J Urban Health (2018) 95:881–887
https://doi.org/10.1007/s11524-018-0320-0

Contributions of Neighborhood Parks to Physical Activity in High-Poverty Urban Neighborhoods

Sujeong Park · Bing Han · Deborah A. Cohen · Kathryn P. Derose

Published online: 15 October 2018

Abstract Neighborhood parks are important venues for the urban population to do moderate-to-vigorous physical activity in leisure time. Parks can be particularly important for low-income neighborhoods, whose residents suffer from high rates of chronic diseases and may have less access to fee-based fitness exercise facilities. This study assessed the contribution of parks to local populations' physical activity in 48 high-poverty neighborhoods in the city of Los Angeles, using systematic observation of park use and surveys of park users and residents conducted between 2013 and 2015. We found that parks accounted for approximately 2.1% (between-park SD = 1.4%) of moderate physical activity time and 3.1% (between-park SD = 2.1%) of vigorous physical activity time of the local population, both of which were notably lower than the city-level average previously reported. Parks' contribution to physical activity was positively associated with park size ($\beta = 0.13$, $p < 0.0001$) and negatively associated with poverty ($\beta = -0.10$, $p < 0.0001$) and local population density ($\beta = -0.25$, $p = 0.005$). Parks in high-poverty neighborhoods in Los Angeles are underutilized, and more efforts are needed to fully realize their potential for population health.

S. Park (✉)
Pardee RAND Graduate School, 1776 Main street, Santa Monica, CA 90405, USA
e-mail: sujeongp@rand.org

B. Han · D. A. Cohen · K. P. Derose
RAND Corporation, Santa Monica, CA, USA

Keywords Parks · Physical activity · Urban neighborhood · Poverty

Introduction

Task Force on Community Preventive Service and the Centers for Disease Control and Prevention (CDC) suggested providing recreational facilities such as parks to encourage physical activity [1, 2]. Previous studies have demonstrated the vital role of neighborhood parks as venues for leisure-time moderate-to-vigorous physical activity(MVPA) [3–6]. Specifically, on average, a neighborhood park in the city of Los Angeles accounted for approximately 2.6% of all moderate physical activity and 15.9% of all vigorous physical activity occurred for residents living within a 1-mi radius of the park [5]. Parks could be an important resource for low-income populations, who suffer from high rates of chronic diseases [7–9] and have less access to fee-based health clubs or other private recreational resources [10, 11] than higher-income populations.

However, previous studies have shown that park use had a significantly negative association with local poverty rate, adjusting for park characteristics and local population density [12–14]. The high crime rates in high-poverty neighborhoods may be a significant barrier for some to use open public space [15, 16] in particular, during evening hours. Low-income populations may not have the preferences for leisure-time MVPA due to other social, economic, and cultural factors [17–19]. Therefore, the actual role of parks in high-poverty

neighborhoods for supporting leisure-time MVPA may be lower than ideal. To our knowledge, no prior study has focused on parks' contribution to local populations' MVPA in high-poverty urban neighborhoods. This study aims to fill this gap.

Method

Rationale for Quantifying Park's Contribution to Local Population's MVPA

We adapted the method from previous studies [4, 5] to quantify the role of parks in local population's MVPA, defined as the fraction of all MVPA of a local population that occurs in a neighborhood park. Figure 1 illustrates the rationale, where rectangle (A) represents park-based MVPA by all park users both locally and elsewhere, rectangle (B) represents the total MVPA accrued by the local population in parks and elsewhere, and the intersection area (C) represents the part of local population's MVPA occurred in their neighborhood park. The role of a neighborhood park for its local population's MVPA is the proportion of the local population's MVPA time that occurred in the park, namely, the ratio between the area of (C) and the area of (B). Area in (A) but not in (C) represents park-based MVPA accrued by non-local users, and area in (B) but not in (C) is the MVPA time of the local residents accrued not in their neighborhood park.

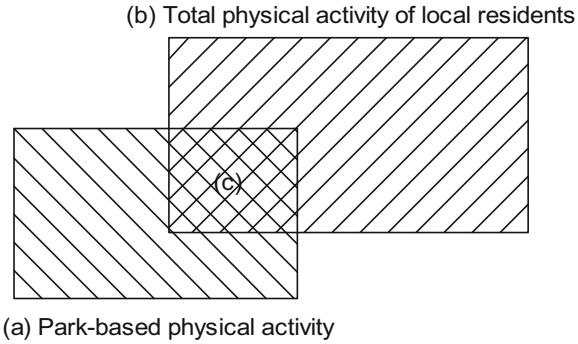

Fig. 1 Rational for quantifying park's contribution to the local population's MVPA: rectangle (A) illustrates park-based MVPA by all park users; rectangle (B) stands for total MVPA of the local population, and the intersection (C) represents park-based MVPA by the local population.

