Long-term effects of a playground markings and physical structures on children’s recess physical activity levels

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Abstract

Objective. The aim of the study was to investigate the impact of a playground redesign intervention across time on children’s recess physical activity levels using combined physical activity measures and to evaluate the potential influence of covariates on the intervention effect.

Method. Fifteen schools located in areas of high deprivation in one large city in England each received £20,000 through a national £10 million Sporting Playgrounds Initiative to redesign the playground environment based on a multicolored zonal design. Eleven schools served as matched socioeconomic controls. Physical activity levels during recess were quantified using heart rate telemetry and accelerometry at baseline, 6 weeks and 6 months following the playground redesign intervention. Data were collected between July 2003 and January 2005 and analyzed using multilevel modeling.

Results. Statistically significant intervention effects were found across time for moderate-to-vigorous and vigorous physical activity assessed using both heart rate and accelerometry.

Conclusions. The results suggest that a playground redesign, which utilizes multicolor playground markings and physical structures, is a suitable stimulus for increasing children’s school recess physical activity levels.

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Keywords: Children; School; Multilevel modeling; Recess

Introduction

Physical activity is an integral component of a healthy lifestyle (Strong et al., 2005). Concern has been expressed that a large proportion of children are insufficiently active to gain health benefits (Andersen et al., 2006). One appropriate and convenient setting for the promotion of physical activity to children is the school environment (Wechsler et al., 2000). Physical education and recess provide the two main opportunities for elementary school-based physical activity. The sustainability and effectiveness of physical education interventions have been documented (McKenzie et al., 1997b), yet little data detail the impact of longitudinal recess-based interventions on activity levels (Ridgers et al., 2006b).

Recess-based interventions have used environmental interventions such as playground markings (Stratton, 2000; Stratton and Mullan, 2005), obstacle courses (Scruggs et al., 2002) and equipment provision (Verstraete et al., 2006) to increase activity on the premise that exposure to supportive physical environments can facilitate physically activity behaviors. Short-term increases in physical activity levels have been reported; however, to the best of our knowledge, no data currently exist which evaluate the longer-term effectiveness of such interventions on recess physical activity levels. The evaluation of the effectiveness and sustainability of recess interventions is required, identifying whether short-term increases are sustained or influenced by novelty effects, as this information could be critical in utilizing recess as a physical activity promotion context.
This study forms part of a longitudinal project that is investigating the impact of a playground intervention on children’s recess physical activity levels. Physical activity was measured objectively using heart rate and accelerometry to investigate the impact on the intervention on both physiological and mechanical stress. The purpose of study was twofold: (a) to investigate the effect of a playground intervention on children’s recess moderate-to-vigorous (MVPA) and vigorous physical activity (VPA) engagement over time, and (b) to evaluate the potential influence of covariates on the intervention effect.

Methods

Participants and settings

Two hundred and thirty-two boys and 238 girls recruited from 26 elementary schools from one large city in the North West England returned signed parental informed consent to participate in the study. All schools were located within one Local Authority that was involved in a national £10 million Sporting Playgrounds’ Initiative. Funding was allocated to Local Authorities situated in areas of high social and economic deprivation in order to improve the playground environment of schools in their locality. The schools in this study were located in one of the most deprived areas in the country (Noble et al., 2004).

Intervention

Fifteen schools (130 boys, 126 girls) each received £20,000 to redesign the playground environment based on the sporting playground zonal design. This involved dividing the playground into three specific color-coded areas: (a) a red sports area, (b) a blue multi-activity area and (c) a yellow quiet play zone. The markings were relevant to the physical activity behavior and social behaviors desired for each area (Stratton and Ridgers, 2003). The physical structures that the school received included soccer goal posts, basketball hoops and fencing around the red sports area and seating in the yellow quiet area (Stratton and Ridgers, 2003). The remaining eleven schools (102 boys, 112 girls) served as socioeconomic matched controls and did not receive any playground markings through the national initiative. Small pieces of sports equipment such as soccer balls, jump rope and tennis balls were available for use in all school playgrounds throughout the duration of the study. Schoolteachers supervised morning and afternoon recess, while lunchtime assistants supervised lunch recess.

