturer's software and used in subsequent analyses.

The Actigraph (Model 7164, MTI Health Services, Florida, USA) is a small uniaxial accelerometer that measures vertical acceleration of human movement. The epoch length was set at 5 seconds. The amount of time that children spent engaged in moderate, high and very high intensities was determined using the 5-sec count thresholds identified by Nilsson et al.[21] Accelerometer data were downloaded using the Actisoft Analysis Software v. 3.2 (MTI Health Services, Florida, USA). MVPA was defined as the summed total time spent in each activity intensity category. VPA was defined as the summed total time spent in the high and very high intensity categories. Total percentage time spent engaged in MVPA and VPA during morning and lunch recess periods was calculated using customized macros and used in the subsequent analyses.

Procedure. Children recruited in to the project were randomly allocated to wear either 1 or 2 activity monitors, which was stratified by sex. All children wore a HR monitor (232 boys, 238 girls), while 300 children wore an accelerometer (150 boys, 150 girls). This was due to monitoring equipment availability during the study. Monitors were worn on 1 school day at each measurement point. Attempts were made to avoid times where children would sit public exams or be out of school on external trips. Baseline measures were conducted between July 2003 and March 2004. Follow-up intervention phase data were collected at 6 months and 12 months following the redesigning of the intervention schools' playgrounds, which occurred between March 2004 and July 2004. Control schools data were also collected during these 3 measurement periods. A previous study conducted with a subgroup of schools in this study revealed no significant day-to-day or seasonal differences in recess physical activity.[22] Children were fitted with the monitors at the start of the school day, instructed to wear them during all recess periods on that day, and to follow their normal daily school routine. Data were collected from all school recess periods on 1 day when children could access the playground. Data recorded during wet recess periods were discarded and repeated on a separate day. At the end of the school day the monitors were removed and the data immediately downloaded.

The flow of children and schools through the study is shown in Figure 1. Children who had not withdrawn from the study or left the school but who were absent from school on the day of testing or experienced monitor problems were recorded as missing data at that point. Since multilevel modeling is robust against missing data points and can estimate intervention effects while using data from children with incomplete follow-up,[23] all longitudinal data collected from the children were included in the analyses.

Data Analysis. Multilevel models were used to determine the effects of the playground intervention, which was the central determinant in the analyses. Since measurements taken from children in the same school are not independent of each other, which violates the assumption of independent observations, multilevel models can analyze the hierarchical nature of such data by taking in to account the dependency of observations (Twisk, 2006). A 3-level multilevel structure was used in this study, where timing of the follow-up measurement (6-months, 12 months; Level 1), pupils (Level 2), and schools (Level 3) served as the grouping variables. This is to account for the measures taken at different points being nested in pupils, who are nested in schools.

To estimate the impact of the intervention on recess physical activity, potential confounding variables were added to the model as they may influence the change in the magnitude of the intervention effect (Twisk, 2006). Time (6 months, 12 months) was a level 1 variable used account for the follow-up measures being conducted at irregularly spaced intervals. Level 2 variables were sex, age, baseline physical activity, and BMI group (normal weight, overweight). Recess duration was a level 3 variable. The intervention term was constructed using a dummy variable, where "0" indicated a control group school, and "1" indicated an intervention school. Analyses were conducted using percentage MVPA and VPA assessed using heart rate ($MVPA_{HR}$, VPA_{HR}) and accelerometry ($MVPA_{ACC}$, VPA_{ACC}) as the outcome variables. Separate analyses for MVPA and VPA were performed for each recess period. The effect of covariance between school intercepts and slopes for each model was investigated using a covariance matrix. No significant effects of covariance were observed, therefore the random structure that was used in this study considered variation between the schools in their intercepts.

Potential effect modification was assessed in the analyses by constructing interaction terms between the intervention and all confounding variables to determine whether the intervention effect was different for different subgroups. Subgroup analyses were conducted where significant effect modification was revealed for dichotomous variables (time, sex, BMI group). The Wald statistic $(\text{Regression coefficient/Standard Error})^2$ was used to assess the significance of the variables and the interaction terms in the analyses.[23] Statistical significance was set at $P \leq .05$, with the exception being the interaction terms were it was set at $P \leq .1$. Higher significance levels are used for interaction terms as they have less power.[23] Multilevel analyses were conducted using MLwiN 1.10 software (Institute of Education, University of London, UK).

