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Neighborhood Park Use by Children:

Use of Accelerometry and Global Positioning Systems

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Abstract

Background—While having a greater number of neighborhood parks may be associated with greater overall physical activity in children, information is lacking about the extent to which children actually use parks for physical activity.

Purpose—This study combined accelerometer, GPS, GIS, and self-report methods to examine neighborhood park availability, perceived proximity, and use for physical activity in children.

Methods—Low-to-middle income children (aged 8–14 years) (n=135) from suburban communities in Southern California wore an Actigraph accelerometer and GlobalSat BT-335 GPS device across 7 days to measure physical activity and park use, respectively. ArcGIS identified parks within a 500m residential buffer of children's homes. Parents reported perceptions of neighborhood park proximity through the Neighborhood Environment Walkability Survey (NEWS). Data were collected from March 2009 to December 2010, and analyzed in 2013.

Results—Fifty-four percent of families lived within 500m of a park. Of these children, GPS data indicated that 16% used it more than 15 minutes and an additional 11% of children used it between 5 and 15 minutes during the 7-day study period. The odds of extended park use (>15 minutes) increased fourfold when the distance between home and the nearest neighborhood park decreased by 100 meters. Additionally, the odds of any park use (>5 minutes) doubled when moving from the 25th to the 75th percentile for park greenness/vegetation density.

Conclusions—Although children's use of neighborhood parks was generally low, it increased substantially when parks were closer to children's homes and had greater vegetation density.

Introduction

Physical inactivity has been declared a global public health problem by the WHO.[1] Estimates suggest that 65% of U.S. children aged 9–11 years do not get at least 20 minutes of daily vigorous physical activity,[2] and this rate may be considerably lower when measured by accelerometer.[3] The public health significance of the problem is underscored by evidence showing that physical inactivity increases risk of many serious health conditions.[4–7] A

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growing body of research has linked children's physical activity levels to neighborhood built environmental characteristics. In particular, neighborhood parks and open spaces have garnered much research attention for the opportunities they may provide children to engage in physical activity.[8–11]

Studies in this area typically investigate the availability of and access to parks (e.g., number of parks, distance to closest park, total park area) in relation to children's total physical activity levels. For example, Cohen et al.[12] found that having a greater number of neighborhood parks was associated with greater nonschool physical activity in girls. For each additional park located within the half-mile around a girl's home, there was an average increase of 17 minutes in girls' moderate-to-vigorous intensity physical activity during nonschool hours across a 6-day period. Also, using data from the California Health Interview Survey, Babey and colleagues[13] found that access to a safe park was related to higher levels of physical activity and lower levels of inactivity among adolescents living in urban areas.

A growing concern about research in this area is that there is spatial or temporal uncertainty about the actual settings that exert contextual influence on the health behaviors under investigation.[14] Known as the uncertain geographic context problem (UGCoP),[15] this methodologic issue is characterized by a lack of clarity about (1) the exact geographic area that has a direct causal influence on health-related behaviors and (2) the timing and duration of individuals' actual exposures to these contextual influences. It is thought that the UGCoP may account for many of the inconsistencies observed in research on the effects of neighborhood built environmental features on health behaviors.[16–18] The UGCoP may be partially caused by assumptions about the degree to which individuals are aware of and use specific physical environmental settings in their neighborhoods that are thought to promote physical activity. Presence of parks on infrequently traveled routes, poorly maintained park facilities, and lack of safety at parks among other concerns may contribute to low awareness and use of the available parks in one's neighborhood.[19] To date, a few studies have systematically examined predictors of park use among children and adults using survey and activity log methodologies,[20–22] which may be prone to self-report errors and biases. Objective measures of children's park use (e.g., accelerometer and GPS) have been deployed in a few descriptive studies.[23–25] However, no known research to date has used these objective methodologies to investigate factors that predict park use.

To close these research gaps, the current study combined objective (i.e., accelerometer, GPS, and GIS) and survey approaches in a sample of children and parents living in low-to-medium density suburban areas of San Bernardino County, California. The goals were to use these methods to differentially describe neighborhood parks in terms of availability (i.e., the presence of neighborhood parks), perceptions of proximity (i.e., awareness of the presence of a park within one's neighborhood), use (i.e., time spent at a neighborhood park) and use for physical activity (i.e., performance of physical activity in a neighborhood park). The study also examined how park characteristics such as distance to the nearest park, total neighborhood park area, number of parks available, and park greenness (i.e., density of vegetation such as trees, shrubs, and grasses) are related to park use.

