J Urban Health (2024) 101:300–307
https://doi.org/10.1007/s11524-024-00856-w

ORIGINAL ARTICLE

Association Between Park Use and Moderate-to-Vigorous Activity During COVID-19 Years among a Cohort of Low-Income Youth

Bing Han · Robert Zarr · Erika L. Estrada · Haoyuan Zhong · Deborah A. Cohen

Accepted: 8 March 2024 / Published online: 4 April 2024

Abstract Neighborhood parks are important venues to support moderate-to-vigorous (MVPA) activity. There has been a noticeable increase promoting physical activity among youth in neighborhood parks. This paper aims to assess the association between park use and MVPA among low-income youth in a large urban area. We recruited a cohort of 434 youth participants during the COVID pandemic years (2020–2022) from low-income households in Washington, D.C. We collected multiple data components: accelerometry, survey, and electronic health record data. We explored the bivariate relationship between the accelerometer-measured daily MVPA time outcome and survey-based park use measures. A mixed-effect model was fitted to adjust the effect estimate for participant-level and time-varying confounders. The overall average daily MVPA time is 16.0 min (SD = 12.7). The unadjusted bivariate relation between daily MVPA time and frequency of park visit is 1.3 min of daily MVPA time per one day with park visits ($p < 0.0001$). The model-adjusted estimate is 0.7 daily MVPA minutes for 1 day with park visit ($p = 0.04$). The duration of a typical park visit is not a significant predictor to daily MVPA time with or without adjustments. The initial COVID outbreak in 2020 resulted in a significant decline in daily MVPA time (−4.7 min for 2020 versus 2022, $p < 0.0001$). Park visit frequency is a significant predictor to low-income youth's daily MVPA time with considerable absolute effect sizes compared with other barriers and facilitators. Promoting more frequent park use may be a useful means to improve low-income youth's MVPA outcome.

Keywords Neighborhood park · Moderate-to-vigorous physical activity · Youth

B. Han (✉) · E. L. Estrada · H. Zhong · D. A. Cohen
Kaiser Permanente Southern California, 100 S Los Robles, Pasadena, CA 91101, USA
e-mail: Bing.x1.han@kp.org

E. L. Estrada
e-mail: erika.l.estrada@kp.org

H. Zhong
e-mail: haoyuan.x.zhong@kp.org

D. A. Cohen
e-mail: deborah.a.cohen@kp.org

R. Zarr
Unity Health Care, Inc, Washington, D.C, USA
e-mail: RLZARR@gmail.com

R. Zarr
Children's Hospital of Eastern Ontario, Ottawa, Canada

Introduction

Regular moderate-to-vigorous physical activity (MVPA) provides a myriad of physical and mental health benefits to young children and adolescents [1–4]. Engaging in MVPA in outdoor settings and public spaces further encourages social interaction, communication, and cooperation [5–7]. Despite the well-known benefits, physical inactivity among youth is highly prevalent [8, 9]. Furthermore, the lack of MVPA among youth worsened during the COVID pandemic years [10, 11].

Neighborhood parks in urban areas provide valuable open spaces and opportunities for children to accrue time engaged in MVPA [12–14]. Neighborhood parks are the preferred site of leisure time exercise in many communities, particularly among minority and disadvantaged groups who cannot afford to join health clubs or may not have access to them [15]. Youth are observed to be more physically active and more likely to engage in MVPA outdoors than indoors [16–18]. Most localities maintain parks, and most Americans have a park within a two-mile radius of their homes [19]. During the COVID-19 pandemic, urban neighborhood parks provided outdoor spaces with social distancing to support the local population's needs for physical activity and exercise.

Various prior studies reported indirect evidence to quantify the contribution of neighborhood park to local youth's MVPA [14, 15, 20]. At the aggregated community level (defined as within a 1-mile or 0.5-mile radius of a neighborhood park), neighborhood parks account for a notable proportion of their local population's MVPA, in particular, time spent in vigorous physical activity [14]. However, parks in low-income neighborhoods may have a much smaller contribution to their local population's MVPA, potentially due to the smaller sizes, higher population densities, and other obstacles such as violent crimes and lack of programming [21, 22].