Instrumentation

Children’s physical activity levels during recess were quantified using heart rate (HR) telemetry and accelerometry. Combined measures were partly used to account for the physiological and biomechanical variance associated with HR and accelerometry respectively but also to assess mechanical (accelerometry) and physiological (HR) strain. Mechanical strain suggests that the musculoskeletal system is being stressed whereas physiological strain stresses the cardiorespiratory system. Combining methods would enable the study to report against two aspects of health promotion respectively and independently in a field setting. The Polar Team System (Polar Electro Oy, Kempele, Finland) HR monitor was used to measure the children’s physiological response to recess. HR was recorded every 5 s. The children’s resting HR (RHR) was determined by averaging the lowest 5 recorded HR values during each phase of data collection. HR reserve (HRR) values of 50% (HRR50) and 75% (HRR75) were used as the threshold values to represent MVPA and VPA respectively (Stratton, 1996). Maximum HR was set at 200 beats min⁻¹ (Stratton, 1996). The percentage time each child spent at or above HRR50 and HRR75 during recess was calculated and used in subsequent analyses.

The ActiGraph (Model 7164, MTI Health Services, Florida, USA) is a uni-axial accelerometer that measures vertical acceleration of human motion. The epoch time length was set at 5 s (Nilsson et al., 2002). Activity cut points of 163–479, 480–789 and ≥790 counts per five-second epoch were used to determine the amount of time children spent in moderate, high and very high intensities respectively (Nilsson et al., 2002). MVPA was defined as the summed total time spent in each activity intensity level during recess. The summed total time spent in high and very high intensity activity represented VPA. Total percentage time spent engaged in MVPA and VPA during recess was calculated and used in the subsequent analyses.

Procedure

Children recruited into the study were randomly allocated to wear either one or two physical activity monitors, which was stratified by gender. All children wore an HR monitor (n=470), while 298 children (149 boys, 149 girls) additionally wore an accelerometer. Monitors were worn on one school day at each measurement point. Baseline measures were collected between July 2003 and March 2004. Intervention phase data were collected 6 weeks and 6 months following the redesigning of the intervention schools’ playgrounds, which occurred between March 2004 and July 2004. Control school data were collected at baseline, and during the two follow-up measurement periods. Seasonality was not controlled for during this study as previous research conducted in a subgroup of schools participating in the project indicated that there were no significant day to day or seasonal differences in recess physical activity levels (Ridgers et al., 2006a). Monitors were fitted at the start of the morning school timetable following a familiarization period and worn during morning, lunch and, where applicable, afternoon recess. Children were then asked to follow their normal daily routine. Monitors were removed at the conclusion of the school day and the data were immediately downloaded.

At follow-up 1 (6 weeks), HR and accelerometry data were collected from 80% and 87% of the available sample in this phase of the project respectively. Children who did not withdraw from the study but who did not record data due to school absence or monitoring problems were recorded as missing data at that point. At follow-up 2 (6 months), HR and accelerometry data were collected from 84% and 92% of the available sample respectively. Despite some missing data, all longitudinal data collected from the children were used in subsequent analyses. Multilevel modeling is robust against missing data points and can estimate intervention effects over time while using data from children with incomplete follow-up (Quené and van den Bergh, 2004).

Data analyses

HR data were analyzed using the Polar Precision Performance™ 3.0 Software (Polar Electro Oy, Kempele, Finland). Accelerometer data were analyzed using the ActiSoft Analysis Software Version 3.2 (MTI Health Services, Florida, USA). Independent t-tests were conducted to examine differences in HR baseline physical activity levels for children wearing one or two physical activity monitors and to examine differences between the intervention and control children at baseline for age, stature, body mass and body mass index (BMI). Descriptive data were analyzed using the Statistical Package for the Social Sciences version 12 (SPSS Inc., Chicago, IL, USA).

