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How much neighborhood parks contribute to local residents' physical activity in the City of Los Angeles: A meta-analysis

Bing Han *, Deborah A. Cohen, Kathryn Pitkin Derose, Terry Marsh, Stephanie Williamson, Laura Raaen

RAND Corporation, United States

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ABSTRACT

Objective. To quantify the contribution of neighborhood parks to population-level, moderate-to-vigorous physical activity (MVPA).

Method. We studied park use in 83 neighborhood parks in Los Angeles between 2003 and 2014 using systematic observation and surveys of park users and local residents. We observed park use at least 3–4 times per day over 4–7 clement days. We conducted a meta-analysis to estimate total, age group and gender-specific park use and total MVPA time in parks.

Results. An average park measuring 10 acres and with 40,000 local residents in a one-mile radius accrued 5301 h of use (SE = 1083) during one week, with 35% (1850 h) spent in MVPA and 12% (635 h) spent in vigorous physical activity (VPA). As much as a 10.7-fold difference in weekly MVPA hours was estimated across study parks. Parks' main contribution to population-level MVPA is for males, teenagers, and residents living within a half mile.

Conclusion. Neighborhood parks contribute substantially to population MVPA. The contribution may depend less on size and facilities than on "demand goods" – programming and activities–that draw users to a park.

Introduction

Modern urban park was established as a place where people could connect with nature, socialize with others in a shared community space, and engage in active sports and passive recreation (Olmsted, 1870). While parks today are largely open access and free to the general public, parks have increasingly been adopting cost-recovery strategies as the economic base of cities have declined (NRPA, 2010). In particular, parks in large cities usually charge fees for participation in exercise classes, sports leagues and other organized activities. This could represent a barrier to those urban residents with limited incomes. An even more significant barrier to park use may be the diminished urban crowding. As society has become more affluent and technology has advanced, most Americans have access to electronic entertainment in comfortable and climate-controlled dwellings, partly obviating the pull to spend leisure time outdoors (BLS, 2013; Gortmaker et al., 1996).

Yet because physically active individuals have lower health care costs, fewer chronic diseases, and greater longevity (Colditz, 1999; Wang et al., 2005; Warburton et al., 2006), the promotion of physical activity is an important societal imperative. Given the predominance of sedentary work and the use of motor vehicles for transportation, leisure time is when most people have the opportunity to engage in moderate-to-vigorous physical activity (MVPA). Increasing the use of neighborhood parks for leisure time MVPA could yield societal dividends that go beyond individual pleasure and well-being.

Parks often have multiple facilities and a substantial amount of land available to support MVPA. Parks' size is associated with park use (Cohen et al., 2010), and often varies within cities, with smaller parks in the dense urban cores and larger ones in the periphery, based on land cost and availability at the time the areas were developed (Dahmann et al., 2010). Prior studies have also indicated that the use of parks is highly dependent on programming within the park, e.g., group exercises, classes, and organized sports events (Cohen et al., 2012a, 2013). Moreover, the use of parks may be reduced where the community considers the spaces unsafe, poorly maintained, or poorly equipped (Babey et al., 2005, 2007).

Given the socio-demographic diversity of park users in most large urban cities, it is an enormous challenge to provide park facilities and services to meet the needs of a growing population base (Gobster, 2002). This study examines the contribution of the neighborhood park system to MVPA in the City of Los Angeles and explores how park systems could support population level MVPA. To our knowledge, the degree to which the neighborhood park system of a major city contributes to leisure time MVPA has not been previously quantified.

The City of Los Angeles Department of Recreation and Parks manages 487 sites totaling approximately 16,000 acres of lands (LARAP, 2013). These parks can be divided into three categories: 1) pocket parks (usually smaller than 1.9 acres, 201 sites totaling 121 acres); 2) neighborhood parks (including recreation centers) primarily serving

* Corresponding author at: RAND Corporation, 1776 Main St., Santa Monica, CA 90407.
E-mail address: bhan@rand.org (B. Han).

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the local population (most between 2 and 25 acres, 222 sites totaling 2162 acres); and 3) regional attractions with large lot sizes (64 sites, 13,721 acres). Eight sites that are over 25 acres are also classified as neighborhood parks, because their functionalities are similar to neighborhood parks rather than regional attractions. Because neighborhood parks are of substantial size and mainly used by the local population, this study is focused on their contribution to their local populations' MVPA.

