Behavior Mapping: A Method for Linking Preschool Physical Activity and Outdoor Design

NILDA G. COSCO[1], ROBIN C. MOORE[1], and MOHAMMED Z. ISLAM[2]

[1]*College of Design, NC State University, Raleigh, NC; and* [2]*University of Engineering and Technology, Dhaka, BANGLADESH*

ABSTRACT

COSCO, N. G., R. C. MOORE, and M. Z. ISLAM. Behavior Mapping: A Method for Linking Preschool Physical Activity and Outdoor Design. *Med. Sci. Sports Exerc.*, Vol. 42, No. 3, pp. 513–519, 2010. The preschool that children attend has been shown to be a significant but variable predictor of physical activity of 3- to 5-yr-olds, whereas the time outdoors has been found to be a strong correlate of physical activity. Researchers speculate that variations in preschool physical activity may be attributed to variations in preschool policies and practices, including the form and content of outdoor physical environments. However, assessment methods linking them to physical activity are limited. Improved understanding of links between environment and activity could be used to influence childcare policy, which is highly regulated, usually at state level, to create outdoor environments more conducive to children's informal play and physical activity. The purpose of this article was to introduce behavior mapping as a direct observation method on the basis of the theories of *behavior setting* and *affordance* and to demonstrate its sensitivity to gathering physical activity and associated environmental data at a sufficiently detailed level to affect built environment design policy. **Methods**: Behavior mapping data, including outdoor environmental characteristics and children's physical activity levels, were obtained in two preschool centers at the Research Triangle region, NC. **Results**: Physical activity levels at the two centers varied across different types of behavior settings, including pathways, play structures, and open areas. The same type of setting with different attributes, such as circular versus straight pathways, and open areas with different ground surfaces, such as asphalt, compacted soil, woodchips, and sand, attracted different levels of physical activity. **Conclusions**: Behavior mapping provides a promising method for objectively measuring relationships between physical behavior settings and directly associated activity levels. **Key Words:** CHILDCARE, OUTDOORS, PREVENTION, BUILT ENVIRONMENT, BEHAVIOR CODING

Behavior mapping is an objective method of observing behavior and associated built environment components and attributes. It provides researchers with an innovative method of assessing behavior linked to detailed physical characteristics of outdoor areas, and it has been applied by the authors in studies of schools, neighborhood parks, children's museums, and zoos (28). The purpose here was to illustrate the method's sensitivity for coding built environment characteristics in childcare center outdoor environments as part of a strategy to prevent sedentary lifestyles of young children by influencing built environment design policy.

Apart from home, preschools are possibly the most common built environment experienced by children (33), potentially offering substantial evidence-based health benefits. For example, the preschool that children attend has been shown to be a significant but variable predictor of physical activity levels of 3- to 5-yr-olds (30), accounting for the highest variance in total daily accelerometer counts (12). Pate et al. (30) speculate that variations in preschool physical activity may be attributed to variations in preschool policies and practices. Because time outdoors is a strong predictor of activity (2,32), we speculate further that outdoor physical environment factors may also influence physical activity and help explain variability in physical activity observed among childcare centers (5). If so, investigations of associations between physical activity and environmental design factors could support the development of evidence-based design policies and practices to positively influence levels of activity and respond to the call by Pate et al. (30) for the specific investigations in this direction.

The prevalence of sedentary lifestyles has increased awareness about the importance of childcare outdoor environments. Childcare experts are realizing that physical changes in play areas are required and are seeking help from landscape architects, architects, play equipment vendors, and contractors. However, these professionals, particularly landscape architects, are unable to deliver appropriate designs

Address for correspondence: Nilda G. Cosco, Ph.D., College of Design, NC State University, 200 Pullen Rd, PO Box 7701, Raleigh, NC 27695; E-mail: nilda_cosco@ncsu.edu.
Submitted for publication December 2008.
Accepted for publication December 2009.

0195-9131/10/4203-0513/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/MSS.0b013e3181cea27a

because evidence-based design guidelines are lacking (26). Quality assessment scales used for licensing (16,17) are available, but they deal almost exclusively with indoor environments and provide insufficient guidance for outdoor design. Landscape architects show how outdoor environments should work, be laid out, and managed (24). To improve effectiveness, evidence-based design guidelines would be welcomed. Because designers work through visual imagery, behavior mapping evidence presented visually will more likely be used and gain support from the American Society of Landscape Architects (1).

