This study investigated the impact of renovation and redesign of a university preschool’s outdoor space on children’s sedentary behavior, light activity, and moderate-to-vigorous-physical-activity (MVPA) during unstructured recess. Physical activity was measured by accelerometry and direct observation in two independent samples of 50 (baseline) and 57 (postintervention) children (Mean age = 4.4 yrs ± 0.5). Controlling for gender, age, BMI and recess length, observational data, but not accelerometry, revealed a significant decrease in intervals spent sedentary (-26.5%) and increases in light physical activity (+11.6%) and MVPA (+14.9%). Higher levels of MVPA were associated with specific environmental changes (new looping cycle path, OR = 2.18; increased playground open space, OR = 7.62; and new grass hill, OR = 3.27). Decreased sedentary behavior and increased light activity and MVPA may be realized with environmental changes that promote continuous and novel movement experiences in more expansive spaces.
juego, OR= 7.62 y una nueva colina de hierva OR = 3.27). La disminución de las conductas sedentarias asociadas con un incremento del nivel de actividad física ligera y de moderada a alta intensidad pueden lograrse con cambios en el medio ambiente que promuevan el desarrollo continuo de movimientos y nuevas experiencias en espacios más amplios.

Physical activity is an integral component of a healthy lifestyle. Engaging in regular physical activity during childhood is hypothesized to benefit health both during childhood and adulthood (32). While national and international guidelines conflict, they collectively recommend that preschool-aged children accumulate at least 2 and up to 3 hr of physical activity daily (Australia; 11, UK; 12, USA; 22). It is becoming apparent, however, that even children in the preschool age group are susceptible to a sedentary lifestyle and its consequences. Physical activity levels of children attending child care centers are typically low, and levels of sedentary behavior are typically high (26). Specifically, young children spend 89% of their time sedentary during the preschool day (3). Overall, more than 25% of preschool-aged children in the United States are considered overweight or obese (24), and overweight preschoolers are significantly less active than their nonoverweight peers during the preschool day (31).

Prevention of physical inactivity and obesity among preschool-aged children is best addressed by focusing on the social and physical environments in which children spend the preponderance of their day (18). Preschools are an appropriate venue to target because greater than 60% of American 3-to-5-year-old children attend them (15), policies aimed at health, wellness, and PA opportunities in preschools already exist (9,13), and preschools are encouraged to provide daily structured physical activity to help children develop basic locomotor skills (19). Nevertheless, child care centers differ systematically with respect to the quality and quantity of PA provided, suggesting that center-level policies and practices, as well as a center’s physical environment, are important influences on children’s physical activity (27,33).

Recess affords an opportunity for physical activity, generally occurs multiple times over the course of a day, and accounts for nearly a quarter of the average school day in primary grades (1). Disappointingly, 4-to-5-year-old children have been found to spend the majority of recess time in sedentary pursuits (3). As recess presents an ideal opportunity to encourage children’s physical activity and contributes to meeting physical activity recommendations (26), intervention on various aspects of recess is warranted.

Physical or built environmental interventions hold potential as a means of promoting physical activity overall (34) and at recess (8,17,27,28). Indeed, the link between supportive environments and physical activity among preschool-aged children is generally supported (10). Multiple recess intervention approaches have shown evidence of effectiveness. Activity-friendly equipment was added to an outdoor preschool playground, increasing preschooler’s MVPA (17), while the same approach coupled with multicolored playground markings did not change MVPA (5). In elementary schools, Ridgers and colleagues reported several studies showing that simple playground markings increased children’s physical activity substantially and for up to 6 months (27,28). There is emerging evidence that specific built environment features of playgrounds are related to children’s physical activity (9). Thus, there are multiple lines of evidence that suggest built environment changes to playgrounds can be an effective intervention. Though park renovation studies have
produced both positive (2,7) and negative outcomes (9), the effects of playground renovations on physical activity of preschoolers have not been examined.

