Health and Place 56 (2019) 127–134

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Would increasing access to recreational places promote healthier weights and a healthier nation?

Sandy J. Slater[a,*], Elizabeth Tarlov[b], Kelly Jones[b], Stephen A. Matthews[c], Coady Wing[d], Shannon N. Zenk[b]

[a] Department of Pharmaceutical Sciences Concordia University Wisconsin School of Pharmacy, 12800 N. Lake Shore Drive, Mequon, WI 53097, United States
[b] Department of Health Systems Science, College of Nursing, University of Illinois at Chicago, United States
[c] Department of Sociology & Criminology, Department of Anthropology, Pennsylvania State University, United States
[d] School of Public and Environmental Affairs, Indiana University, United States

ABSTRACT

Addressing gaps in evidence on causal associations, this study tested the hypothesis that better access to recreational places close to home helps people to maintain lower body mass index (BMI) using a retrospective longitudinal study design and up to 6 years of data for the same individuals (1,522,803 men and 183,618 women). Participants were military veterans aged 20–64 who received healthcare through the U.S. Department of Veterans Affairs in 2009–2014 and lived in a metropolitan area. Although there were cross-sectional associations, we found no longitudinal evidence that access to parks and fitness facilities was associated with BMI for either men or women in the full sample or in subgroups of residential movers and stayers. Our findings suggest that simply increasing the number of parks and fitness facilities may not be enough to achieve needed population-level reductions in weight.

1. Introduction

Obesity is a serious public health concern in the United States (Flegal et al., 2016; Institute of Medicine Committee to Accelerate Progress in Obesity Prevention, 2012; Ogden et al., 2016) for which physical inactivity and sedentary behavior are major risk factors (Strong et al., 2005). Local parks and fitness facilities (i.e., health clubs, sporting clubs, YMCAs) may help facilitate physical activity and support obesity prevention efforts. Prior research has linked residing in an area with greater access to recreational places such as parks and fitness facilities to greater physical activity and healthier body weight (Slater et al., 2016a, 2013, 2010; Powell et al., 2007; Adams et al., 2015; Dumbaugh and Frank, 2015). Public parks or open space may be the most frequently utilized physical activity setting (Cohen et al., 2007; Giles-Corti and Donovan, 2002), although this finding is not universal (Kaczynski and Henderson, 2007). Yet access to these resources varies considerably across neighborhoods including by socioeconomic characteristics and urbanization (Jones et al., 2015; Wen et al., 2013; Powell et al., 2006; Powell, Slater and Chaloupka, 2004).

Several governmental and other authoritative bodies have argued that increased access to parks and fitness facilities, along with other built environment changes, are critical to population-wide prevention of obesity (Institute of Medicine Committee to Accelerate Progress in Obesity Prevention, 2012; U.S Department of Heath and Human Services, 2015; National Prevention Council, 2011; Pate, 2009; Heath et al., 2006; Frank, Kavage, 2009; White House Task Force on Childhood Obesity, 2010; Institute of Medicine, 2009; Institute of Medicine Committee on Physical Activity and Physical Education in the School Environment, 2013; Khan et al., 2009; Eyler, 2011). For example, the Community Preventive Services Task Force in the U.S. recently recommended combining land use and environmental design with public transportation-related interventions to increase population-level physical activity. (Community Preventive Services Task Force, 2016) However, others acknowledge that there are considerable gaps in our understanding. A recent National Academies of Sciences report states that “while our understanding of the role of the social determinants of health, including features of the physical and social environments, has greatly improved over the last several decades, the scientific progress has not [been] so great on how, when and where to intervene” (p. 3–49) (National Academies of Sciences, Engineering and Medicine, 2017).

Environmental changes are costly and long-lasting. An ongoing criticism of research to date is that most studies rely on cross-sectional designs that do not control for neighborhood self-selection and may, as a result, overstate the causal relationship between the built environment and body weight outcomes (Chandrabose et al., 2018; Garfinkel-Castro et al., 2017a; McCormack and Shiell, 2011; Ewing and Cervero, 2010). Longitudinal studies that track neighborhood change and

* Corresponding author.
E-mail address: Sandra.Slater@cuw.edu (S.J. Slater).

https://doi.org/10.1016/j.healthplace.2019.01.013
Received 21 December 2017; Received in revised form 23 December 2018; Accepted 15 January 2019

relocation of individuals to different neighborhoods are needed to strengthen evidence on causal relationships between the environment and body weight and thus determine whether large-scale environmental changes are likely to achieve population improvements in body weight (National Academies of Sciences, Engineering and Medicine, 2017; Chandrabose et al., 2018; Garfinkel-Castro et al., 2017b). There is some movement towards building this evidence. For example, a recent study by Hobbs et al. (2018) examined the longitudinal association between access to recreational places and weight and found no association. However, this study had limitations including use of self-reported height and weight, only two years of individual-level data, only one year of environmental data, and not accounting for bias that might be present due to residential self-selection.

Using the largest reported study sample to date, the purpose of this study was to examine longitudinal associations between neighborhood recreational places (parks and fitness facilities) and body mass index (BMI). Using a retrospective longitudinal study design and up to 6 years of data for the same individuals, this study tested the hypothesis that better access to recreational places close to home helps people to maintain lower body mass index (BMI). This study advances previous research in three important and distinct ways: 1) it includes 1.7 million adults living in metropolitan areas across the country providing ample statistical power to detect even small associations between the built environment and clinically measured BMI; 2) it accounts for changes in the built environment over a 6-year period including as a result of built environment changes (e.g., opening or closing of a fitness facility) and relocation of individuals to different neighborhoods; and 3) it addresses residential self-selection biases unaccounted for in previous cross-sectional studies.

2. Methods

2.1. Design

In this paper, we utilized a retrospective longitudinal study design and data from the Weight and Veterans' Environments Study (WAVES), which is the largest national study of the connection between residential environments and body weight ever conducted in the U.S. (Zenk et al., 2018). WAVES leveraged the U.S. Department of Veteran Affairs (VA)'s long-established electronic health record (EHR) system and the lifetime healthcare coverage afforded to enrolled veterans that provides clinical data on millions of individuals over multiple years. We linked individual-level data from the VA Corporate Data Warehouse, a repository of clinical and administrative data from the EHR and other sources, to secondary data on park and fitness facility (e.g., health clubs) locations.