Multilevel modeling was used to determine the effects of the playground redesign intervention across time. A three-level data structure was used, where the three levels of analysis were the timing of the follow-up measurement (level 1), pupil (level 2) and school (level 3). Data were analyzed using MLwiN1.10 software (Institute of Education, University of London, UK). MVPA and VPA assessed using HR and accelerometry following the intervention were the outcome variables. Baseline values for MVPA, VPA, BMI, age and recess time (continuous variables) and gender (dichotomous variable) were identified a priori as potential covariates. Two analyses were conducted on MVPA and VPA for each method to examine the effect of the intervention over time. The crude analysis determined the effect of the intervention over time while controlling for baseline physical activity and time. The adjusted analysis determined the intervention effect when the covariates were added to the model (Twisk, 2006). To evaluate the influence of covariates on the intervention effect, effect modification was assessed by constructing interaction terms between the intervention group and all covariates. Separate analyses were conducted for MVPA and VPA measured using each method. Regression coefficients in the model were assessed for significance using the Wald statistic. Statistical significance was set at p<0.05, and at p<0.10 for interaction terms. Interaction
Table 1
Descriptive baseline anthropometric data (collected in North West England between July 2003 and March 2004) for boys and girls in the intervention and control schools (mean, SD).

<table>
<thead>
<tr>
<th>School</th>
<th>Boy</th>
<th>Girl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Int</td>
<td>Con</td>
</tr>
<tr>
<td>Age (years)</td>
<td>8.4 (1.9)*</td>
<td>7.9 (1.4)*</td>
</tr>
<tr>
<td>Sature (m)</td>
<td>1.33 (0.08)</td>
<td>1.31 (0.09)</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>31.9 (7.8)</td>
<td>30.3 (8.6)</td>
</tr>
<tr>
<td>Body mass Index (kg²/m²)</td>
<td>17.8 (2.8)</td>
<td>17.3 (2.9)</td>
</tr>
</tbody>
</table>

Key: Int = Intervention group; Con = Control group.
* Significant inter-group difference: control > experimental group, p<0.05.

Table 2 shows summary statistics (raw scores) for children’s physical activity levels at baseline, 6 weeks and 6 months post-intervention. Table 3 shows the effect of the intervention on MVPA and VPA across time assessed using HR and accelerometry from the multilevel modeling analysis. HR

A statistically positive intervention effect across time was found for both MVPA (p<0.05) and VPA (p<0.05; Table 3).

Data collected in North West England between July 2003 and January 2005.
Key: Int = intervention group; Con = control group; MVPA=moderate-to-vigorous physical activity; VPA=vigorous physical activity; HR=heart rate; ACC=accelerometry.
* Significant inter-group difference: control > experimental group, p<0.05.
  b Significant inter-group difference: control < experimental group, p<0.05.
Intervention school children engaged in 4% and 2.4% more MVPA and VPA respectively during recess than control school children (adjusted scores). A positive interaction term was found between the intervention and recess duration for both MVPA and VPA ($p < 0.05$), indicating that the intervention effect was stronger with increasing recess duration. In addition, inverse interaction terms were found between the intervention and baseline MVPA and VPA ($p < 0.05$ and 0.10 respectively), indicating that the intervention effect was stronger for children who were less active at baseline. All other interaction terms (with time, gender, age and BMI) showed $p$-values $> 0.10$.

**Accelerometry**

A statistically positive intervention effect across time was found for both MVPA ($p < 0.05$) and VPA ($p < 0.05$; Table 3). Intervention school children engaged in 4.5% and 2.3% more MVPA and VPA respectively during recess than control school children (adjusted scores). An inverse interaction between the intervention and age was found for MVPA ($p < 0.05$), indicating that the intervention effect was stronger for the younger children. In addition, a positive interaction was found between the intervention and recess duration for MVPA ($p < 0.10$), indicating that the intervention effect was stronger with increasing recess duration. A positive interaction was found between the intervention and time for VPA ($p < 0.05$), suggesting that the intervention effect strengthened longitudinally across time. All other interaction terms showed $p$-values $> 0.10$.