BEHAVIOR MAPPING APPROACH

Behavior mapping is an unobtrusive, direct observational method for recording the location of subjects and measuring their activity levels simultaneously. Results help researchers understand the behavioral dynamics of the built environment. Early examples used pencil-and-paper methods to gather data and hand graphics to spatially represent results at the level of residential neighborhoods, parks, playgrounds, and schoolyards (4,19,24,25,29). van Andel (36) was the first investigator to digitally code outdoor behavior and its environmental attributes linked to a relational database. The advent of Geographical Information Systems combined with handheld digital coding devices created an almost paperless data gathering protocol, allowing many more variables to be coded, including accurate location of physical activity (11). Behavior mapping now provides environment–behavior researchers with an efficient method for gathering, processing, analyzing, and representing data. Behavior mapping is based on the concepts of *behavior setting* (3,18) and *affordance* (14,15).

Behavior setting. Behavior settings are ecological units where the physical environment and the behavior are indissolubly connected. These ecobehavioral units were first described by Barker (3) who, through direct observation of children, noticed that behavior settings have clearly identifiable spatial and temporal boundaries with components that function independently of adjacent ecobehavioral units. Behavior settings are composed of people, physical components, and behavior. The concept is applied in design research by disaggregating the functional parts of the outdoor environment (i.e., climbing area, sand pit, water play setting, tricycle path, vegetable garden, etc.) as opposed to treating the play area as a generalized context for behavior. Linking setting type and level of physical activity is essential for understanding the impact of design on children's behavior, for guiding design interventions, and for informing childcare licensing policy and accreditation regulations that may support active childhoods (34).

Affordance. Affordances are the perceived properties of the physical environment that support the individual's actions (15). The approach helps investigators understand how the physical components of built environments stimulate, attract, or "afford" children's activities. Affordance has been embraced as a construct with practical utility by environmental design researchers and investigators of children's environments. Environmental psychologist Heft (18) published a taxonomy of children's environmental affordances presenting a preliminary conceptual and operational framework. Fjørtoft (13) applied affordance to interpret the results of a study of Norwegian preschool children's motor development and fitness related to landscape topography and vegetation. Kyttå (20) used affordance in comparative studies of children's environments and mobility in Finland and Belarus. The concept of affordance stresses the relationship between perception and action, which, according to Gibson and Pick (14), helps children learn both about the functional properties of the environment (layout, objects, and events) and about themselves by using the environment in relation to their developing abilities. In the context of play areas, the concept of affordance can be used to analyze similarities and differences among behavior settings by describing physical attributes or qualities of behavior setting components that offer specific behavioral responses (e.g., shrubs for hiding).

OBSERVATIONAL METHODS AND MAPPING BEHAVIOR

Several direct observation systems are available for coding children's physical activity, including Behavior of Eating and Activity for Child Health Evaluation System (22), Child Activity Rating Scale (CARS) (2,10,31), System for Observing Play and Leisure Activity in Youth (SOPLAY) (21), Observational System for Recording Physical Activity in Children – Preschool Version (OSRAC-P) (7), and, most recently, Environment and Policy Assessment Observation (EPAO) (6). Three of these systems code for child's location. OSRAC-P includes codes for "indoors," "outdoors," and "transition" and also "outdoor activity context" (e.g., "games," "snacks," etc.) and limited predefined physical setting codes (e.g., "sandbox," "open space," etc.). SOPLAY defines observation "target areas," which include three outdoor "area types" ("court space," "play space," and "field"), and codes for "area improvements" (exclusively sports-related). EPAO includes eight "physical activity environment" subscales, two of which include outdoor physical environment items: "portable play environment" and "fixed play environment" (coded present or not present). The OSRAC-P uses the CARS five-point scale (which does not include physical environment codes). None of the tools

TABLE 1. Play area square footage, no. settings, no. children observed, no. observations, and physical activity mean.

	Play Area Square Footage	No. Settings	No. Children Observed	No. Observations	Physical Activity Mean[a]
Center 1	7497.12	13	23	210	2.34
Center 2	6784.84	13	30	234	2.93

[a] Physical activity was measured using five-point scale CARS (1 = sedentary; 5 = vigorous).

APPLIED SCIENCES

TABLE 2. List of behavior settings per center.

	Dramatic Play Area(s)	Gathering Area(s)	Open Area(s)	Pathway	Play Equipment	Porch/Transition	Sand Play
Center 1	2	N/A	5	Mix (linear and loop)	1 composite structure	1	1
Center 2	1	1	2	2 Linear	5 2 composite structures 1 set of swings 1 individual play equipment 1 merry-go-round	None	1

uses a "measured base map" (as behavior mapping does); therefore, square footage and precisely plotted child locations cannot be included in the analysis to produce design-sensitive results. For that reason, Cosco (9) modified earlier behavior mapping approaches to develop a protocol suitable for preschool environments (including codes for manufactured, natural, and mixed environmental components; physical activity level; wheeled toy use; and gender). The resulting childcare center maps show the spatial pattern of behavior delineated by behavior settings, which are usually defined by material lines on the ground subdividing physical components; for example, the edge of a pathway or boundary of a playhouse.