Results

Data concerning average recess times are shown in Table 1. The descriptive (mean ± SD) anthropometric characteristics of the children at baseline, and at 6 months and

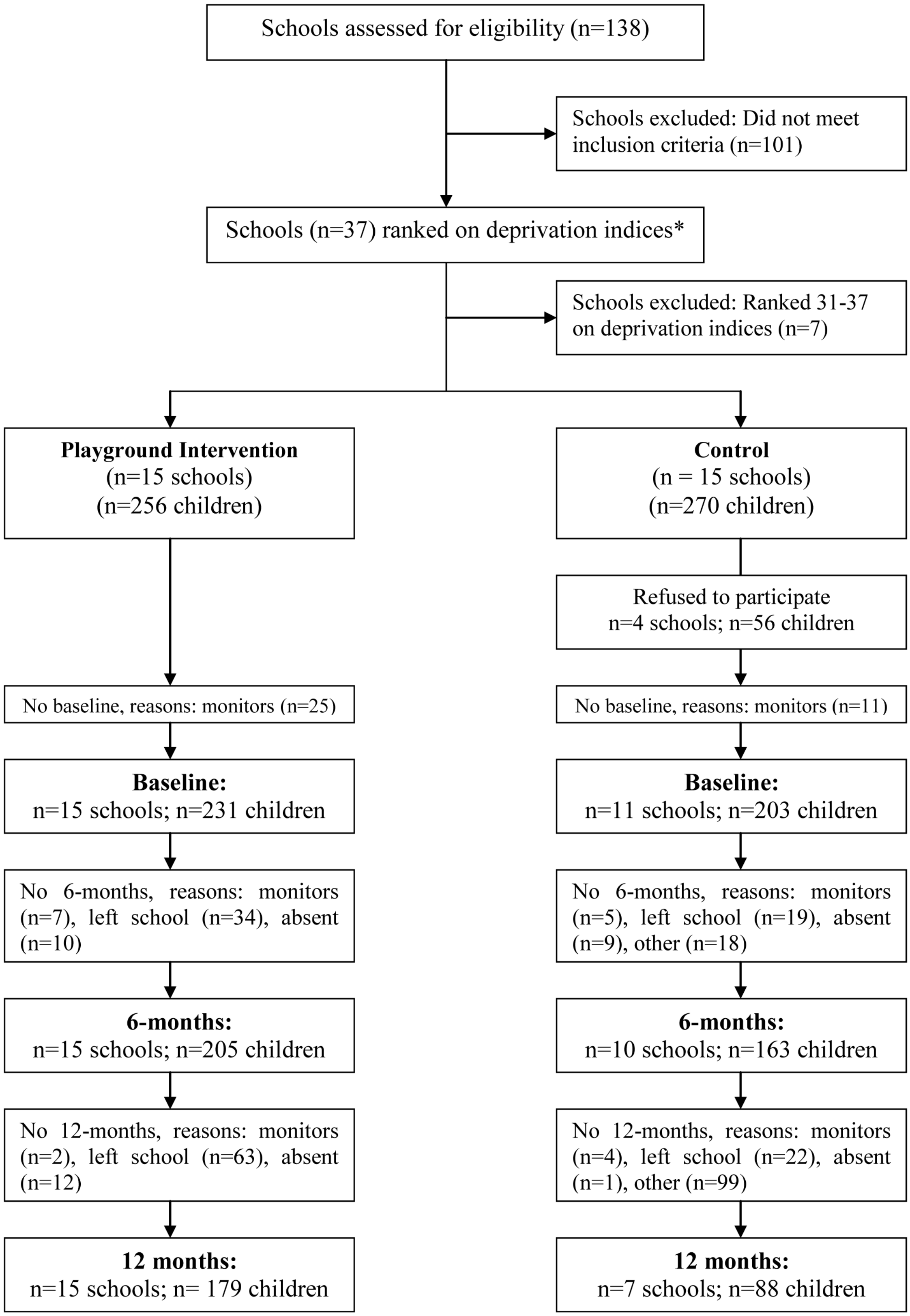

Figure 1 — Flow of schools and children in the study. Measurements were taken at baseline, and 6 months and 12 months post-intervention. Key: * = 15 schools ranked highly on deprivation indices were allocated to intervention. Monitors = monitoring problems experienced and data lost.