Methods

Data source and measurements

We pooled data collected from five primary studies conducted by us (Cohen et al., 2007, 2010, 2012a,b, 2013) between 2003 and 2014 (one study is still ongoing). The five previous studies included 37% (n = 83) of the neighborhood park and recreation center system in the City of Los Angeles, covering a wide variety of neighborhoods with mild oversampling in low-income areas. Fig. 1 visualizes the variations in locations, acreages, and neighborhood poverty level of the 83 study parks.

In all five previous studies, we measured park use by the System of Observing Play and Recreation in Communities (SOPARC) (McKenzie et al., 2006). Based on systematic momentary time sampling, SOPARC provides multiple snapshots of MVPA occurring within parks. Selection of parks has been changing among the previous studies due to different goals and sampling designs. Among the 83 study parks, 18 were observed in one year, 37 were observed in two years, 11 were observed in three years, 13 were observed in 4 years, and 4 were observed in five or more years. In each year of observation, a park was measured three to four times a day (with 3–4 h between any two adjacent visits), three to four days in the same week (including both weekdays and weekends), and over two to three weeks (in the same season). Except for the 18 parks measured only in one year, the other parks all have four or more weeks of measurement. All observations were conducted under clement weather conditions. When it rained on the scheduled the observations were postponed to the next week on the same day of week and at the same hours.

We also conducted surveys among users of study parks and neighborhood residents whose households were randomly chosen within three spatial strata defined by the distance to park (0.25, 0.25–0.5, and 0.5 to 1 mile). See (Cohen et al., 2013) for an example of the survey protocol, and the other four studies used the same or very similar survey protocol.

Each study park was divided into target areas to facilitate systematic observation, yielding 2925 target areas across the 83 parks. In all previous studies we conducted roughly 10,900 whole park observations. During these observations, we documented approximately 325,000 users, among whom 110,000 users were engaged in MVPA. The pooled survey data has approximately 11,000 respondents intercepted in parks and another 10,000 local residents surveyed in their homes.

Statistical analysis

We conducted two sets of analyses to estimate the cumulative time of park use and the contribution of parks to local populations' MVPA, respectively. Our methods were based on the statistical approach in Han et al. (2013).

We estimated the average cumulative time of park use during a week, denoted by T. We chose to estimate the weekly use instead of daily use because of the cyclic pattern of park use during a week. Let $Y(t)$ be the number of users in a park at time t. Then $T = \int_1^{14} \mathrm{E}[Y(t)]\ dt$. This expression suggests a two-step estimation procedure: first estimating the mean park use at time t, $\mathrm{E}[Y(t)]$, and then integrating the estimated $\mathrm{E}[Y(\mathrm{t})]$ over time within a week. We used a mixed-effect longitudinal model to estimate the mean park over time. The specific model is $y_{i,d,t(i,d)} = \alpha_t + \beta_d + \gamma_{d,t} + a_{i,d(t)} + \varepsilon_{i,d,t}$, where the response variable is the number of park users from SOPARC whole park scans in park i ($i = 1 \ldots 83$) on weekday d ($d = 1 \ldots 7$) and at hour t, and $t = \mathrm{t}(i, d)$ denotes the varying observation schedules among parks and between days.

To allow for completely flexible trajectory shapes, the mean trajectories were modeled by a group of indicators for hours of a day, days of a week, and their interactions. Fixed effects α_t, β_d, $\gamma_{d,t}$ represented the overall mean effects of hours of a day, days of a week, and interaction effects, where the interaction effect $\gamma_{d,t}$ is important because weekdays and weekends have different hourly trajectories. The random effects $\alpha_{i,d(t)}$ represented the deviations of each park from the overall mean trajectory, where $\alpha_{i,d(t)}$ consists of a group of

