Permanent Play Facilities in School Playgrounds as a Determinant of Children’s Activity

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Background: To investigate whether the number of permanent playground facilities in schools influences objectively measured physical activity. Methods: Physical activity was measured using Actical accelerometers over 2 to 5 days in 417 children (5–12 years) from 7 schools. The number of permanent play facilities likely to encourage physical activity in individuals or groups of children (eg, adventure playgrounds, swings, trees, playground markings, courts, sandpits) were counted on 2 occasions in each school. The surface area of each playground (m²) was also measured. Results: The number of permanent play facilities in schools ranged from 14 to 35 and was positively associated with all measures of activity. For each additional play facility, average accelerometry counts were 3.8% (P < .001) higher at school and 2.7% (P < .001) higher overall. Each additional play facility was also associated with 2.3% (P = .001) or 4 minutes more moderate/vigorous activity during school hours and 3.4% (P < .001) more (9 minutes) over the course of the day. School playground area did not affect activity independent of the number of permanent play facilities. Findings were consistent across age and sex groups. Conclusion: Increasing the number of permanent play facilities at schools may offer a cost-effective and sustainable option for increasing physical activity in young children.

Keywords: physical activity, accelerometers, child, playground

Physical activity during growth has multiple health benefits including the prevention of excess weight gain,1,2 improving bone density,3 and positively influencing academic performance,4 social development,5 psychological welfare,6 and adult activity level.7,8 Although debate continues as to whether children of today are less active than in previous generations,9–11 it is clear that insufficient daily activity in children has increased risks for ill health.2,12,13

Schools provide a unique critical setting for the promotion of physical activity in children via structured physical education (PE), recess, extracurricular sports, and promotion of community activities.14,15 Although quality PE programs make an important contribution to activity in children,15 considerable barriers to curriculum implementation exist.17 Thus, exploration of the potential for noncurricular approaches to increasing activity in children is warranted and understudied.18 Because recess may contribute up to 40% of moderate/vigorous activity19,20 approaches which increase activity during playtime are of interest. Several studies have demonstrated that provision of equipment at recess or play area can influence activity in children.21–26 While such initiatives may offer a cost-effective approach to increasing activity, they may still require staff to distribute and/or monitor equipment, which may limit their use.20 Limited work has evaluated the potential for more permanent structures to influence activity in children. School facilities are related to activity in middle-school children21 and children were more likely to be active in more equipped areas of a single school playground.27 Whether playground structure can affect total daily activity is unknown as all studies mentioned have only evaluated activity during recess or lunch breaks. Given the concern regarding self-report measures of physical activity,28 the use of accelerometry allows us to examine the effect of playground facilities activity during school and out of school time, using objective measures.

The aim of this study was to investigate whether the number of permanent playground facilities in schools and total playground area influences objectively measured daily school and total physical activity in children age 5 to 12 years.

Methods

Subjects

The subjects were primary-school children age 5 to 12 years from 7 schools in semirural communities in New Zealand who were participating in the APPLE Study.29,30 APPLE was a community-based, 2-year, obesity prevention trial where the main initiative was the provision of
activity coordinators in intervention schools. Their role was to encourage every child to be a little more physically active every day primarily through the provision of recess and lunchtime physical activity programs utilizing community volunteers. All schools serving 2 geographic areas (southern- and northern-coastal Otago) agreed to participate in the study and sociodemographic variables were checked to ensure the schools were broadly comparable (2001 New Zealand Census, Department of Statistics). The data presented in this article were collected in spring (September to November) 2004. At the time of the study, 578 children age 5 to 12 years attended the 7 primary schools, from which 521 consented to participate in the study (90% response rate). Measurements were obtained from data collected at the end of the first year of the intervention. Due to absences on measuring days, data were obtained from 495 (86%) subjects. Participants were predominantly Caucasian (82%), with 17% identifying as Maori (indigenous New Zealanders) and 1% as Pacific Islanders. Ministry of Education 2003 School Decile ratings were used as a crude indicator of socioeconomic status. A school’s decile indicates the extent to which the school draws its students from low socioeconomic communities (based on 5 indicators of SES from national census data). Decile 1 schools are the 10% of schools with the highest proportion of students from low socioeconomic communities, whereas decile 10 schools are the 10% of schools with the lowest proportion of these students. APPLE schools had school decile ratings of 3 to 7. Ethical approval for the study was obtained from the University of Otago Ethics Committee. Height to the nearest 0.1 cm (portable stadiometer) and weight to the nearest 0.1 kg (electronic scales) were measured in duplicate using standard techniques. Body mass index (BMI) was calculated (height in meters divided by weight in kilograms squared) and US reference data were used to calculate z-scores and to define children as overweight or obese (≥85th percentile for age and sex).