2.2. Sample

The analytical sample consists of 1.7 million adults (ages 20–64 years in 2009) residing in 382 metropolitan areas in the continental US. Excluded from the sample were people without at least one VA healthcare encounter in the two years prior to baseline; with long-stay nursing home residence at baseline; without at least one geocodable home address; and without at least one valid and clinically plausible height and weight measurement.

2.3. Measures

Body mass index (BMI). We calculated each person's BMI in each year using height and weight measurements taken during patient encounters. Some patients had multiple height measures across study years. In those cases, we set the person's height equal to his/her modal height measurement across the study period. Most patients had multiple available weights within a calendar year. Here, whenever possible, we used the average weight during the second half of the calendar year (July 1-December 31) to help ensure that the measurements were contemporaneous with the address location information and that the outcome measure (BMI) was taken after the treatment measure (recreational places) If no valid weight measurement was available during the second half of the year, we used the average weight value from the first half of the calendar year. More information on the BMI measures can be found elsewhere. (Zenk et al., 2017)

Recreational places. Park and fitness facility measures were constructed using a raster database approach (Zenk et al., 2018). Specifically, using geographic information system (GIS) software (ArcGIS 10.x, ESRI), we divided the continental U.S. into 30 × 30 m cells, totaling approximately 8.98 billion cells. We counted the number of each setting (park, fitness facility) within buffers of varying radii around each grid cell's centroid. For each data year (2009–2014) home address geocodes, based on the best known home address as of the end of each VA fiscal year (September 30), were obtained from the Veterans Health Administration Planning Systems Support Group (US Department of Veterans Affairs, Health Services Research and Development Service, Information Resource Center May, May, 2016). Time-varying annual values for the environmental measures were assigned to each veteran based on the grid cell in which his or her home address geocode was located.

We measured park access as the number of local public (i.e., municipal/city or county) parks within 1-mile of residence. We selected one mile because people tend to visit parks that are located close to where they live, i.e., within 1-mile (Sugiyama et al., 2010; Rodríguez et al., 2012). To enhance the completeness of the park measure, we merged and de-duplicated two commercial sources of park data (NAVTEQ, TeleAtlas) for two years: 2010 and 2014. NAVTEQ provides quarterly updates (fourth quarter 2010 and third quarter 2014 were available for this study) and TeleAtlas releases their data annually. Park count grids were generated by first creating a raster of the merged park polygons using GIS. The values in the resulting park grid cells represent the number of unique park counts. We then counted the number of unique local parks within 1-mile. Because park footprints are relatively stable over time, i.e., show little change, and due to data availability, park counts were constructed for two time points: 2010 and 2014. To the extent possible, park values were assigned to veterans so that their measurement would precede or be concurrent with the BMI measurement: 2010 park values were linked to 2009–2013 individual data and 2014 park values were linked to 2014 individual data. For ease of interpretation, the park access measure was constructed as a set of dummy variables, based on tertiles of the non-zero distribution of values, representing low (1), medium (2 − 3), high (4 or more) park access, plus a referent category for no park within a 1-mile buffer.

After cleaning the commercial business data in order to maximize their accuracy and utility (Jones et al., 2017), we constructed annual measures of the number of fitness facilities within 3 miles of veterans' home addresses using annual (4th quarter) fitness facility data from InfoUSA. We selected 3 miles because people tend to exercise more than 1-mile from their residence (Holliday et al., 2017), with adults traveling just over 2.5 miles to use fitness facilities (McCormack et al., 2006). Fitness facilities were operationalized using 62 separate standard industrial classification (SIC) codes such as sports clubs, instructional facilities (e.g., dance and martial arts studios, ski and swimming schools), general fitness (e.g., health clubs, gymnasiums), and courts and courses (e.g., golf courses, tennis clubs), as well as name searches for 179 large fitness clubs (e.g., Curves, Equinox) and for YMCA, YWCA and JCC under a broad set of SIC codes. We linked individuals' residential location to commercial fitness facility values in the 4th quarter of the prior year. For ease of interpretation, the fitness facility access measure was constructed as a set of dummy variables based on quartiles of the distribution of values: 0–5 (the referent category), 6–16, 17–31, and 32 or more facilities within a 3-mile buffer.

Covariates. Individual time-invariant variables included age at baseline, gender, and race/ethnicity. Individual time-varying covariates included marital status and ten chronic health conditions (diabetes, hypertension, cardiovascular disease/stroke, breast cancer, colon cancer, hyperlipidemia, osteoarthritis, congestive heart failure, myocardial infarction, and depression). Area time-varying covariates included: census division, urbanicity (county level), (Ingram and Franco, 2014) census tract demographics (percent of residents below the federal poverty line, median household income), and walkability (including street connectivity and population and housing density) and access to supermarkets, grocery stores, convenience stores, and fast food restaurants within a 1-mile buffer.

2.4. Data analysis

We estimated cross-sectional models with year fixed effects and longitudinal models that incorporated both year and individual fixed effects. The individual fixed effects adjust for a broad class of potential confounding factors that could undermine the internal validity of cross-sectional regressions. In particular, by exploiting within person change over time, the longitudinal (panel model) study design minimizes bias from residential self-selection. For example, people who choose to live in neighborhoods with good access to recreational places may have (unmeasured) preferences for a physically active lifestyle. In that case, cross-sectional associations between recreational place access and BMI might reflect relationships between the physically active lifestyle and BMI, rather than effects of the recreational place itself. Under the assumption that people's lifestyle preferences are fixed over time, the longitudinal (panel model) study design is a significant advance over cross-sectional analyses in regard to identifying causal effects of recreational place access. Notably, this design allows us to exploit two sources of within-person variation in recreational place access: changes in access to recreational places that occur because a place opens or closes in a person's neighborhood, and changes that occur when a person relocates or moves to new neighborhood with different access to recreational places.

Although the longitudinal fixed-effects model can reduce the impact of residential self-selection we recognize that lifestyle preferences do sometimes change over time. In that case, the effect of a change in access to recreational places associated with a residential move could not be distinguished from the effect of a lifestyle change on BMI. To address this problem, we also estimated models separately for two groups: residential movers and stayers (defined as those whose home geocode was within 0.25 miles). For residential stayers, change in access to recreational places over time is largely out of the control of the individual. Therefore, estimates obtained from those models should be less affected by residential self-selection. All models accounted for clustering of individuals within counties at baseline. Because men comprise almost 90% of the sample and have a very different demographic profile from women in the VA, we estimated separate models for men and women.