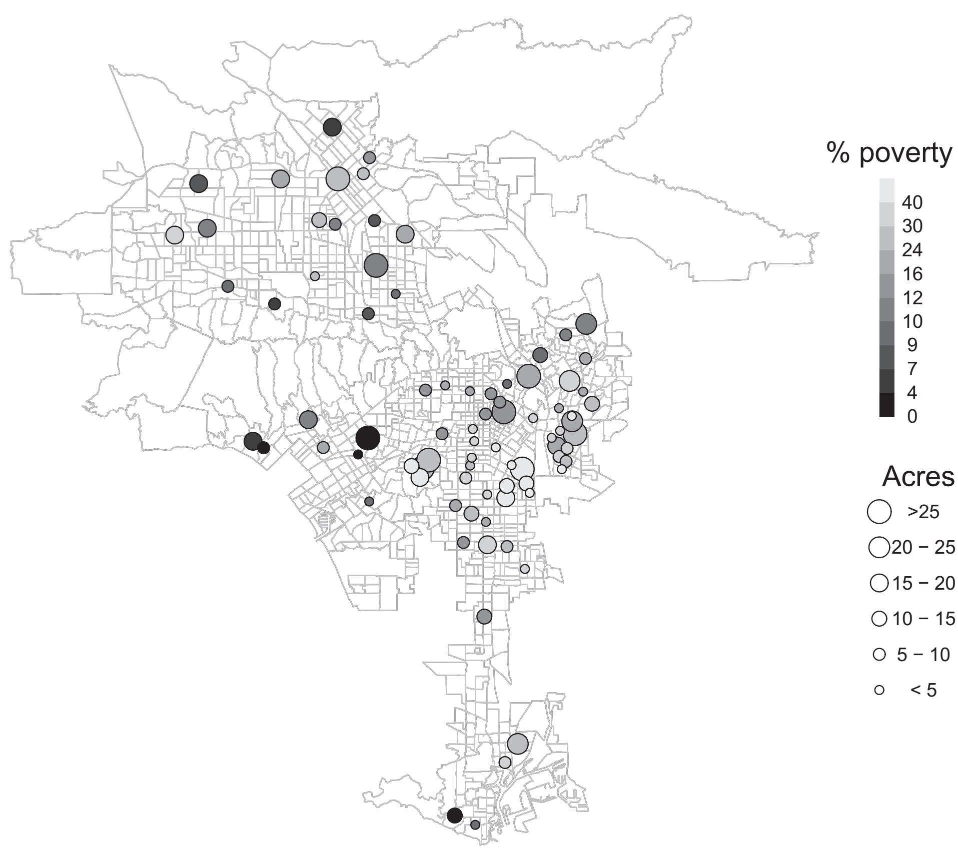

Fig. 1. Map of the 83 study parks: overlays are the census tracts overlapping with the City of Los Angeles.

independent normal random variables with mean zero and unknown and unequal variances. The last term $\varepsilon_{i,d,t}$ is the random measurement error. This flexible mixed-effect model addressed the large variation both within and between parks. Park-specific trajectories were estimated using the empirical linear unbiased predictor (EBLUP). The total park use over a week T is the integral of the hourly trajectories, which is readily given by a regular numerical integration method called the linear quadrature. The mixed-effect model was fitted by SAS PROC MIXED. Numerical integration and standard errors were coded by us in R 2.13.1. We applied this approach to estimate the weekly total park use time as well as time spent in MVPA, both for all users and by age group and gender.

To quantify the contribution of parks to local population's MVPA, we applied the same approach as in (Han et al., 2013). Given T = Time of MVPA in a park, S = Time of MVPA accumulated by the park's local population, and ρ = % of park users from the local neighborhood. The first term T was already estimated. The second term S was estimated by a stratified analysis by gender and age groups and based on the existing results of National Health and Nutrition Examination Survey (NHANES) accelerometry data analysis (Troiano et al., 2008). The last term ρ was estimated by the park user surveys. A parks' contribution is assessed by a ratio $\omega = \frac{T \times \rho}{S}$, which is a proxy of the percentage of a local population's MVPA occurring in parks.

Results

Table 1 lists the sample mean and standard deviation of the neighborhood characteristics for the study parks. The neighborhood characteristics are slightly different from the average of the LA city because of the oversampling of parks in low-income areas. We found that an average park measuring 10 acres and with 40,000 residents in a 1-mile radius was used for 5301 h during a single week, where roughly 35% or 1850 h were spent in MVPA and 12% or 635 h were spent in vigorous PA. It was also estimated that such an average park has on average 54 users (19 users engaging in MVPA) at any time between 7 am and 9 pm under clement weather conditions.