Measurement of Physical Activity

Physical activity was measured using Mini-Mitter (Bend, OR) omnidirectional Actical accelerometers worn on the hip, providing an objective independent assessment of PA.32,33 The Actical (AC) accelerometer is a small (3 cm × 3 cm × 1 cm) lightweight (about 30 g), electronic motion-sensor comprising an omnidirectional accelerometer which is sensitive to movement in all directions, with the piezo-electric sensor of the AC accelerometer oriented such that maximum sensitivity is obtained when the center of body mass is moved against gravity. Counts were cumulated every 15 seconds (epoch length) and the total and average counts per epoch and per minute were saved in the memory. The accelerometers were worn by each child for 2 to 5 days. Children were instructed to put the accelerometer on as soon as they woke up and to take it off just before bed. Several belts were provided for each child so that the accelerometers could be worn during bathing and swimming. Due to variation in sleeping patterns in children, accelerometry data were analyzed for each child from 8 AM to 8 PM. To ensure that the accelerometer measures of daily PA were not corrupted by including data from periods when the accelerometers were not being worn, FilemakerPro7 (Macintosh, USA) was used to automatically delete missing data (defined as continuous sequences of zeros longer than 10 min, based on the observation that this could only be caused by the accelerometer not being worn). This technique has been recommended as an important part of ensuring the reliability of accelerometer data.34,35 Children failing to provide a minimum of 2 separate days of 12 h of valid recording, after removal of missing data, were excluded from the study (n = 78). Time spent in moderate (medium exertion in a standing position or 1500 to 6499 counts per minute) and vigorous (high level of exertion in the standing position or ≥6500 counts per minute) physical activity was calculated according to the threshold cut-offs validated by Puyau et al.31 Data were analyzed for 2 time periods: school-time was classified as 9 AM to 3 PM on weekdays and home-time consisted of 8 AM to 9 AM and 3 PM to 8 PM on weekdays, and 8 AM to 8 PM on weekend days. As data from year one of the intervention were used in these analyses, the presence of an activity coordinator was adjusted for.

Measurement of School Ground Characteristics

School playgrounds were evaluated using 2 measures: the surface area of each school playground (m²) and the number of permanent play facilities. The area of the school playgrounds was measured using a 100-m measuring tape and duplicate measurements were obtained. As no validated, objective methods exist for quantifying permanent play facilities in school grounds, we developed our method based on the literature regarding children’s play36–38 and on previous qualitative observational studies of children’s play activities in school breaks. Essentially, play facilities were defined and counted as physical structures in the school grounds if they had previously been observed to be used by children for play and/or sports activities during break-time observations in different schools (17 observations at 10 New Zealand schools and 44 observations at 22 Danish schools, Nielsen, unpublished). From these observations, permanent play facilities were defined as school-ground physical structures (excluding buildings) that could encourage physical activity in individuals (eg, swings, slides) or groups of children (eg, cluster of trees, playground markings). Examples of items counted as play facilities included: goals and hoops for ball activities such as soccer, rugby, netball, and basketball; playground markings for self-invented or established games such as hopscotch and 4-square; playground elements shown to provide a sufficient structure for one group to play on at a time (eg, a tower, a climbing frame, a seesaw); clusters of trees or bushes that were big and close enough to enable games such as hide-and-seek, catch or self-invented role play;
tennis nets; walls designated and constructed for playing ball against; sandpits; and trampolines. The number of school-ground play facilities at each school was counted twice on different occasions by 1 researcher (GN) while the children were at play. If discrepancies occurred, additional observations of children’s play were undertaken and the facilities recounted. This occurred twice, with counts differing by 2 and 3. A third and final count was completed and used in analyses.

Statistical Analysis

All data were analyzed using STATA (StataCorp, Stata Statistical Software, Release 8.0 College Station, TX, Stata Corporation; 2003). Variables not normally distributed were log-transformed before analysis and the raw data presented. Because schools (not students) were the sampling unit, generalized estimating equations (GEE) were used to analyze the data. Robust standard errors (based on the Sandwich estimate) were used to estimate the confidence intervals and p values. In the regression analysis adjustments were made for age, sex, the presence of activity coordinators at some of the schools30 and school roll (number of pupils). Interaction terms between age, sex and the presence of activity coordinators were also considered (P < .05 indicated significance).

