Influence of Schoolyard Renovations on Children's Physical Activity: The Learning Landscapes Program

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Objectives. We examined whether schoolyard improvements led to increased physical activity levels among both boys and girls and assessed the aspects of schoolyard design that have an impact on physical activity.

Methods. In a quasi-experimental research design, 6 schools with renovated schoolyards and 3 control schools were divided into activity areas. We calculated measures of children's physical activity by area during school hours as well as after-school hours.

Results. The volume of schoolyard use was significantly higher at schools with renovated schoolyards than at control schools, and students were significantly more active at these schools. Also, activity levels were significantly higher among both boys and girls in certain schoolyard areas, such as those with soft surfaces.

Conclusions. Because few public elementary schools in the United States provide daily physical education or its equivalent for all students throughout the school year, noncurriculum approaches to increasing children's physical activity are important. Renovated schoolyards increase the number of children who are physically active, as well as their overall activity levels, and reduce sedentary behaviors. (*Am J Public Health.* 2010;100:1672–1678. doi:10.2105/AJPH.2009.178939)

The percentage of children who are overweight or obese has increased rapidly over the past few decades.[1,2] The change in norms within US culture has led to higher consumption of fatty and calorie-rich foods and an increase in sedentary behavior. To combat this change, new norms must be established that include increases in physical activity. To ensure that future generations are spared the cost of obesity, this normative change must start during development, in childhood.

According to most recent recommendations, children should participate in at least 60 minutes of moderate to vigorous activity every day.[3] Considering the sedentary lifestyles many children lead, the majority of children do not meet these recommendations.[4] With the average child spending 1300 hours at school each year,[5] schools have the potential to provide numerous opportunities for the promotion of physical activity,[6–10] including physical education, recess, intramural programs, interscholastic sports, and access to school physical activity facilities during and outside of school hours.[11–15]

Although school time allocated for physical activity has been reduced,[16] schools are still healthy spaces for students[17,18] and are the opportune setting in which to increase physical activity. According to the Centers for Disease Control and Prevention, however, only 2% of elementary schools provide daily physical education or its equivalent during the entire school year for students in all grades.[19] Although there is an obvious need to increase the amount of school time devoted to physical activity, noncurriculum approaches to increasing children's activity levels may be important as well.[16] For example, providing access to recreational facilities during breaks in the school day (e.g., lunchtime and recess) and outside of school hours can potentially encourage children to engage in physical activity.[20–28]

Several studies have shown that concentrating on individual behavior changes to combat obesity can be effective; however, these changes are typically not sustained and have little true effect on people's behavior.[3,29,30] Thus, social ecology and the built environment have been focal points for obesity prevention. With respect to environment–behavior research, socioecological theory explains human activity as a function of interactions between people and their environments.[31,32] Environments include a range of behavior settings that are seen to provide, to different degrees, opportunities for desired behaviors. Thus, environments exert probabilistic influences, making certain behaviors more or less likely.

Changing children's school environment can alter their activity levels and their exposure to physical activity.[33] One school environment change that has been shown to increase physical activity is upgrading and changing schoolyard spaces. The available quantitative and qualitative research supports the hypothesis that improvements in schoolyard design, including schoolyard markings (e.g., painted asphalt) and renovations, are accompanied by increases in physical activity.[22,23,34–36] However, research on the effects of schoolyards on children's physical activity is sparse, and most studies have been limited in both the number of children observed and the number of sites evaluated. In addition, few studies have divided schoolyards into individual components in an attempt to understand which components encourage and discourage physical activity.

We compared renovated schoolyards with nonrenovated schoolyards at elementary schools in the metropolitan Denver area to assess whether specific schoolyard improvements increase physical activity. In addition, in an effort to understand gender-specific effects of schoolyard equipment components, we compared different components to determine those that hinder physical activity among boys or girls and those that provide increased opportunities for physical activity for all children.

