Journal of Physical Activity and Health, 2014, 11, 564-573
http://dx.doi.org/10.1123/jpah.2012-0064

JOURNAL OF
Physical Activity & Health
Official Journal of ISPAH
www.JPAH-Journal.com
ORIGINAL RESEARCH

An Assessment of Schoolyard Features and Behavior Patterns in Children's Utilization and Physical Activity

Peter Anthamatten, Lois Brink, Beverly Kingston, Eve Kutchman, Sarah Lampe, and Claudio Nigg

***Background*:** Careful research that elucidates how behavior relates to design in the context of elementary school grounds can serve to guide cost-efficient design with the goal of encouraging physical activity (PA). This work explores patterns in children's PA behavior within playground spaces with the specific goal of guiding healthy playground design. ***Methods*:** Data on children's utilization and PA behavior in 6 playgrounds divided into 106 observation zones were collected in 2005 and 2006 at Denver elementary school playgrounds using the System for Observing Play and Leisure Activity in Youth. Analyses of variance and *t* tests determined whether there were differences in utilization and behavior patterns across observations zones and between genders. ***Results*:** This study provides evidence that children prefer to use certain types of playground zones and that they are more likely to practice moderate-to-vigorous physical activity (MVPA) in some zones. The authors observed statistically significant differences between genders. Boys were more likely to engage in MVPA in zones without equipment, girls were more likely to use zones with equipment. ***Conclusions*:** This work suggests that the inclusion or omission of specific playground features may have an impact on the way that children use the spaces.

***Keywords*:** playground, schools, pattern analysis, exercise

As childhood obesity has become a global pandemic,[1] with a particularly high growth in prevalence in the United States,[2] promoting physical activity (PA) among children has become a primary public health goal.[3] In addition to contributing to a healthy energy balance and reducing risk of obesity, PA confers numerous health benefits to children, including reduced risk for cardiovascular disease and diabetes,[4] reduced risk for systematic inflammation,[5] and improved cognitive development and brain function.[6]

Particularly in light of the widespread increase in obesity rates, researchers have begun to consider the role of the physical environment in encouraging PA, which children are less likely to practice as they age.[7] Perhaps due to the complex nature of threading apart a variety of geographic factors that include economic, social, and cultural factors, determining the role of the environment in encouraging PA has been difficult. There is a general consensus that the environment is important at a variety of geographic scales and the importance of recreational amenities in promoting PA and reducing obesity has become established.

School-aged children who live near playgrounds, for example, are much less likely to be overweight or obese.[8] Residential proximity and park density are associated with higher levels of PA.[9] With the average child spending over 1000 hours at school each year,[10] the school environment plays a critical role in children's PA behavior. A recent study estimates that school recess contributed 17.9% and 15.5% of boys' and girls' daily moderate-to-vigorous PA (MVPA), respectively.[11] Additionally, school playgrounds may also offer a valuable PA resource outside of recess. For instance, work examining several states across the United States observed that schools represented 44% of potential local sites for PA.[10] Efforts to improve PA environments specifically at school grounds can therefore provide an efficient and focused means of addressing the PA opportunities for young children.

School grounds provide a valuable community resource in Denver because they are open for public use. Providing these community resources is particularly

Anthamatten is with the Dept of Geography and Environmental Sciences, University of Colorado, Denver, CO. Brink is with the Colorado Center for Community Development, College of Architecture and Planning, University of Colorado, Denver, CO. Kingston and Kutchman are with the Institute of Behavioral Science, Center for the Study and Prevention of Violence, University of Colorado, Denver, CO. Lampe is with the Colorado Association of Local Public Health Officials, Denver, CO. Nigg is with the Dept of Public Health Sciences, John A. Burns School of Medicine, University of Hawaii at Manoa, Honolulu, HI.

important for low-income neighborhoods, which traditionally lack sufficient physical resources and are characterized by obesogenic environmental factors.[12] The careful design of playground facilities is especially critical to disadvantaged groups such as ethnic minorities and low-income children, who are less likely to practice PA[13,14] and more likely to attend schools with poor quality school grounds and recreational facilities.[15]

Several studies, encompassing a variety of data collection methodologies and settings, have identified specific playground features in parks and schools that are associated with higher levels of utilization and rates of PA. Studies in Cleveland, Ohio,[16] and Denver, Colorado,[17–19] have shown that utilization rates are higher in renovated than in unrenovated school grounds. The timeframe over which renovation is associated with improved utilization remains unclear. In a study of 24 schools in San Diego, Sallis et al observed environmental modifications that were associated with increased PA of students at different times of the day.[20] Recent work has identified additional, specific facets of playgrounds that can serve to improve utilization and PA at schools, such as permanent playground equipment,[21–24] playground markings,[25] and the provision of game equipment.[26,27] In spite of an enormous amount of work on the ways in which the built environment is associated with PA behavior among children at different scales of analysis, relatively little is known about how they behave within playgrounds or how knowledge of playground behavior could serve to inform healthy playground design.