Results

This analysis concerns the 417 children (80%) for which valid accelerometry data were obtained. Table 1 presents the characteristics of the study population. Boys and girls were of similar age, height, weight and BMI and 31% of children were overweight or obese. Children with accelerometry data were slightly older than the nonrespondents (8.6 vs 8.0 years, P = .009) but did not differ in BMI z-score (P = .925) or sex distribution (P = .448). Accelerometry data were obtained for 2.8 (SD 1.3) days in males and 2.7 (1.2) days in females (P = .504). No differences in compliance, sex/age distribution, or length of play time were observed between the schools (data not shown).

Activity counts and time in moderate and vigorous activity at school, home and combined are shown in Table 2. Children were spending more than 4 hours per day in moderate activity and an additional 17 to 20 minutes engaged in vigorous activity. No sex differences in activity were observed for any measure presented. However, mean activity counts were negatively associated with age in girls (4.9% decline per year of age, P = .005) but not boys (–0.9%, P = .585). Children were more active at school but differences were small (43 counts, P = .042; 6 more minutes moderate activity, P = .037, 2 more minutes vigorous activity, P < .001).

### Table 1  Characteristics of the Study Population

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
<th>Total group</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>215</td>
<td>202</td>
<td>417</td>
</tr>
<tr>
<td>Age (years)</td>
<td>8.6 (1.9)</td>
<td>8.7 (1.9)</td>
<td>8.6 (1.9)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>131.5 (12.4)</td>
<td>131.7 (12.7)</td>
<td>131.6 (12.5)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>32.5 (10.8)</td>
<td>32.6 (10.7)</td>
<td>32.5 (10.8)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>18.3 (3.4)</td>
<td>18.3 (3.3)</td>
<td>18.3 (3.3)</td>
</tr>
<tr>
<td>BMI z-score</td>
<td>0.72 (0.86)</td>
<td>0.60 (0.90)</td>
<td>0.66 (0.88)</td>
</tr>
<tr>
<td>Weight status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>133/56/26</td>
<td>137/37/28</td>
<td>270/93/54</td>
</tr>
</tbody>
</table>

Note. Data are presented as Mean (SD) except for Weight status, which is expressed as number of children classed as normal weight/overweight/obese according to CDC reference data.

### Table 2  Physical Activity at Home, at School, and Total Activity

<table>
<thead>
<tr>
<th>Period</th>
<th>Males</th>
<th>Females</th>
<th>Total group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home*</td>
<td>Average counts (counts/min) 927 (481)</td>
<td>904 (417)</td>
<td>916 (451)</td>
</tr>
<tr>
<td></td>
<td>Moderate activity (mins/day) 134 (40)</td>
<td>140 (42)</td>
<td>137 (41)</td>
</tr>
<tr>
<td></td>
<td>Vigorous activity (mins/day) 9 (12)</td>
<td>8 (10)</td>
<td>9 (11)</td>
</tr>
<tr>
<td>School*</td>
<td>Average counts (counts/min) 1024 (504)</td>
<td>943 (435)</td>
<td>986 (474)</td>
</tr>
<tr>
<td></td>
<td>Moderate activity (mins/day) 146 (48)</td>
<td>146 (48)</td>
<td>146 (48)</td>
</tr>
<tr>
<td></td>
<td>Vigorous activity (mins/day) 12 (15)</td>
<td>11 (12)</td>
<td>12 (13)</td>
</tr>
<tr>
<td>Total*</td>
<td>Average counts (counts/min) 969 (449)</td>
<td>935 (396)</td>
<td>953 (424)</td>
</tr>
<tr>
<td></td>
<td>Moderate activity (mins/day) 260 (90)</td>
<td>260 (94)</td>
<td>260 (92)</td>
</tr>
<tr>
<td></td>
<td>Vigorous activity (mins/day) 20 (23)</td>
<td>17 (18)</td>
<td>18 (21)</td>
</tr>
</tbody>
</table>

Note. Data are presented as Mean (SD).