Methods

Sample

This study used data from children and parents enrolled in the control group of a 4-year natural experiment, called Healthy PLACES "Effects of a Smart Growth Community of Prevention of Family Obesity Risk." Participants lived in low-to-medium density suburban municipalities in San Bernardino County. Only control group participants were included in the present study because members of the experimental group lived in close proximity to each other (within 1km) within a smart growth community and lacked variability in park access. Participants were recruited through informational flyers, posters, and letters. Inclusion criteria consisted of the following: (1) child currently enrolled in Grades 4 through Grade 8, (2) living in Chino CA or a surrounding community, and (3) annual household income less than $210,000. Written informed consent and minor assent was obtained from participants. This research was reviewed and approved by the IRB at the University of Southern California and the Committee on the Protection of Human Subjects, University of California, Berkeley.

Study Design and Procedures

Baseline data from the 4-year study were used. Data were collected from March 2009 to December 2010. No data collection took place from late July to August or during January due to typically adverse temperatures and weather conditions that could affect outside activity in that part of Southern California. Parents and children completed surveys during a data-collection appointment at a community site or their homes. Children additionally wore an accelerometer and GPS device over a 7-day period. Further details about the study design and procedures are available elsewhere.[26, 27]

Measures

Park availability—Parents provided home address information. A 500-meter radial buffer was then created around participants' residences as this distance is between one-third and one-quarter mile, which is generally considered by planners as "walkable."[28] Using ArcGIS, land-use data provided by Environmental Systems Research Institute (ESRI) Business Analyst[29] was used to identify the presence of parks within the residential buffer. Park spaces included public (national, state, county, city) parks, forests and open spaces. General open spaces such as vacant lots and undesignated or private natural areas were not included. Satellite imagery and Google maps were used to verify that all 41 parks identified using GIS do exist and are accessible by public paths or roadways.

Perceptions of park proximity—Parents' perceptions of the neighborhood environment were measured using the Neighborhood Environment Walkability Survey (NEWS) instrument.[30–33] The instrument measures perceptions of walking proximity from home to various types of destinations including parks, with the following responses: 1–5 min., 6–10 min., 11–20 min., 21–30 min., and >30 min. walking distance.

Park use—Moment-to-moment data describing geographic locations were recorded through portable GPS devices worn by both children and parents. Data were gathered for a 7-day period with the BT-335 Bluetooth GPS (16M bit, 1575.42 MHz) data-logger device by GlobalSat Technology Corp (Taipei) attached to a belt worn around the waist along with the accelerometer. This device records time, date, speed, altitude, and GPS location at preset intervals. It is Wide Area Augmentation System (WAAS) enabled and uses a SiRF star III chipset that has receiver sensitivity of −159 dBm while tracking. The spatial accuracy is within 5 meters and the average cold, warm, and hot start times are 42, 38, and 1 seconds, respectively.[34] The recording interval was set to a 30-second epoch to match the accelerometer specifications. Children's GPS data points falling on or within 5 meters of a neighborhood park space were identified in GIS and classified as occurring at a park. Park use was defined as none (≤5 minutes), any (>5 minutes) or extended (>15 minutes) of continuous or discontinuous GPS data falling within a neighborhood park space (i.e., a park located within the 500m radial buffer of their residence).

Park use for physical activity—GPS data points were combined with time-matched accelerometer data to assess the extent to which parks were used by children for physical activity. The Actigraph, Inc. GT2M model activity monitor (firmware v06.02.00) provided an objective measure of activity. The devices were not worn when sleeping, bathing, or swimming. MVPA thresholds (in counts per minute) were defined using age-specific prediction equations posed by Freedson.[35,36] A threshold for moderate activity of 4 METs was used for children (as opposed to a 3 METs moderate activity cut-off for adults) to account for higher resting energy expenditure in children and youth.[37,38] Park use for physical activity was measured in terms of the number of minutes of MVPA within a neighborhood park space, as indicated by combined accelerometer and GPS data.