In this paper, we used a sample of low-income children living in Washington, D.C., with objective physical activity measurements by accelerometer and self-reported park use questionnaires fielded during the first three COVID pandemic years (2020–2022). This unique dataset enabled us to directly quantify individual-level associations between park use and MVPA among socioeconomically disadvantaged minority children and during the pandemic years. From the population health perspective, parks have the great potential to support much more leisure-time MVPA in low-income neighborhoods. This paper adds to the literature quantitative references of potential effect sizes for designing future park-based intervention studies for promoting MVPA among low-income youth.

Methods

Study Sample of Low-Income Children

The study sample is the baseline cohort of a parent study, which tests the effectiveness of an intervention to promote physical activity in a randomized controlled trial. The parent study was approved by the institutional review board (ClinicalTrials.gov identifier: NCT04114734 registered on October 3, 2019). Recruitment has been conducted at Unity Health Care, Inc., a Washington, D.C.–based federally qualified health center. Study eligibility criteria include ages (6 to 16 years old), any chronic condition that usually requires two or more routine health care provider visits per year, and one or more eligible diagnoses (ADHD, overweight or obesity, hypertriglyceridemia, hypercholesterolemia, pre-diabetes, and type 2 diabetes). Although household income is not among the eligibility criteria of the parent study, the study participants were recruited from a Federally Qualified Health Center that typically serves patients from low-income households and enrolled in Medicaid. Consented patients were further checked to exclude those with prior exposure to similar physical activity promotion programs, those who may be leaving the Washington, D.C., area, i.e., the study's geographical area, during the study period, and those with a sibling already enrolled. For additional details of the parent study, see Zarr, Han, Estrada, and Cohen [23].

The primary data consisted of 434 individuals and data were collected between March 2020 and June 2022.

Physical Activity Measurement

The primary outcome is daily accelerometer-measured MVPA time as measured by Actigraph GT3x accelerometers. We categorized moderate activity as 3000–5200 counts/min and vigorous activity as > 5200 counts/min [24]. All participants were given instructions to correctly wear the waist-worn accelerometer consecutively for a week except during sleep, swimming, shower, and other special times inappropriate for accelerometer use. After the initial week of wearing the accelerometer, devices were collected, and the participant's wear time was checked using the proprietary software tool ActiLife. If a participant had fewer than 3 valid days with a valid day having eight or more hours of wear time, the participant was requested to wear the accelerometer again for another week.

Children Survey

As a part of the baseline data collection, bilingual (Spanish in English) research assistants administered surveys to participants right after their enrollment. Survey items include demographic information, park use frequency and duration, and PE attendance at school. Surveys were conducted before any intervention effort in the parent study.

Electronic Medical Record

Electronic medical records at Unity Health Care were used to prescreen potentially eligible participants. Body mass index (BMI) measurements in the past 24 months prior to enrollment were retrieved. The mean BMI age percentiles were calculated.

Statistical Analysis

The main outcome is the total person-day level MVPA time in minutes. The primary predictors of interest are park use frequency (days going to the park in a usual week) and park use duration (minutes of a typical park visit). Those who reported not visiting parks usually could have a non-zero response to the duration of a typical park visit. Any missing values in the duration question, where the response to the frequency question was zero, have been imputed as zero. Person-level covariates include age at enrollment, self-reported sex and race/ethnicity, living condition with parents or guardians, school physical education (PE) class attendance, and average BMI age-percentile in the past two years prior to enrollment. Time-varying covariates include the total wear time at the person-day level and the time of measurement (calendar year, season, weekend vs. weekday).

Our analysis dataset has a standard format of longitudinal data, where each participant had multiple person-day level records. First, we formed a person-level exploratory dataset by averaging the MVPA outcome within a participant. Bivariate descriptive analysis was conducted to explore the marginal and unadjusted relationship between the person-level MVPA outcome and each of the two park use predictors (weekly frequency and duration of a typical visit). Next, we fitted a linear mixed effect model to estimate the adjusted relationship between the daily MVPA time and the park use predictors controlling for static and time-varying covariates. A person random effect was deployed to account for the strong intra-class correlation within a participant. Sensitivity analyses included modeling the MVPA outcome by repeated-measure Poisson regression and modeling the temporal trend by calendar years and months. All data preprocessing and statistical analyses were performed using ActiLife software v6.13.4 and SAS 9.4.