3. Results

Summary statistics for the full samples of men and women aged 20–64 in 2009 (base year of the analysis) are presented in Table 1 as well as for those men and women who did not change residential locations over the study period (residential stayers) and those who did change locations (residential movers). The total sample includes 1,522,803 men and 183,618 women, and 1,034,375 men and 112,670 women were included in the residential stayers analyses. The average BMI was 30.2 kg/m^2 for men and 29.6 kg/m^2 for women. Also, 81.8% of men and 73.5% of women were overweight or obese. The majority of the sample remained at the same address for the follow-up period with 32.1% and 38.6% of men and women respectively moving at some point during the study period. Approximately one-third of veterans had no park within 1 mile of their home. However, 26.3% of men and 24.0% of women had 4 or more parks within 1-mile. Approximately one in four had five or fewer fitness facilities within 3 miles of their home. Table 1 descriptive statistics show little difference between the full sample, residential stayers, and residential movers. For example, average BMI and weight status were similar across the full sample, stayers, and movers.

3.1. Cross-sectional results

Table 2 shows cross-sectional associations between access to recreational places and BMI for men and women. For men (column 1), relative to having no parks within 1 mile, high park access within 1 mile was associated with 0.09-unit lower BMI ($p < 0.05$). High access to fitness facilities within 3 miles was associated with a 0.15-unit lower BMI ($p < 0.001$). Among women (column 2), there were no significant cross-sectional associations between park access within 1 mile and BMI. However, medium and high fitness facility access within 3 miles was associated with 0.13-unit ($p < 0.05$) and 0.38-unit ($p < 0.001$) lower BMI, respectively.

3.2. Longitudinal results

Table 3 presents results of longitudinal associations for the full samples of men and women and further stratified by those who did and did not move during the follow-up period. For the full sample of men (Column 1), having access to at least one park within 1 mile was associated with a 0.02-unit higher BMI compared to those males with no park within 1 mile ($p < 0.01$). Similar results were found for men who moved during the study period ($b = 0.01$, $p < 0.05$). Having even more (2–4, 4 +) parks within 1 mile was not associated with BMI differences compared to those with no parks, either among the full sample or movers. There were no significant longitudinal associations between fitness facility access and BMI in the full sample, stayers, or movers. Among women, we found no longitudinal evidence that access to parks or fitness facilities was associated with BMI in the full sample or in the residential mover and stayer samples.

3.3. Sensitivity analyses

We conducted additional analyses (results not shown) to confirm our initial findings. Sensitivity analyses included estimating the same longitudinal models in subgroups defined by urbanicity, race, and ethnicity. Further, because we only had two waves of park data, we tested all models using a long-difference data structure. Similar to our multi-year longitudinal models, the long-difference models incorporated individual fixed effects and, thus, removed time-invariant omitted variable bias, and were designed to examine whether the effect of recreational places on weight status compounds over time. Although some statistically significant relationships were found in these long-difference models, their magnitudes were not clinically meaningful and results were consistent with the findings presented in this paper, overall.

4. Discussion

Similar to the large body of research examining cross-sectional associations between the built environment and weight (Slater et al., 2016a, 2013, 2010; Powell et al., 2007; Adams et al., 2015; Dumbaugh and Frank, 2015; Garfinkel-Castro et al., 2017b; Ding and Gebel, 2012; Ewing et al., 2003), we found small but statistically significant cross-sectional associations in the hypothesized direction between BMI and both park (men only) and fitness facility (men and women) access in this study. However, these results suggest a correlation and may not indicate causality. Results from our longitudinal person fixed effects models, which better control for unmeasured residential self-selection and also consistent with previous research (Kostova, 2011), suggest that there is no clinically meaningful relationship between access to

Table 1
Descriptive Statistics for the Full Sample, Residential Stayers, and Residential Movers at Baseline by Sex.