Park characteristics—In ArcGIS, land-use data from Environmental Systems Research Institute (ESRI) Business Analyst[29] was utilized to estimate park proximity (i.e., Euclidian distance to the nearest park boundary from each participant's home address), total park area and number of parks (within each participant's neighborhood buffer). Also, the Normalized Difference Vegetation Index (NDVI), a LANDSAT satellite-based indicator of vegetation, was used to estimate the average level of greenness for all parks within the neighborhood buffer.[39, 40]

Demographic variables—Age, gender, annual household income, and race/ethnicity were assessed through child and parent self-report surveys. Ethnicity was coded as non-Hispanic white, non-Hispanic black, Hispanic, Asian and Other (Hawaiian/Pacific Islander, American Indian, mixed).

Data Merging and Processing

Accelerometer and GPS files were imported into the R version 2.9.2 programming language interface. Date and time stamps to the nearest 30-second epoch were used to match all accelerometer and GPS records. Overnight (11PM–5AM) and school (9AM–2PM on weekdays during the school season) hours were removed from the analyses. Strings of consecutive readings of 0 activity counts lasting 60 minutes or more were considered accelerometer nonwear and excluded from analyses in a manner similar to other studies on children[41] and national surveillance data.[3] Activity outliers were identified as records with greater than 16,383 counts per 30-second epoch.[40] Motorized activity was also excluded from the analyses, which were identified by records with speeds greater than 32 kph since typical bicycling speeds range from 15 to 30 kph (9.32 to 18.64 mph). Once these records were removed, children were determined to have sufficient data for inclusion in the analysis if they had a minimum of 3 valid days of matched data—where a valid day was defined as having a minimum of 4 hours of matched accelerometer and GPS data points, similar to other studies.[23]

Data Analyses

Logistic regression analyses tested whether distance to the nearest park, level of neighborhood park greenness, total neighborhood park area and number of parks available predicted the likelihood of neighborhood park use by children. These analyses controlled for children's age, gender, race/ethnicity and annual household income. Statistical analyses were conducted in statistical program R v.2.15.2 in 2012–2013. Data were analyzed in 2013.

Results

Descriptive Statistics

A total of 1023 parent–child pairs responded to the recruitment materials of which 667 pairs were reached by phone for eligibility screening. Among those who were screened, 447 pairs met eligibility criteria of which 407 pairs further consented to participate in the study. Baseline data were collected from 386 pairs. From this group, 208 had a sufficient amount of matched accelerometer and GPS data to be included in the analysis of which 143 pairs resided in the control communities for the larger trial. The average percent missing accelerometer and GPS data were 0.91% (range 0–24.20) and 29.93% (range 2.51–77.54), respectively. It is unknown whether missing GPS data were due to signal loss or if the unit was powered off. After exclusions for missing parent survey data (*n*=8), a remaining 135 children were included in the data analyses. Demographic characteristics for children with sufficient data are shown in Table 1 (N=135). Half of the children were female, and 48% were Hispanic. The majority of parents participating in this study were women (91%) with a mean age around 40.0 years (SD=5.5 years, range=27–52 years). Forty-two percent of the households in the sample earned less than $40,000 annually. The age, race, and gender distributions were similar for children who were excluded from the analysis for having insufficient accelerometer and GPS as for those included in the analysis (chi-square test $p>0.05$), while the excluded children had a significantly higher annual household income (mean 69,000 USD) compared to those included in the analysis (mean 57,000 USD) ($p<0.05$).