The impacts of large urban design projects are not often empirically evaluated, or, when they are, the work does not serve to inform the design process.[28] Research that elucidates how behavior relates to design can serve to guide cost-efficient schoolyard designs with the goal of encouraging PA. The goal of this work is to examine specific facets of playground renovation on PA of children, specifically (1) which features children use the most, (2) which features of the playground are associated with the highest rates of vigorous physical activity (VPA), and (3) to what extent there are gender differences in these patterns.

Methods

Setting

The original intent behind data collection in this study was to evaluate the impacts of the Learning Landscapes (LL) program on children's PA levels, a citywide initiative to renovate elementary school playgrounds in Denver. LL school grounds were designed to provide children with nontraditional landscape design elements that are not part of typical schoolyards. These elements include shade structures, gardens, art from students and the public, and tile art. The first schoolyard was completed in 1998, and by 2012, all elementary schools in Denver had a LL schoolyard. Initial phases of the LL program targeted low-income schools facing economic, social, and educational challenges in deprived neighborhoods located in Denver's industrial crescent.

The schools in this study were from low- to mid-socioeconomic–status neighborhoods. Over 80% of the students qualified for free and reduced lunch fees on the basis of their family's income. The students at 3 of the schools were predominately African American and the remaining 6 schools had primarily Latino populations, reflecting much of the social landscape in Denver. Because this work was conducted in an elementary school setting, the study population consisted of children between the ages of 5 and 11. Every school the authors approached agreed to participate in the study.

Study Design

Three elementary schools that had recently undergone LL construction were selected for the study. Each school with recent LL construction was subsequently matched with an elementary school that had no LL construction and another with older LL construction. The comparison schools were selected on the basis of neighborhood demographics and school size. This selection process serves the current study by providing a representative sample of playgrounds at various stages of renovation. There were 3 schools in each study group and a total of 9 schools observed in the study.

Data Collection

Data collection took place for 4-day periods between September 19 and October 29, 2005, and again the following year between September 29 and October 19, 2006, using the System for Observing Play and Leisure Activity in Youth (SOPLAY). SOPLAY is a well-established observational method for evaluating PA levels of individuals in school settings.[29] Since its inception, this method has been used extensively to observe PA and associated activity at schoolyards in a variety of contexts.[16,24,30–33] SOPLAY uses predefined target areas that are delineated around where students are most likely to be active.

Observations in both 2005 and 2006 included all of the schools in the study, and schools were equally represented in both years of data collection; 75% of the observations were from 2005 and the remaining 25% from 2006. Each schoolyard studied was divided into observation zones, from which trained and certified observers recorded the number of children or adults present, their activity levels ("sedentary," "walking," or "moderately to vigorously active"), and the gender of the child observed. While specific age is not a part of the traditional SOPLAY protocol and was not recorded in the study, adults were distinguished from children and were excluded from this analysis. The study was approved by the Colorado Multiple Institutional Review Board.

Observers were trained over 2 days, including field practice to conduct SOPLAY observations by a certified SOPLAY instructor. To preserve the integrity of the observed data, observers were not members of the

investigator team. Two observers measured the same study areas for 20% of data collection, yielding an inter-rater reliability of 87%. Because the SOPLAY method requires that observation zones be carefully defined, it is possible to examine utilization and activity levels at different scales of aggregation, including entire school grounds,[17,19,34] specific features on the grounds, such as fixed play equipment and court markings,[31] or comparing activity in zones with manufactured equipment with green areas.[24] Activity was observed in 106 observation zones across the 9 playgrounds.

Each schoolyard was divided into between 8 and 14 zones, defined by the authors, that represented distinct environmental characteristics. Zones were classified according to their primary design or activity feature, including swings, play equipment (such as jungle gyms and slides), tetherball, and basketball. The authors also analyzed playground spaces without equipment, including paved surfaces ("hard-surface play areas"), grassy areas specifically designed for activities ("play field areas"), and grassy areas without any programming or play equipment ("unprogrammed areas").

Analysis

Estimates for particular zones were aggregated for all periods of observation, which included time before school, during the school recess period, after school, and on weekends. The sample size for the study was therefore derived from the number of zones across the 9 study schools; the study zones were the unit of analysis. Because a representative sample of low-income schools was observed across multiple time periods, these data reasonably estimated activity patterns within each playground zone.