Most playground studies have used either accelerometers (5,17,28) or direct observation (2,3,15) to evaluate physical activity outcomes. A shortcoming of using a single measurement type, however, is that they may differ on sensitivity to change. Combining accelerometry and direct observation for the purpose of quantifying and qualifying physical activity in conjunction with an environmental intervention is rare in the literature (30). Thus, we employed both measurement methods to answer the following questions: What effect did a physical reconfiguration and repurposing of a playground’s spaces have on preschool children’s physical activity? What contextual characteristics of children’s play behavior were related to changes in physical activity?

Method

Participants and Setting

Two independent cross-sectional samples of 50 (n = 21 boys; baseline) and 57 (n = 34 boys; postintervention) 4-to-5-year old preschoolers, enrolled in a university campus children’s center, participated in the study. The study protocol was approved by the university IRB, and parents provided written informed consent. Baseline data were collected during fall 2009, the playground was changed during spring 2010, and postintervention data were collected during fall 2010. For baseline and postintervention samples, respectively, 84.1% and 86.2% of the children were classified as having a healthy weight for height (i.e., BMI) and racial-ethnic composition included White (70.2% and 63.2%), Hispanic (7.0% and 13.2%), Asian (12.3% and 13.2%), and Black (10.4% and 10.3%).

Supervising and master teachers were the same throughout the study. There were two student intern changes over the same time period. No instruction about ways to interact with preschoolers during recess was provided to the teachers during the study. Both sets of measurements were performed during the fall season in a large coastal city in southern California. Weather was qualitatively classified each day of measurement by the second author as sunny/partly cloudy/cloudy, hot/mild/cool, and no rain/rain. No differences in weather patterns between the two time periods were noted.

Intervention

Renovation of the outdoor space was inspired by Richard Louv’s urban naturalism concepts (19), whereby natural elements (e.g., purposeful plantings and topographical contours) of the environment are major design features intended to promote individual discovery and social interaction. Paired with this theme was physical reconfiguration and repurposing of various playground elements thought to foster desired play forms and sustain higher levels and duration of MVPA. Specifically, an L-shaped linear bike path (16m) on the perimeter of the outdoor space was transformed into a looping path (35m) around an existing open grass area; a grassy hill (slope of 40%) on the northern part of the grass area was created; and removal of two medium-sized plastic climbing/sliding structures (surface occupied 10m²) effectively created more open space in the playground area.
Measures

**Anthropometric Assessment.** Height was measured without shoes to the nearest 0.5 cm using a straight edge (i.e., sliding horizontal headpiece) and cloth tape measure vertically affixed to and trued with the edge of a door jamb. Weight in light clothing and without shoes was measured to the nearest 0.1 kg using a portable digital scale (Healthometer LED Split Mat, Alsip, IL, USA). Age- and gender-norm BMI percentiles were computed using the Children’s BMI Tool for Schools (6).

**Observation of Physical Activity.** The Observational System for Recording Activity in Children-Preschool Version (OSRAC-P) was developed by Brown et al. (4) to measure the type, intensity, and contexts of preschoolers’ physical activity. Specifically adapted for this study (23), data were collected on (a) physical activity intensity (5 levels), (b) physical activity type (15 categories; stand, sit/squat/kneel, walk, run, climb/hang, pull/push, ride, rock, jump/skip, throw/kick/catch, lie down, crawl, rough and tumble, dance, and roll), (c) play context (9 categories; open space, fixed equipment, wheel, sandbox, ball/object, portable equipment, teacher arranged, socioprops, and game), (d) group composition (5 categories), and (e) location (5 categories; playground, cement path, grass north, grass south, and sandbox). Individual children were observed for at least 15 and no more than 30 min utilizing 5s-observation/25-s recording intervals, which were cued by an external media device (Ipod Nano). Recordings were made on paper forms and started as soon as the child appeared outside for recess and continued until the child returned inside for lunch. Each child was observed twice, yielding a total of 214 observations across the two groups. For each child, categorical means generated from both observations were used for analyses.

Three coders were trained by the second author who has substantial background in systematic observation techniques and served as the gold standard. Fifteen interobserver agreement (IOA) checks were performed: seven during the latter stage of observer training and eight during data collection at baseline and postintervention. IOA audits were performed midway through baseline (i.e., before environmental changes) [physical activity intensity,  \( M = 85.4 \pm 4.7\% \); physical activity type  \( M = 87.3 \pm 7.7\% \); play context  \( M = 87.8 \pm 12.5\% \); and location  \( M = 97.5 \pm 3.1\% \)] and during postenvironmental changes [physical activity intensity,  \( M = 80.0 \pm 5.1\% \); physical activity type  \( M = 91.7 \pm 2.5\% \); play context  \( M = 93.9 \pm 4.9\% \); and location  \( M = 93.6 \pm 4.4\% \)].