	Men (n = 1,522,803)			Women (n = 183,618)		
Sample:	**Total**	**Residential Stayers**	**Residential Movers**	**Total**	**Residential Stayers**	**Residential Movers**
n:	1,522,803	1,034,375	488,428	183,618	112,670	70,948
	% or Mean (SD)	**% or Mean (SD)**	**% or Mean (SD)**	**% or Mean (SD)**	**% or Mean (SD)**	**% or Mean (SD)**
Body mass index						
Mean (SD)	30.2 (6.0)	30.3 (6.0)	30.0 (6.1)	29.5 (6.4)	29.6 (6.4)	29.4 (6.4)
Body weight status, %						
Underweight or normal weight	18.2	17.6	19.7	26.5	25.9	27.5
Overweight	35.9	35.9	35.8	31.1	31.2	30.8
Obese	45.9	46.5	44.5	42.4	42.9	41.7
Age						
Mean (SD)	51.8 (11.5)	52.5 (11.3)	50.3 (11.7)	43.4 (11.5)	44.5 (11.3)	41.5 (11.5)
Marital status, %						
Unknown	1.4	1.6	1.1	2.1	2.4	1.6
Married	48.8	53.0	39.9	33.3	36.6	28.1
Separated or divorced	26.2	23.8	31.4	31.6	30.1	33.9
Widowed	1.8	1.7	2.0	2.2	2.2	2.2
Single	21.8	19.9	25.6	30.8	28.7	34.2
Race/ethnicity, %						
Non-Hispanic white	60.5	60.9	59.4	50.1	49.8	50.6
Non-Hispanic black	22.5	20.8	26.0	32.1	31.1	33.6
Hispanic	6.0	6.0	6.2	6.0	5.8	6.4
Other	2.5	2.6	2.4	3.3	3.3	3.3
Unknown	8.5	9.7	5.9	8.5	10.1	6.0
Medical diagnoses, %						
Breast cancer	0.0	0.0	0.0	1.3	1.4	1.2
Cerebrovascular disease	2.7	2.7	2.8	1.2	1.3	1.2
Colon cancer	0.4	0.4	0.4	0.2	0.2	0.2
Congestive heart failure	3.1	3.1	3.0	0.8	0.8	0.8
Depression	20.1	18.2	24.0	29.2	27.1	32.6
Diabetes	19.1	19.3	18.7	8.0	8.1	7.8
Hyperlipidemia	32.4	33.1	31.0	17.2	19.1	16.2
Hypertension	41.3	41.4	41.2	21.8	22.2	21.1
Myocardial infarction	1.7	1.6	1.8	0.4	0.3	0.4
Osteoporosis	0.5	0.5	0.4	1.6	1.8	1.4
Urbanicity, %						
Large central metro	29.9	28.9	32.0	30.2	28.9	32.1
Large fringe metro	24.0	24.4	23.0	24.1	24.3	23.6
Medium metro	29.9	30.2	29.3	30.8	31.2	30.0
Small metro	16.3	16.5	15.7	15.0	15.5	14.2
Census Division, %						
New England	3.7	3.9	3.4	2.5	2.6	2.4
Middle Atlantic	9.5	9.9	8.7	7.3	7.6	6.8
East North Central	13.4	13.3	13.7	10.5	10.1	11.1
West North Central	5.8	5.8	5.8	4.8	4.8	4.8
South Atlantic	24.7	24.8	24.5	30.8	31.3	29.9
East South Central	7.1	7.2	7.0	7.3	7.5	6.9
West South Central	14.0	14.0	14.2	15.8	15.7	15.9
Mountain	8.4	8.2	8.7	9.0	8.8	9.2
Pacific Alaska	13.3	13.0	14.0	12.1	11.6	12.9
Median household income, Census tract						
Mean (SD)	52,334.3 (21346.8)	53,374.4 (21,462.8)	50,131.6 (20,929.0)	53,192.7 (20,672.6)	54,160.5 (20,930.6)	51,655.9 (20,161.)
Poverty rate, Census tract						
Mean (SD)	14.9 (11.5)	14.3 (11.0)	16.0 (12.3)	14.4 (10.8)	14.1 (10.5)	14.9 (11.1)
Population density (per square mile), Census tract						
Mean (SD)	4139.5 (8866.6)	4050.6 (8957.9)	4327.8 (8668.3)	4034.3 (8274.4)	3957.9 (8525.6)	4155.5 (7857.6)
Park access, 1 mi						
0 parks	33.5	34.1	32.3	34.8	35.9	33.1
1 park	17.8	18.3	16.9	19.0	19.4	18.4
2–3 parks	22.4	22.4	22.5	22.2	21.8	22.8
4 or more parks	26.3	25.3	28.3	24.0	23.0	25.7
Fitness facility access, 3 mi						
0–5 facilities	23.1	23.5	27.5	20.6	21.8	25.1
6–16 facilities	25.0	26.0	26.2	27.6	28.6	27.8
17–31 facilities	25.8	25.6	17.4	26.6	25.9	18.6
32 + facilities	26.1	25.0	28.9	25.3	23.7	28.5
Walkability index, 1 mi[1]						
Mean (SD)	0.03 (1.00)	0.002 (0.99)	0.08 (1.03)	− 0.002 (0.91)	− 0.02 (0.92)	0.03 (0.89)
Supermarkets, 1 mi						
1 or more stores	52.8	51.8	54.9	52.8	51.1	55.4
Grocery stores, 1 mi						
1 or more stores	48.2	46.8	51.2	47.5	45.8	50.1

(*continued on next page*)

Table 1 (*continued*)

Sample:	Men (n = 1,522,803) Total	Residential Stayers	Residential Movers	Women (n = 183,618) Total	Residential Stayers	Residential Movers
n:	1,522,803	1,034,375	488,428	183,618	112,670	70,948
	% or Mean (SD)	% or Mean (SD)	% or Mean (SD)	% or Mean (SD)	% or Mean (SD)	% or Mean (SD)
Fast food restaurants, 1 mi						
0 restaurants	21.5	21.9	20.6	19.8	21.0	17.8
1–4 restaurants	25.2	26.3	22.8	26.6	27.8	27.4
5–11 restaurants	25.8	25.8	25.6	26.7	26.3	30.1
12 + more restaurants	27.6	26.0	30.9	27.0	25.0	17.8
Convenience stores, 1 mi						
0 stores	23.4	23.9	22.3	21.6	22.9	19.7
1–2 stores	22.1	23.1	19.9	23.6	24.5	22.0
3–5 stores	24.5	24.6	24.2	26.2	25.9	26.5
6 + stores	30.0	28.3	33.6	28.6	26.6	31.2

[1] Standardized – mean of 0 and SD of 1.

Table 2
Cross-Sectional Associations between Access to Recreational Places and BMI (Full Sample).

	Men	Women
n:[a]	6668,033	773,511
Park Access (1 mile buffer of home)[b]		
1 park	0.00	0.06
	(−0.02)	(−0.04)
2–3 parks	− 0.04	0.10
	(−0.02)	(−0.05)
4 + parks	− 0.09*	0.11
	(−0.04)	(−0.07)
Fitness Facility Access (3 mile buffer of home)[b]		
6–16 facilities	− 0.01	− 0.08
	(−0.02)	(−0.04)
17–31 facilities	− 0.04	− 0.13*
	(−0.02)	(−0.06)
31 + facilities	− 0.15***	− 0.38***
	(−0.03)	(−0.07)
Adjusted R-squared		
	0.12	0.11

Individual-level covariates included: age, gender, race/ethnicity, marital status, and ten chronic health conditions (diabetes, hypertension, cardiovascular disease/stroke, breast cancer, colon cancer, hyperlipidemia, osteoarthritis, congestive heart failure, myocardial infarction, and depression). Area-level covariates included: census division, urbanicity (county level), census tract demographics (percent of residents below the federal poverty line, median household income), neighborhood walkability (including street connectivity and population and housing density) and access to supermarkets, grocery stores, convenience stores, and fast food restaurants.
* * $p \le 0.01$.
[a] Total number of observations included in analyses.
[b] Reference category: 0 parks/0–5 fitness facilities.
* $p \le 0.05$.
*** $p \le 0.001$.

recreational places and BMI. These results imply access to recreational places alone is not sufficient to induce physical activity change to the extent needed to achieve measurable reductions in BMI over time. We also did not find significantly different longitudinal results for those veterans who moved. These findings do not support the idea that people with lower weight, or those who are motivated to be more physically active, move into neighborhoods with higher densities of recreational places.