The total number of children observed in activity zones could not be directly compared because the zones had different sizes, and overall playground utilization varied across observation times. To standardize for these factors, the authors calculated a "location quotient" (LQ) for the sum of activity observed in each playground zone. An LQ is the ratio of the percentage of children observed in a particular zone to the percentage of the total area of that zone. Zones with higher levels of activity than one would observe if utilization were perfectly distributed over the schoolyard have values greater than 1, and zones with less activity had values less than 1. LQs were examined with a *t* test to determine whether the LQs were significantly different from the null hypothesis, which suggests that a zone experienced its "share" of utilization, wherein the LQ is equal to 1.

Among the SOPLAY data collected were the number of children observed to be engaged in MVPA. Rate of MVPA was calculated by dividing that number by the total number of children observed. Previous work has validated the use of SOPLAY to collect MVPA data with accelerometer data.[35] While utilization LQs estimated of the number of children observed in any particular schoolyard zone, the rate of MVPA indicated the likelihood that children were active at a predefined intensity level. Descriptive statistics of rates of MVPA were calculated for each zone class. The authors employed analyses of variance (ANOVA) to test for statistically significant variation in the observations between the zone classes for both utilization LQs and MVPA. Finally, using the gender data collected with the SOPLAY methodology, the authors conducted paired sample *t* tests for each zone class to test whether boys and girls behaved differently with respect to their use of the schoolyards.

Results

Utilization

There were statistically significant differences in utilization in 4 of the 9 zone classes examined (Table 1). LQs were high for all children in swing areas (with a 95% confidence interval [CI] of 1.71–3.16), hard-surface play areas (95% CI, 1.27–1.78), and play equipment areas (95% CI, 3.10–5.64). LQs were low in play field areas (95% CI, 0.20–0.40). An ANOVA indicated that there were statistically significant differences ($P < .001$) in utilization LQs across zone categories for all children combined, as well as in specific LQs for boys and girls (Table 2).

Moderate-to-Vigorous Physical Activity

A summary of rates of MVPA is provided in Table 3. The average rate for MVPA, the percentage of children observed exhibiting MVPA across all observations, was 37.9%. In all zones containing playground equipment (51 zones in total), the authors observed significantly higher rates of MVPA. These zones include swing areas (66.6% of children observed in the zone were engaged in MVPA), play equipment areas (47.8%), basketball areas (45.2%), and tetherball areas (41.7%). Zones without equipment—play field areas (27.4%), hard-surface areas (27.9%), and unprogrammed areas (4.4%)—had lower rates of MVPA. ANOVA also indicated that were also statistically significant ($P < .001$) differences in MVPA across zone categories (Table 2).

Gender Differences

Paired sample *t* tests were conducted to determine whether there were differences in gender, both for utilization LQs (Table 4) and rates of MVPA (Table 5). Differences were calculated for both tests by subtracting the sample value for girls from the sample value for boys. Therefore, positive values in these tables indicate greater utilization or PA rates among boys, and negative values indicate greater values for girls. There were distinct differences in activity across gender, both in terms of utilization and PA. Utilization was significantly higher for boys in play field and basketball areas and higher for girls in play equipment areas. Rates of MVPA were significantly higher for boys in play field areas, hard-surface play areas, and play equipment areas.

Table 1 Location Quotients of Utilization by Schoolyard Zones Type

Zone type	n	Mean	SE	95% Confidence Interval		*P*
				Lower	Upper	
Zones with equipment						
Basketball areas	9	1.34	0.28	0.71	1.97	.252
Boys		1.78	0.34	0.99	2.56	.051
Girls		0.83	0.20	0.36	1.30	.427
Play equipment areas	23	4.37	0.61	3.10	5.64	<.001*
Boys		3.94	0.62	2.63	5.25	<.001*
Girls		4.88	0.61	3.62	6.15	<.001*
Tetherball areas	8	1.87	0.41	0.89	2.84	.073
Boys		1.45	0.25	0.87	2.03	.108
Girls		2.32	0.65	0.79	3.85	.080
Swing areas	11	2.43	0.33	1.71	3.16	<.001*
Boys		2.22	0.39	1.35	3.09	<.001*
Girls		2.70	0.30	2.04	3.37	<.001*
Zones without equipment						
Hard-surface play areas	23	1.53	0.12	1.27	1.78	<.001*
Boys		1.52	0.12	1.28	1.76	<.001*
Girls		1.53	0.15	1.22	1.85	.002*
Play field areas	15	0.30	0.05	0.20	0.40	<.001*
Boys		0.38	0.05	0.26	0.50	<.001*
Girls		0.21	0.05	0.11	0.31	.001*
Unprogrammed Areas	17	1.67	0.38	0.87	2.47	.093
Boys		1.40	0.28	0.82	1.99	.164
Girls		1.97	0.51	0.89	2.06	.259

* $P < .01$.

Note. n refers to the number of zones observed.