**Accelerometry.** ActiGraph GT3× (ActiGraph, Pensacola, FL, USA) units were used to measure physical activity. An elastic band with snapping buckles was threaded through the unit and cinched around a child’s waist with the device placed in line with the right hip. Activity count cut-offs identified by Sirard and colleagues (29) for 15-s epochs were applied to vertical axis data and corresponded to sedentary (i.e., \( \leq 1.5 \text{ MET} \leq 364 \text{ and } < 399 \text{ counts for 4- and 5- year old children, respectively} \)), light (i.e., \( > 1.5 \text{ MET} \geq 364 \text{ or } > 399 \text{ counts and } < 3 \text{ MET} \geq 812 \text{ or } > 891 \text{ counts for 4- and 5- year old children, respectively} \)) and MVPA (i.e., \( \geq 3 \text{ MET} \geq 812 \text{ or } > 891 \text{ counts per 15-s epochs for 4- and 5-year old children, respectively} \)). Accelerometers were worn during school day, three times for determining the mean percent of epochs spent sedentary, in light activity, and in MVPA.
**Physical Space Measurement.** Before baseline measurement, the authors consulted children’s center administration and parent committee members regarding their plans for physical modification of the playground. After joint visual inspection of the playground with staff, we divided the space into zones based on current location/purpose and projected changes. By retaining the original zones from baseline, we used the OSRAC-P at postintervention to determine shifts in location by activity type and detect changes in physical activity intensity. In all, five zones were identified: cement path, sandbox, playground, grass south, and grass north.

**Data Analysis**

Data were analyzed using SPSS Statistics software (version 19.0). Accelerometer measurements were downloaded using ActiLife Data Analysis Software (version 4.3.0) and analyzed using MeterPlus software (version 4.2). For observed intensity, OSRAC-P intervals recorded as Levels 1 and 2 were combined and categorized as sedentary; Level 3 was categorized as light activity; and Levels 4 and 5 were combined and categorized as MVPA (3).

For physical activity intensity, the percentage of epochs or intervals spent sedentary, in light activity, and in MVPA were used as dependent variables (Table 1). Kolmogorov-Smirnov tests were used to check for normality. Because observation-based MVPA was not normally distributed, it was square root transformed.

Independent $t$-tests were conducted to examine differences between child groups at baseline and postintervention for age, BMI, and recess duration. Statistical tests were conducted separately for observation- and accelerometer-based measures of physical activity intensity. Two-way analyses of covariance (ANCOVA) were computed (pre- and post-environmental changes × gender) to measure intervention and gender main effects and their interaction. Covariates included age and BMI percentile (as continuous variables) while dependent variables were percentage of epochs or intervals spent sedentary, in light intensity and in MVPA. Follow-up analyses were performed using one-way ANCOVA while controlling for gender, age, and BMI. Finally, post hoc contrasts were computed (Table 2).

Chi-square tests were used to determine differences between MVPA percentage from baseline to postintervention for the modified areas and their associated most frequent activity types and play contexts (Table 3). For example, whereas at baseline the physical activity types of pull/push and ride associated with wheeled toy play contexts occurred on the cement path, postintervention they primarily occurred on the new track located in the grass area. Thus, we determined how MVPA changed as a result of using wheeled toys in the new dedicated location. Effect sizes were computed using odds ratios for chi-square (16).

