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Walk Score and objectively measured physical activity within a national cohort

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ABSTRACT

Background There have been mixed findings regarding the relationship between walkability and level of physical activity in adults.

Methods Participants from The REasons for Geographic and Racial Differences in Stroke (REGARDS) national cohort (N=7561) were used to examine the association between Walk Score and physical activity measured via accelerometry. The subsample included geographically diverse adults, who identified as black or white, and were over the age of 45. Linear regression was used to examine the direct effects, as well as the interaction, of Walk Score by sex, age and race.

Results The majority of participants lived in a 'Very Car-Dependent' location (N=4115). Only 527 lived in a location that was 'Very Walkable/Walker's Paradise'. Living in a location with a Walk Score of 'Very Car-Dependent' compared with 'Very Walkable/Walker's Paradise' was associated with 19% (0.81; 95% CI 0.73 to 0.90) lower predicted minutes of moderate to vigorous physical activity per day, after adjustment for covariates. There was no evidence of statistically significant interactions between Walk Score and sex, age or race (p>0.05).

Conclusion Accumulated daily time in moderate to vigorous physical activity was higher for participants living in neighbourhoods designated as 'Very Walkable/ Walker's Paradise'. This effect was not moderated by sex, age or race of participants.

INTRODUCTION

There is a large body of work examining aspects of the built environment in relation to physical activity (PA) behaviour, in particular the walkability of a neighbourhood.[1–3] The walkability of a neighbourhood is often characterised by distance to amenities, length and connectivity of streets, and availability of green space within a community.[4] Previous work has used geographical information systems (GIS) to create a walkability index surrounding a specific address.[5–12] Among these, the majority have found positive associations between GIS-derived walkability of a neighbourhood and objectively measured PA.[5–7 10–12] However, GIS-derived scores are created using many different algorithms, making comparisons across studies challenging.

Walk Score is one measure of walkability that is a publicly available tool. Walk Score was developed by professionals in urban planning and measures pedestrian friendliness through the use of multiple data sources (eg, Google).[13] The 2018 measure of Walk Score uses hundreds of walking routes to nearby amenities from a particular address.[13] This measure has consistently been found to be a valid assessment of neighbourhood walkability when compared with the gold standard of other research-based walkability indices.[14–17] Two studies have previously examined Walk Score of a neighbourhood and its association with objectively measured PA and found inconsistent results. One study reported a positive association between Walk Score and objectively measured PA while the other reported a null result.[9 18] A potential reason for this disagreement may be the demographics of the populations studied, and limitations in geographical and socioeconomic variability. Inconsistent findings of the association between Walk Score and PA may be best explained by allowing for interactions between Walk Score and demographic characteristics in order to capture potential differential associations across groups.[19]

Few studies capture objectively measured PA and objective built environment measures in large samples with significant demographic variability to investigate these moderating effects. This has limited the opportunity to observe associations between Walk Score and PA within different demographic groups. Demographic factors have been shown to influence the association between environmental characteristics and PA behaviour.[20 21] Therefore, it is important to allow for differential relationships between built environments and PA among participants with varying age, sex and race. This paper examines the heterogeneity of effects that Walk Score has on PA behaviour using a racially diverse sample over multiple ages. It is hypothesised that higher Walk Scores are associated with greater PA. Furthermore, among individuals self-identifying as black, women and those under the age of 65, the association between Walk Score and PA would be of greater magnitude than among whites, men and those over the age of 65.[20 21]

METHODS

Study population

Participants were drawn from the REasons for Geographic and Racial Differences in Stroke (REGARDS) cohort. REGARDS is a prospective closed cohort study investigating the risk factors associated with incident stroke.[22] Potential participants were randomly selected from a commercially available national list; black participants and those living in the stroke belt (states of AL, AR, GA, LA, MS, NC, SC and TN) were oversampled due to their higher stroke mortality.[22] Participants

Table 1 Participant characteristics, REasons for Geographic and Racial Differences in Stroke, M (SD) or N (%)