EXAMPLES OF BEHAVIOR MAPPING APPLIED TO CHILDCARE CENTERS

To illustrate the sensitivity of behavior mapping as an innovative method for assessing built environment components and attributes associated with physical activity levels, we present data from two childcare centers. The outdoor areas were similar in square footage and number of behavior settings (Table 1). However, the *layout* of the sites and the mix of *types of settings* were different (Table 2). Center 1 included two dramatic play settings (play houses), three open areas, a pathway (linear and loop), one composite play structure, a porch/transition area, and a sand play setting. Center 2 included a dramatic play setting (play house), two gathering settings (benches), two open areas, a linear pathway, five pieces of play equipment, and a large sand play setting.

For the illustrative maps described in Figures 1 and 2, observers systematically scanned each behavior setting consecutively using a paper map to record subject locations and a handheld computer (PDA Dell Axim Pocket PC, Austin, TX) with pull-down menus to code for gender, behavior setting type, physical attributes, and physical activity level using CARS (10). Two observers collected data after predefined clockwise and counterclockwise walking itineraries to cover the whole play area while avoiding overlaps.

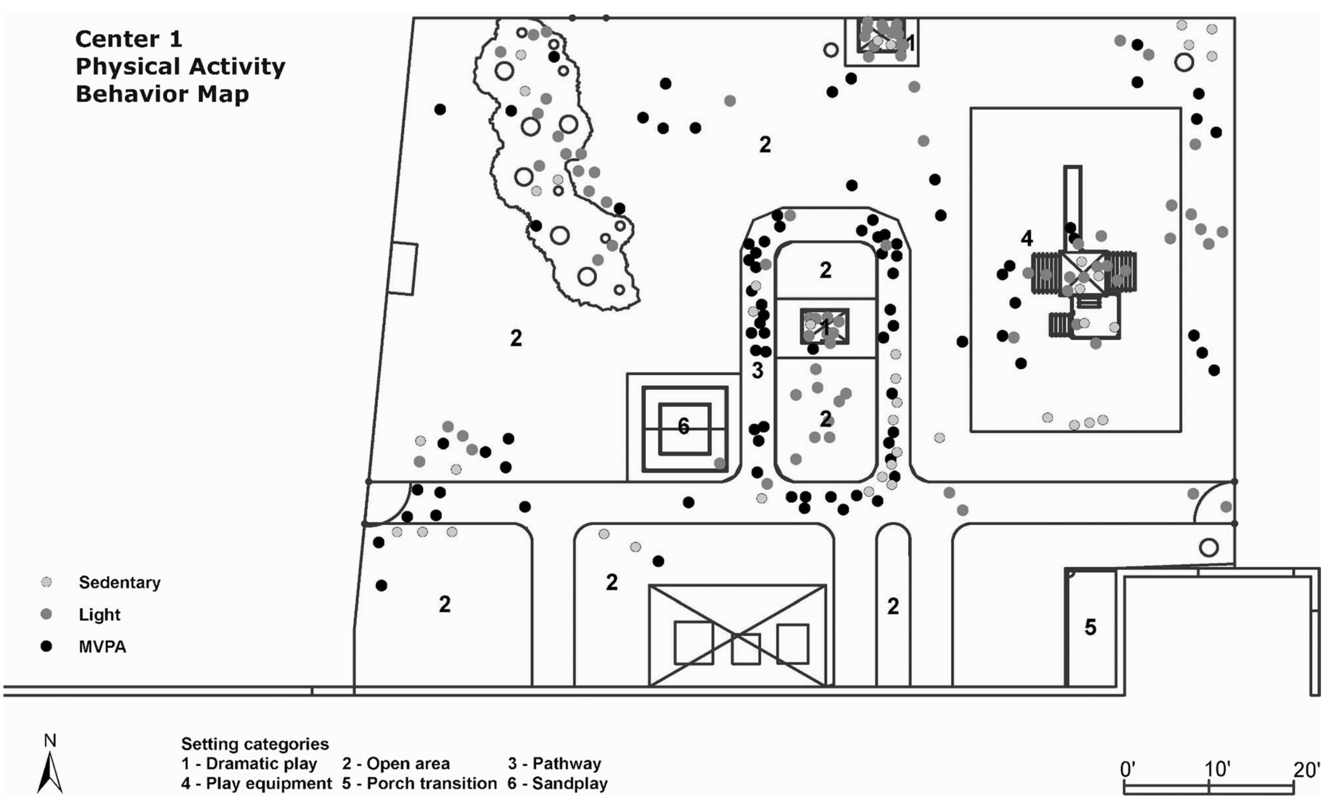

FIGURE 1—Center 1. Physical activity behavior map.