Table 1 Average Morning and Lunch Recess Duration at Baseline and 6 Months and 12 Months Post-intervention (Mean ± SD)

	Baseline	6 months	12 months
Morning recess (min)	19.5 ± 5.8	20.5 ± 4.7	21.4 ± 6.3
Lunch recess (min)	59 ± 10.1	57.3 ± 8.1	57.6 ± 8.9
Total recess time (min)	78.5 ± 11.8	77.8 ± 9.8	78.0 ± 10.9

Table 2 Characteristics of the Available Sample of Intervention and Control Children at Baseline and 6 Months and 12 Months Post-intervention (Mean ± SD)

		Baseline		6 months		12 months	
	Gender	Exp	Con	Exp	Con	Exp	Con
Age (yrs)	Boy	8.4 ± 1.9	7.9 ± 1.4	9.6 ± 1.8	8.9 ± 1.3	10.1 ± 1.8	8.7 ± 1.3
	Girl	8.2 ± 1.7	8.1 ± 1.5	9.3 ± 1.6	8.8 ± 1.3	9.9 ± 1.5	9.2 ± 1.3
Stature (m)	Boy	1.33 ± 0.08	1.31 ± 0.09	1.38 ± 0.08	1.33 ± 0.11	1.38 ± 0.07	1.31 ± 0.09
	Girl	1.31 ± 0.09	1.3 ± 0.11	1.38 ± 0.09	1.33 ± 0.09	1.38 ± 0.09	1.32 ± 0.09
Body Mass (kg)	Boy	31.9 ± 7.9	30.1 ± 8.5	35.2 ± 8.8	32.4 ± 10.6	35.4 ± 8.8	30.7 ± 8.0
	Girl	30.6 ± 8.3	30.5 ± 9.7	34.4 ± 9.0	31.6 ± 7.9	35 ± 9.3	32.2 ± 7
BMI (kg·m^{-2})	Boy	17.8 ± 2.9	17.3 ± 2.9	18.2 ± 3.3	17.9 ± 3.5	18.4 ± 3.5	17.6 ± 2.7
	Girl	17.4 ± 2.9	17.7 ± 3.4	17.9 ± 3.0	17.8 ± 3.5	18.1 ± 3.0	18.3 ± 2.9

Abbreviations: Exp, experimental (intervention) group; Con, control group.

12 months post-intervention are detailed in Table 2. The results of the multilevel analyses for morning and lunch recess are reported in Tables 3 and 4, respectively.

A significant positive intervention effect was found for VPA_{ACC} during lunch recess, with the intervention children engaging in 1.4% more VPA_{ACC} than the control children (Table 4). No other significant intervention terms were observed. Sex was a significant negative predictor of physical activity levels, except for $MVPA_{HR}$ and VPA_{HR} during morning recess. Boys engaged in significantly more MVPA and VPA during morning and lunch recess than girls (Tables 3 & 4). Age was a significant negative predictor for $MVPA_{HR}$ and VPA_{HR} during morning recess, and $MVPA_{ACC}$ during lunch recess. The results highlighted that as age increased, physical activity during morning and lunch recess decreased. BMI group was a significant predictor for lunch recess $MVPA_{ACC}$, where overweight children were less active than normal weight children. Contrasting significant results were found for morning recess duration, with VPA_{HR} engagement increasing with increased recess duration, but VPA_{ACC} decreasing as recess duration increased.

Potential effect modification analyses revealed significant interaction terms between time and $MVPA_{HR}$ and VPA_{HR} for morning recess, and time and $MVPA_{HR}$, VPA_{HR}, and $MVPA_{ACC}$ for lunch recess. Follow-up analyses indicated that the intervention effect was significant and positive at 6 months post-intervention for all interactions except VPA_{HR} during lunch recess, but the effects were not apparent at 12 months. All other interaction terms were found to be nonsignificant ($P > .1$).

Discussion

The aim of this study was to investigate the effects of a playground markings and physical structures intervention on children's physical activity levels during morning and lunch recess periods 6 months and 12 months following the intervention. The results demonstrated a significant intervention effect on children's lunch recess VPA_{ACC} compared with the control school children. More longitudinal studies are needed to ascertain whether playground interventions can significantly increase both MVPA and VPA during discrete recess periods, and the effects these may have on children's risk profiles, cardiovascular function, and bone health.[4–6]

The current study revealed that time was a significant negative predictor of VPA_{HR} and VPA_{ACC} during morning recess, and $MVPA_{HR}$ and VPA_{HR} during lunch recess. In addition, a number of time by intervention effect interactions were significant. These findings highlight that physical activity levels were lower at 12 months compared with 6 months, and the greatest impact of the intervention was observed at 6 months. It is possible that a combination of strategies may be required at 12 months post-intervention, such as the training of supervisors and increasing the availability of manipulative playground equipment, which can positively influence physical

Table 3 Estimated Effect of Covariates and Intervention (Playground Markings) on Percentage Time Spent in Moderate to Vigorous (%MVPA) and Vigorous Physical Activity (%VPA) During Morning Recess (Assessed Using Heart Rate and Accelerometry)