Table 2 lists the detailed estimates of total weekly park use time by subgroups of users and PA levels at the group level. Female park users seem to be relatively more active (39.7% of their time in parks was spent in MVPA) than male users (31.7% of their time in parks was spent in MVPA). However, on an absolute basis, because males spent more time in parks, they accrued roughly twice as many MVPA hours as females (1266 h versus 584 h weekly). Estimates among age groups are heterogeneous. Children were the most active subgroup in parks where roughly half of their time in parks (51.2%) was spent in MVPA. Teenagers and adults spent about 33.9% and 27.2% of their time in parks in MVPA, respectively. Seniors spent only 7% of time in parks in MVPA. On an absolute basis, a majority of total sedentary hours of in parks (62%) were accumulated by adults. Adults and children accumulated similar total MVPA hours in parks even though children under age 18 represent about 25% of the population in Los Angeles. Teenagers spent fewer MVPA hours than adults and children in parks, but had roughly the same sedentary hours as children in parks. Seniors spent very few hours in parks.

Table 2
Estimated average park use time (person × hours) and between-park standard deviation (SD) by PA levels and user subgroups (under clement weather conditions).

	Sedentary (SD)	Moderate (SD)	Vigorous (SD)
Total	3451 (1573)	1215 (535)	635 (396)
Males	2157 (1057)	815 (381)	451 (272)
Females	1293 (561)	400 (172)	184 (130)
Children	633 (230)	425 (128)	241 (68)
Teenagers	543 (209)	257 (92)	118 (30)
Adults	2134 (972)	524 (149)	274 (57)
Seniors	141 (76)	9 (16)	2 (1)

There are remarkable variations in park use both between parks and within a park. We note that within the same park, peak hours (4–8 pm during weekdays; late AM and early PM on weekends) can see 1.5 to 4 times more users than average, but the non-busy hours can attract only 5 to 10% of the average use. Between-park variations are even larger. In particular, many small parks in low-income areas were nearly empty for most times of a day. Popular parks during peak hours were heavily used. A large number of supervised and organized activities as well as many park users were observed during these periods. Fig. 2 illustrates a difference as large as 10.7-fold in the estimated weekly MVPA hours among study parks of similar sizes and with similar facilities. There is a weak but statistically significant correlation between park size and weekly MVPA estimates (R^2 = 0.25, $p < .0001$). The correlation reflects several outliers: a few of the largest parks had disproportionately fewer total MVPA hours. (See the right side of Fig. 2.)

The estimated average weekly MVPA hours in a single park in Table 1 are roughly equivalent to 111 children, 63 teenagers, 319 adults, and 4 seniors or a total of 497 individuals: meeting the national physical activity guidelines (i.e. 60 minutes/day for children and adolescents, and 2.5 h for adults and seniors per week).

Based on the park surveys in which respondents reported the location of their homes, we estimated a neighborhood park's contribution to its local population, where the local population was defined as residents living within either ½-mile or 1-mile radiuses of parks' registered addresses. Approximately 63.9% of park users lived within a ½-mile radius of parks, and 84.1% lived within a 1-mile radius of parks. Table 3

Table 1
Park and neighborhood characteristics of the study parks (n = 83).

Characteristics	Mean	Standard deviation
Park size (acres)[a]	10	7
# Target areas in a park [b]	35	17
Population (1000)[c]	40	20
# Households (1000) [c]	10	6
% households in poverty [c]	22	10
% race: white[c]	46	10
% race: black[c]	10	14
% race: Asian[c]	11	8
% Hispanic (of any race) [c]	58	27
% gender: male [c]	50	2
% Age: ≤12 [c]	18	4
% Age: 12 – 19 [c]	10	3
% Age: 20 – 64 [c]	62	5
% Age: ≥65[c]	10	4

[a] According to the City of Los Angeles Department of Recreation & Parks
[b] To use SOPARC, we split each park to target area. Each target area usually has a unique functionality (e.g., playground, tennis court) and is sufficiently small for quick visual scans.
[c] According to the 2010 U.S. Decennial Census Summary File 2.