Results

Table 1 reports the descriptive statistics of our study sample's characteristics. Study participants had roughly even distributions in self-reported sex and enrollment years. Most study participants were Latinos (86%) and African Americans (11%). The majority of participants lived with both parents (65%). The mean age is 10.4 years (SD = 2.5 years). The mean age sex-adjusted BMI percentile is 94.9 (SD = 6.1).

Table 1 also reports the descriptive statistics of physical activity, PE, and park use measures. Most participants reported at least some park use during a usual week (82%) or attending some PE classes at their schools (75%). Among self-reported park users, a typical visit to the park had a duration longer than 30 min (77%). In a usual week and on average, a participant visited parks on 2.1 days (SD = 1.8) and had PE classes on 1.6 days (SD = 1.5). The average daily MVPA time per participant was 16.0 min (SD = 12.7 min). On average, a participant wore their accelerometer for more than 8 h on 6.8 days (SD = 3.7 days).

Figure 1 plots the unadjusted bivariate relationship between self-reported park use measures versus the distribution of participants' daily MVPA time. Except for the outliers (park use frequency = 6 days in a week), the data suggest a roughly homoscedastic and positive relationship between park use frequency and daily MVPA. The unadjusted simple ordinary least square estimate for linear slope is 1.3 min of daily MVPA time per day of visiting the park ($p < 0.0001$). Excluding the outlier with 6 days/week of park use, the slope estimate is 1.2 min of daily MVPA per day of visiting the park ($p < 0.0001$). The

Table 1 Univariate descriptive statistics of all study variables ($n = 434$)

Categorical characteristics	Percentage (n)
Self-reported sex	
Female	50.5 (219)
Male	49.5 (215)
Enrollment year	
2020	35.9 (156)
2021	38.5 (167)
2022	25.6 (111)
Race/ethnicity	
Asian	0.5 (2)
African American	11.0 (48)
Others or unknown	2.1 (9)
Latino of all races	86.4 (375)
Living with both parents	65.0 (282)
During a typical visit to the park	
0 ~ 30 min	23.0 (100)
31 ~ 60 min	36.4 (158)
> 60 min	40.6 (176)
Not using parks in a usual week	17.7 (77)
Not having PE classes at school	24.7 (107)
Continuous characteristics	**Mean (SD)**
Age	10.4 (2.6)
# Days visiting parks in a usual week	2.1 (1.8)
# Days of having PE classes at school	1.6 (1.5)
Daily MVPA minutes	16.0 (12.7)
Daily minutes wearing accelerometer	730 (130)
# Days > 8 h wearing accelerometer	
Total	6.8 (3.7)
On weekend	1.6 (1.4)
BMI percentile	94.9 (6.1)

duration of a typical park visit does not seem to have a clear relationship with daily MVPA. Those who reported the shortest park visit duration (0 ~ 30 min) had a lower average daily MVPA time than those who reported longer park visit durations. However, the overall F-test from one-way ANOVA is insignificant ($p = 0.062$).

Table 2 reports the mixed-effect model estimates for the daily MVPA outcome after adjusting for participant-level and time-varying confounders. The main parameters of interest are the coefficients of park use frequency and duration. Park use frequency has a significant relationship with the daily MVPA outcome: 1 day with park use is associated with 0.7 min of daily MVPA time on average (95% CI: 0.1, 1.3, $p = 0.04$). Short duration in a typical park visit is related to lower daily MVPA time but the difference is not statistically significant: -1.2 min difference ($p = 0.38$) between short park visit duration (0 ~ 30 min) and long duration (> 60 min).