Although we did not observe longitudinal associations with BMI, access to parks has more consistent associations with more proximate outcomes such as physical activity (Ranchod et al., 2014) and fitness levels (Roux et al., 2007; Ranchod et al., 2013a). Indeed, three recent longitudinal studies of adults found greater fitness facility or park access was associated with greater physical activity or less decline in physical activity. (Ranchod et al., 2013b; Halonen et al., 2015; Christian et al., 2017) Further, cross-sectional research suggests park access may mitigate the development of chronic health conditions, such as heart disease and diabetes (Besenyi et al., 2014). Therefore, it is possible that access to recreational places positively affects physical activity behaviors and lowers the risk of chronic health conditions through pathways other than lowering BMI.

Potential explanations for our statistically and clinically insignificant longitudinal results may be related to characteristics of our sample of military veterans who receive care through the VA. First, our sample tends to be older (mean age of 51.8 with 35% > age 60 for men and mean age of 43.4 with 7% > age 60 for women). Research has found younger adults are more likely to use fitness facilities than middle-aged adults (i.e., > 45) (McCormack et al., 2006), and older adults (≥60 years of age) are less likely than any other age group to visit parks for recreation (Cohen et al., 2016). Some prior longitudinal research has found an inverse relationship between park access (Wolch et al., 2011) and green space (Bell et al., 2008) and weight status in youth. Moreover, Hobbs et al. found inverse associations between park access and fitness facilities and body weight outcomes were confined to younger adults. (Hobbs et al., 2018) Thus, there may be a point along the age continuum where the influence of park and fitness facility access as an obesity prevention strategy plateaus and is no longer an effective weight management tool.

There are other potential factors that may explain our findings. Access to nearby recreational places may only matter if the social environment (i.e., safety, social capital) is supportive (King, 2008; Van Cauwenberg et al., 2017). For example, Van Cauwenberg et al. found in a cross-sectional study of mid-older adults that park proximity was only associated with greater recreational walking among those who reported higher levels of social trust and cohesion. (Van Cauwenberg et al., 2017) Additionally, salubrious effects of nearby parks and fitness facilities may only be found if these recreational places are of high quality and, in the case of fitness facilities, are not cost prohibitive. (Van Cauwenberg et al., 2017; Kruger, Carlson and Kohl, 2007; Rundle et al., 2013; Kelly et al., 2016) Our data did not allow us to explore those factors.

4.1. Study strengths and limitations

Study strengths include the use of a large, nationwide sample with repeated observations over several years, detailed health data, and geocoded addresses. Additional strengths include the person-specific measures of spatial access to recreational places and objectively measured height and weight across multiple time points. However, this

Table 3
Longitudinal Relationships between Access to Recreational Places and BMI, Stratified by Sex and Residential Movers vs. Stayers.

Sample:	Men			Women		
	Full	Residential Movers	Residential Stayers	Full	Residential Movers	Residential Stayers
n:[a]	6,668,033	2,438,306	4,229,727	773,511	349,182	424,329
Park Access (1-mile buffer of home)[b]						
1 park	0.02**	0.01*	0.02	0.02	0.01	0.03
	(−0.01)	(−0.01)	(−0.01)	(−0.02)	(−0.02)	(−0.04)
2–3 parks	0.01	0.01	0.00	− 0.01	− 0.01	− 0.01
	(−0.01)	(−0.01)	(−0.01)	(−0.02)	(−0.02)	(−0.05)
4 + parks	0.00	− 0.01	0.00	0.00	− 0.01	0.05
	(−0.01)	(−0.01)	(−0.02)	(−0.02)	(−0.02)	(−0.05)
Fitness Facility Access (3-mile buffer of home)[b]						
6–16 facilities	0.00	0.01	− 0.01	0.00	− 0.02	0.02
	(0.00)	(−0.01)	(−0.01)	(−0.02)	(−0.02)	(−0.02)
17–31 facilities	0.01	0.01	− 0.01	0.01	0.01	− 0.01
	(−0.01)	(−0.01)	(−0.01)	(−0.02)	(−0.02)	(−0.03)
31 + facilities	0.00	0.01	− 0.01	0.01	0.01	− 0.01
	(−0.01)	(−0.01)	(−0.01)	(−0.02)	(−0.03)	(−0.04)
Adjusted R-squared						
	< 0.00	< 0.00	< 0.00	0.01	0.02	0.01

Individual-level covariates included: age, gender, race/ethnicity, marital status, and ten chronic health conditions (diabetes, hypertension, cardiovascular disease/stroke, breast cancer, colon cancer, hyperlipidemia, osteoarthritis, congestive heart failure, myocardial infarction, and depression). Area-level covariates included: census division, urbanicity (county level), census tract demographics (percent of residents below the federal poverty line, median household income), neighborhood walkability (including street connectivity and population and housing density) and access to supermarkets, grocery stores, convenience stores, and fast food restaurants.

*** p ≤ 0.001.

[a] Total number of observations included in analyses.

[b] Reference category: 0 parks/0–5 fitness facilities.

* p ≤ 0.05.

** p ≤ 0.01.

study also has several limitations. First, the park and fitness facility access measures provide no information about their quality and features, which may be relevant. Future research should examine how availability and condition of specific park and fitness facility features (e.g., sport fields, courts, exercise equipment, walking paths/track) influence weight status over time. Second, given we used EHR data, we do not have information on physical activity behavior, the more proximal outcome. Third, there is some evidence showing that place-based physical activity may not fully overlap with residential buffer geographic locations (Holliday et al., 2017). However, we used varying buffer sizes for our park and fitness facility measures to help account for this emerging distinction and found the same results regardless of buffer size. Fourth, there are some differences between the population of veterans using VA healthcare and the U.S. adult population, as well as adult populations in other countries, that could have bearing on generalizability of our study results. Our sample skews older and, because laws governing VA eligibility mandate its role as a “safety net” for veterans, has a larger proportion of low-income individuals. Also, while precise estimates of mobility impairment for our sample are not available, it is likely that prevalence is higher than among U.S. adults generally. BMI in individuals with mobility impairment may not be as sensitive as non-impaired counterparts to built environment features. These differences notwithstanding, given the sparse available evidence on the connection between access to recreational spaces and weight, the diverse person-level and regional sample provided by the VA data, as well as the ability to account for individual self-selection, this study provides an important and much needed contribution to the literature. Finally, although we control for access to local food environments (i.e., supermarkets, grocery stores, convenience stores, and fast food restaurants), we do not have information on dietary behaviors for study participants. However, the fixed effects models assume that within person changes in the availability of recreational facilities is not systematically associated with within person changes in other factors, such as the opening and closing of a fast food restaurant, that may affect the person's diet. In other words, it is unlikely that the opening and closing of a fast food restaurant, or other food outlet, in a specific geographic area, is caused by the simultaneous change in dietary habits of individuals living in the surrounding area.