**Discussion**

The aim of this study was to evaluate the effects of a playground redesign intervention on a large sample of children’s recess MVPA and VPA using combined measures over time and to evaluate the potential influence of covariates on the intervention effect. This builds on previous recess interventions that have evaluated short-term effects using single measures of physical activity.

This study indicated that the playground intervention was effective in increasing children’s recess MVPA and VPA over time. Previous studies have reported that playground-based interventions have increased recess physical activity in the short-term following an intervention (Scruggs et al., 2002; Stratton, 2000; Stratton and Mullan, 2005; Verstraete et al., 2006). However, no comparable data currently exist concerning the longer-term effects of interventions within the recess context, nor do the short-term studies acknowledge the hierarchical nature of this type of investigation. While the increases in recess physical activity observed in this longitudinal study are smaller, the general lack of intervention by time interactions indicates that the provision of playground markings and physical structures is a suitable stimulus for increasing and sustaining increases across time. This is of note as previous research has suggested that increases in children’s physical activity have not been maintained across time (Dishman and Buckworth, 1996).

Individual- and group-level variables affect children’s behavior during recess. One such variable is recess duration, which interacted with the intervention effect in this study. Specifically, the intervention effect on MVPA and VPA was stronger with higher daily recess duration. Previous research has indicated that activity decreases as recess time proceeds (McKenzie et al., 1997a). This study suggests that longer daily recess periods allowed children to engage in more physical activity following the intervention, which may be explained in several ways. Firstly, the children may have had more time to take advantage of the increased activity opportunities during recess (Zask et al., 2001). Secondly, longer recess durations may allow time for the initial organization of games and activities while reducing the impact these social interactions could have on activity levels. Physical education research has suggested that up to one quarter of lessons can be accounted for by the organization of teams, activities and games rules (McKenzie et al., 1997b), and it is possible that organizing games during recess may also account for some of the time available.

The playground intervention effect was stronger for children who engaged in less MVPA and VPA at baseline. This is significant from a public health perspective as less active children often remain less active than their more active peers (Pate et al., 1996). Furthermore, physical inactivity has been linked to obesity in youth (Strong et al., 2005). Recess interventions could be important for the promotion of physical activity as children spend time outdoors on the playground, they increase their access to facilities and may decrease their perceived barriers to activity engagement as a number of activities were offered in the specific zones within well resourced playgrounds. These determinants have been identified as having consistent relationships with physical activity (Sallis et al., 2000). However, in this study, this finding was only found for HR monitoring. Thus our data suggest that the strain placed on the cardiorespiratory system increased, while mechanical stress may not have been greatly influenced. Future recess studies should implement direct observation to discern what activities these children engaged in both at baseline and follow-up. This would help clarify these findings further.

Several limitations exist with this study. The first is the number of missing data at both follow-up measurement points, particularly for HR, which were largely attributable to technical difficulties and child absence from school on the testing day. However, it should be noted that multilevel modeling analyses can handle missing data while estimating the effects of the intervention using their data at baseline and 6 weeks (Quené and van den Bergh, 2004). A second limitation is that combining HR and accelerometry to quantify physical activity has produced differing results in this study. This could also be considered a strength as combining measures has enabled the assessment of both physiological and mechanical strain, highlighting that playground activities stress the body in different ways leading to differing findings.

**Conclusion**

This study utilized multiple methods in a large sample of children to analyze the 6 months effects of a playground redesign
intervention, building on previous recess intervention studies that have determined the effects of interventions in smaller sample sizes over shorter follow-up periods (Ridgers et al., 2006b). The results indicate that playground markings and physical structures are an effective method for significantly increasing children’s recess physical activity levels in the longer-term. From a public health perspective, it is noteworthy that children who were less active at baseline benefited more from the intervention than their more active peers. In conclusion, increases observed in this study were sustained over time and not attributable to the novelty effect of the intervention.

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References


