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ParkIndex: Development of a standardized metric of park access for research and planning

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Abstract

A lack of comprehensive and standardized metrics for measuring park exposure limits park-related research and health promotion efforts. This study aimed to develop and demonstrate an empirically-derived and spatially-represented index of park access (ParkIndex) that would allow researchers, planners, and citizens to evaluate the potential for park use for a given area. Data used for developing ParkIndex were collected in 2010 in Kansas City, Missouri (KCMO). Adult study participants (n=891) reported whether they used a park within the past month, and all parks in KCMO were mapped and audited using ArcGIS 9.3 and the Community Park Audit Tool. Four park summary variables – distance to nearest park, and the number of parks, amount of park space, and average park quality index within 1 mile were analyzed in relation to park use using logistic regression. Coefficients for significant park summary variables were used to create a raster surface (ParkIndex) representing the probability of park use for all 100m x 100m cells in KCMO. Two park summary variables were positively associated with park use – the number of parks and the average park quality index within 1 mile. The ParkIndex probability of park use across all cells in KCMO ranged from 17 to 77 out of 100. ParkIndex represents a standardized metric of park access that combines elements of both park availability and quality, was developed empirically, and can be represented spatially. This tool has both practical and conceptual significance for researchers and professionals in diverse disciplines.

Keywords: parks, built environment, planning, measurement

Introduction

Access to and use of parks are associated with diverse environmental, economic, social, psychological, and physical health benefits.¹⁻⁴ Consequently, significant resources have been expended to study a variety of factors related to park access⁵⁻¹³ (e.g., proximity, features, quality, surrounding neighborhood) and to plan for their provision throughout communities.¹⁴⁻¹⁷ However, despite such enthusiasm among researchers and planners in several fields (e.g., urban planning, parks and recreation, public health), it remains unclear which park metrics are most associated with park use and how best to combine diverse indicators into a parsimonious measure of park access and exposure.¹⁸⁻²³ This is in contrast to other areas of built environment research where, for example, standardized metrics such as Walk Score²⁴⁻³¹ and Frank et al.'s walkability index³²⁻³⁹ have become widely adopted. Development of a common and relatively simple measure for parks would facilitate efforts related to research, surveillance, planning, and advocacy, including the identification and remediation of 'park deserts' in communities in order to promote health-related environmental justice.⁴⁰⁻⁴⁵ Therefore, the purpose of this study was to develop and demonstrate a prototype index of park access (ParkIndex) that could be empirically-derived and spatially-represented and would allow researchers, planners, and citizens to evaluate the potential for park use for a given area (e.g., residential address, census tract).

Methods

Study Design and Data Collection

The ParkIndex prototype was developed using secondary data from the Kansas City Parks and Physical Activity Project, which was approved by the IRB at Kansas State University and has been described extensively elsewhere.^{8,13,23} At the time of the study, Kansas City, Missouri (KCMO) had a population of 475,830 residents from diverse backgrounds⁴⁶ and 219 parks that ranged in size from 0.16 to 1805 acres.⁴⁷ In 2010, a mail survey was conducted with a cluster random sample of residential addresses geographically-dispersed across KCMO. 893 completed surveys were returned (response rate=27.4%) and all but two households were successfully geocoded using ArcGIS 9.3.

Measures

Park use was captured by asking one adult over the age of 18 years in each household to report whether he or she had visited a park within the past 30 days (yes/no)⁴⁸. This measure has demonstrated good test-retest reliability,⁴⁸ but did not ask about specific park destinations. A GIS parks shapefile was obtained from partners at the City of KCMO and all public parks were audited using the Community Park Audit Tool (CPAT)⁴⁹ to determine usability for recreation and to collect detailed information about the park environments. The CPAT demonstrated excellent interrater reliability in this setting, with percent agreement for the vast majority of its items ranging from 80% to over 90%⁴⁹.

Using these comprehensive park data and based on numerous past studies,^{10,23,50–55} four main summary variables related to park access were included in the initial ParkIndex model. Three of these focused on park proximity or availability – the street network distance to the nearest park from the participant's home address, the number of parks within a 1 mile street network, and the amount of park space within a 1 mile street network. In general, regular use of a park decreases with increased distance to the park, and similar to several other studies^{7,23,56,57}, we have used a 1-mile buffer as cut-off for the maximum distance people are likely to travel to a park they use regularly.