Park Availability, Perceived Proximity, and Use

The GIS mapping indicated that 54% (*n*=73) of families had at least one park available within 500 meters (i.e., about a 10-minute walk) of their geocoded home. For families with an available neighborhood park, 64% had one park and 36% had two or more parks within 500 meters. Parent-report data from the NEWS survey indicated that 86% (n=63) of parents with an available park in their 500-meter neighborhood perceived the proximity of the closest park to be within a 10-minute walking distance of home. An additional 11% (*n*=8) perceived the closest park to be within a 20-minute walking distance of home. However, none of the children whose parents perceive their closest neighborhood park to be greater than a 10-minute walking distance, used this neighborhood park. Of the 73 children with an available neighborhood park, GPS location data showed that 27% (*n*=20) had any use (>5 minutes) of that park space and 16% (*n*=12) had extended use (>15 minutes) of that park space during the assessment week based on minutes of GPS data within a neighborhood park space. Of the children with extended neighborhood park use, 58% (n=7) engaged in at least 15 minutes of MVPA (indicated by matched accelerometer data) within the park space. Among the 73 children who had a neighborhood park, there were 41 different parks, and the twelve children classified as extended park-users visited nine different parks. Children who had extended use of a neighborhood park (>15 minutes) went to only one park and spent a median of 80.25 minutes (range=18–458.50 min) per week at the park and engaged in a median of 44.25 minutes (range=8.5–163.5 min) of MVPA per week within the park space. On average, children visited their neighborhood park between 3 to 4 times/week (mean=3.8, SD=2.2, range=1 to 7 days).

Park Characteristics Predicting Park Use

Table 2 shows the results for the logistic regression analyses predicting park use as a function of park characteristics. Park proximity was significantly related to any (>5 minutes) and extended (>15 minutes) park use. For each 100 meter decrease in distance to the nearest park, the odds of extended (>15 minutes) park use more than quadrupled (OR=4.06, 95% CI=1.61, 10.24) after controlling for children's age, gender, race/ethnicity and annual household income (Table 2). Greater park greenness was associated with a significantly greater likelihood of any (> 5 minutes) park use. The odds of any park use for parks within the 75th percentile for greenness were almost 3 times the odds of use of parks within the 25th percentile for greenness (OR=2.46, 95% CI= 1.03–5.89) after adjusting for children's age, gender, race/ethnicity and household income (Table 2). Neither total park area nor number of parks within the neighborhood buffer were related to any or extended park use. The age of the child did not modify these associations. Also, age, gender, race/ethnicity and household income characteristics did not differ for children who used their park (any or extended use) compared to children who did not use their park (p>0.05).

Discussion

This study combined accelerometer, GPS, GIS, and survey methods to examine park availability, perceived proximity, and use among families with children. About one third of children with an available neighborhood park had some exposure to it (>5 minutes) and only 16% had extended use (>15 minutes) of that park space within the study week. Results from this study underscore the need for greater spatial and temporal certainty about the actual settings that exert contextual influence on the health behavior as described by the UGCoP.[15] While having a greater number of neighborhood parks may be associated with greater physical activity[12, 13] these data indicate that only a small portion of children may actually engage in physical activity in those neighborhood parks. Having available neighborhood parks may be correlated with greater access to other locations for physical activity (e.g., larger backyards, community centers, gyms, athletic facilities). Without measuring actual park use or controlling for access to other nonpark facilities, inappropriate conclusions may be drawn about the association between park availability and physical activity in children.

The fact that the odds of extended park use increased fourfold when the distance between home and the nearest neighborhood park decreased by 100 meters underscores the importance of park proximity to facilitating greater use. These results are similar to the findings produced by Edwards et al.[21] who in a study of Australian adolescents, found a positive association between distance to parks and use of those environments for physical activity. Park proximity also emerged as influencing park use in a recent review of qualitative studies.[19] What is particularly interesting about the results of the current study is the sharp slope of decline in the distance decay function (i.e., odds quadrupling every 100 meters). These findings suggest that the introduction of small pocket parks on a single vacant building lot or on small, irregular pieces of land within existing neighborhoods to increase park proximity to children’s homes may promote greater park use. These results also found that the likelihood of any park exposure over 5 minutes doubled when moving from the 25th to the 75th percentile for park greenness. Using accelerometers combined with GPS, Coombes and colleagues[42] found that green environments such as gardens, parks, grassland and farmland were particularly supportive of vigorous intensity activity. However, post-hoc visualization of the GPS data suggest that much of the park exposures lasting between 5 and 15 minutes were discontinuous, suggesting that children may actually be passing by the park on a nearby sidewalk or road instead of spending time within the park boundaries. Nonetheless, these children may represent a potentially important group to target for interventions to increase park use, since these parks may already be on frequently traveled routes.