Conclusion

An understanding of how children use constructed space around schoolyards may give landscape architects, education policy makers, and public health advocates important insights into building healthy playgrounds that encourage utilization and PA. An understanding of how gender is associated with this behavior can provide additional insight to those who wish to design spaces that encourage activity among girls, who do not generally exhibit as much MVPA as boys. The purpose of this work is to explore patterns in activity among school children within playgrounds to serve these goals. This work provides evidence that there is a great deal of differential use within playgrounds. Some playground spaces are more heavily used than others, some contained higher rates of PA, and there are some striking differences in the ways that boys and girls use the playgrounds.

Utilization

The first step in exploring ways to improve design of recreational facilities for children as a public health intervention may be to encourage children to use these spaces. Some recent work examines the impacts of specific features in playgrounds on overall playground use.[34] In a direct observation study in Cleveland, Ohio, for example, the authors conclude that cleanliness, shade for resting features, and safety are associated with different rates of utilization among different groups.[16] Little work has examined the relative utilization patterns within playgrounds at elementary schools.

A systematic examination of utilization within schoolyards presents the problem that the 104 different zones observed in the study have different sizes, and that different playgrounds have different populations at different times. To account for these factors, the authors have used the LQ to provide an indication of which parts of the playground experienced high relative utilization. Significantly greater utilization was noted both in zones with constructed features (play equipment and swing areas) and without) equipment (hard-surface play areas. A well-balanced schoolyard that contains—at a minimum—play equipment, swing sets, and some open hard-surface play areas, may serve as an effective starting point for planners. While play field areas can serve

Table 2 Analysis of Variance (ANOVA) of Utilization LQs and MVPA Rates by Zone Classes

	df	Mean square	F	*P*
Utilization LQ				
All zones	105			
Between groups	6	184.74	11.6	<.001**
Within groups	99	262.92		
Boys	105			
Between groups	6	140.37	9.0	<.001**
Within groups	99	258.27		
Girls	105			
Between groups	6	255.6	13.7	<.001**
Within groups	99	308.6		
Rate of MVPA				
All zones	105			
Between groups	6	3149.0	21.4	<.001**
Within groups	99	160.1		
Boys	105			
Between groups	6	2855.6	15.4	<.001**
Within groups	99	185.2		
Girls	105			
Between groups	6	4940.5	20.9	<.001**
Within groups	99	236.8		

** $P < .01$.

Note. n refers to the number of zones observed.

important function to school activities and programs, they do not appear to be an effective use of schoolyard space in terms of utilization. These spaces, however, might serve an important function in terms of school curriculum and other activities.

Moderate-to-Vigorous Physical Activity

Examining the rate of PA addresses a different question from utilization; namely, what are children's behavior patterns once they are physically in these spaces? Existing playground research offers valuable insight by identifying features that are associated with higher rates of MVPA. For example, previous work has discovered that contextual conditions, such as the availability of school ground equipment and the presence of adult supervisors,[30] playground markings,[36] the quantity of play equipment[23,37] are associated with higher rates of MVPA. Some work has also begun to explore patterns of activity within playgrounds. Dyment et al[24] determine that manufactured equipment at schools in Canada and Australia contained the highest levels of MVPA. Farley et al conclude from a study in New Orleans that children are more likely to be active in areas with installed play equipment and basketball goals.[22]

The current study supports the notion that fixed manufactured equipment, such as slides and jungle gyms, is important for designing active elementary school playgrounds. In zones containing constructed features in this study, children were twice as likely to engage in MVPA; zones with equipment had an average MVPA rate of 50.4%, and zones without equipment had an average rate of 25.7%. Among the types of zones that were examined, swing areas had the highest rate of MVPA, with a rate of 66.6%. Supporting a similar finding from Dyment et al (2009), "unprogrammed areas," open grassy areas without markings, equipment, or other features, had the lowest rates of MVPA (4.4%).

Gender

There is general consensus that boys are more likely to engage in active play than girls in recreational settings.[11,17,38] Although the body of evidence generally shows that boys are more active than girls during recess, there is some evidence to the contrary.[39] The reasons for these observations may stem from the fact that boys generally use school recess as an opportunity to engage in competitive sports, whereas girls are more likely to use this time for social play.[40] In the current study, boys engaged in MVPA 40% of the time, compared with 33% among girls (Table 5).

Exploring designs that encourage girls to be active is an important public health and design consideration.