The fourth summary variable was an average park quality index for all parks within a 1 mile street network of the participant's home address. This score for each park was comprised of six key composite variables created using the CPAT-based park environment data.⁴⁹ Further information about the CPAT instrument, guidebook, and protocol can be found at <http://activelivingresearch.org/community-park-audit-tool-cpat>. The six composite variables included in the park quality index included: i) sum of six park access amenities (i.e., adjacent sidewalk, public transit stop, parking, external trail or path, bike route/lane, traffic signal), ii) sum of 14 park facilities (i.e., playground, sports field, baseball field, swimming pool, splash pad, basketball court, tennis court, volleyball court, trail, fitness equipment/stations, skate park, off-leash dog park, open/green space, lake), iii) sum of three key park amenities (i.e., restroom, drinking fountain, lighting), iv) sum of seven park aesthetic features (i.e., landscaping, artistic feature, historical/educational feature, wooded area, trees throughout, water feature, meadow), v)

sum of eight park quality concerns (i.e., graffiti, vandalism, excessive litter, excessive animal waste, excessive noise, poor maintenance, evidence of threatening persons or behavior, dangerous spot), and vi) sum of ten neighborhood quality concerns (i.e., poor lighting, graffiti, vandalism, excessive litter, heavy traffic, excessive noise, vacant or unfavorable buildings, poorly maintained properties, lack of eyes on the street, evidence of threatening persons or behavior). For each of these six variables, a standardized sub-score (0-100) was created (with the latter two variables reverse-coded) and then all six variables were averaged to obtain the park quality index for each park (0-100). An average park quality index (0-100) was then calculated for each participant based on the parks within 1 mile.

Analyses

The data were analyzed in 2015 using IBM SPSS statistics version 22. Descriptive statistics explored characteristics of the sample and key variables. Logistic regression was used to identify which of the four park summary variables were significantly associated with park use and model fit was examined using post-hoc Hosmer-Lemeshow tests. All models were adjusted for age, gender and combined race and ethnicity. To demonstrate the concept of an empirically-derived and spatially-represented ParkIndex, the coefficients calculated in the final model were used to estimate the probability of park use for the centroid of each cell on a raster surface of 100m x 100m cells (n=82,302) in KCMO given the availability and attributes of nearby parks.

Results

Participant characteristics are presented in Table 1. Approximately 43.7% of participants reported using a park within the past month. Table 2 shows the results of the logistic regression analyses. Of the four park summary variables, two were significantly associated with park use – number of parks within 1 mile (OR=1.14, 95% CI=1.06-1.23) and the average park quality index for parks within 1 mile (OR=1.02, 95% CI=1.00-1.04). The final model including these factors exhibited acceptable Hosmer-Lemeshow model fit ($X^2=3.38$ p=0.91). In the full model, the other two park summary variables were not significantly associated with park use: distance to the nearest park (OR=0.79, 95% CI=0.40-1.57) and the amount of park space within 1 mile (OR=1.00, 95% CI=0.99-1.00).

Figure 1a displays the ParkIndex raster surface obtained when extrapolating model coefficients for the number of parks and average park quality index within 1 mile to all 100m x 100m cells in KCMO. White or blank areas represent cells with no park access within 1 mile and a ParkIndex value of 0 (n=30,854). For the rest of the map, the probability of park use ranged from 0.17 to 0.77, or a ParkIndex value of 17 to 77 out of 100 (mean=41.6, s.d.=9.3). Figure 1b illustrates ParkIndex values within a specific census tract in KCMO and for several individual points (cells) therein.