4.2. Implications for future research

This study has multiple implications for future research. First, overall, results of this study suggest that access to recreational environments alone is not enough to achieve measurable reductions in adult BMI over time. Thus, simply deploying more resources to neighborhoods without fully understanding related facilitators and barriers may not result in the desired population-level health outcomes. Research is needed beyond exploring the association between access to neighborhood resources and health outcomes. Possible future directions include intervention strategies that test the effect of access improvements in combination with facility enhancements (Slater et al., 2016b; Lapham et al., 2015), program provision (Wolch et al., 2011; Cohen et al., 2010), or how the available features or equipment, such as walking/running paths, sports courts, etc., (Kaczynski et al., 2014) could be evaluated for their effect in inducing utilization to a level that reduces weight over time. Moreover, research is needed to test multilevel interventions that couple supportive environments with complementary behavioral (i.e., physical activity) interventions (Lv et al., 2017). Research that examines effects of access to recreational places in the broader environment where people spend time could provide important insights. Growing research (Holliday et al., 2017; Zenk et al., 2011) suggests that residential environments and these broader activity-space environments can differ significantly and thus exclusive focus on the residential environment may mis-specify environmental exposures and weaken environment-body weight associations. More broadly, future qualitative and quantitative research to help understand why people of different ages do and do not use specific recreational places could help to make them more attractive and thereby enhance their potential as resources for health promotion. Finally, much work is being done in harnessing access to big data sets related with both health and the environment. More research is needed that aligns these rich data sources together to examine relationships between different environments and health outcomes.

5. Conclusion

In conclusion, our study provides much needed longitudinal evidence of the relationship between access to recreational places and body weight. Its longitudinal design and ample statistical power removes uncertainty from prior studies. Our findings suggest that simply increasing the availability of parks and fitness facilities may not be enough to achieve needed population-level reductions in weight.

Acknowledgments

This research was funded by the National Cancer Institute (R01CA172726). This material is also based upon work supported in part by the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Health Services Research and Development. The content is solely the responsibility of the authors and does not necessarily represent the official position or policy of the Department of Veterans Affairs.