**Results**

**Descriptive Results**

Independent $t$-tests conducted on baseline and postintervention groups for age, BMI, and recess duration revealed that the postintervention group was significantly younger than the baseline group [$t(105)=3.08$, $p=.003$] (Table 1). BMI and recess duration were not significantly different between groups.
<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th></th>
<th>Post intervention</th>
<th></th>
<th>Post intervention</th>
<th>Difference</th>
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</thead>
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<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
<td>Baseline</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>n = 21</td>
<td>n = 29</td>
<td>n = 34</td>
<td>n = 23</td>
<td></td>
<td>n = 23</td>
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<tr>
<td>Age (yr)</td>
<td>4.8 (0.3)</td>
<td>4.7 (0.3)</td>
<td>4.3 (0.2)</td>
<td>4.4 (0.3)</td>
<td>4.7 (0.7)</td>
<td>4.3 (0.2)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.3 (0.4)**</td>
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<tr>
<td>BMI (percentile)</td>
<td>53.3 (28.3)</td>
<td>45.8 (29.5)</td>
<td>50.7 (27.7)</td>
<td>61.6 (32.5)</td>
<td>48.0 (29.4)</td>
<td>55.1 (30.0)</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>+ 7.1 (29.9)</td>
</tr>
<tr>
<td>Measurement duration (min)</td>
<td>23.3 (4.1)</td>
<td>23.2 (3.6)</td>
<td>23.7 (4.5)</td>
<td>24.9 (4.9)</td>
<td>23.3 (3.8)</td>
<td>24.2 (4.6)</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>+ 0.9 (4.2)</td>
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<td>Accelerometry</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary (% of Epochs)</td>
<td>49.7 (17.8)</td>
<td>56.9 (12.0)</td>
<td>52.1 (14.5)</td>
<td>60.6 (12.4)</td>
<td>53.8 (15.0)</td>
<td>55.6 (14.2)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>+ 1.8 (15.0)</td>
</tr>
<tr>
<td>Light (% of Epochs)</td>
<td>32.6 (7.7)</td>
<td>27.5 (6.5)</td>
<td>30.9 (7.9)</td>
<td>24.7 (6.1)</td>
<td>29.3 (7.5)</td>
<td>27.8 (7.6)</td>
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<td></td>
<td></td>
<td></td>
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<td>-1.5 (6.9)</td>
</tr>
<tr>
<td>MVPA (% of Epochs)</td>
<td>17.7 (13.5)</td>
<td>15.6 (10.4)</td>
<td>17.0 (9.4)</td>
<td>15.2 (9.2)</td>
<td>16.3 (9.2)</td>
<td>16.1 (9.3)</td>
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<td></td>
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<td>-0.2 (9.3)</td>
</tr>
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<td>Observation</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary (% of intervals)</td>
<td>79.5 (8.5)</td>
<td>80.7 (8.5)</td>
<td>50.3 (9.6)</td>
<td>58.7 (10.7)</td>
<td>80.2 (8.4)</td>
<td>53.7 (10.8)</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-26.5 (9.2)</td>
</tr>
<tr>
<td>Light (% of intervals)</td>
<td>14.9 (9.5)</td>
<td>13.8 (9.2)</td>
<td>27.4 (8.3)</td>
<td>23.6 (8.8)</td>
<td>14.3 (9.3)</td>
<td>25.8 (9.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ 11.5 (8.3)</td>
</tr>
<tr>
<td>MVPA (% of intervals)</td>
<td>5.6 (5.7)</td>
<td>5.5 (4.7)</td>
<td>22.3 (8.4)</td>
<td>17.7 (8.4)</td>
<td>5.5 (5.1)</td>
<td>20.5 (8.6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ 14.9 (7.0)</td>
</tr>
</tbody>
</table>

Note. **p < .01.
Accelerometer-Based Physical Activity Differences

Controlling for gender, age and BMI, postintervention percentages of accelerometer epochs spent sedentary, in light intensity, and in MVPA were not significantly different from baseline (Table 2). A gender main effect was found for percentage of epochs spent sedentary \( [F(1, 102)=7.78, \ p= .006, \ \text{partial } \eta^2=.08] \) and in light activity \( [F(1, 102)=22.01, \ p< .001, \ \text{partial } \eta^2=.17] \). Compared with boys, girls were categorized as sedentary \( (M_{\text{Difference}}=+7.32\%) \) and in light physical activity \( (M_{\text{Difference}}=-6.11\%) \) for greater and lesser percentages of epochs, respectively.