APPLIED SCIENCES

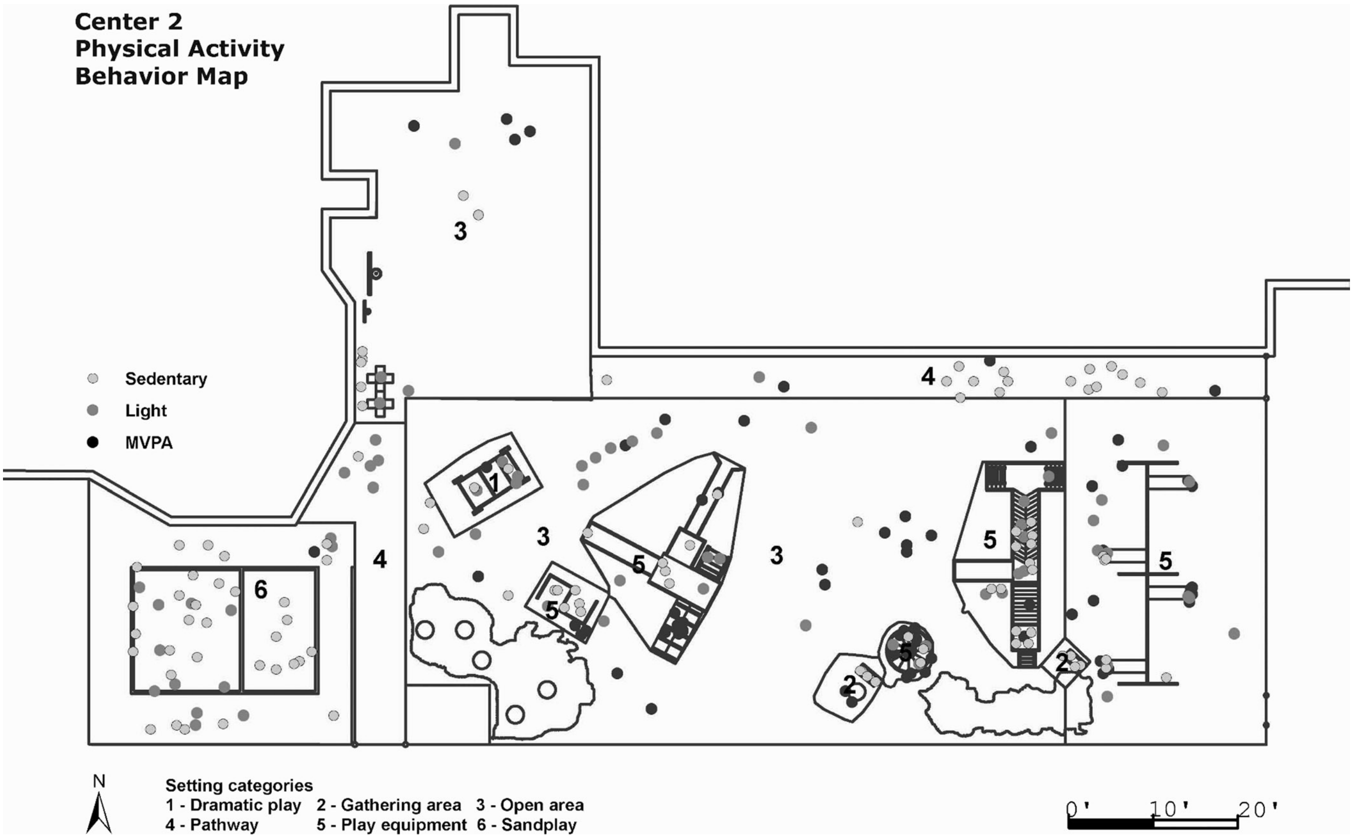

FIGURE 2—Center 2. Physical activity behavior map.

Observers were trained to observe children's behavior and physical activity using CARS (10). Each observer collected four maps during the observation session in the morning outdoor playtime (center 1 session = 55 min, 13 min per map; center 2 session = 46 min, 11 min per map). Data were gathered on mild climate days (center 1 = 56°F; center 2 = 64°F). In total, eight behavior maps were collected per session (four per observer). The data were used to create the attribute tables in Geographical Information Systems (11) and represent the compilation of all observations gathered during each observation session. Each dot represents the observation of an individual child and his/her level of physical activity (light gray = sedentary, medium gray = light activity, black = MVPA). Behavior settings are identified in a numbered key.