Table 3 Rates of MVPA by Schoolyard Zones Type

				95% Confidence Interval	
Zone type	n	Mean	SE	Lower	Upper
All zones	106	37.90	1.81	34.02	41.19
Boys		39.63	1.79	36.10	43.17
Girls		32.90	2.18	38.57	37.23
Zones with equipment	51	50.43	13.2	49.72	54.14
Boys		51.88	13.1	48.19	55.56
Girls		47.60	17.9	42.56	52.64
Basketball areas	9	45.23	3.78	36.51	53.96
Boys		49.11	3.63	40.74	57.49
Girls		34.94	21.70	18.27	51.62
Play equipment areas	23	47.78	1.72	44.20	51.35
Boys		51.48	2.37	46.57	56.39
Girls		45.01	8.22	41.46	48.56
Swing areas	11	66.55	3.18	59.45	73.64
Boys		60.74	2.51	55.15	66.32
Girls		69.88	4.39	60.11	79.70
Tetherball areas	8	41.73	4.59	30.90	52.57
Boys		43.93	6.92	27.56	60.30
Girls		38.65	4.17	28.78	48.51
Zones without equipment	55	25.71	2.0	21.76	29.66
Boys		28.28	2.0	24.23	32.34
Girls		19.27	2.3	14.65	23.90
Hard-surface play areas	23	27.88	2.14	23.45	32.31
Boys		30.95	2.30	26.17	35.73
Girls		23.47	2.46	18.37	28.57
Play field areas	15	27.38	3.39	20.12	34.65
Boys		31.29	3.47	23.85	38.73
Girls		15.64	3.94	7.18	24.10
Unprogrammed areas	17	4.42	4.82	11.09	31.51
Boys		4.70	4.68	12.10	31.54
Girls		2.96	5.68	4.76	28.84

Note. n refers to the number of zones observed.

Table 4 Paired Sample *t* Test of Utilization LQ by Gender and Zone Type

				95% Confidence Interval		
Zone type	n	Mean	SE	Lower	Upper	*P*
Zones with equipment	51	–0.50	0.16	–0.83	–0.17	.004*
Basketball areas	9	0.95	0.20	1.42	0.48	.002*
Play equipment areas	23	–0.95	0.20	–1.36	–0.53	<.001*
Tetherball areas	8	–0.87	0.50	–2.06	0.32	.128
Swing areas	11	–0.48	0.52	–1.04	0.08	.083
Zones without equipment	55	–0.14	0.12	–0.37	0.09	.242
Hard-surface play areas	23	0.01	0.12	–0.26	0.23	.904
Play field areas	15	0.17	0.05	0.17	0.27	.003*
Unprogrammed areas	17	–0.57	0.31	–1.24	0.09	.088

* $P < .01$.

Note. n refers to the number of zones observed.

Table 5 Paired Sample *t* Test of Percent MVPA by Gender and Zone Type

Zone type	n	Mean	SE	95% Confidence Interval		*P*
				Lower	Upper	
Total	106	6.73	1.63	3.50	9.97	>.001*
Zones with equipment	51	4.28	2.25	–0.24	8.79	.063
Basketball areas	9	14.17	7.50	–3.12	31.47	.095
Play equipment areas	23	6.47	1.97	2.38	10.56	.003*
Tetherball areas	8	5.29	5.78	–8.38	18.95	.391
Swing areas	11	–9.15	4.26	–18.6	0.3	.057
Zones without equipment	55	9.01	2.33	4.33	13.69	>.001*
Hard-surface play areas	23	7.48	2.18	2.96	12.00	.002*
Play field areas	15	15.65	4.07	6.94	24.47	.002*
Unprogrammed areas	17	5.22	5.86	–7.20	17.65	.386

* $P < .01$.

Note. n refers to the number of zones observed.

Colabianchi et al found that girls are slightly more likely to use playgrounds with a wide variety of play features, but with respect to other features observed, girls' behavior patterns were similar to boys.[34] Anthamatten et al (2011) observed that girls were more likely to use school playgrounds before school and less likely to use them on weekends.[17]

Differences in utilization and activity in the current study support the notion that boys engage in competitive sports on the school grounds. Overall, girls were more likely to use zones without equipment, whereas boys were significantly more likely to engage in MVPA in those zones. Boys were more likely to use basketball areas and playfield areas, spaces designed specifically for competitive sports, and were significantly more active than girls on hard-surface play areas (which often contain markings for activities such as four square) and play field areas. Girls were significantly more likely to *use* play equipment areas, whereas boys exhibited higher rates of MVPA on the equipment. This work may shed some insight on the way that gender operates and provide some guidelines for designers who wish to construct schoolyard environments that address the needs of both boys and girls. Notably, constructed equipment, and particularly swings, may be important features to include for girls.