Observation-Based Physical Activity Differences

Controlling for gender, age and BMI, percentages of observation intervals spent sedentary \( [F(1, 102)=184.70, \ p< .001, \ \text{partial } \eta^2=.65] \), in light intensity \( [F(1, 102)=98.41, \ p< .001, \ \text{partial } \eta^2=.48] \), and in MVPA \( [F(1, 102)=114.92, \ p< .001, \ \text{partial } \eta^2=.52] \) were significantly different compared with baseline (Table 2). At postintervention, children spent significantly fewer intervals sedentary \( (M_{\text{Difference}}=-25.6\%) \) and significantly more intervals in light activity \( (M_{\text{Difference}}=+11.6\%) \), and in MVPA \( (M_{\text{Difference}}=+14.9\%) \). A gender main effect was only found for percentage of intervals spent sedentary \( [F(1, 102)=6.71, \ p= .01, \ \text{partial } \eta^2=.06] \). Compared with boys, girls spent a greater percentage of intervals sedentary \( (M_{\text{Difference}}=+ 9.5\%) \). An interaction was found between gender with pre- and postenvironmental changes for percentage of intervals spent sedentary \( [F(1, 101)=4.94, \ p = .03, \ \text{partial } \eta^2=.04] \). Boys demonstrated a greater drop in percentage of intervals spent sedentary compared with girls \( (M_{\text{Difference}}= 8.4\%) \).
Table 3  Percentage of Observation Intervals Spent in Different Activity Intensities or Type Before and After Space Renovation

<table>
<thead>
<tr>
<th></th>
<th>Cement Path%&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Playground %</th>
<th>Grass %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>PI</td>
<td>Baseline</td>
</tr>
<tr>
<td>Sedentary</td>
<td>82.1</td>
<td>67.3</td>
<td>95.1</td>
</tr>
<tr>
<td>MVPA</td>
<td>7.9</td>
<td>32.7</td>
<td>4.9</td>
</tr>
<tr>
<td>$\chi^2$</td>
<td>106.93***</td>
<td></td>
<td>173.95***</td>
</tr>
<tr>
<td>Odds ratios</td>
<td>2.18</td>
<td></td>
<td>7.62</td>
</tr>
</tbody>
</table>

**Descriptive data**

<table>
<thead>
<tr>
<th>MVPA type&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Baseline</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pull/push</td>
<td>21.4</td>
<td>45.6</td>
</tr>
<tr>
<td>Ride</td>
<td>71.0</td>
<td>51.8</td>
</tr>
<tr>
<td>Run</td>
<td>4.8</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Jump</td>
<td>&lt;1.0</td>
<td>8.4</td>
</tr>
<tr>
<td>Walk</td>
<td>&lt;1.0</td>
<td>5.3</td>
</tr>
</tbody>
</table>

<sup><i>Note.</i></sup> *** $p < .001$

PI = Postintervention

<sup>a</sup> Primary play contexts analyzed: cement path = wheel; playground = ball, open space, teacher arranged; grass = ball, open space, teacher arranged

<sup>b</sup> Only physical activity types that totaled greater than 1% of all intervals are reported
Specific Environmental Changes and Observed MVPA Differences

There were significant associations between observation intervals in MVPA at postintervention and the original linear cement path location [$\chi^2 (1)=106.93, p < .001, OR = 2.18$], playground open space as a result of removing two structures [$\chi^2 (1)=173.95, p < .001, OR = 7.62$], and open space grass area, which at postintervention encompassed a majority of the new looping cycle track as well as a grass hill [$\chi^2 (1)=60.82, p < .001, OR = 3.27$].

Analyses focusing on physical activity type at pre- and postintervention detailed which OSRAC-P types of activity were performed at the recess locations affected by the intervention (Table 3). Overall, the new looping cycle path was associated with as many riding opportunities as pull/push skills. The removal of two medium-sized plastic climbing/sliding structures was associated with greater physical activity type variability (i.e., from 100% running at baseline to less running and the inclusion of jumping and walking at postintervention). Finally, the creation of a grassy hill in the grass north zone was associated with more running, jumping and walking.

Discussion

The physical alteration of a playground was accompanied by an observed decrease in sedentary behavior (-26.5%, although still the majority) and an increase in light activity (+11.6%) and MVPA (+14.9%) compared with preintervention conditions. Moreover, specific environmental modifications were associated with higher levels of children’s physically active play during recess.