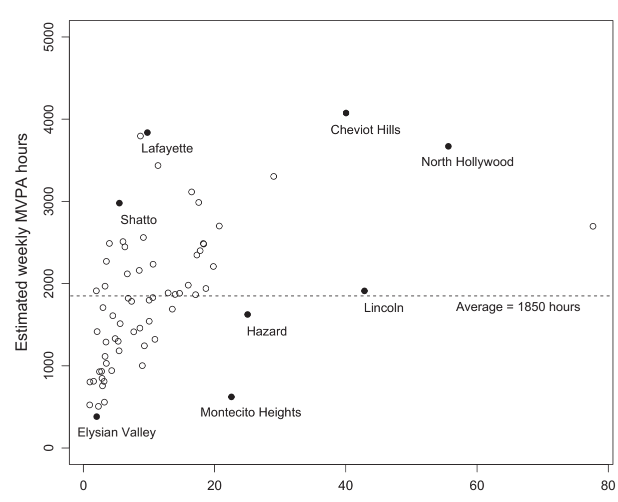

Fig. 2. Plot of estimated weekly MVPA time (person × hours) in parks versus acreage (R^2 = .25 and $p < .0001$) where a few remarkable parks were labeled with park names.

Table 3
Estimated parks' average contribution and between-park standard deviation to local residents' MVPA, i.e., $\omega = \frac{T \times \rho}{S}$.

Subpopulation	% of all moderate PA occurring in park		% of all vigorous PA occurring in park	
	½-mile neighborhood	1-mile neighborhood	½-mile neighborhood	1-mile neighborhood
Male	7.9 (5.9)	3.0 (2.1)	39.8 (5.9)	18.0 (16.6)
Female	5.6 (3.8)	2.1 (1.4)	29.7 (25.5)	12.5 (13.9)
Child	6.2 (4.7)	2.2 (1.3)	19.1 (13.5)	6.9 (3.9)
Teenage	17.6 (13.5)	6.2 (3.7)	42.2 (28.0)	16.0 (9.9)
Adult	8.0 (5.7)	2.8 (1.4)	22.2 (16.2)	7.8 (4.4)
Senior	1.1 (1.6)	0.4 (0.6)	9.2 (4.7)	3.7 (2.0)
All	7.0 (4.8)	2.6 (1.8)	36.3 (26.6)	15.9 (15.6)

The two values in each cell are the mean of ω among all study parks (between-park standard deviation).

shows that, on average, a single park provides a small proportion of moderate PA (7.0% vs 2.6% for residents in ½- and 1-mile radiuses, respectively), but a relatively large proportion of vigorous PA (36.3% vs 15.9% for ½- and 1-mile radiuses, respectively). Parks' contribution to MVPA is the highest for teenagers, the lowest for seniors, and roughly the same for adults and children.

We applied the weekly average park use estimates to the system of 222 neighborhood parks, less than half or all parks serving nearly four million residents in LA. At scale, we estimated an average of 1.1 million hours of neighborhood park use during a week under clement weather conditions (SE ≈ 242,000), among which 378,000 h are spent in MVPA. During a week the neighborhood park system receives approximately 660,000 visits (SE ≈ 133,000) and 404,000 visitors (SE ≈ 86,000).

Discussion

It is a challenging task to assess the contribution of the park system to local populations' MVPA in a large metropolitan area. Given the large variation in MVPA outcomes both within and between parks, as well as the great geographic diversity and distances in a major city, it requires extensive data collection efforts in many parks throughout the city and over a long period of time. Observations of park use in the health literature are usually sparse in space and time, and not sufficient for estimating the park system's contribution on an absolute scale. While it is very difficult for a single primary study to accomplish this formidable objective, this meta-analysis is based on our long-term effort in studying park-based MVPA in Los Angeles during the past 12 years, and is among the first of its kind to reveal the role of the neighborhood park system in supporting the local population's MVPA in a major city.

Overall, this study suggests that neighborhood parks in LA play a significant role in serving local residents and supporting MVPA, in particular, vigorous PA. The finding of great heterogeneity in park use within and across parks serving similar populations implies that parks could potentially attract more users and could serve as a venue for even larger amounts of MVPA among local residents. Roughly 60% of the between-park variance in park use can be explained by population size, programming, availability and accessibility of facilities, and parks' marketing efforts (Cohen et al., 2013).