METHODS

Our study, conducted during 2005 and 2006, focused on 9 elementary schools in the Denver public school district. Using a quasi-experimental design, we matched 3 schools with established schoolyards (i.e., in place for at least 2 years) with 3 schools whose schoolyards had been recently built (i.e., within the past year) and 3 control schools. Schools in the first 2 categories had been renovated as part of the Learning Landscapes program (as described subsequently). The control schools were 50 years old on average, with typical schoolyards and minimal improvements over the years.

In 2000, 75 of the elementary schools in this school district were identified as requiring moderate to extensive renovations or upgrades to adequately meet current schoolyard standards. Those most in disrepair were located in inner-city, low-income areas. They consisted mostly of hard play surfaces such as gravel or concrete, were devoid of plant life, and had limited play equipment. Parents have described the schoolyards as "asphalt jungles," unprotected from the hot sun and unusable during otherwise desirable play periods.[37]

Since 1998, through a successful collaboration between the school district and multiple stakeholders, the Learning Landscapes program has transformed 48 neglected elementary schoolyards in the district into attractive and safe multiuse schoolyards tailored to the needs and desires of the local community, creating fun, participatory play areas that encourage outdoor play and learning, improve opportunities for physical activity for children of all ages, and "green" the grounds. The program has been sponsored through a broad-based, public–private partnership and directed by expert faculty and master's-level students from the College of Architecture and Planning at the University of Colorado Denver.

Although each Learning Landscapes schoolyard has unique attributes, there are common elements. At each schoolyard, 3 areas of age-appropriate play equipment are installed, along with asphalt areas for structured games such as basketball and tetherball and a grassed multipurpose playfield, typically with a track. All of the schoolyards have a central gathering space with a shade structure. Additional gathering spaces vary from site to site and can include outdoor classrooms, informal seating areas, and stages or amphitheaters. Trees are planted in hard surface and grassed areas to increase shade.

Landscaped areas also vary from site to site and can include vegetable gardens, habitat areas, native ecosystems, and cultural plantings. At each school, children's art is displayed in the form of tiles, banners, or murals. Some schools have community art projects as well, and all have a community gateway. Parents, children, community members, and school staff provide input into the design of the schoolyard, raise funds to support it, and assist in its construction.[38]

Study Population

The 9 schools selected for participation were grouped into 3 matched categories (A, B, C; Table 1); all of the schools were located in low-income neighborhoods. Because the school district designated schools at which Learning Landscapes schoolyards would be installed, randomization of the treatment schools was not possible. Schools in group A were located in northeastern Denver, approximately 3 miles (4.8 km) from the central business district. In the northern reaches of this area, which is home to many middle-class African Americans, the average annual family income is $21 000, and these neighborhoods have suffered economically over the years. Gang activity is prevalent, and the elementary schools face the challenge of low parental involvement.[39]

Schools in group B were located in southwestern Denver, approximately 5 miles from the central business district. This area was formerly home to primarily White residents; within the past 10 years, however, the population has become increasingly Hispanic. The elementary schools in the area are among the largest in the district; serve rapidly expanding, diverse student populations in prekindergarten to fifth grade (students aged 4–11 years); and face difficult social and economic problems.

Schools in group C were located in western Denver, approximately 3 miles from the central business district, in an area that is beginning to gentrify and is made up of mostly Hispanic residents. The Hispanic population in the area has one of the highest school dropout rates in

TABLE 1—Descriptions of Learning Landscapes Schools and Matched Controls: Denver Public Elementary Schools, 2005–2006