Despite the strengths of this study such as the objective measures of environmental exposures and behaviors (i.e., accelerometer, GPS, GIS), there were a few limitations. Data were cross-sectional, which makes it difficult to rule out neighborhood selection bias.[43–45] Also, the small sample size for park users limited the analytic ability to predict park-based MVPA as an outcome. In addition, the GPS units have differential measurement error depending on available satellites, meteorology, and physical obstructions, with errors often around 5m, but also occasionally larger (i.e., >15m), which could have resulted in misclassification of land use types when the child was near the border separating two different land use parcels. Further, the Euclidian distance used to create the GIS buffers may underestimate the true distance between a child’s home and the nearest park entrance if the road network is not direct. Although satellite imagery and Google maps were used to verify that all parks identified using GIS exist, it is possible that some parks may exist that were not included in ESRI's Business Analyst dataset such as parks that were established subsequent to ESRI data collection. Also, children living in neighborhoods without formal parks may use general open spaces such as vacant lots and undesignated natural areas for physical activity for which data were not available. Furthermore, data on the quality of programming, facilities, and equipment at parks or park safety may predict park use, but were not accessible for this study. Lastly, results may not be generalizable to urban populations, since the data were primarily captured in suburban communities.

Overall, this study found that about a third of children had some direct exposure to a neighborhood park during the study week. Among those children who showed extended use of a neighborhood park, most engaged in some park-based physical activity during those visits. The odds of any park exposure increased substantially when parks were within closer proximity of children's homes and had greater vegetation density.

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Table 1

Demographic characteristics of children included in the analysis (N=135)

	***n*(%)**
Gender	
Male	67 (50)
Female	68 (50)
Age (years)	
8–10	49 (36)
11–14	86 (64)
Race	
Non-Hispanic white	34 (25)
Non-Hispanic black	3 (2)
Hispanic	65 (48)
Asian	8 (6)
Other (Haw/Pisl, Am. Ind, mixed, other)	25 (19)
Annual household income: ($1000s USD) median (range)	50 (5 – 160)

Table 2

Logistic regression predicting any and extended neighborhood park use by children

	Any neighborhood park use (0: ≤ 5 min park use, 1: > 5 mins. within park)			Extended neighborhood park use (0: ≤ 15 min park use,1: > 15 mins. within park)		
		Fully adjusted models			Fully adjusted models	
Predictor Variables	**Single predictor model[a] OR (95% CI)**	**Single predictor model[b] OR (95% CI)**	**Multi-predictor model[b] OR (95% CI)**	**Single predictor model[a] OR (95% CI)**	**Single predictor model[b] OR (95% CI)**	**Multi-predictor model[b] OR (95% CI)**
Park distance[c] (unit=100 meters)	**2.06 (1.27, 3.35)**	**2.40 (1.33, 4.31)**	**2.49 (1.35, 4.59)**	**2.96 (1.47, 5.95)**	**4.11 (1.66, 10.18)**	**4.06 (1.61, 10.24)**
Park greenness[d] (comparing 25th to 75th percentile)	1.60 (0.90, 2.83)	1.70 (0.92, 3.16)	**2.46 (1.03, 5.89)**	1.31 (0.70, 2.46)	1.63 (0.72, 3.68)	2.12 (0.61, 7.31)
Park area[e]	1.00 (0.99, 1.00)	1.00 (0.99, 1.00)	1.00 (0.99, 1.00)	1.00 (0.99, 1.00)	1.00 (0.99, 1.00)	0.99 (0.99, 1.00)
Number of parks[e]	1.12 (0.66, 1.90)	1.10 (0.59, 2.03)	0.92 (0.43, 1.96)	1.36 (0.76, 2.43)	1.41 (0.66, 3.01)	1.18 (0.42, 3.30)

Note: Analyses included all children with a neighborhood park space (*n*=73).

[a] Single predictor model with no adjustment for demographics

[b] The fully adjusted models controlled for child’s age, gender, race/ethnicity, and annual household income.

[c] The Euclidian distance between residence and the nearest park boundary

[d] The Normalized Difference Vegetation Index (NDVI) was used to estimate the average level of greenness for parks within the neighborhood buffer. NDVI was derived from LANDSAT satellite imagery data and is an indicator of level of vegetation.

[e] Total park area and number of parks that intersect the area within 500 meters of a child’s home