*Home time defined as 8 AM–9 AM and 3 PM–8 PM on weekdays and 8 AM–8 PM on weekends; school time as 9 AM–3 PM on weekdays; and Total time as 8 AM–8 PM on all days.
The number of permanent play facilities at each school ranged from 14 to 35 (mean = 28.2, SD = 6.8) and the area ranged from 5014 m² to 24,102 m² (mean = 12,657, SD = 5984). Figure 1 demonstrates the unadjusted average accelerometry counts in relation to the number of play facilities at each school \( (r = .34, P < .001) \), as well as the school roll, number of children per playground facility, and the playground structure density (area of school playground per pupil). Table 3 demonstrates that a higher number of play facilities at school was consistently associated with higher levels of activity, both at school and for total activity. For each additional play facility, average accelerometry counts during school hours were 3.8% (2.5, 5.1%) higher once adjusted for age, sex, staffing and school roll (number of pupils). Children also spent more time engaged in moderate (1.9%, \( P = .003 \)) or vigorous (10.1%, \( P < .001 \)) activity. These differences translated to about 4 more minutes of MVPA per extra playground facility during school hours and 9 minutes overall. Higher school-time activity at schools with more play facilities was not compensated for by decreased activity outside of school hours; total activity was also strongly correlated with the number of play facilities (Table 3). Moreover the effect of play facilities on activity was seen in both sexes and across all ages studied (5–12 years).

Both school roll and the area of the school grounds were correlated with the number of play facilities \( (r = .72 \text{ and } r = .73 \text{ respectively, both } P < .001) \). However, neither variable showed significant independent effects on physical activity and adjusting for area as well as roll did not significantly change the estimates between play facilities and activity (data not shown).

**Discussion**

Our study demonstrated that the number of permanent play facilities in schools is positively related to activity in children, whether expressed in terms of total activity or the amount of time engaged in activity of moderate to vigorous intensity. Each additional play facility was associated with higher total activity during school hours by 3.8%, and time in MVPA by 2.3%, equivalent to 4 minutes. Importantly, higher school-based activity was not compensated for by decreased activity during home time; patterns for total daily activity were similar to that observed for during school hours.

It is conceivable that individual schools could increase the number of play facilities by 5 to 10 per school given that many of the structures included were relatively inexpensive options such as soccer goals, basketball hoops or playground markings for games.
such as hopscotch and four-square. Thus an additional 5 facilities in our study was associated with a 15% to 20% increase in overall activity, with substantial increases in the time spent in moderate (10% to 15% or 14 minutes) and vigorous (50% or 6 minutes) activity. Furthermore, many of the more expensive structures, such as climbing towers, slides, and forts, last a number of years with minimal maintenance requirements. Through observation and discussions with school staff, over 80% of the facilities counted in our study were estimated to be 5 to 10 years old. Thus, investigating the cost-effectiveness of improving school playgrounds in relation to activity would be of interest.

Although we controlled for multiple factors in our analyses, it is possible that our findings could be confounded if the schools with the most permanent play facilities on their grounds were also the schools with the most extensive physical education programs or other physical activity supportive policies and practices, which we did not assess. However variation in such factors was not our impression from working with the schools. Furthermore, any potential effects of such school-specific confounding were partly countered in the analysis by adjusting for clustering and the presence of activity coordinators at some of the schools, in the models. It is also feasible that variation in socioeconomic status may influence activity or playground facilities within schools. However, we saw no need to adjust for socioeconomic status as little variation in school decile rating was observed in our study sample (range of 3 to 7 from possible 1 to 10). Because our study was relatively small, replication in a larger, more diverse sample is required. Furthermore, our analyses used data after 1 year of intervention. While we adjusted for intervention status in the analyses, it is possible that children from intervention schools would be more motivated to participate in activity because they were part of an activity promoting intervention. While we cannot exclude this possibility as we did not measure motivation per se, we do not believe that it would confound our findings to any great extent.