Among adjusted participant-level confounders, notable results include the following. Girls have significantly less daily MVPA time than boys (-5.6 min/day, $p < 0.0001$). Living with both parents is associated with more MVPA time (2.2 min/day, $p = 0.05$). Older age corresponds to fewer daily MVPA minutes: each additional age year is associated with 0.5 fewer minutes of daily MVPA time ($p = 0.03$). Among time-varying confounders, the most notable finding is the temporal trend: compared with 2022, the year 2020 saw a significant decline in daily MVPA time (-4.7 min, $p < 0.0001$). Time wearing accelerometer was a significant confounder ($p < 0.0001$). Seasons of accelerometer measurement have a large effect: fall and spring see 4 to 5 more daily MVPA minutes than winter ($p < 0.0001$), while the difference between summer and winter is insignificant.

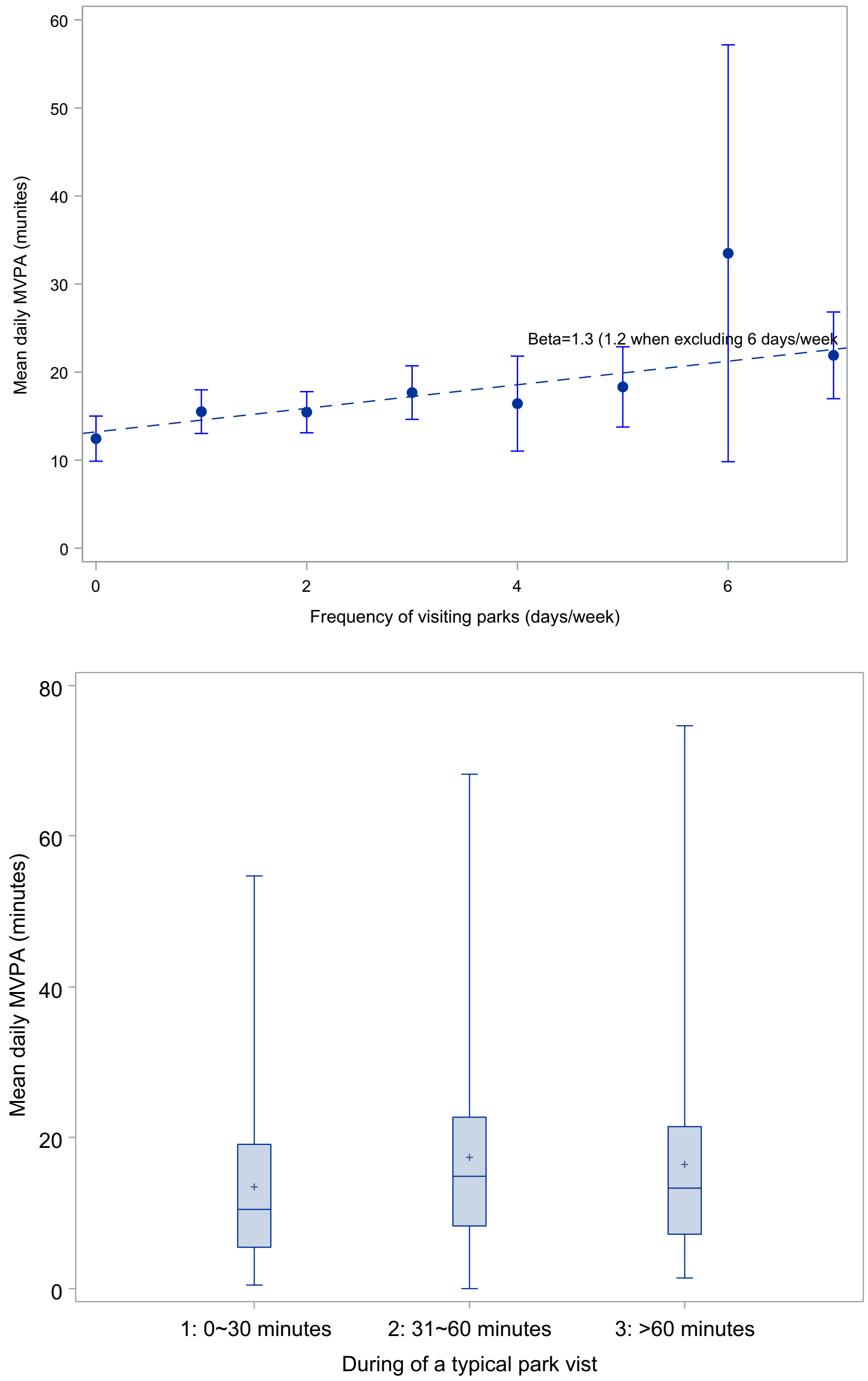
Latinos and African Americans do not show significant differences in daily MVPA time. Whether the acetometer measurement was taken during weekends, the number of days attending PE classes at school, and BMI percentile were pre-specified confounders and included in the model, but none had either statistically or practically significant coefficient estimates.