	%MVPA				%VPA			
	Heart rate		Accelerometry		Heart rate		Accelerometry	
Parameter	®[1](SD)	95%CI	®[1](SD)	95%CI	®[1](SD)	95%CI	®[1](SD)	95%CI
Baseline PA	**0.2 (0.1)**	**0.1, 0.3*****	**0.1 (0.1)**	**0.0, 0.3***	**0.2 (0.1)**	**0.1, 0.3*****	**0.3 (0.1)**	**0.2, 0.4*****
Intervention	4.1 (3.1)	–1.9, 10.0	1.2 (2.0)	–2.8, 5.2	3.6 (2.1)	–0.5, 7.7	1.4 (0.9)	–0.4, 3.1
Time	–3.2 (1.9)	–7.0, 0.6	–2.7 (1.5)	–5.6, 0.2	**–2.5 (1.2)**	**0.2, 4.8***	**–1.6 (0.8)**	**–3.1, –0.1***
Sex	–3.0 (2.3)	–7.4, 1.5	**–10.1 (2.0)**	**–14.1, –6.1*****	–1.2 (1.3)	–3.7, 1.4	**–2.3**	**–3.9, –0.7*****
Age	**–3.0 (0.8)**	**–4.6, –1.4*****	–0.8 (0.8)	–2.4, 0.9	**–1.8 (1.3)**	**–2.8, –0.9*****	–0.4 (0.3)	–0.9, 0.1
BMI group	3.5 (2.4)	–1.1, 8.2	–0.1 (0.3)	–0.7, 0.6	0.1 (1.4)	–2.6, 2.8	0.3 (0.9)	–1.4, 2.0
Recess duration	0.4 (0.3)	–0.2, 1.0	0.1 (0.2)	–0.3, 0.5	**0.5 (0.2)**	**0.1, 0.8*****	**–0.2 (0.1)**	**–0.4, –0.1*****

Note. Significant effects indicated in bold: *$P \leq .05$, **$P \leq .01$, ***$P \leq .001$. For intervention, time, sex, and BMI group, control, 6 months, boys and normal weight children are the reference groups, respectively. The intervention ® value represents the estimated difference in physical activity for the intervention schools against the control schools when time, sex, age, BMI group, and recess duration are included in the final model. A positive ® value indicates a positive intervention effect on the physical activity levels of the intervention children compared with the control school children during recess over time.

Table 4 Estimated Effect of Covariates and Intervention (Playground Markings) on Percentage Time Spent in Moderate to Vigorous (%MVPA) and Vigorous Physical Activity (%VPA) During Lunch Recess (Assessed Using Heart Rate and Accelerometry)

	%MVPA				%VPA			
	Heart rate		Accelerometry		Heart rate		Accelerometry	
Parameter	®[1](SD)	95%CI	®[1](SD)	95%CI	®[1](SD)	95%CI	®[1](SD)	95%CI
Baseline PA	0.2 (0.01)	0.1, 0.3***	0.2 (0.1)	0.1, 0.3***	0.2 (0.1)	0.1, 0.2***	0.2 (0.1)	0.1, 0.3***
Intervention	3.0 (2.1)	–1.2, 7.2	3.6 (1.9)	–0.3, 7.4	0.9 (1.3)	–1.6, 3.5	1.4 (0.7)	0.1, 2.7*
Time	–3.5 (1.5)	–6.4, –0.6*	–1.3 (1.2)	–3.6, 1.0	–3.0 (0.9)	–4.8, –1.2***	–0.8 (0.5)	–1.8, 0.2
Sex	–8.8 (1.8)	–12.4, –5.3***	–10.5 (1.4)	–13.2, –7.8***	–4.2 (1.0)	–6.3, –2.1***	–2.8 (0.6)	–4.0, –1.6***
Age	–2.1 (0.7)	–3.4, –0.8***	–1.3 (0.6)	–2.4, –0.2*	–1.5 (0.4)	–2.3, –0.7***	–0.4 (0.2)	–0.8, 0.1
BMI group	0.2 (1.9)	–3.5, 4.0	–2.3 (1.5)	–5.2, 0.5	–1.1 (1.1)	–3.2, 1.2	–1.5 (0.7)	–2.8, –0.2*
Recess duration	–0.1 (0.1)	–0.3, 0.2	–0.01 (0.1)	–0.2, 0.2	–0.01 (0.1)	–0.2, 0.1	–0.02 (0.1)	–0.1, 0.1