Group Designation	Schoolyard Category	No. of Students	Free or Reduced Lunch, %	Racial/Ethnic Breakdown				No. of Boys Observed	No. of Girls Observed
				African American, %	Latino, %	White, %	Asian, %		
A1	Established	336	94	56	41	2	1	907	757
A2	Recently built	219	88	76	28	1	1	992	759
Ã3	Control	272	91	66	30	2	2	782	652
Total		827	91	66	33	2	1	2681	2168
B4	Established	605	97	0	94	3	3	1276	1128
B5	Recently built	492	96	7	86	3	2	1152	1114
B6	Control	579	92	0	94	4		823	675
Total		1676	95	2	91	3	2	3251	2917
C7	Established	350	94	2	88	8	2	830	958
C8	Recently built	385	90	5	75	9	7	1274	1084
C9	Control	450	94	4	91	4	1	748	594
Total		1185	93	4	85	7	3	2852	2636

the nation, and the percentage of non–English-proficient students at the area's schools nearly doubled between 1995 and 2001.[40]

The 6 schools that were part of the Learning Landscapes program varied according to schoolyard size and amount and types of play opportunities. For example, although all of the schools had 3 areas of age-appropriate play equipment, different vendors installed the equipment at each school. In addition, the schools varied in terms of unprogrammed components, such as sitting areas and gardens.

Because we used an analysis of Denver elementary school boundaries to select areas with a range of schoolyards that exhibited similar traits, we did not control for demographics in the school selection process. Schools with established Learning Landscapes schoolyards were matched with those with recently built Learning Landscapes schoolyards and control schools according to the percentage of students receiving free or reduced lunches, students' race/ethnicity, and school size. The 9 sites represented a broad range of ethnic and minority groups (Table 1). The principals from all of the schools agreed to participate in this study.

During the course of the study, funding was approved for one of the control schools to build an Learning Landscapes schoolyard. Rather than drop the school or its entire group (group A) from the design, the SOPLAY (System for Observing Play and Leisure Activity in Youth) preconstruction data were analyzed with the control group data, whereas the postconstruction SOPLAY data were analyzed with data from schools in the recently built category. Because we tested data relative to schoolyard type rather than individual school, population definitions remained consistent in our analyses. Numbers of observations recorded by school type are presented in Table 1.

SOPLAY, a validated direct observation tool designed to assess physical activity and associated environmental characteristics in free play settings, was used to measure (by gender) children's physical activity before, during, and after school hours.[41] To identify the schoolyard variables with the greatest impact on children's physical activity, design experts divided schoolyards into activity areas based on area type, size, and existence of permanent improvements.

Four days of SOPLAY observation are necessary to obtain a reliable measurement (intraclass correlation of 0.8 for both genders from reliability observations done during data collection).[42] Therefore, we observed each school for 4 days during each wave of data collection. As a means of testing the reliability of the data, 2 observers simultaneously observed activity areas on 20% of the data collection days. To ensure the objectivity of our data collection, observers were not part of the research team.

Data Analysis

Children's physical activity levels were grouped into 3 different categories (validated by heart rate monitors[43,44] and accelerometers[45]): sedentary, moderately active or walking, and very active. From these activity levels, SOPLAY defines the energy expenditure rate (EER) as follows:

$$(1)\ \mathrm{EER} = 0.051\ \mathrm{kcal/kg/min} \times \mathrm{Sedentary} + 0.096\ \mathrm{kcal/kg/min} \times \mathrm{Moderately\ Active} + 0.144\ \mathrm{kcal/kg/min} \times \mathrm{Very\ Active}$$

To conduct a design analysis, we needed a spatial delineation of activity areas at each schoolyard. Surface condition was used as a basis for comparison to accommodate the range of elements and areas between the control and Learning Landscapes schoolyards. Physical activity varies according to surface type; for instance, hard surface areas are limited to running and jumping, whereas soft surface areas provide a greater variety of options. On average, schools had approximately 10 to 12 mapped areas.

Four major categories were created: (1) hard surface structured (basketball and tetherball asphalt areas), (2) hard surface unstructured (unprogrammed creative play or educational marking areas, sitting or social gathering areas, and overhead structure or shade areas), (3) soft surface structured (play equipment requiring fall zones and play fields with grass [Learning Landscapes schools] or without grass [control schools]), and (4) soft surface unstructured (planted areas with or without sitting areas and trails, cultivated or habitat garden areas, and grassed or planted unprogrammed areas). Control schools had only nongrass soft surface areas such as pea gravel.