Data Sources and Measurements

Study Parks

We studied 48 parks in neighborhoods in the city of Los Angeles where the proportion of households in poverty was above the median of all census tracts within the city boundaries. These parks were selected as part of a clinical trial to promote physical activity in high-poverty neighborhoods [6]. Each park had a recreational center, on-site full-time staff, and multiple recreational facilities.

Direct Observations of Park-Based Physical Activity

We employed the System of Observing Play and Recreation in Communities (SOPARC) developed by McKenzie et al. [20] to observe park use and park-based physical activity. The data collected by SOPARC included the total number of people in different physical activity levels (sedentary, moderate, and vigorous), and subgroup counts by age and gender. We observed park-based physical activity three times on 1 day monthly for 6 months for wave 1 between 2013 and 2014. Half of observation days were weekend days, and the other half of them were weekdays. We repeated this process for wave 2 between 2014 and 2015.

Park User Survey

We selected park users for the survey based on quotas by gender and physical activity level. We targeted 50% males and one third of park users who were observed as being engaged in MVPA before the survey. Across the 48 study parks, we fielded 3175 responses from park users. On average, we had 66 responses per park.

Local Population Data and Population-Level Physical Activity

We considered a park's local neighborhood as 1-mi buffer centered at the park's geocoded location. The local population information was retrieved using the tract-level census data from the 2010 US Decennial Census. Population-level physical activity was based on the National Health and Nutrition Examination Survey (hereafter, NHANES) accelerometer-based estimates [21].

Statistical Analysis

In this paper, MVPA was measured as the total time accrued by all people for a 1-week period (in the unit of person-hours). We estimated the park-based MVPA (A), the total MVPA by local population (B), and the intersection (C) in Fig. 1 using different data sources.

Estimating Park-Based Physical Activity by Park Users (A)

The park-based MVPA estimation assumed no inclement weather conditions and was based on the direct observation data for park use. We first fitted a mixed-effect model to estimate the hourly MVPA levels. We defined $Y_{t,w,i}$ as the observed number of park users engaging in MVPA at hour t ($t = 8$ am to 10 pm) on day w (w = 1,…,7) in park i ($i = 1,\ldots 48$). We estimated the predicted number of park users at time t during weekdays and weekends separately since we assumed that the number of park users differed during weekdays and the weekend. The specific model is $\log(Y_{t,\ w,\ i}) = \beta_{0i} + \beta_1 * pop_i + \beta_2 * pov_i + \beta_3 * acres_i + \beta_{4t} * hour_t + \beta_{5w} weekend_w + \beta_{6tw} * hour_t * weekend_w + \varepsilon_{iwt}$ where the dependent variable is the log-transformed outcome. We used interaction effect to allow for different temporal trend between weekdays and weekend days. Fixed effects β_1 to β_5 represent the mean effect of park characteristics and observation time such as the population within 1 mi (pop_i), poverty level in neighborhood (pov_i), park size ($acres_i$), observation time including hours of day ($hour_t$) and days ($weekend_w$), and β_6 represents the interaction effect between observation time and observation day ($hour_t * weekend_w$). Random effects at the park level (β_{0i}) are also included. The log transformation was necessary to account for the skewed distribution in the raw outcome.

Next, we calculated the average of weekly park use time for MVPA in a study park by integrating hourly park use estimations. We assumed that a park was usable between 8 am and 10 pm, i.e., 14 h a day. The daily park-based MVPA is estimated by $\int_8^{22} E[Y(t)]\ dt$, where weekdays and weekend days have different estimates. The weekly park-based MVPA is equal to the sum of all daily estimates in a week. We estimated both park-based MVPA by all park users and by subgroups of park users (age group and gender). The mixed-effect model and numerical integration for each age and gender group were all coded in SAS 9.4.