RESULTS FROM BEHAVIOR MAPPING

For centers 1 and 2 together, the majority of total activity observations were distributed across four types of behavior setting: open areas, sand play settings, pathways, and play equipment (Table 3). However, the proportions of total activity by setting were different in each center (Figs. 1 and 2). In center 1, the majority (87.6%) of total activity was observed in three types of behavior setting: open areas (40.0%), pathways (32.4%), and play equipment (15.2%). The center 1 sand play setting accounted for a negligible (0.5%) amount of total physical activity. In center 2, the majority of activity (81.6%) was again observed in three types of setting: play equipment (42.7%), sand play setting (19.7%), and open areas (19.2%). However, low pathway activity (11.1%) was displaced by higher sand play activity (19.7%).

DISCUSSION

Differences in total activity created by different types of behavior setting and by different forms of the same type of behavior setting (pathways, play equipment, sand play, and

TABLE 3. List of behavior settings per center.

	Sedentary (%)	Light (%)	MVPA (%)	Total Physical Activity (%)
Center 1				
Dramatic play	1.40	10.00	0.50	11.90
Open area	7.60	18.10	14.30	40.00
Pathway	5.70	3.80	22.90	32.40
Play equipment	4.30	7.60	3.30	15.20
Porch/transition	0.00	0.00	0.00	0.00
Sand play	0.00	0.50	0.00	0.50
Subtotal	19.00	40.00	41.00	100.00
Center 2				
Dramatic play	0.90	1.70	0.40	3.00
Gathering area	3.40	0	0.90	4.30
Open area	4.70	6.80	7.70	19.20
Pathway	7.30	2.60	1.30	11.10
Play equipment	14.50	11.50	16.70	42.70
Sand play	13.70	5.60	0.40	19.70
Subtotal	44.50	28.20	27.40	100.00

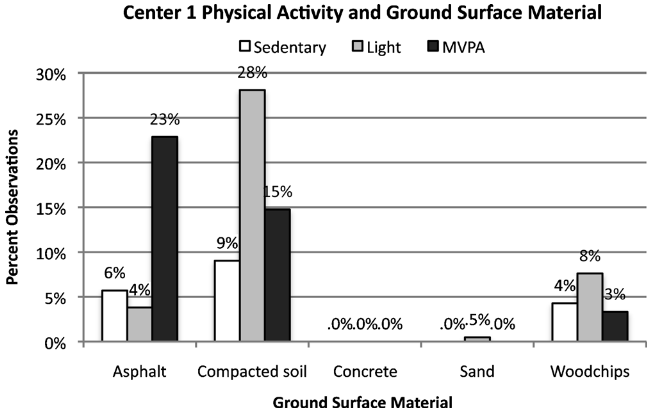

FIGURE 3—Center 1. Physical activity and ground surface material.

open areas) (Table 3) might help us understand the impact of affordances. Pathway is a type of setting typically associated with movement and higher levels of physical activity. However, the amount of use and level of activity afforded can be substantially affected by attributes such as surface quality (hard, soft), path width (wide, narrow), and pathway form (curvy, looped, linear). Cosco (9) showed that children are attracted by and are more active on hard-surface, curvy pathways because they afford easier wheeled toy play and running.

Pathways. We may speculate that children perceived the looped pathway of center 1 as described above, thus contributing more than half of the total MVPA (22.9% of 41.0%; Table 3) for the whole outdoor area. The playhouse installed in the center of the loop may have added perceptual complexity by visually blocking the direct view across the loop, thereby affording peekaboo (now you see me, now you don't), which seemed to accentuate the affordance of *circular motion* that young children often find enjoyable.

In contrast, the center 2 linear pathway adjacent to the building attracted only a small proportion of total activity (11.1%). In this case, we speculate that a linear pathway affords a less interesting experience to children because it obliges them to travel back and forth, which is particularly awkward to perform with wheeled toys and can result in conflict as children try to maneuver around each other in opposite directions. We also observed that the pathway was alongside the building so that at the beginning of playtime, children ran straight across it to more distant settings. Furthermore, the pathway lacked additional attributes (in contrast to the center 1 playhouse) that could have offered additional affordances. Layouts that include continuous, circular pathways appear intrinsically more attractive than the affordance of linear pathways (9).