In the current study, accelerometer-based findings were statistically nonsignificant. Previous interventions utilizing accelerometers and 15-s sampling intervals (as in our study) have demonstrated equivocal findings. With a similar sample size, but without controlling for BMI, Hannon and Brown (17) found that the simple addition of preschool playground equipment was followed by decreased sedentary behavior (41%, -16%), increased light activity (34%, +4%), and increased MVPA (24%, +12%). Conversely, Cardon et al. (5) found no effects on sedentary behavior and physical activity when providing markings and play equipment to 40 preschools. Although accelerometry is considered a highly valid means for measuring preschoolers’ physical activity, it is unable to detect increases in energy cost due to walking/running up an incline, static work, upper-body movements, cycling and carrying loads (25). In our study, two of the three playground alterations involved elements designed to produce similar activities; thus, activity counts may not have represented true energy costs that were captured by direct observation. Moreover, descriptive analyses of physical activity type at pre- and postintervention indicated increases in those behaviors. Finally, in the current study direct observations were based on a 5-s sampling interval compared with a 15-s sampling for accelerometry, which suggest that intervention effects among preschoolers may be more readily detected using a shorter sampling interval. Though short 5-s accelerometer epochs are often recommended for children (14,20,33), studies show nonsignificant differences between children’s physical activity estimates comparing 5-s and 15-s epochs (14,20). However, McClain and colleagues (20) reported lower MVPA estimates for all epochs of accelerometry data compared with direct observation.

Gender differences were found for sedentary behavior. Girls had a greater percentage of sedentary intervals than boys ($M_{Difference}=+9.5\%$), however, no differ-
ence was found for MVPA. Further, the intervention was more effective at reducing the percentage of intervals boys spent sedentary. Sedentary activities for boys took place mainly inside the sandbox while girls tended to stand and talk with a teacher or sit with other girls to play and talk. These results partially support equipment intervention findings by Cardon et al. (5) but contradict those found by Hannon and Brown (17), who found no gender-related differences. It is useful to continue to evaluate gender effects in response to recess and playground interventions.

**Specific Environmental Changes and MVPA Changes**

Direct observation provides opportunities to understand specific environmental circumstances related to physical activity. Our results confirmed that environmental interventions hold promise as means of promoting physical activity (34). Specifically, results indicated that the new looping cycle path, the playground open space, and the grass hill were associated with greater MVPA than their unmodified analogs. Findings for the modified bike path confirmed previous descriptive results (9). On the playground, the main fixed and large equipment was preserved but the plastic slide structures were removed, which created more open space. This result suggests the importance of offering opportunities to be active in different ways (i.e., running, jumping, walking) on/within structures that otherwise tend to induce more sedentary forms of activity. Finally, results demonstrated that an overarching theme governing design (e.g., Louv’s urban naturalism) can be made consonant with enhancing physical activity even among preschoolers (e.g., north part of the grass area transformed into a grassy hill).

**Strengths and Limitations of the Study**

Study strengths included (a) the use of two independent objective physical activity measures, and (b) evaluating the effects of a permanent environmental intervention. Nevertheless, the study had several limitations. Generalizability of results may be limited. First, participants represented a single university laboratory preschool. Second, prevalence of overweight/obesity was nearly 10% less than national rates, mainly due to the parents being highly educated. Third, the use of two cross-sectional samples and lack of a “control” site mean that causality cannot be inferred. For these reasons, this study’s findings should be considered preliminary in nature. It would be useful to conduct similar studies in diverse settings (i.e., child care, home, park) and with a larger prospective sample to examine the generalizability of present findings.

Future observational research should systematically explore what playground features relate to particular social and cognitive play elements and how these in turn are related to physical activity. In cases where interventions include changes in natural elements (e.g., plantings, water, lithoscape, etc.) observation can be made of children’s direct interaction with these elements and their association with physical activity intensity.

**Notes**

1. Nine students participated in both baseline and postintervention measures but their few numbers precluded prospective cohort analysis and are omitted from this study. Baseline students
either matriculated to kindergarten or did not return the following academic year when postintervention measures were collected.

References