Discussion

The goal of this study was to develop and demonstrate the potential of ParkIndex, a standardized measure of park access and exposure that is based on empirical data and can be represented spatially. Using data from KCMO, two park summary variables were significantly related to park use – the number of parks and the average park quality index within 1 mile of participants' homes – which is consistent with past research showing the importance of similar park constructs.^{8,19,21,53,58} Even with this relatively simple model for predicting park visitation, substantial spatial variation was observed in the values for ParkIndex across the study location (17 to 77 out of 100). ParkIndex can be calculated for a residential buffer (like Walk Score⁵⁹) or for another meaningful area such as a census tract, municipal planning district, council ward, or entire city. This information has both practical and conceptual significance in that it can be used by researchers in diverse disciplines (e.g., to apply consistent, empirically-derived metrics of park access across studies) and by public health, parks and recreation, and urban design professionals as a scenario planning tool for encouraging greater population-level park access and use (e.g., to estimate the effects of adding a certain-sized park to a neighborhood or a sports field or restroom to an existing park). ParkIndex can also facilitate the examination of park access within an area over time or to compare two neighborhoods or cities of similar geographic or population parameters. Additionally, as Park Prescriptions⁶⁰ and Exercise is Medicine⁶¹ programs continue to grow, ParkIndex will prove to be a useful tool in connecting the healthcare system with publicly available resources for physical activity. One current limitation, especially with Park Prescriptions programs, is the exchange of knowledge between a physician desiring to prescribe visits to parks and knowing the accessibility and amenities available to specific patients. Among its many other uses, ParkIndex will provide a tool for overcoming this gap.

Limitations

This initial ParkIndex prototype has limitations. For example, it was based on data from one community and should be cross-validated and further refined in other locations with varying park and population characteristics. Also, although we incorporated comprehensive park availability and audit data, other park metrics, distance thresholds (e.g., ½ mile), and weighted methods (e.g., Kernel Density Estimation) should be tested. Moreover, the low response rate and use of a self-report measure of park use⁴⁸ may introduce some bias (e.g., about level of park use or which park elements of park access influence use); therefore, future studies should consider including objective measures of park visitation (e.g., GPS). Finally, ParkIndex should be corroborated in relation to not only park use, but also other health outcomes such as physical activity, obesity, and chronic disease rates, all of which have been associated with park access in past research.^{20,53,62–65}

Conclusion

Future steps for further developing and validating ParkIndex include obtaining input from an advisory board of parks, planning, and public health stakeholders, and refinement of the ParkIndex algorithm using data from multiple communities. These and other advancements will further the utility of ParkIndex to parks, environmental justice, and public health planning efforts at the local and national levels.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest.

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Table 1
Participant Characteristics^a

Participant Characteristic	%
Gender (n=885)	
Female	60.8%
Male	39.2%
Race/Ethnicity (n=880)	
White, non-Hispanic	66.9%
Black, non-Hispanic	24.5%
Hispanic/Latino of any race	4.7%
Other, non-Hispanic	2.3%
Asian, non-Hispanic	1.6%
Age (n=865)	
18-39 years	29.6%
40-59 years	24.3%
60 years or more	31.3%
Park Use within the Past Month (n=887)	
Yes	43.7%
No	56.3%
Distance to the nearest park (miles) (n=891)	Mean=0.65, s.d.=0.46
Number of parks within 1 mile (n=891)	Mean=2.42, s.d.=2.21
Amount of park space within 1 mile (acres) (n=891)	Mean=37.69, s.d.=53.23
Average park quality index within 1 mile ^{b,c} (n=891)	Mean=53.38, s.d.=9.20

Table 1 notes:

- Data were derived from the Kansas City Parks and Physical Activity Project, 2010.
- The average park quality index represents a value from 0 to 100 calculated using the mean park quality index value for all parks within 1 mile from home. The park quality index for individual parks ranged from 16.7-82.3, with a mean of 51.3 (s.d.=11.9).
- For participants that did not have a park within 1 mile, the average park quality index within 1 mile was set to 0.