Play equipment. The difference between centers 1 and 2 in play equipment observed activity (15.2% and 42.7%) as well as MVPA (3.3% and 16.7%) may have resulted from the combined affordance of five play equipment settings in center 2 compared with only one in center 1. Further research might yield information about the appropriate number and type of play equipment most suitable to support higher levels of physical activity.

Sand play. By nature, sand play is sedentary. In center 2, it attracted almost one-fifth (19.7%) of observed activity but a negligible amount of MVPA. The difference in sand play setting attraction between the centers may reflect the difference in setting size. The ample size of the center 2 sand play setting may have afforded increased social interaction, therefore stimulating more activity, compared with the small size of the center 1 sand play setting.

Open areas. Observed activity and MVPA in open areas were approximately double in center 1 compared with those in center 2. Because facilitated activities are mainly afforded in open areas, activity levels may be influenced by program components (e.g., ball play) and teacher–child interactions (e.g., group games). In center 1, behavior mapping may reflect the influence of an active play program (including ball play) conducted in the open areas on the day of the observation session. Further research can be conducted to assess the impact of programming and teacher facilitation in open areas.

Ground surface. As a safety attribute, ground surface has long appeared in the playground safety guidelines published by the US government (35). However, association with MVPA has only recently been investigated (7). Behavior mapping provides linked physical activity data to extend the investigation of different ground surface materials, which we speculate afford different levels of physical activity because of the variability of their responsive qualities to children's ambulation. In centers 1 and 2, MVPA was found in settings with harder ground surfaces such as asphalt, compacted soil, and concrete (Figs. 3 and 4). The high level of MVPA attracted by the center 1 hard surface pathways (Fig. 3) may reflect the impact of the added affordance of wheeled toys as play objects, which are easier to use on hard, smooth surfaces. This trend, supported by previous research (7), has clear implications for design because ground surface selection is considered a critical decision by designers, which, until now, is driven by safety criteria rather than by physical activity objectives.

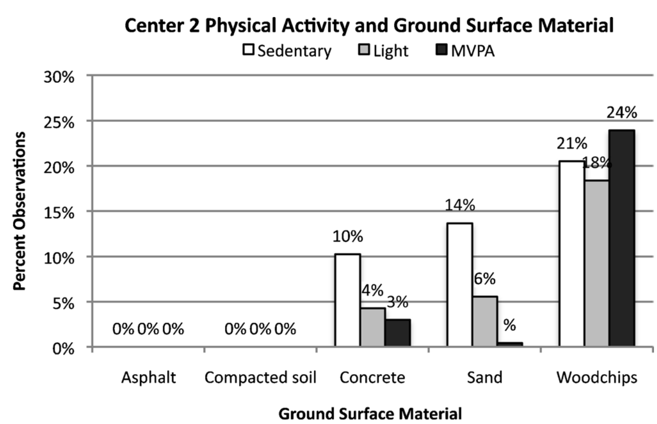

FIGURE 4—Center 2. Physical activity and ground surface material.

APPLIED SCIENCES

On the other hand, MVPA is negatively influenced by sand (Figs. 3 and 4), most likely because it makes running difficult. Entire playgrounds are sometimes covered with sand to meet safety standards; however, sand may inhibit higher levels of MVPA. Knowledge about the impact of specific ground surfaces on MVPA may help designers and policy makers understand the need to carefully delineate the required safety zones around play equipment, thus allowing space for diversified ground surfaces to support higher MVPA, especially with wheeled toys, balls, and similar loose or moveable play objects and equipment (6).

BEHAVIOR MAPPING: POTENTIAL AND FUTURE DIRECTIONS

Longitudinal studies could use behavior mapping to assess the impact of seasonality and climate (e.g., sun orientation, precipitation, plant characteristics, climatic zones, etc.) on year-round physical activity or the influence of different types of outdoor programs on preschool activity, including gardening. Behavior mapping could also address the potential differences in the use of behavior settings by children from different ethnicity or racial backgrounds and the influence of teacher–child interaction, among other social factors. Behavior mapping may be a viable method for pre–post intervention studies that could yield valuable data showing the impact of environmental improvements on preschool physical activity. A useful affordance factor with design implications is *layout*. Currently, however, it is not possible to infer how the layout and mix of behavior settings might work synergistically to support children's MVPA. Studies conducted at sites designed with high variability of setting layout, pathway type, ground surfaces, and moveable play objects may help increase understanding of the behavioral influence of more diverse environments on MVPA. Additional design and policy-sensitive variables that could be studied in relation to active outdoor play include overall play area size and child–square foot ratio, setting size, and cost-effectiveness of various setting types and attributes.