Note. Significant effects indicated in bold: $^{*}P \le .05$, $^{**}P \le .01$, $^{***}P \le .001$. For intervention, time, sex, and BMI group, control, 6 months, boys and normal weight children are the reference groups, respectively. The intervention β value represents the estimated difference in physical activity for the intervention schools against the control schools when time, sex, age, BMI group, and recess duration are included in the final model. A positive β value indicates a positive intervention effect on the physical activity levels of the intervention children compared with the control school children during recess over time.

activity levels.[8] These additional approaches may support the initial investment made in to the physical playground changes, and further enrich the playground environment and encourage children to be physically active.[13]

Concern has been expressed that despite introducing new structures on playgrounds, the hierarchy of the playground based on age will eventually return over time.[14,15] This study provides some initial support for this notion, particularly as MVPA and VPA decreased between 6 months and 12 months post-intervention. Interestingly, all models in this study demonstrated that age was a negative predictor of physical activity during morning and lunch recess, with it being a significant predictor for $MVPA_{HR}$ and VPA_{HR} during morning recess and for $MVPA_{HR}$, $MVPA_{ACC}$ and VPA_{HR} during lunch recess. This indicates that older children were less active than young children. It could be suggested that the playground has not reverted back to its previous hierarchy and that younger children, are benefiting from the restriction of previously dominant activities, such as soccer, and accessing more playground spaces.[24] Alternatively, it may be suggested that the playground activities introduced are more suited to younger elementary children than older children. This, however, is relatively speculative, and there is a need to combine physical activity monitoring and direct observation to identify what behaviors children engage in when they are being physical activity or sedentary within a recess context.[13]

Only 1 previous study using accelerometry has documented the effects of a recess intervention on physical activity levels during morning and lunch recess. Verstraete and colleagues[8] found that boys' MVPA and VPA decreased during morning recess between baseline and posttest, but boys' and girls' MVPA and VPA increased during lunch recess. The accelerometry findings from this study lend some support to Verstraete et al,[8] as the effect of the intervention was greater during lunch recess than morning recess. It has been suggested that the longer lunch recess duration enabled children to organize and play games, which led to children being active for a greater percentage of time.[8] However, this study found that the intervention effect was greater during morning recess when MVPA and VPA were assessed using heart rate. It may be that activities engaged in during morning recess stressed the cardiovascular system but was associated with little vertical motion, which could be linked to numbers of children on the playground and space for children to play in.[25] During lunch recess, as the time children spend eating their lunch is staggered, there is often more space on the playground for children to be active and may explain the closer congruence between the heart rate and accelerometry results. It is also possible that factors other than movement, such as the muscle groups performing the activity and emotional stress, were affecting heart rate results during morning recess.[19] This further emphasizes the need to combine monitoring methods to identify how active children are and the behaviors they engage in during morning and lunch recess.

There are a number of limitations that should be noted with this study. The first is the use of the cut-points used to investigate children's physical activity levels. There is much ongoing debate concerning the use of cut-points on accelerometry data, with different studies identifying different threshold levels.[26] However, the thresholds used in this study have been used in previous recess studies,[12,27] and the use of a short epoch length provides a detailed picture of children's activity during recess[28] compared with studies that have used longer epoch settings that may mask higher intensity activity.[8] In addition, since the focus of this study is the change in physical activity levels, the relatively small differences between heart rate and accelerometry results suggests that the impact of the playground intervention on activity levels has been identified. The second limitation of this study is the number of missing data at both 6 months and 12 months post-intervention, though multilevel modeling is able to account for missing data.[23] At 6 months, this was largely attributable to monitoring problems and absence from school on the day of testing. At 12 months, this was mostly attributable to children having left the schools involved in the project, and schools being removed from the project for changing the playground project independently of this study. Lastly, the aim of the intervention was to increase physical activity and to tackle social exclusion and playground issues. The lack of significant effects at 12 months may be attributed to the 2 aims affecting each other. Direct observation could be used in future recess studies to determine how changing the playground environment influences activity and playground issues, and to further inform potential interventions of this nature.

Conclusion

This study demonstrates that a playground markings and physical structures intervention had a positive effect on intervention children's morning and lunch MVPA and VPA when assessed using heart rate and accelerometry, but this effect was strongest 6 months post-intervention and decreased between 6 months and 12 months. A number of potential confounding variables influence the intervention effect, and should be controlled for in future studies that aim to investigate the impact of school-based environmental interventions over time.[7] There is a need for further studies to document the longitudinal effects of such interventions, and to examine the impact on children's physical activity levels both within the school environment and across the whole school day.

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