Estimating Park-Based Physical Activity by the Local Population (C)

We first calculated the proportion of local park users among all park users using the park user survey, where we asked survey respondents to select the distance stratum of theirs (within 0.5 mi, within 1 mi, and more than 1 mi). We estimated the proportion of local park users for each park separately since each park could have different user characteristics. We assumed the same mean park-based MVPA time per person. The portion of park-based MVPA by the local population (C) was equal to the total park-based MVPA (A) multiplied by the proportion of local park users.

Estimating the Total Physical Activity of the Local Population (B)

We used two datasets in this estimation: the 2010 US census and the 2003–2004 NHANES accelerometry data. The NHANES data provided the national average MVPA per person, and the census data provided the size and composition of the local population. Previous studies [4, 5] did not consider the race/ethnicity factor. However, since our study neighborhoods had predominantly African American and Latinos residents and there were sizable differences in physical activity among radical-ethnic groups [21], we estimated the total MVPA of the local population by race/ethnicity subgroups.

We retrieved the average MVPA per person by gender-age-race/ethnicity strata and by the modified 10-min activity bouts from Troiano et al. [21]. Since the NHANES and census data had different definitions for age groups, we adjusted both using proportional estimation to match the observation data that used four categories for age—child (0–11), teenager (12–19), adult (20–64), and senior (65+). In each adjusted age-gender-race/ethnicity stratum, the average MVPA time multiplied by the population count yielded the estimate MVPA in that stratum. Lastly, we aggregated across all strata to find the total MVPA for the local population.

Estimating the Contribution of Parks to PA of the Local Population (Ratio Between C and B)

Taking the results from previous steps, we calculated the ratio of park-based MVPA by the local population (C) and the total MVPA by the local population (B) for each park separately. This ratio quantified the contribution of

a specific park to its local population's MVPA. We also examined the between-park standard deviations and explored the association between parks' contribution and park size, poverty, and local population density.

Results

Table 1 shows the characteristics of the 48 study parks and their neighborhoods. On average, a park in high-poverty neighborhood had 8.4 ac of land. A high-poverty park neighborhood had 51,713 local residents, where 69% were Hispanics and 27% of households were in poverty. On average, the local population within a 1-mi radius of a park had 52,596 person-hours of moderate physical activity (range 23,338–129,802 person-hours) and 5975 person-hours of vigorous physical activity (range 2687–14,525 person-hours). Most of the MVPA time were due to male residents. Also, on average, 84.0% of park users were the local residents of the park (range 54.8–100%).

Table 2 presents the estimated park use in high-poverty neighborhoods. The mean park use is approximately 4089 person-hours in 1 week. Males spent 2750 person-hours while females spent only around 1339 person-hours. Adults used parks the most (2279 person-hours). Children (1151 person-hours) and teenagers (583 person-hours) followed. Seniors utilized parks the

Table 1 Characteristics of the 48 study parks and their neighborhoods

	Mean	Range
Park and its neighborhood characteristics		
Percent of households in poverty?	27%	13–41%
Population within 1 mi of park	51,713	23,355–132,274
% Hispanic (of any race) within 1 mi of park	69%	12–97%
% Non-Hispanic Black within 1 mi of park	12%	0.3–71%
% Other races within 1 mi of park	19%	1.7–84%
% Gender: males within 1 mi of park	50%	45–61%
% Age ≤ 11 within 1 mi of park	18%	6–25%
% Age 12–19 within 1 mi of park	13%	4–17%
% Age 20–64 within 1 mi of park	61%	54–77%
% Age ≥ 65 within 1 mi of park	8%	4–15%
% Park users living within 1 mi from park	84.0%	54.8–100%
Size (in acres)	8.4	1.5–25.8
Neighborhood (within 1 mi) estimated moderate physical activity (person-hours)		
All	52,596	23,338–129,802
Males	33,501	15,048–84,186
Females	19,095	8291–45,617
Children	17,968	6738–40,011
Teenagers	7098	1989–14,124
Adults	25,511	11,773–69,992
Seniors	2019	712–5675
Neighborhood (within 1 mi) estimated vigorous physical activity (person-hours)		
All	5975	2687–14,525
Males	4180	1840–10,275
Females	1795	800–4250
Children	3048	1141–6802
Teenagers	974	291–1956
Adults	1926	770–5691
Seniors	27	10–76

Table 2 Estimates of weekly park use (person-hours) and between-park standard deviation (SD) by subgroups.