Behavior mapping is not a tool but a method for collecting information and, as such, is sensitive to recording variations in activity intensity between different types of settings. As weather, programming, educational philosophy, and age may influence children's physical activity, it is advisable to control for these variables and test the methodology in a larger sample of play areas before generalizing the results. In addition, collection of demographic information, such as socioeconomic status and race/ethnicity, could help identify potential confounders. Because the method codes the setting rather than specific children, fast-moving children may be coded more than once or not coded if they vacated the setting before being targeted. Conversely, stationary children may be coded more than once if they do not move between rounds of observation. Coding for multiple days and under different conditions (free play, teacher-directed games, etc.) will bring to light the setting pattern of use more accurately.

CONCLUSIONS

Behavior mapping provides a promising method for objectively measuring relationships between children's outdoor physical settings and preschool physical activity. Used in conjunction with existing validated tools for measuring physical activity, the method can be used to accurately link environmental components and affordances of behavior settings to children's activity. Such evidence may be used to develop policies and standards for adoption by professional organizations to help guide design and investment in childcare outdoor areas as a cost-effective disease prevention strategy delivered through appropriate childcare licensing policies and accreditation regulations.

Of special interest to designers is the identification of *specific environmental components* associated with increased activity. Research results may provide guidance for environmental interventions that could help create healthy, active preschool outdoor areas. Dissemination may influence the training of designers and childcare providers by increasing awareness about how the physical environment and its components support or hinder children's physical activity.

This study was supported by the exploratory grant no. 1 R21 ESO 14178-01, National Institute of Environmental Health Sciences. The authors thank Tom Danninger, Earth Observation Center, NC State University, for the illustrative maps and Prof. Dianne Ward, Department of Nutrition, UNC, for reviewing and offering helpful suggestions. No financial disclosures are reported by the authors.

The results of the present study do not constitute endorsement by the American College of Sports Medicine. All study procedures were reviewed and approved by the NC State University institutional review board.

REFERENCES

1. American Society of Landscape Architects Web Site [Internet]. Washington (DC): American Society of Landscape Architects; [cited 2008 Oct 25]. Available from: http://www.asla.org.
2. Baranowski T, Thompson W, DuRant RH, Baranowski J, Puhl J. Observations on physical activity in physical locations: age, gender, ethnicity, and month effects. *Res Q Exerc Sport*. 1993; 64:127–33.
3. Barker R. On the nature of the environment. In: Proshansky H, Ittelson W, Rivlin L, editors. *Environmental Psychology: People and Their Physical Settings*. New York (NY): Holt, Rinehart & Winston; 1976. p. 12–26.
4. Björklid P. *Children's Outdoor Environment. A Study of Children's Outdoor Activities in Two Housing Estates from the Perspective of Environmental and Developmental Psychology*. Stockholm (Sweden): Stockholm Institute of Education; 1982; 92 p.
5. Boldemann C, Blennow M, Dahl H, et al. Impact of pre-school environment upon children's physical activity and sun exposure *Am J Prev Med*. 2006;42(4):301–8.