Study Limitations

By shifting the scale of analysis from schoolyards to zones within schoolyards, this work is able to examine novel facets to children's behavior and PA patterns. This work is limited, however, by the fact that data are aggregated into observation zones. Any analysis that relies on boundaries is subjected to the modifiable areal unit problem, which is "the geographic manifestation of the ecological fallacy in which conclusions based on data aggregated to a particular set of districts may change if one aggregates the same underlying data to a different set of districts" (page 104).[41] While this is not as significant a problem when analysis zones are not designated arbitrarily—in this case, zones were defined around functional spaces of the schoolyard, different zone designation schemes could yield different results. Similarly, different means of classifying zones, such as a scheme that examines zones with playground markings, zones that contain equipment, and those that contain no equipment, could also have an effect on the results. The best approach to address these issues is to conduct different analyses using a variety of zoning schemes. If the findings are robust, they should manifest similarly across these analyses.[42]

This work relied on direct observation, which is subject to some degree of human error. While it would certainly present a daunting cost and human subjects research challenge, examining children's specific patterns in recreational spaces using accelerometers to measure activity in combination with GPS devices to track location could overcome these problems and offer additional, valuable insight to the relationship between design and activity patterns. Tracking the precise locations of children in play spaces would also overcome problems associated with aggregating data into zones.

The schools in this study consisted of low-income, highly urban schools in Denver, and it supports findings from some other research set in other places and contexts. However, it is difficult to generalize these findings beyond this particular context because of the culturally and socially specific nature of health and activity behaviors. It is possible, for example, that different playground features could assume a completely different role in children's behavior in mid-income, rural areas, where the constraints of physical space and availability of other recreational opportunities are different. This work does not address how school curriculum frames PA through, for example, recess policies and extracurricular programming, which may have an impact on activity patterns. It is likely that children practice different PA patterns during and outside of school or that adult supervision affects

activity in some way. Finally, the open-use policies of Denver school grounds may be a unique policy of the city, which is often not the case in cities. Additional work using existing direct observation systems, in a variety of geographic and social contexts, is needed to address these problems.

Future Work

Our measure of utilization is a relative one; by standardizing for both area and the playground population, the LQ indicates zones where the distribution of children's activity is biased in some way. Activity in zones may be affected by other zones around them, or indeed by the context in which the playground finds itself. The relation between specific schoolyard design features and PA may be grounded in local geographies, mediated by factors such as parental perceptions of crime,[43,44] the socioeconomic status of the children and surrounding neighborhoods,[14] and specific cultural contexts. What may ultimately prove to be particularly useful for planners, designers, and public health workers is a set of general principles for constructing active spaces for children.

One factor that may drive children's activity may be the density of structured design equipment. Children may behave differently on a playground with sparsely located equipment from one with densely located equipment. Future work could address this issue by counting various classes of playground features, such as play equipment or playground markings, and testing whether there is any association between density and activity.

While this work provides insight into some of the dynamics of playground behavior and how these differ between genders, it does little to explain the reasons behind these gender differences. Previous work, for example, has found that school recess is associated with higher rates of physical activities among girls.[37] This study did not consider the ways in which the time of day relates to gender differences, nor did it compare in-school activity with activity outside of school. Additional work could determine whether boys and girls alter their behavior on playgrounds according to the time and context of their use of the spaces.

It is our hope that this work will serve to begin to improve our understanding of playground design in a way that will inform landscape architects and school planners interested in producing healthy schoolyard design. For instance, it would seem that including fixed playground equipment is important for encouraging better utilization and higher rates of MVPA among boys, and that playground equipment, particularly swing sets, is important for girls. Work that brings greater statistical power and more nuanced analysis—by, for example, modeling within-playground behavior with other factors such as child's age, weather conditions and temperature, and age of playground equipment—could serve to bring important and actionable insight to schoolyard design.

Acknowledgments

This study was supported by 2 grants from the Robert Wood Johnson Foundation. The contents are solely the responsibility of the authors and do not necessarily represent the official views of the Robert Wood Johnson Foundation.