	Sedentary (SD)	Moderate (SD)	Vigorous (SD)	Total
Males	1748 (1293)	846 (523)	156 (107)	2750 (1867)
Females	987 (622)	312 (175)	40 (21)	1339 (800)
Children	628 (387)	439 (246)	85 (48)	1151 (671)
Teenagers	339 (265)	206 (141)	37 (38)	583 (437)
Adults	1705 (1303)	502 (351)	72 (62)	2279 (1645)
Seniors	63 (80)	11 (9)	2 (1)	76 (87)
All	2735 (1885)	1158 (686)	196 (123)	4089 (2633)

least (76 person-hours). Among the weekly park use time, 2735 person-hours were in sedentary activity, 1158 person-hours were in moderate activity, and 196 person-hours were in vigorous activity, respectively.

The proportion of park use time spent in MVPA indicates the aggregated physical activity level of park users. Overall, 33.1% of park use time was spent in MVPA. Females were notably less active than males: 26.3% of park use time by females were in MVPA and 36.4% by males. The level of physical activity dropped with age, reflected on the decreasing proportion of park use time spent in MVPA: children and teenagers were most active (45.5% and 41.8%, respectively), adults were less active (25.2%), and seniors were the least active age group (17.1%).

Table 3 shows the average contribution of a park to local residents' MVPA. Overall, a park's contribution was 2.1 (between-park SD = 1.4%) for moderate activity and 3.1% (between-park SD = 2.1%) for vigorous activity for the local population. For the entire local population and every gender and age group, a park's contribution was always higher for vigorous activity than for moderate activity. Parks' contribution was higher for males than for females. Compared with other age groups, parks' role for vigorous activity is the highest for seniors. In general, parks only accounted for a small part of the local population's MVPA time in high-poverty neighborhoods.

Figure 2 shows the associations between the estimated park contribution to local population's MVPA (%) and key park-level variables (park size, the proportion of the household who live below the poverty line, and the number of the population). Park acreage was positively associated with parks' contribution ($\beta = 0.13$, $R^2 = 0.32$). Poverty level was negatively associated to parks' contribution ($\beta = -0.10$, $R^2 = 0.29$). Population density had a negative relationship with parks' contribution ($\beta = -0.25$, $R^2 = 0.16$). All associations were statistically significant with p value < 0.01.

Discussion

This study found that parks in high-poverty neighborhoods played a small role for their local population's MVPA. Parks in high-poverty neighborhoods in Los Angeles were underutilized compared to parks in other neighborhoods of the same city. People in high-poverty neighborhood visited parks less and were also less active in parks. Compared to the previous study for the

Table 3 Estimated mean contribution of parks to local population physical activity (residents living within 1 mi of parks)

	Moderate activity Mean (between-park SD)	Vigorous activity Mean (between-park SD)
Males	2.4% (1.7%)	3.5% (2.4%)
Females	1.5% (1.1%)	2.2% (1.4%)
Children	2.4% (1.7%)	2.8% (2.0%)
Teenagers	2.7% (1.7%)	3.5% (3.3%)
Adults	1.8% (1.4%)	3.3% (2.5%)
Seniors	0.5% (0.5%)	7.0% (4.5%)
All	2.1% (1.4%)	3.1% (2.1%)

Children are 0–11 years old, teenagers are 12–19 years old, adults are 20–64 years old, and seniors are 65 years old or more