6. Bower J, Hales D, Tate DF, Rubin DA, Benjamin SE, Ward DS. The childcare environment and children's physical activity. *Am J Prev Med*. 2008;34(1):23–9.
7. Brown WH, Pfeiffer KA, McIver KL, Dowda M, Almeida MJ, Pate RR. Observational System for Recording Physical Activity in Children – Preschool Version. *Res Q Exerc Sport*. 2006;77:167–76.
8. Cardon G, Van Cauwenberghe E, Labarque V, Haerens L, De Bourdeaudhuij I. The contribution of preschool playground factors in explaining children's physical activity during recess. *Int J Behav Nutr Phys Act*. 2008;26:5–11.
9. Cosco N. Motivation to move: physical activity affordances in preschool play areas [dissertation]. Edinburgh (Scotland): School of Landscape Architecture, Heriot Watt University; 2006; p. 65–6.
10. Durant RH, Baranowski T, Puhl J, et al. Evaluation of the Children's Activity Rating Scale (CARS) in young children. *Med Sci Sports Exerc*. 1993;25(12):1415–21.
11. ESRI. GIS and Mapping Software Web Site [Internet]. Redlands (CA): ESRI; [cited 2008 Oct 15]. Available from: http://www.esri.com.
12. Finn K, Johannsen N, Specker B. Factors associated with physical activity in preschool children. *J Pediatr*. 2002;140(1):81–5.
13. Fjørtoft I. The natural environment as a playground for children: the impact of outdoor play activities in pre-primary school children. *Early Child Educ J*. 2001;29(2):111–7.
14. Gibson E, Pick A. *An Ecological Approach to Perceptual Learning and Development*. New York (NY): Oxford University Press; 2000. p. 24–5.
15. Gibson J. *The Ecological Approach to Visual Perception*. Hillsdale (NJ): Erlbaum; 1986. p. 129.
16. Harms T, Clifford R, Cryer D. *Early Childhood Environment Rating Scale*. Revised ed. New York (NY): Teachers College Press; 1998. 40 p.
17. Harms T, Cryer D, Clifford R. *Infant/toddler Environment Rating Scale*. Revised ed. New York (NY): Teachers College Press; 2006. 62 p.
18. Heft H. Towards a functional ecology of behavior and development: the legacy of Joachim F. Wohlwill. In: Görlitz D, Harloff HJ, Mey G, Valsiner J, editors. *Children, Cities, and Psychological Theories: Developing Relationships*. Berlin (Germany): Walter De Gruyter; 1998. p. 85–110.
19. Kinoshita I. Children's participation in Japan: an overview of municipal strategies and citizen movements. *CYE* [Internet]. 2007 [cited 2008 Oct 15];17(1):269–86. Available from: http://www.colorado.edu/journals/cye/17_1/17_1_16_MunicipalStrategies.pdf.
20. Kyttå M. Affordances of children's environments in the context of cities, small towns, suburbs and rural villages in Finland and Belarus. *J Environ Psychol*. 2002;22:109–23.
21. McKenzie TL, Marshall MA, Sallis JF, Conway TL. Leisure-time physical activity in school environments: an observational study using SOPLAY. *Prev Med*. 2000;30:70–7.
22. McKenzie TL, Sallis JF, Patterson TL, et al. BEACHES: an observational system for assessing children's eating and physical activity behaviors and associated events. *J Appl Behav Anal*. 1991; 24:141–51.
23. *Merriam-Webster, Third New International Dictionary*. Springfield (IL): Merriam-Webster; 1981. 611 p.
24. Moore R. Meanings and measures of child/environment quality: some findings from the environmental yard. In: Rogers W, Ittelson W, editors. *New Directions in Environmental Design Research*. Washington (DC): EDRA; 1978. p. 287–306.
25. Moore R. The power of nature: orientations of girls and boys toward biotic and abiotic settings on a reconstructed schoolyard. *Child Environ Q*. 1986;3(3):52–69.
26. Moore R, Cooper Marcus C. Healthy planet, healthy children: designing nature into the daily spaces of childhood. In: Kellert S, Heerwagen J, Mador M, editors. *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*. Hoboken (NJ): John Wiley & Sons; 2008. p. 153–203.
27. Moore R, Cosco N. What makes a park inclusive and universally design? A multi-method approach. In: Ward Thompson C, Travlou P, editors. *Open Space People Space*. New York (NY): Taylor; 2007. p. 85–110.
28. Moore R, Cosco N. Using behaviour mapping to investigate healthy outdoor environments for children and families: conceptual framework, procedures, and applications. In: Ward Thompson C, Bell S, Aspinall P, editors. *Innovative Approaches to Research Excellence in Landscape and Health*. London (UK): Taylor and Francis; (in press).
29. Moore R, Wong H. *Natural Learning: Creating Environments for Rediscovering Nature's Way of Teaching*. Berkeley (CA): MIG Communications; 1997. p. 238–9.
30. Pate RR, Pfeiffer KA, Trost SG, Ziegler P, Dowda M. Physical activity among children attending preschools. *J Pediatr*. 2004; 114(5):1258–63.
31. Puhl J, Greaves K, Hoyt M, Baranowski T. Children's Activity Rating Scale (CARS): description and calibration. *Res Q Exerc Sport*. 1990;61:26–36.
32. Sallis J, Nader PR, Broyles SL, et al. Correlates of physical activity at home in Mexican-American and Anglo-American preschool children. *Health Psychol*. 1993;12(5):390–8.
33. Sonenstein F, Gates G, Schmidt S, Bolshun N. *Primary Child Care Arrangements of Employed Parents: Findings from the 1999 National Survey of America's Families (Occasional Paper Number 59)*. Washington (DC): The Urban Institute; 2002. p. 3–4.
34. Trost S, Ward D, Senso M. Effects of child care policy and environment on physical activity. *Med Sci Sports Exerc*. 2010;42(3): 520–5.
35. US-CPSC. *Public Playground Safety Handbook–US Consumer Product Safety Commission*. [Internet]. 2008 [cited 2009 May 7]. Available from: http://www.cpsc.gov/CPSCPUB/PUBS/325.pdf.
36. van Andel J. Effects on children's behavior of physical changes in a Leiden neighborhood. *Child Environ Q*. 1984–1985;1(4):46–54.