To investigate the impact of schoolyard environment on children's physical activity, we conducted a standard 2-sample *t* test between each school type in which we compared means for both number of children and total energy expenditure per observational scan. In addition, we compared activity levels between each set of groups by calculating the *z* score for binomially distributed variables; in these analyses, p_i was the probability of being sedentary and $(1-p_i)$ was the probability of being moderately or very active for group *i*, as follows:

$$(2)\ z = (p_1 - p_2)/\sqrt{\{[p_1 \times (1 - p_1)/n_1] + [p_2 \times (1 - p_2)/n_2]\}}$$

We subsequently determined that collapsing the moderately active and very active levels into a single category would provide the best understanding of the number of children who were active. Thus, we included 2 activity levels in our analyses: active and sedentary. SPSS version 16.0 (SPSS Inc, Chicago, IL) was used to conduct all analyses.

RESULTS

The volume of student traffic was higher at Learning Landscapes schools than at control schools, as can be seen in Table 2. In addition, the percentage of active boys was significantly higher at Learning Landscapes schools than at control schools, whereas the percentage of active girls was higher at control schools than at schools with recently built Learning Landscapes schoolyards. The higher volume of student traffic translated into a significantly higher average number of student sightings per observational scan. Table 3 shows differences in the mean numbers of student sightings. P values below .001 were found between control schools and both groups of Learning Landscapes schools in most cases; no significant differences at the $P=.05$ level were found between the 2 types of Learning Landscapes schools in any circumstance.

Energy Expended

Average EER followed a pattern similar to average number of student sightings. The amount of energy burned per scan was significantly higher at both Learning Landscapes schools with established schoolyards and Learning Landscapes schools with recently built schoolyards ($P<.001$ and

TABLE 2—Numbers of Students Observed, by Activity Status, Gender, and School Category: Denver Public Elementary Schools, 2005–2006

Schoolyard Category	Sedentary Boys, No. (%)	Active Boys, No. (%)	Sedentary Girls, No. (%)	Active Girls, No. (%)	Total Sedentary Students, No. (%)	Total Active Students, No. (%)	Total Students, No. (%)
Control	657 (34.1)	1272 (65.9)	602 (37.1)	1020** (62.9)	1259 (35.5)	2292 (64.5)	3551 (21.5)
Established	910 (30.2)	2103* (69.8)	1074 (37.8)	1771 (62.3)	1984 (33.9)	3874 (66.1)	5856 (35.5)
Recently built	1151 (30.0)	2691** (70.0)	1305 (40.1)	1951 (59.9)	2453 (34.6)	4642 (65.4)	7098 (43.0)
Total	2718 (30.9)	6066 (69.1)	2981 (38.6)	4742 (61.4)	5696 (34.5)	10808 (65.5)	16505 (100.0)

*$P < .005$ (established vs control).
**$P < .002$ (recently built vs control).

$P < .002$, respectively) than at control schools. An implication of this finding is that the volume of children at Learning Landscapes schools was significantly greater than was the volume of children at non–Learning Landscapes schools (Table 4).

Impact of Surface Area

Analyses by surface type (hard surface structured, hard surface unstructured, soft surface structured, or soft surface unstructured) revealed that both boys' and girls' activity rates were significantly greater on Learning Landscapes schools' soft surface structured areas than they were in the control environments (Table 4). On hard surface structured areas, however, no significant differences were evident between the different types of schools. In comparison with control schools, the percentage of active boys was dramatically higher on Learning Landscapes schools' hard surface unstructured areas (49.6% vs 63.3%), whereas the percentage of active girls was slightly but not significantly lower (56.2% vs 54.0%).