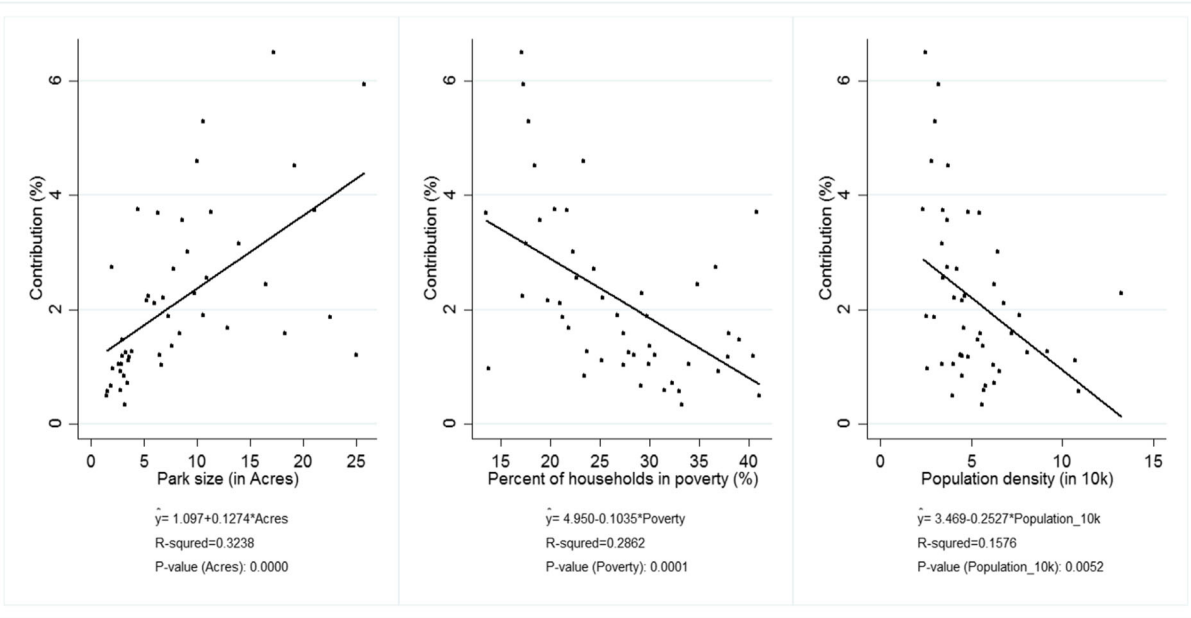

Fig. 2 Associations between parks' contribution and key park-level variables

entire Los Angeles City [5], the population within 1 mi of the park in high-poverty neighborhoods was 30% larger (51,713 and 40,000, respectively), while the average park size was 15% smaller (8.4 ac and 10 ac, respectively). On average, local residents in high-poverty neighborhood had less park land per capita. The proportions of park use time spent in MVPA (33.1%) and vigorous physical activity (4.8%) were also lower than the city-level averages (35% and 12%, respectively) [5]. The contribution of a park to local populations' MVPA in a high poverty neighborhood (2.1% for moderate and 3.1% for vigorous) was much lower than the city-level average (2.6% for moderate and 15.9% for vigorous activity, respectively) [5]. Empirically, our regression analysis found that parks' contribution to local residents' MVPA is negatively associated with poverty rate, positively associated with park acreage, and negatively associated with population density. These findings predict that parks in poor neighborhoods should have smaller contributions compared to parks in higher-income neighborhoods.

Several reasons might explain low utilization. The finding of lower park utilization in high-poverty neighborhoods is consistent with previous studies [14]. Crime and concern for safety may be a barrier for the local populations to use public space in high-poverty neighborhoods [15, 16, 22]. Moreover, a lack of programs and facilities for physical activity could attract fewer people to come to parks. For example, a national study [14] showed that the facilities such as walking loops increased the MVPA hours in parks. We checked top and bottom five parks by estimated contributions and found that three of the top five parks had walking path while none of the bottom five parks had it. There are many useful suggestions in the literature for promoting park-based physical activities, included but not limited to adding walking paths, programming, marketing, and intensive interventions [6, 14, 23]. In summary, parks in high-poverty neighborhoods have not realized their potentials, and more efforts are needed to promote park-based MVPA.

This study has several limitations. First, the 2003–2004 NHANES accelerometry data is known to have various measurement biases and is inconsistent with the more recent 2013–2014 NHANES accelerometry data (using wrist-wear accelerometer instead of the standard waist-wear accelerometer). We still adopted 2003–2004 data to be consistent with the previous studies. Although this may lead to biased estimates, the results for high-poverty neighborhood can be directly compared to the previous findings for the city-level average. Second, our assumption that all park users had the same mean park-based MVPA may not hold since the duration of park visits may well depend on physical activities in parks. Third, park user survey was a convenient sample instead of a representative sample. It is challenging to draw a

probability sample in open space and trace individual-level activities in parks. Lastly, park use is highly volatile, and we only had 24 observation hours for each park. The sample size in each park limited the precision in estimating park-level contributions.

Acknowledgements This paper was supported by NIH/NHLBI grant R01HL114283. The work however does not represent the opinion of the funding agencies. We are grateful to Dmitry Khodyakov, Michele Abbott, Simon Hollands, Lisa Jonsson, Rouslan Karimov, PhuongGiang Nguyen, and Sara Turner for useful comments.