Results from sensitivity analyses had very similar findings with minor differences. The Poisson regression modeled the multiplicative effects of predictors compared with the additive effects in the main analyses. The year-month temporal trends were complicated due to month-to-month variations and had slightly weakened the statistical power of other predictors due to the increased number of model parameters. We omitted these lengthy results from the paper.

Discussion

Neighborhood parks have been praised for their potential to support the recreational MVPA of the local population [19, 25]. Many park-based intervention programs have been designed and implemented to promote park use and MVPA in parks [12]. Based on person-level objective physical

Fig. 1 Bivariate relationship between the daily MVPA time and park use measures: frequency of visiting parks in a typical week (top) and duration of a typical park visit (bottom). The ordinary least square estimate for slope is 1.3 min/day of park visit or 1.2 by excluding the outliers with 6 days/week ($p < 0.0001$). The one-way ANOVA for the duration of a typical park visit is insignificant ($F = 2.8$, d.f. = 2, 431, $p = 0.062$)



activity measure and self-reported park use data and adjusting various confounders, this paper reports the quantified associations between park use and the health-beneficial physical activity outcome. Our key finding is the significant relationship between the frequency of park use and daily MVPA time among youth living in low-income households. Our model-adjusted estimated effect size of park use frequency is 0.7 daily MVPA minutes for 1 day with park visit. This effect estimate may seem small but is relatively

Table 2 Model estimates for the daily MVPA outcome

Predictor	Estimate (SE)	*p*-value	95% CI
Intercept	16.9 (8.6)	0.05	(0.0, 33.8)
Self-reported sex			
Female	− 5.6 (1.2)	< 0.0001	(− 7.9, − 3.3)
Male	–	–	–
Race/ethnicity			
Asian	− 6.2 (1.6)	< 0.0001	(− 9.4, − 3.0)
African American	0.7 (1.7)	0.69	(− 2.6, 3.9)
Others or unknown	− 1.4 (4.9)	0.78	(− 10.9, 8.2)
Latino of all races	–	–	–
Living with both parents	2.2 (1.1)	0.05	(0.0, 4.3)
During a typical visit to the park			
0 ~ 30 min	− 1.2 (1.4)	0.38	(− 4.0, 1.5)
31 ~ 60 min	0.2 (1.3)	0.90	(− 2.3, 2.7)
> 60 min	–	–	–
Age	− 0.5 (0.3)	0.03	(− 1.0, − 0.1)
# Days visiting parks in a usual week	0.7 (0.3)	0.04	(0.1, 1.3)
# Days of having PE classes at school	0.3 (0.4)	0.38	(− 0.4, 1.0)
Daily hours wearing accelerometer	0.7 (0.1)	< 0.0001	(0.5, 0.9)
Year of measurement			
2020	− 4.7 (1.7)	< 0.0001	(− 8.0, − 1.4)
2021	− 2.0 (1.4)	0.16	(− 4.7, 0.8)
2022	–	–	–
Season of measurement			
Fall	5.1 (1.7)	< 0.0001	(1.7, 8.5)
Spring	4.3 (1.5)	< 0.0001	(1.3, 7.2)
Summer	− 0.6 (1.8)	0.74	(− 4.2, 3.0)
Winter	–	–	–
Measurement on weekend	− 0.1 (0.7)	0.88	(− 1.6, 1.3)
BMI percentile	0.0 (0.1)	0.57	(− 0.2, 0.1)