References

Adams, M.A., Todd, M., Kurka, J., Conway, T.L., Cain, K.L., Frank, L.D., Sallis, J.F., 2015. Patterns of walkability, transit, and recreation environment for physical activity. Am. J. Prev. Med. 49 (6), 878–887.
Bell, J.F., Wilson, J.S., Liu, G.C., 2008. Neighborhood greenness and 2-year changes in body mass index of children and youth. Am. J. Prev. Med. 35 (6), 547–553.
Besenyi, G.M., Kaczynski, A.T., Stanis, S.A.W., Bergstrom, R.D., Lightner, J.S., Hipp, J.A., 2014. Planning for health: a community-based spatial analysis of park availability and chronic disease across the lifespan. Health Place 27, 102–105.
Chandrabose, M., Rachele, J., Gunn, L., Kavanagh, A., Owen, N., Turrell, G., Giles-Corti, B., Sugiyama, T., 2018. Built environment and cardio-metabolic health: systematic review and meta-analysis of longitudinal studies. Obes. Rev.
Christian, H., Knuiman, M., Divitini, M., Foster, S., Hooper, P., Boruff, B., Bull, F., Giles-Corti, B., 2017. A Longitudinal analysis of the influence of the neighborhood environment on recreational walking within the neighborhood: results from RESIDE. Environ. Health Perspect. 125 (7).
Cohen, D.A., Han, B., Nagel, C.J., Harnik, P., McKenzie, T.L., Evenson, K.R., Marsh, T., Williamson, S., Vaughan, C., Katta, S., 2016. The first National study of Neighborhood Parks: Implications for physical activity. Am. J. Prev. Med.
Cohen, D.A., Marsh, T., Williamson, S., Derose, K.P., Martinez, H., Setodji, C., McKenzie, T.L., 2010. Parks and physical activity: why are some parks used more than others? Prev. Med. 50, S9–S12.
Cohen, D.A., McKenzie, T.L., Sehgal, A., Williamson, S., Golinelli, D., Lurie, N., 2007. Contribution of public parks to physical activity. Am. J. Public Health 97 (3), 509–514.
Community Preventive Services Task Force, 2016. Physical activity: built environment approaches combining transportation system interventions with land use and environmental design. Community Guide.
Ding, D., Gebel, K., 2012. Built environment, physical activity, and obesity: What have we learned from reviewing the literature? Health Place 18 (1), 100–105.
Dumbaugh, E., Frank, L., 2015. Traffic safety and safe routes to schools: synthesizing the empirical evidence. Transp. Res. Rec.: J. Transp. Res. Board.
Ewing, R., Cervero, R., 2010. Travel and the built environment: a meta-analysis. J. Am. Plan. Assoc. 76 (3), 265–294.
Ewing, R., Schmid, T., Killingsworth, R., Zlot, A., Raudenbush, S., 2003. Relationship between urban sprawl and physical activity, obesity, and morbidity. Am. J. Health Promot. 18 (1), 47–57.
Eyler, A., 2011. Promoting physical activity through policy. Res. Dig. 12 (3), 1–9.
Flegal, K.M., Kruszon-Moran, D., Carroll, M.D., Fryar, C.D., Ogden, C.L., 2016. Trends in Obesity Among Adults in the United States, 2005 to 2014. JAMA 315 (21), 2284–2291.
Frank, L., Kavage, S., 2009. A national plan for physical activity: the enabling role of the built environment. J. Phys. Act. Health 6.
Garfinkel-Castro, A., Kim, K., Hamidi, S., Ewing, R., 2017a. Obesity and the built environment at different urban scales: examining the literature. Nutr. Rev. 75 (suppl_1), 51–61.
Garfinkel-Castro, A., Kim, K., Hamidi, S., Ewing, R., 2017b. "Obesity and the built environment at different urban scales: examining the literature. Nutr. Rev. 75 (suppl 1), 51–61.
Giles-Corti, B., Donovan, R.J., 2002. The relative influence of individual, social and physical environment determinants of physical activity. Social. Sci. Med. 54 (12), 1793–1812.
Halonen, J.I., Stenholm, S., Kivimäki, M., Pentti, J., Subramanian, S., Kawachi, I., Vahtera, J., 2015. Is change in availability of sports facilities associated with change in physical activity? A prospective cohort study. Prev. Med. 73, 10–14.
Heath, G.W., Brownson, R.C., Kruger, J., Miles, R., Powell, K.E., Ramsey, L.T., 2006. The effectiveness of urban design and land use and transport policies and practices to increase physical activity: a systematic review. J. Phys. Act. Health 3.
Hobbs, M., Griffiths, C., Green, M., Christensen, A., McKenna, J., 2018. Examining longitudinal associations between the recreational physical activity environment, change in body mass index, and obesity by age in 8864 Yorkshire health study participants. Social. Sci. Med.
Holliday, K.M., Howard, A.G., Emch, M., Rodriguez, D.A., Evenson, K.R., 2017. Are buffers around home representative of physical activity spaces among adults? Health Place 45, 181–188.
Ingram, D.D., Franco, S.J., 2014. 2013 NCHS Urban-Rural Classif. Scheme Cties.
Institute of Medicine, 2009. Local Government Actions to Prevent Childhood Obesity. he National Academies Press, Washington, DC.
Institute of Medicine Committee on Physical Activity and Physical Education in the SchoolEnvironment, 2013. Educating the Student Body: taking Physical Activity and Physical Education to School. The National Academies Press, Washington, DC.
Institute of Medicine Committee to Accelerate Progress in Obesity Prevention, 2012. Accelerating progress in obesity prevention: solving the weight of the nation. The National Academies Press, Washington, DC.
Jones, K.K., Zenk, S.N., Tarlov, E., Powell, L.M., Matthews, S.A., Horoi, I., 2017. A step-by-step approach to improve data quality when using commercial business lists to characterize retail food environments. BMC Res. Notes 10 (1), 35.
Jones, S.A., Moore, L.V., Moore, K., Zagorski, M., Brines, S.J., Roux, A.V.D., Evenson, K.R., 2015. Disparities in physical activity resource availability in six US regions. Prev. Med. 78, 17–22.
Kaczynski, A.T., Besenyi, G.M., Stanis, S.A.W., Koohsari, M.J., Oestman, K.B., Bergstrom, R., Potwarka, L.R., Reis, R.S., 2014. Are park proximity and park features related to park use and park-based physical activity among adults? Variations by multiple socio-demographic characteristics. Int. J. Behav. Nutr. Phys. Act. 11 (1), 1.
Kaczynski, A.T., Henderson, K.A., 2007. "Environmental correlates of physical activity: a review of evidence about parks and recreation. Leis. Sci. 29 (4), 315–354.
Kelly, S., Martin, S., Kuhn, I., Cowan, A., Brayne, C., Lafortune, L., 2016. Barriers and facilitators to the uptake and maintenance of healthy behaviours by people at mid-life: a rapid systematic review. PloS One 11 (1), e0145074.
Khan, L.K., Sobush, K., Keener, D., Goodman, K., Lowry, A., Kakietek, J., Zaro, S., 2009. Recommended community strategies and measurements to prevent obesity in the United States. Department of Health & Human Services, Centers for Disease Control and Prevention, US.
King, D., 2008. Neighborhood and individual factors in activity in older adults: results from the neighborhood and senior health study. J. Aging Phys. Act. 16 (2), 144–170.
Kostova, D., 2011. Can the built environment reduce obesity? The impact of residential sprawl and neighborhood parks on obesity and physical activity. East. Econ. J. 37 (3), 390–402.
Kruger, J., Carlson, S.A., Kohl, H.W., 2007. Fitness facilities for adults: differences in perceived access and usage. Am. J. Prev. Med. 32 (6), 500–505.
Lapham, S.C., Cohen, D.A., Han, B., Williamson, S., Evenson, K.R., McKenzie, T.L., Hillier, A., Ward, P., 2015. How important is perception of safety to park use? A four-city survey. Urban Stud (pp. 0042098015592822).
Lv, N., Azar, K.M., Rosas, L.G., Wulfovich, S., Xiao, L., Ma, J., 2017. Behavioral lifestyle interventions for moderate and severe obesity: a systematic review. Prev. Med.
McCormack, G.R., Giles-Corti, B., Bulsara, M., Pikora, T.J., 2006. Correlates of distances traveled to use recreational facilities for physical activity behaviors. Int. J. Behav. Nutr. Phys. Act. 3 (1), 18.
McCormack, G.R., Shiell, A., 2011. In search of causality: a systematic review of the relationship between the built environment and physical activity among adults. Int J. Behav. Nutr. Phys. Act. 8 (1), 125.
National Academies of Sciences, Engineering and Medicine, 2017. Communities in action: pathways to health equity (edn). The National Academies Press, Washington, D.C.. https://doi.org/10.17226/24624.
National Prevention Council, 2011. Natl. Prev. Strategy. ⟨http://www.surgeongeneral.gov/initiatives/prevention/strategy/index.html⟩ (2011, July 1).
Ogden, C.L., Carroll, M.D., Lawman, H.G., Fryar, C.D., Kruszon-Moran, D., Kit, B.K., Flegal, K.M., 2016. Trends in Obesity Prevalence Among Children and Adolescents in the United States, 1988–1994 Through 2013–2014. JAMA 315 (21), 2292–2299.
Pate, R.R., 2009. A national physical activity plan for the United States. J. Phys. Act. Health 6 (Supplement 2), S157.
Powell, L.M., Slater, S., Chaloupka, F.J., 2004. The relationship between community physical activity settings and race, ethnicity and socioeconomic status. Evid.-Based Prev. Med. 1 (2), 135–144.
Powell, L.M., Chaloupka, F.J., Slater, S.J., Johnston, L.D., O'Malley, P.M., 2007. The availability of local-area commercial physical activity–related facilities and physical activity Among adolescents. Am. J. Prev. Med. 33 (4), S292–S300 (Supplement).
Powell, L.M., Slater, S., Chaloupka, F.J., Harper, D., 2006. Availability of physical activity–related facilities and neighborhood demographic and socioeconomic characteristics: a national study. Am. J. Public Health 96 (9).
Ranchod, Y.K., Diez Roux, A.V., Evenson, K.R., Sánchez, B.N., Moore, K., 2014. Longitudinal associations between neighborhood recreational facilities and change in recreational physical activity in the multi-ethnic study of atherosclerosis, 2000–2007. Am. J. Epidemiol. 179 (3), 335–343.
Ranchod, Y.K., Diez Roux, A.V., Evenson, K.R., Sánchez, B.N., Moore, K., 2013a. Longitudinal associations between neighborhood recreational facilities and change in recreational physical activity in the multi-ethnic study of atherosclerosis, 2000–2007. Am. J. Epidemiol. 179 (3), 335–343.
Ranchod, Y.K., Diez Roux, A.V., Evenson, K.R., Sánchez, B.N., Moore, K., 2013b. Longitudinal associations between neighborhood recreational facilities and change in