References

1. Services TFCP. Recommendations to increase physical activity in communities. *Am J Prev Med*. 2002;22(4):67–72.
2. Khan LK, Sobush K, Keener D, et al. Recommended community strategies and measurements to prevent obesity in the United States. *Morb Mortal Wkly Rep Recomm Rep*. 2009;58(7):1–29.
3. Cohen DA, McKenzie TL, Sehgal A, Williamson S, Golinelli D, Lurie N. Contribution of public parks to physical activity. *Am J Public Health*. 2007;97(3):509–14.
4. Han B, Cohen D, McKenzie TL. Quantifying the contribution of neighborhood parks to physical activity. *Prev Med*. 2013;57(5):483–7.
5. Han B, Cohen DA, Derose KP, Marsh T, Williamson S, Raaen L. How much neighborhood parks contribute to local residents' physical activity in the City of Los Angeles: a meta-analysis. *Prev Med*. 2014;69:S106–S10.
6. Cohen D, Han B, Derose KP, et al. Promoting physical activity in high-poverty neighborhood parks: a cluster randomized controlled trial. *Soc Sci Med*. 2017;186:130–8.
7. Verhaak PF, Kerssens JJ, Dekker J, Sorbi MJ, Bensing JM. Prevalence of chronic benign pain disorder among adults: a review of the literature. *Pain*. 1998;77(3):231–9.
8. Drewnowski A, Specter S. Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr*. 2004;79(1):6–16.
9. Vart P, Gansevoort RT, Coresh J, Reijneveld SA, Bültmann U. Socioeconomic measures and CKD in the United States and The Netherlands. *Clin J Am Soc Nephrol*. 2013;8:1685–93.
10. McNeill LH, Kreuter MW, Subramanian S. Social environment and physical activity: a review of concepts and evidence. *Soc Sci Med*. 2006;63(4):1011–22.
11. Meyer OL, Castro-Schilo L, Aguilar-Gaxiola S. Determinants of mental health and self-rated health: a model of socioeconomic status, neighborhood safety, and physical activity. *Am J Public Health*. 2014;104(9):1734–41.
12. Cohen DA, Marsh T, Williamson S, Derose KP, Martinez H, Setodji C, et al. Parks and physical activity: why are some parks used more than others? *Prev Med*. 2010;50:S9–S12.
13. Cohen DA, Han B, Derose KP, Williamson S, Marsh T, Rudick J, et al. Neighborhood poverty, park use, and park-based physical activity in a Southern California city. *Soc Sci Med*. 2012;75(12):2317–25.
14. Cohen DA, Han B, Nagel CJ, Harnik P, McKenzie TL, Evenson KR, et al. The first national study of neighborhood parks: implications for physical activity. *Am J Prev Med*. 2016;51(4):419–26.
15. Echeverria SE, Kang AL, Isasi CR, Johnson-Dias J, Pacquiao D. A community survey on neighborhood violence, park use, and physical activity among urban youth. *J Phys Act Health*. 2014;11(1):186–94.
16. Han B, Cohen DA, Derose KP, Li J, Williamson S. Violent crime and park use in low-income urban neighborhoods. *Am J Prev Med*. 2018;54:352–8.
17. Ford ES, Merritt RK, Heath GW, Powell KE, Washburn RA, Kriska A, et al. Physical activity behaviors in lower and higher socioeconomic status populations. *Am J Epidemiol*. 1991;133(12):1246–56.
18. Jin-Hyung L, Scott D, Floyd MF. Structural inequalities in outdoor recreation participation: a multiple hierarchy stratification perspective. *J Leis Res*. 2001;33(4):427.
19. Marshall SJ, Jones DA, Ainsworth BE, Reis JP, Levy SS, Macera CA. Race/ethnicity, social class, and leisure-time physical inactivity. *Med Sci Sports Exerc*. 2007;39(1):44–51.
20. McKenzie TL, Cohen DA, Sehgal A, Williamson S, Golinelli D. System for Observing Play and Recreation in Communities (SOPARC): reliability and feasibility measures. *J Phys Act Health*. 2006;3(s1):S208–S22.
21. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008;40(1):181–8.
22. Foster S, Giles-Corti B. The built environment, neighborhood crime and constrained physical activity: an exploration of inconsistent findings. *Prev Med*. 2008;47(3):241–51.
23. Bedimo-Rung AL, Mowen AJ, Cohen DA. The significance of parks to physical activity and public health: a conceptual model. *Am J Prev Med*. 2005;28(2):159–68.