Interestingly, more than half the time children spend in a park is MVPA time. This 50% benchmark is a stated goal of school-based physical education (McKenzie and Lounsbery, 2013), and also provides parents a guideline for the minimal amount of time their children should spend in a park to meet physical activity guidelines. That higher levels of vigorous activity appear to accrue to those who live within a one-half mile radius of the park supports the common call for more neighborhood parks (Boone-Heinonen et al., 2010).

"We also found that a higher proportion of female park user's time in the park was spent in MVPA, but since male park users spent more time in parks, males' hours of MVPA were twice as high. Previous research has found that women in lower socioeconomic conditions (both individual and neighborhood) may benefit in particular from having a neighborhood park/gym (Lee et al., 2007), and that women in general may be more sensitive to environmental conditions (Stafford et al., 2005). Thus, getting women to the parks more frequently for longer periods of time could be an important step toward increasing PA."

The finding of a more than 10-fold difference in park use across parks of similar sizes and with similar facilities supports previous studies that have demonstrated the importance of programming and outreach to attract users. Furthermore, some the of the smallest parks accrued similar hours of MVPA as did parks 4–5 times their size, indicating that space may not be an absolute limiting factor in serving local populations, especially where programs are well-organized and scheduled.

Jacobs called services like programming and events sponsored in city parks as "demand goods" (Jacobs, 1961). Demand goods may effectively compete with the ubiquitous electronic entertainment options that capture the attention of most Americans in their leisure time [2.8 h/day for television alone (BLS, 2013)]. The variation in park use by neighborhood may be one factor that underlies the finding that location of residence matters in individual health (Gordon-Larsen et al., 2006). Park-based physical activity is likely one mechanism through which public goods and investments may translate into different health outcomes.

Limitations

In this meta-analysis we were not able to study secular trends, since we did not follow the same park for the entire duration. The long-term secular trend or inter-year variance is largely confounded with the selection of parks over time and, thus, difficult to estimate. Nevertheless, The past few years have seen a decline in total park use and MVPA outcomes, concurrent with budget cuts affecting the recreation and parks department (Cohen et al., 2013). For example, accessibility of park facilities was reduced in 2010 (e.g., most indoor facilities were closed on Sunday). However, the secular trend constituted a very small change compared to the large heterogeneity due to other factors: the inter-year variance was only between 0 and 2% of the intra-day variance and 0 to 15% of inter-day variance (Cohen et al., 2013). All same-park variance components were one order of magnitude smaller than between-park variances.

The ratio ω is a measure of parks' contribution which accounts for the local population's size and age-gender structure, but may be an inaccurate estimate for the absolute contribution of parks. First, the percentage of MVPA time in parks accrued by local users, namely, ρ, was estimated from self-reports of sampled park users. Because most of the survey respondents were sedentary when interviewed, we may have over or underestimated the proportion in MVPA time in parks by local users. The NHANES data was drawn from national survey sample and may not accurately reflect the local neighborhoods. However, these errors should be similar among parks, and thus the ratio ω is still a good measure for local comparisons.

Conclusion

Although this study focuses on the Los Angeles City and may not be generalizable, it does provide a model of park use and describes a heterogeneous picture of park use that depends less on size and facilities than other local factors, which this study alone cannot enumerate. The study suggests that in practice, parks have the capacity to serve a local population very well, but that, in fact, most parks are not realizing their potential to foster MVPA among the majority of local residents. While the study supports the call for more parks to be located within a half mile of all residences (Potwarka et al., 2008), it also shows that having a park within a half-mile is, by itself, not sufficient for drawing people to the park. Other factors related to "demand goods" may be more important than size and location.

Other local services considered critical to health, like education and medical care, receive state and federal funding sources. Given the reliance of park systems on local taxes for financial support combined with the potential of parks to address health issues and costs that have ripple effects beyond the scope of local taxpayers, it may be prudent to consider the development of a more stable and reliable system of funding parks and the demand goods that contribute to MVPA, and thus to the health and well-being.

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