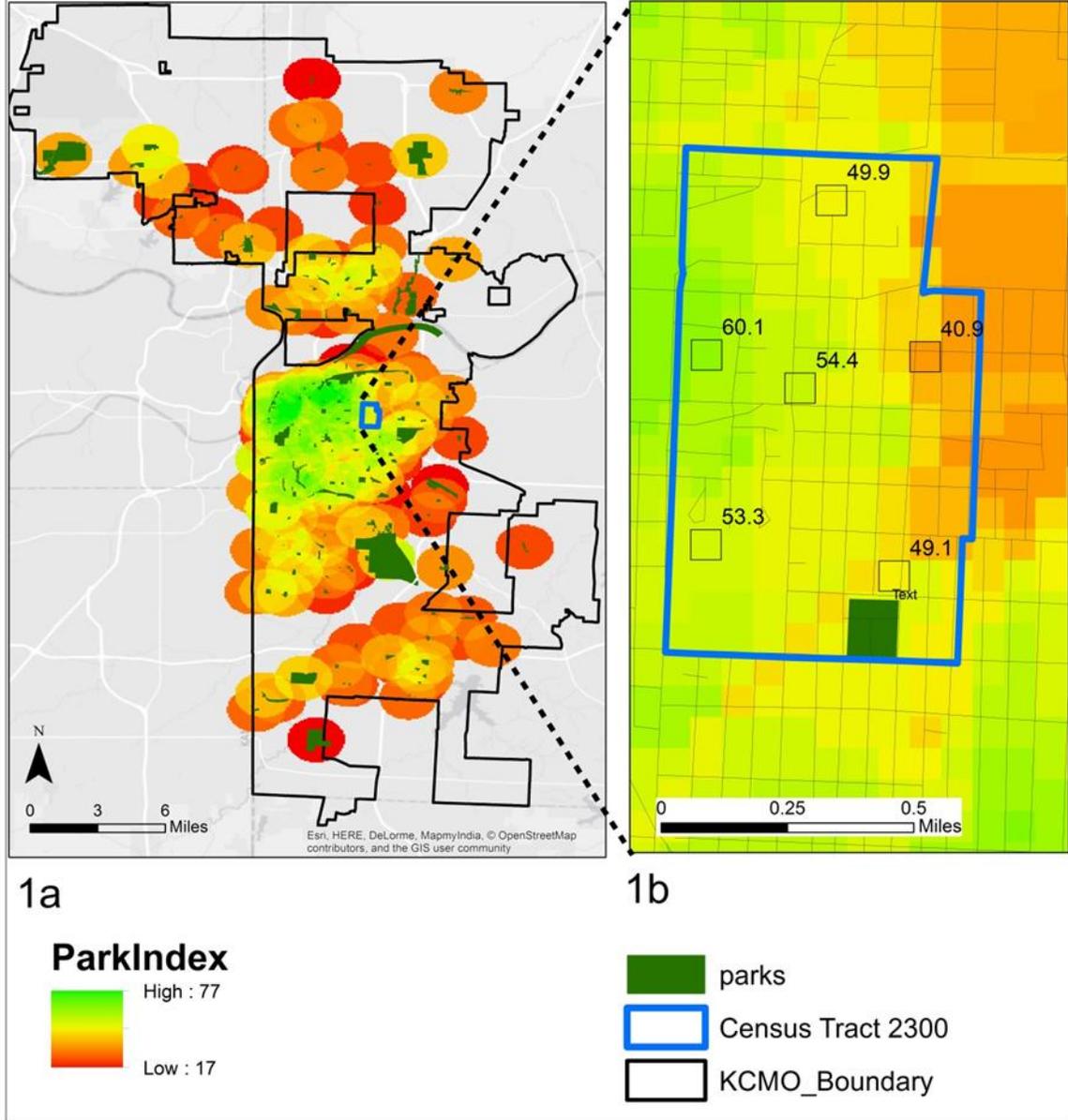
Table 2
Association of Park Summary Variables with Park Use

Park Summary Variables	Initial Model				Final Model			
	B	OR	95% CI	p	B	OR	95% CI	p
Number of parks ^b	0.09	1.09	1.01-1.18	.03	0.13	1.14	1.06-1.23	<.001
Distance to closest park ^b	-0.23	.79	0.40-1.57	.51				
Total park area ^b	0.00	1.00	0.99-1.01	.31				
Average park quality index ^b	0.02	1.02	1.01-1.04	.02	0.02	1.02	1.01-1.04	.04
Constant	-1.50	.22		.00	-2.12	.12		.00

Table 2 notes:

- a. Data were derived from the Kansas City Parks and Physical Activity Project, 2010.
- b. All park variables were calculated within 1 mile of the participant's home address.

Figure 1: ParkIndex in KCMO



Highlights

- No empirically-derived, composite measures exist combining diverse park variables
- Park access and use data were used to create a standardized metric of park access
- Number of parks and average park quality index were positively related to park use
- The probability of park use displayed spatially ranged from 17 to 77 out of 100
- ParkIndex has value for both research and applied public health planning