recreational physical activity in the multi-ethnic study of atherosclerosis, 2000–2007. Am. J. Epidemiol. 179 (3), 335–343.
Rodríguez, D.A., Cho, G., Evenson, K.R., Conway, T.L., Cohen, D., Ghosh-Dastidar, B., Pickrel, J.L., Veblen-Mortenson, S., Lytle, L.A., 2012. Out and about: association of the built environment with physical activity behaviors of adolescent females. Health Place 18 (1), 55–62.
Roux, A.V.D., Evenson, K.R., McGinn, A.P., Brown, D.G., Moore, L., Brines, S., Jacobs Jr, D.R., 2007. Availability of recreational resources and physical activity in adults. Am. J. Public Health 97 (3), 493–499.
Rundle, A., Quinn, J., Lovasi, G., Bader, M.D., Yousefzadeh, P., Weiss, C., Neckerman, K., 2013. Associations between body mass index and park proximity, size, cleanliness, and recreational facilities. Health Promot. 27 (4), 262–269.
Slater, S.J., Ewing, R., Powell, L.M., Chaloupka, F.J., Johnston, L.D., O'Malley, P.M., 2010. The association between community physical activity settings and youth physical activity, obesity, and body mass index. J. Adolesc. Health 47 (5), 496–503.
Slater, S.J., Nicholson, L., Chriqui, J., Barker, D.C., Chaloupka, F.J., Johnston, L.D., 2013. Walkable Communities and Adolescent Weight. Am. J. Prev. Med. 44 (2), 164–168.
Slater, S.J., Nicholson, L., Zayd, H.A., Chriqui, J.F., 2016a. Does pedestrian danger mediate the relationship between local walkability and active travel to work? Front. Public Health 4.
Slater, S., Pugach, O., Lin, W., Bontu, A., 2016b. If you build it will they come? does involving community groups in playground renovations affect park utilization and physical activity? Environ. Behav. 48 (1), 246–265.
Strong, W.B., Malina, R.M., Blimkie, C.J., Daniels, S.R., Dishman, R.K., Gutin, B., Hergenroeder, A.C., Must, A., Nixon, P.A., Pivarnik, J.M., 2005. Evidence based physical activity for school-age youth. J. Pediatr. 146 (6), 732–737.
Sugiyama, T., Francis, J., Middleton, N.J., Owen, N., Giles-Corti, B., 2010. Associations between recreational walking and attractiveness, size, and proximity of neighborhood open spaces. Am. J. Public Health 100 (9), 1752–1757.
U.S Department of Health and Human Services, 2015. Surg. General.'S. EveryBody Walk.! Initiat. 〈http://www.surgeongeneral.gov/priorities/active-living/〉.
US Department of Veterans Affairs, Health Services Research & Development Service, Information Resource Center May, 2016. VIReC Research User Guide: pssg Geocoded Enrollee Files, 2015 Edition. US Department of Veterans Affairs, Hines, IL.
Van Cauwenberg, J., Cerin, E., Timperio, A., Salmon, J., Deforche, B., Veitch, J., 2017. Is the association between park proximity and recreational physical activity among mid-older aged adults moderated by park quality and neighborhood conditions? Int. J. Environ. Res. Public Health 14 (2), 192.
Wen, M., Zhang, X., Harris, C.D., Holt, J.B., Croft, J.B., 2013. Spatial disparities in the distribution of parks and green spaces in the USA. Ann. Behav. Med. 45 (1), 18–27.
White House Task Force on ChildhoodObesity, 2010. Solving the Problem of Childhood Obesity within a Generation–Report to the President. Available: 〈http://www.letsmove.gov/obesitytaskforce.php〉 [2010, June 1].
Wolch, J., Jerrett, M., Reynolds, K., McConnell, R., Chang, R., Dahmann, N., Brady, K., Gilliland, F., Su, J.G., Berhane, K., 2011. Childhood obesity and proximity to urban parks and recreational resources: a longitudinal cohort study. Health Place 17 (1), 207–214.
Zenk, S.N., Schulz, A.J., Matthews, S.A., Odoms-Young, A., Wilbur, J., Wegrzyn, L., et al., 2011. Activity space environment and dietary and physical activity behaviors: a pilot study. Health Place 17 (5), 1150–1161.
Zenk, S.N., Tarlov, E., Wing, C., Matthews, S.A., Jones, K., Tong, H., Powell, L.M., 2017. Geographic accessibility of food outlets not associated with body mass index change among veterans, 2009–14. Health Aff. 36 (8), 1433–1442.
Zenk, S.N., Tarlov, E., Powell, L.M., Wing, C., Matthews, S.A., Slater, S., Gordon, H.S., Berbaum, M., Fitzgibbon, M.L., 2018. Weight and Veterans' environments study (waves) I and II: Rationale, methods, and cohort characteristics. Am. J. Health Promot (pp. 0890117117694448).