large compared with other malleable factors or non-malleable environmental predictors. Per-day of exposure, park visit frequency's effect size is more than twice as large as the effect size of attending PE class at school (0.3 daily MVPA minutes per day of having PE). When comparing children with no park use to the overall study participants, the sample average of 2.1 days with park visits per week corresponds to 1.5 min of daily MVPA time. This value is comparable in magnitude to the negative effects associated with aging by 3 years (− 1.5 min of daily MVPA) or not living with both parents (− 2.2 min of daily MVPA).

Compared with no park visits, 7 days of park visits correspond to an effect size of roughly 4.9 daily MVPA minutes, which is similar in magnitude to the strongest predictors for daily MVPA, such as sex, seasonality, and interruption by COVID.

The duration of a park visit is not a significant predictor of daily MVPA time. One potential reason is that park visit duration and park visit frequency are partially confounded: most participants who reported not using parks also had a visit duration of 0 min. Survey respondents may have inaccurate estimate for their stay time. It is also possible that a longer stay in the park may not have a significant additional contribution to daily MVPA than shorter stays, conditioning on a fixed number of park visits.

COVID-19 had introduced a notable and major interruption in MVPA. The year 2020 saw a steep dip in the mean daily MVPA outcome, with an effect size (− 4.7 daily MVPA minutes for

2020 versus 2022) as large as the sex difference (−5.1 min of daily MVPA for girls versus boys) or the climate effect (e.g., −4.3 min of daily MVPA for winter versus spring), adjusting for all other predictors. The two subsequent years saw a quick and steady rebound in the mean daily MVPA time.

This paper has a number of limitations that can restrict the external generalizability of results. First, our study sample was from a single metropolitan area. Neighborhood parks as well as urban geographic setting may be similar within our study region of Washington, D.C., and may not be representative of other major cities in the US. Second, our study participants included mainly Latinos and a small percentage of African Americans and lacked sufficient representation of non-Latino White and Asians. Our results may be biased for estimating parks' contributions to Asians and non-Latino White subpopulation. Third, the accelerometry data had some fundamental limitations: measurements were limited to a relatively short period (1 to 2 weeks) per participant; the accelerometer device did not have the capability to record the geographic location data; and MVPA could have occurred while a participant did not wear the accelerometer device. We were not able to differentiate MVPA occurring in parks versus other locations.

Despite its limitations, this paper underscores the importance of neighborhood parks in fostering physical activity among youth in urban settings. By the unique sample collected during the COVID years, coupled with objective measures of MVPA, we confirm and quantify that park visit frequency is a significant predictor of youth's daily MVPA, even among low-income youth, when multiple studies have confirmed that parks in high poverty neighborhoods are used less than parks in higher income areas [12, 21, 26]. In light of the relatively low utilization of urban parks and the insufficient physical activity levels among youth, implementing park-based programs holds significant promise in promoting public health among this demographic.

Acknowledgements This work is funded by NIH/NHLBI grant no. R01HL147574. We declare no conflict of interest.

Data Availability Non-identifiable data used in this paper are available upon request.