Although observations showed that there were significantly more active boys on the soft surface structured play areas, there were increases in the percentages of both active boys and girls on these areas relative to other areas. Soft surface unstructured areas were not compared with control schools because these areas did not exist on the control school schoolyards. However, a gender comparison showed that there was no significant difference between the numbers of active boys and girls on these play areas.

DISCUSSION

With obesity at the front line of health issues facing America's children, there is a need to attack this problem within the communities that are the most affected. Redevelopment of schoolyards is an obvious strategy to change the physical activity habits of children in their daily routine. Our study supports the concept that enhancement of the built environment, specifically the outdoor environment, can improve children's behavioral patterns, in particular their physical activity. By merely increasing the volume of children using a play space and decreasing sedentary behaviors, Learning Landscapes has developed schoolyard designs that foster the childhood inclination to play. In addition to increasing the number of children using play spaces and decreasing the number of sedentary children, the spaces themselves increase energy expenditure.

Our findings showed that activity levels were significantly higher among children at Learning Landscapes schools with both

TABLE 3—Average Number of Sightings per Observation and Energy Expenditure Rate, by Gender: Denver Public Elementary Schools, 2005–2006

	Mean Sedentary Observations			Mean Active Observations			Mean Total Observations			Mean Energy Expenditure Rate		
Schoolyard Category	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Both
Control	0.50	0.46	0.96	1.47	1.24	2.70	0.97	0.78	1.74	0.1474	0.1205	0.2670
Established	0.56	0.66	1.22	1.85	1.75	3.60	1.29	1.09	2.38	0.1898	0.1702	0.3597
Recently built	0.55	0.63	1.18	1.85	1.57	3.42	1.29	0.94	2.23	0.1874	0.1463	0.3331
Overall										0.1777	0.1473	0.3244
Control vs established *P* value	NS	<.001	NS	<.003	<.001	<.001	<.001	<.001	<.001	<.002	<.001	<.001
Control vs recently built *P* value	NS	<.001	NS	.003	.004	<.001	.001	NS	.001	<.002	.017	<.002
Established vs recently built *P* value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	.036	NS

Note. NS = nonsignificant.

TABLE 4—Percentages of Students Classified as Active According to Observational Measurements, by Surface Type, Schoolyard Category, and Gender: Denver Public Elementary Schools, 2005–2006

Surface Type	Active Boys, %	Schoolyard P	Active Girls, %	Schoolyard P	Overall, %	Schoolyard P	Gender P
Hard surface structured		NS		NS		NS	
Non-LL schools	67.6		57.2		65.7		<.02
LL schools	70.1		53.1		62.2		<.001
Hard surface unstructured		<.001		NS		<.003	
Non-LL schools	49.6		56.2		52.2		NS
LL schools	63.3		54		58.7		<.001
Soft surface structured		<.05		0.58		<.003	
Non-LL schools	70.6		65.2		67.9		<.006
LL schools	73.6		68.3		71.2		<.001
Soft surface unstructured		. . .		. . .		. . .	
Non-LL schools	. . .		. . .		. . .		. . .
LL schools	67.1		66.5		66.8		NS

Note. LL = Learning Landscapes; NS = nonsignificant. Ellipses indicate the feature was not present on non-LL sites.

established and recently built schoolyards than at control schools. Other research also has revealed that schoolyard renovations lead to increases in physical activity during as well as after school hours.[32–35] Most of these studies have shown short-term effects in comparisons of renovated and nonrenovated schoolyards.

Our study indicates that although effects were greater when Learning Landscapes schoolyards were first installed, they continued over time. Why did these effects endure? Our results suggest that the actual design of the schoolyard, as opposed to its relative newness, triggers increased and sustained use. Learning Landscapes schoolyards provide a wider variety of options for play. Such environments are more supportive of children's erratic play behavior, thus resulting in increased volumes of activity. In addition, installation of these schoolyards increased opportunities for socialization—moments to pause between spurts of physical activity—possibly as a result of children's increased levels of volume and activity.