Few other studies have examined the potential for permanent or stationary play structures to influence physical activity in children. Sallis et al demonstrated that play area, size and improvements (eg, basketball hoops) were associated with activity in girls whereas facilities and adult supervision influenced participation in boys. These data should be interpreted with caution given that only 1.6% of girls and 5.5% of boys (total sample pool n = 1081) were deemed to be physically active by observation. Farley et al investigated whether particular types of play equipment influenced activity during after school hours in one school playground. Observations demonstrated that diversity of facilities was important and that children congregated in the adventure playground and concrete court areas. We did not measure diversity or quality of playground structures in our study as the aim was simply to determine if the number of facilities influenced activity in any way. In our study, although playground area was strongly correlated with the number of permanent facilities, it did not exert any independent effects on activity once adjusted for the number of facilities. Each of our schools

Table 3  The Effect of the Number of Permanent Play Facilities on School Time and Total Activity

<table>
<thead>
<tr>
<th></th>
<th>Ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home time activitya</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average counts</td>
<td>1.026</td>
<td>1.010, 1.042</td>
<td>0.001</td>
</tr>
<tr>
<td>Time in moderate activity</td>
<td>1.010</td>
<td>0.997, 1.024</td>
<td>0.140</td>
</tr>
<tr>
<td>Time in vigorous activity</td>
<td>1.049</td>
<td>1.029, 1.071</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time in moderate/vigorous activity</td>
<td>1.013</td>
<td>0.999, 1.027</td>
<td>0.078</td>
</tr>
<tr>
<td>School time activitya</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average counts</td>
<td>1.038</td>
<td>1.025, 1.051</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time in moderate activity</td>
<td>1.019</td>
<td>1.007, 1.031</td>
<td>0.003</td>
</tr>
<tr>
<td>Time in vigorous activity</td>
<td>1.101</td>
<td>1.072, 1.132</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time in moderate/vigorous activity</td>
<td>1.023</td>
<td>1.010, 1.037</td>
<td>0.001</td>
</tr>
<tr>
<td>Total activitya</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average counts</td>
<td>1.027</td>
<td>1.012, 1.041</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time in moderate activity</td>
<td>1.031</td>
<td>1.013, 1.050</td>
<td>0.001</td>
</tr>
<tr>
<td>Time in vigorous activity</td>
<td>1.102</td>
<td>1.066, 1.139</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time in moderate/vigorous activity</td>
<td>1.034</td>
<td>1.015, 1.054</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Note. Data are presented as ratios per unit increase in play facilities adjusted for age, sex, the presence of activity coordinators at school, and school roll.
a Home time defined as 8 AM–9 AM and 3 PM–8 PM on weekdays and 8 AM–8 PM on weekends; school time as 9 AM–3 PM on weekdays; and Total time as 8 AM–8 PM on all days.
had quite large play areas (5014 m² to 24,102 m²) given the number of students. Others have demonstrated that play area can influence activity, but only in boys and that less able boys tend to be excluded from activity as space decreases.29

Studies have demonstrated that additional playground markings may offer an inexpensive alternative for promoting physical activity in children. However, novelty may contribute to these findings given than measures of activity at follow-up occurred only 4 weeks later.24,40 Only 1 study appears to have undertaken more sustained follow-up (6 months) after the introduction of playground markings, soccer goals, basketball hoops and fencing around designated play areas. Intervention children participated in 4.5% more moderate/vigorous activity at recess adjusted for multiple confounders, and intervention effects were stronger for those who were less active at baseline.41

Our study supports and extends these findings by showing that higher school based activity is not compensated for by reductions in activity outside of school hours. Our use of accelerometers to assess activity provides an objective assessment of activity that can be analyzed according to time frames of interest and intensity of activity.42 However, actual values used to define moderate and vigorous activity vary in the literature and also differ by accelerometer type. We used the cut-offs for moderate and vigorous activity developed for Actical by Puyau et al.33 Here, the lower cut-off used to define moderate activity included quite light movement such as slow walking (3.2 km/hour) or tossing a ball (0.04 kcal·kg⁻¹·min⁻¹). This cutoff appears to be at the lower end of the range used in other research.43–46 Use of this less conservative cutoff may contribute to the lack of sex differences in activity observed in the current study, which are typically found in this age group.28,44 It would also explain the apparently high participation in activity observed in our children, in contrast to other work reporting much less time in MVPA.45,46 Our participants also wore accelerometers for an average of 2.8 days, which may be insufficient to measure habitual activity in children.47 However, there is no reason to expect that deviations from habitual would differ more in children from schools with fewer play facilities.

In conclusion, it appears that increasing the number of permanent play facilities in school playgrounds may offer a cost-effective, long-term initiative for increasing physical activity in children. Potential benefits include positive effects for children of all ages and in both sexes. Such an intervention may be attractive to teachers and schools due to not impacting on curriculum load or supervisory duties and only warrants the initial outlay for facilities rather than the ongoing costs required of interventions utilizing people.48

References