References

1. Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. *Int J Pediatr Obes*. 2006;1(1):11–25. PubMed doi:10.1080/17477160600586747
2. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA*. 2006;295(13):1549–1555. PubMed doi:10.1001/jama.295.13.1549
3. US Department of Health and Human Services, Office of Disease Prevention and Health Promotion. Healthy People 2020 objective target areas and page numbers. 2011; Available from: http://healthypeople.gov/2020/topicsobjectives2020/pdfs/hp2020objectives.pdf
4. Oliver M, Schofield G. Policy responses and the physical environment. In: Pearce J, Witten K, eds. *Geographies of obesity: environmental understandings of the obesity epidemic. Farnham, Surrey*. Burlington, VT: Ashgate; 2010:175–204.
5. Sabiston CM, Castonguay A, Low NCP, et al. Vigorous physical activity and low-grade systemic inflammation in adolescent boys and girls. *Int J Pediatr Obes*. 2010;5(6):509–515. PubMed doi:10.3109/17477160903572019
6. Davis CL, Tomporowski PD, McDowell JE, et al. Exercise improves executive function and achievement and alters brain activation in overweight children: a randomized, controlled trial. *Health Psychol*. 2011;30(1):91–98. PubMed doi:10.1037/a0021766
7. van Mechelen W, Twisk JWR, Post GB, Snel J, Kemper HCG. Physical activity of young people: the Amsterdam Longitudinal Growth and Health Study. *Med Sci Sports Exerc*. 2000;32(9):1610–1616. PubMed doi:10.1097/00005768-200009000-00014
8. Potwarka LR, Kaczynski AT, Flack AL. Places to play: association of park space and facilities with healthy weight status among children. *J Community Health*. 2008;33(5):344–350. PubMed doi:10.1007/s10900-008-9104-x
9. Day DR. *Council of School A, National School Boards A. Environmental law: fundamentals for schools*. Alexandria, Va.: NSBA Council of School Attorneys; 1995.
10. Scott MM, Cohen DA, Evenson KR, et al. Weekend schoolyard accessibility, physical activity, and obesity: The Trial of Activity in Adolescent Girls (TAAG) study. P. *Prev Med*. 2007;44(5):398–403. PubMed doi:10.1016/j.ypmed.2006.12.010
11. Ridgers ND, Saint-Maurice PF, Welk GJ, Siahpush M, Huberty J. Differences in physical activity during school recess. *J Sch Health*. 2011;81(9):545–551. PubMed doi:10.1111/j.1746-1561.2011.00625.x
12. Franzini L, Taylor W, Elliott MN, et al. Neighborhood characteristics favorable to outdoor physical activity: disparities by socioeconomic and racial/ethnic