The overall energy expenditure increase observed at Learning Landscapes schoolyards indicates that more students were using these schoolyards than were using control schoolyards. This increase demonstrates that students in Learning Landscapes schools not only were more active than were those in control schools but also were expending more energy each day. Stratton et al.[13] found that schoolyard markings in British schools increased physical activity, although they did not include energy expended in their comparisons of schools. Our energy expenditure measure is more demonstrable of the effects of Learning Landscapes schoolyards than of children's physical activity level because it combined volume of use with activity level.

The higher volume of observations in Learning Landscapes schools suggests that increased opportunities for play trigger reductions in the time spent in a single area; it suggests as well the importance of the spatial arrangement of activity areas with respect to type, variety, and size. Although the higher volume could also be explained simply by increased use of the schoolyards by several classes or ages at one time, our observations showed that this was not the case.

The numbers of boys classified as active did differ between control and Learning Landscapes schools, and significantly fewer boys in Learning Landscapes schools were sedentary. When children move away from sedentary activities and become more active, they have ample opportunities to expel more calories and decrease their likelihood of becoming obese in adulthood. Several studies[4,12,13,46] have shown that boys are more likely to be active than are girls. However, we found significantly increased physical activity levels among both boys and girls in certain schoolyard areas, an example being soft surface structured play areas in Learning Landscapes schools, which included swings, monkey bars, play equipment, and play fields. Although a gender bias was found within Learning Landscapes schools, this bias was similar to that present in the control schools. Overall, our results indicate that girls will engage in physical activity at a level similar to that of boys if appropriate equipment is available and the environment is one where they feel comfortable playing.

Limitations

A pretest–posttest study with randomized selection would have been the optimal means of showing that these schoolyard designs truly affect play and physical activity. However, the timing and funding of new Learning Landscapes schoolyards in Denver precluded this option. Although this was a limitation of our study, it allowed us to compare recently built schoolyards with those that had been built at least 2 years before the study and to observe resulting changes in children's physical activity. The control schools selected mirrored the demographic makeup of the Learning Landscapes schools and were located in the same geographic area.

Another limitation is that we used only the SOPLAY measure, and thus we were able to track overall activity volumes but not individual movements. Data on children's individual schoolyard movement patterns could provide a greater understanding of the effects of different types of activity areas, as well as the varieties of activity occurring within those areas. Such information could also be helpful in evaluating cumulative levels of energy expenditure per person. SOPLAY in combination with pedometers, accelerometers, and spatial tracking systems would allow for a greater understanding of the potential correlations between spatial relationships and physical activity in children. SOPLAY data can be used to conduct in-depth analyses of physical activity levels by time of day, and we hope to conduct such analyses in future research.

That differences between Learning Landscapes schools with recently built and established schoolyards were negligible infers that the effects of the designs do not lessen over time, when the novelty of a new schoolyard has diminished. Such effects should be studied on a longitudinal scale to understand changes in schoolyards and student populations over time. The Learning Landscapes schools introduced an entirely new spatial environment category: soft surface unstructured areas. Physical activity and energy expenditure levels can be increased through the design of a greater variety of such activity areas whose intended use is both passive and active.

If improved schoolyard designs can trigger general increases in physical activity among children, then the potential exists for such schoolyard environments to facilitate increased physical activity in the specific case of the physical education curriculum. Although preliminary studies have demonstrated effective use of schoolyards within the formal structured physical activity curriculum, more rigorous studies must be conducted to ensure the usefulness of such spaces outside of unstructured play.

Conclusions

We sought to provide a preliminary understanding of the effects of the built environment, specifically schoolyard redevelopment, on children's physical activity levels. As the built environment continues to have an increasing impact on physical activity, the relationship between how spaces are designed and how people interact within those spaces will be a significant area of emphasis. ■

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Contributors

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Human Participant Protection

Because of the observational nature of this study, no protocol approval was needed.

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