References

1. Poitras VJ, Gray CE, Borghese MM, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab.* 2016;41(6 Suppl 3):S197-239. https://doi.org/10.1139/apnm-2015-0663.
2. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act.* 2010;7(1):1–16.
3. Pate RR, Hillman C, Janz K, et al. Physical activity and health in children under 6 years of age: a systematic review. *Med Sci Sports Exerc.* 2019;51(6):1282.
4. Sothern M, Loftin M, Suskind R, Udall J, Blecker U. The health benefits of physical activity in children and adolescents: implications for chronic disease prevention. *Eur JPediatr.* 1999;158:271–4.
5. Wray A, Martin G, Ostermeier E, Medeiros A, Little M, Reilly K, Gilliland J. Evidence synthesis-physical activity and social connectedness interventions in outdoor spaces among children and youth: a rapid review. *Health Promot Chron Dis Prev Canada: Res Policy Pract.* 2020;40(4):104.
6. Raney MA, Hendry CF, Yee SA. Physical activity and social behaviors of urban children in green playgrounds. *Am J Prev Med.* 2019;56(4):522–9.
7. Cohen DA, Talarowski M, Han B, et al. Playground design: contribution to duration of stay and implications for physical activity. *Int J Environ Res Public Health.* 2023;20(5):4661.
8. Troiano RP. Physical inactivity among young people. *N Engl J Med.* 2002;347(10):706–7.
9. Singh GK, Stella MY, Siahpush M, Kogan MD. High levels of physical inactivity and sedentary behaviors among US immigrant children and adolescents. *Arch Pediatr Adolesc Med.* 2008;162(8):756–63.
10. Do B, Kirkland C, Besenyi GM, Smock C, Lanza K. Youth physical activity and the COVID-19 pandemic: a systematic review. *Prev Med Rep.* 2022;29:101959.
11. Rossi L, Behme N, Breuer C. Physical activity of children and adolescents during the COVID-19 pandemic—a scoping review. *Int J Environ Res Public Health.* 2021;18(21):11440.
12. Wallace DD, Han B, Cohen DA, Derose KP. The effects of park-based interventions on health-related outcomes among youth: a systematic review. *Am J Health Promot.* 2022;36(6):1029–44.
13. Cohen DA, Han B, Williamson S, Nagel C, McKenzie TL, Evenson KR, Harnik P. Playground features and physical activity in US neighborhood parks. *Prev Med.* 2020;131:105945.
14. Han B, Cohen D, McKenzie TL. Quantifying the contribution of neighborhood parks to physical activity. *Prev Med.* 2013;57(5):483–7.
15. 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.

16 Kerr J, Sallis JF, Saelens BE, Cain KL, Conway TL, Frank LD, King AC. Outdoor physical activity and self rated health in older adults living in two regions of the U.S. *Int J Behav Nutr Phys Act.* 2012;9:89. https://doi.org/10.1186/1479-5868-9-89.
17. Wheeler BW, Cooper AR, Page AS, Jago R. Greenspace and children's physical activity: a GPS/GIS analysis of the PEACH project. *Prev Med.* 2010;51(2):148–52. https://doi.org/10.1016/j.ypmed.2010.06.001.
18. Oreskovic NM, Perrin JM, Robinson AI, et al. Adolescents' use of the built environment for physical activity. *Bmc Public Health.* 2015;15. https://doi.org/10.1186/s12889-015-1596-6
19. Godbey G, Graefe AR, James SW. *The benefits of local recreation and park services: a nationwide study of the perceptions of the American public.* Arlington: National Recreation and Park Association; 1992.
20. Rodriguez DA, Merlin L, Prato CG, et al. Influence of the built environment on pedestrian route choices of adolescent girls. *Environ Behav.* 2015;47(4):359–94. https://doi.org/10.1177/0013916513520004.
21. Park S, Han B, Cohen DA, Derose KP. Contributions of neighborhood parks to physical activity in high-poverty urban neighborhoods. *J Urban Health.* 2018;95:881–7.
22. 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(3):352–8.
23. Zarr R, Han B, Estrada E, Cohen DA. The Park Rx trial to increase physical activity among low-income youth. *Contemp Clin Trials.* 2022;122:106930.
24. Treuth MS, Schmitz K, Catellier DJ, et al. Defining accelerometer thresholds for activity intensities in adolescent girls. Research Support, U.S. Gov't P.H.S. *Med Sci Sports Exerc.* 2004;36(7):1259–66.
25 Bowler DE, Buyung-Ali LM, Knight TM, Pullin AS. A systematic review of evidence for the added benefits to health of exposure to natural environments. *J Artic Bmc Public Health.* 2010;10(1):456. https://doi.org/10.1186/1471-2458-10-456.
26. Cohen DA, Han B, Nagel CJ, et al. The first national study of neighborhood parks: implications for physical activity. *Am J Prev Med.* 2016;51(4):419–26. https://doi.org/10.1016/j.amepre.2016.03.021.