composition. *Health Place*. 2010;16(2):267–274. PubMed doi:10.1016/j.healthplace.2009.10.009
13. Franzini L, Elliott MN, Cuccaro P, et al. Influences of physical and social neighborhood environments on children's physical activity and obesity. *Am J Public Health*. 2009;99(2):271–278. PubMed doi:10.2105/AJPH.2007.128702
14. Sallis JF, Zakarian JM, Hovell MF, Hofstetter CR. Ethnic, socioeconomic, and sex differences in physical activity among adolescents. *J Clin Epidemiol*. 1996;49(2):125–134. PubMed doi:10.1016/0895-4356(95)00514-5
15. Fernandes M, Sturm R. Facility provision in elementary schools: correlates with physical education, recess, and obesity. *Prev Med*. 2010;50:S30–S35. PubMed doi:10.1016/j.ypmed.2009.09.022
16. Colabianchi N, Kinsella AE, Coulton CJ, Moore SM. Utilization and physical activity levels at renovated and unrenovated school playgrounds. *Prev Med*. 2009;48(2):140–143. PubMed doi:10.1016/j.ypmed.2008.11.005
17. Anthamatten P, Brink L, Lampe S, Greenwood E, Kingston B, Nigg C. An assessment of schoolyard renovation strategies to encourage children's physical activity. *Int J Behav Nutr Phys Act*. 2011;8(1):27. PubMed doi:10.1186/1479-5868-8-27
18. Brink LA, Nigg C, Lampe S, Kingston B, Mootz A, van Vliet W. Influence of schoolyard renovations on children's physical activity: the Learning Landscapes program. *Am J Public Health*. 2010;100(9):1672–1678. PubMed doi:10.2105/AJPH.2009.178939
19. Nigg C, Anwar MMU, Lampe S, et al. Does the built environment make a difference? Observed physical activity in renovated vs. non-renovated elementary school playgrounds. *Ann Behav Med*. 2011;41:S72–S72.
20. Sallis JF, Conway TL, Prochaska JJ, McKenzie TL, Marshall SJ, Brown M. The association of school environments with youth physical activity. *Am J Public Health*. 2001;91(4):618–620. PubMed doi:10.2105/AJPH.91.4.618
21. Cardon G, Labarque V, Smits D, De Bourdeaudhuij I. Promoting physical activity at the pre-school playground: the effects of providing markings and play equipment. *Prev Med*. 2009;48(4):335–340. PubMed doi:10.1016/j.ypmed.2009.02.013
22. Farley TA, Meriwether RA, Baker ET, Rice JC, Webber LS. Where do the children play? The influence of playground equipment on physical activity of children in free play. *J Phys Act Health*. 2008;5(2):319–331. PubMed
23. Nielsen G, Taylor R, Williams S, Mann J. Permanent play facilities in school playgrounds as a determinant of children's activity. *J Phys Act Health*. 2010;7(4):490–496. PubMed
24. Dyment JE, Bell AC, Lucas AJ. The relationship between school ground design and intensity of physical activity. *Child Geogr*. 2009;7(3):261–276. doi:10.1080/14733280903024423
25. Stratton G. Promoting children's physical activity in primary school: an intervention study using playground markings. *Ergonomics*. 2000;43(10):1538–1546. PubMed doi:10.1080/001401300750003961
26. Verstraete SJM, Cardon GM, De Clercq DLR, De Bourdeaudhuij IMM. Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment. *Eur J Public Health*. 2006;16(4):415–419. PubMed doi:10.1093/eurpub/ckl008
27. Zask A, van Beurden E, Barnett L, Brooks LO, Dietrich UC. Active school playgrounds—myth or reality? Results of the "move it groove it" project. *Prev Med*. 2001;33(5):402–408. PubMed doi:10.1006/pmed.2001.0905
28. Pronk NP, Goetzel RZ. The practical use of evidence practice and research connected. *Am J Prev Med*. 2010;38(2):S229–S231. PubMed doi:10.1016/j.amepre.2009.11.003
29. McKenzie TL. System for observing play and leisure activity in youth (SOPLAY). 2002 [cited 2010 July 7, 2010]; Available from: http://www.drjamessallis.sdsu.edu/SOPLAYprotocol.pdf
30. McKenzie TL, Crespo NC, Baquero B, Elder JP. Leisure-time physical activity in elementary schools: analysis of contextual conditions. *J Sch Health*. 2010;80(10):470–477. PubMed doi:10.1111/j.1746-1561.2010.00530.x
31. Willenberg LJ, Ashbolt R, Holland D, et al. Increasing school playground physical activity: a mixed methods study combining environmental measures and children's perspectives. *J Sci Med Sport*. 2010;13(2):210–216. PubMed doi:10.1016/j.jsams.2009.02.011
32. McKenzie TL, Marshall SJ, Sallis JF, Conway TL. Leisure-time physical activity in school environments: an observational study using SOPLAY. *Prev Med*. 2000;30(1):70–77. PubMed doi:10.1006/pmed.1999.0591
33. Bocarro JN, Kanters MA, Cerin E, et al. School sport policy and school-based physical activity environments and their association with observed physical activity in middle school children. *Health Place*. 2012;18(1):31–38. PubMed doi:10.1016/j.healthplace.2011.08.007
34. Colabianchi N, Maslow AL, Swayampakala K. Features and amenities of school playgrounds: a direct observation study of utilization and physical activity levels outside of school time. *Int J Behav Nutr Phys Act*. 2011;8:32. PubMed
35. Saint-Maurice PF, Welk G, Ihmels MA, Krapfl JR. Validation of the SOPLAY direct observation tool with an accelerometry-based physical activity monitor. *J Phys Act Health*. 2011;8(8):1108–1116. PubMed
36. Stratton G, Mullan E. The effect of multicolor playground markings on children's physical activity level during recess. *Prev Med*. 2005;41(5-6):828–833. PubMed doi:10.1016/j.ypmed.2005.07.009
37. Haug E, Torsheim T, Sallis JF, Samdal O. The characteristics of the outdoor school environment associated with physical activity. *Health Educ Res*. 2010;25(2):248–256. PubMed doi:10.1093/her/cyn050
38. Stratton G, Ridgers ND, Fairclough SJ, Richardson DJ. Physical activity levels of normal-weight and overweight girls and boys during primary school recess. *Obesity (Silver Spring)*. 2007;15(6):1513–1519. PubMed doi:10.1038/oby.2007.179
39. Mota J, Silva P, Santos MP, Ribeiro JC, Oliveira J, Duarte JA. Physical activity and school recess time: differences

between the sexes and the relationship between children's playground physical activity and habitual physical activity. *J Sports Sci*. 2005;23(3):269–275. PubMed doi:10.1080/02640410410001730124

40. Blatchford P, Baines E, Pellegrini A. The social context of school playground games: sex and ethnic differences, and changes over time after entry to junior school. *Br J Dev Psychol*. 2003;21:481–505. doi:10.1348/026151003322535183
41. Waller LA, Gotway CA. *Applied spatial statistics for public health data*. Hoboken, N.J.: John Wiley & Sons; 2004.
42. Flowerdew R, Manley DJ, Sabel CE. Neighbourhood effects on health: does it matter where you draw the boundaries? *Soc Sci Med*. 2008;66(6):1241–1255. PubMed doi:10.1016/j.socscimed.2007.11.042
43. Miles R. Neighborhood disorder, perceived safety, and readiness to encourage use of local playgrounds. *Am J Prev Med*. 2008;34(4):275–281. PubMed doi:10.1016/j.amepre.2008.01.007
44. Davidson Z, Simen-Kapeu A, Veugelers PJ. Neighborhood determinants of self-efficacy, physical activity, and body weights among Canadian children. *Health Place*. 2010;16(3):567–572. PubMed doi:10.1016/j.healthplace.2010.01.001