	Overall	Very Car-Dependent	Car-Dependent	Somewhat Walkable	Very Walkable/Walker's Paradise	P value*
	(n=7561)	(n=4115)	(n=1892)	(n=1027)	(n=527)	
	M (SD)/%	M (SD)/%	M (SD)/%	M (SD)/%	M (SD)/%	
Age (years)	63.4 (8.5)	63.1 (8.3)	64.0 (8.7)	63.6 (8.8)	63.7 (8.8)	<0.0001
Sex						0.0196
Male	45.4	47.1	46.3	40.3	38.0	
Female	54.6	52.9	53.7	59.7	62.0	
Neighbourhood SES						<0.0001
High neighbourhood SES	33.3	37.0	32.0	24.1	27.1	
Mid neighbourhood SES	33.4	33.5	32.0	34.6	34.7	
Low neighbourhood SES	33.3	29.5	32.0	41.3	38.1	
Race						<0.0001
White	68.5	79.0	62.5	51.7	41.6	
Black	31.5	21.0	37.5	48.3	58.4	
Region						<0.0001
Non-Belt	45.2	32.4	51.7	63.7	85.8	
Belt	54.8	67.6	48.3	36.3	14.2	
Education						0.0002
College graduate and above	45.0	45.7	42.9	44.2	48.4	
Some college	26.6	26.3	27.2	28.0	23.0	
High school graduate	22.4	22.5	23.3	21.0	20.9	
Less than high school	6.1	5.4	6.7	6.7	7.8	
Income						<0.0001
US$75k and above	22.3	24.3	20.1	19.9	19.7	
US$35k–US$74k	35.1	36.8	33.9	32.9	30.0	
US$20k–US$34k	21.9	20.2	23.4	24.4	24.5	
Less than US$20k	10.7	8.5	12.4	13.7	15.6	
Refused	10.0	10.2	10.2	9.1	10.2	
Marital status						<0.0001
Married	67.1	75.7	61.8	54.0	43.6	
Single	1.7	2.5	5.2	6.8	15.4	
Divorced	12.7	9.1	15.3	18.2	21.1	
Widowed	13.9	11.7	16.1	17.9	15.0	
Other	4.7	1.0	1.5	3.0	4.9	
Self-rated health						0.0057
Excellent	22.3	23.5	21.4	18.9	22.0	
Very good	36.3	38.2	33.7	34.9	33.4	
Good	31.9	29.5	35.0	34.2	34.7	
Fair	8.3	7.4	9.1	10.7	8.2	
Poor	1.2	1.4	0.8	1.4	1.7	
Urban group						<0.0001
Urban	72.6	54.8	91.4	95.8	100.0	
Mixed	12.7	19.9	5.5	3.8	0.0	
Rural	14.6	25.4	3.1	0.4	0.0	
Body mass index†						0.2598
Underweight	0.9	1.0	1.0	0.6	1.1	
Normal	26.4	26.9	26.3	25.0	26.0	
Overweight	38.9	40.3	37.4	37.2	36.2	
Obese	33.8	31.9	35.4	37.2	36.6	
Moderate to vigorous physical activity (min/day)‡	13.6 (17.9)	14.2 (17.8)	12.4 (17.3)	12.2 (17.4)	15.7 (21.3)	<0.0001
Total physical activity (min/day)§	204.1 (85.6)	212.7 (85.2)	198.0 (87.6)	188.8 (84.5)	188.2 (89.6)	<0.0001

*P value from χ^2 test for categorical variables and a one-way ANOVA for continuous variables.
†Normal weight: 18.5–24.9 kg/m^2; overweight: 25.0–29.9 kg/m^2; obese: >30.0 kg/m^2.
‡All accumulated activity counts greater than 1065 cpm.
§All accumulated activity counts greater than 50 cpm.
SES, socioeconomic status.

Table 2 Multiple linear regression analysis examining the relationship between Walk Score and log-transformed moderate to vigorous physical activity adjusted for demographic and area-level characteristics

	B (SE)	P value
Intercept	3.31 (0.06)	<0.0001
Walk Score		
Very Walkable/Walker's Paradise	0	.
Somewhat Walkable	−0.22 (0.05)	<0.0001
Car-Dependent	−0.22 (0.05)	<0.0001
Very Car-Dependent	−0.21 (0.05)	<0.0001
Age (years)*	−0.06 (0)	<0.0001
Sex		
Male	0	.
Female	−0.41 (0.02)	<0.0001
Neighbourhood SES		
High neighbourhood SES	0	–
Mid neighbourhood SES	−0.18 (0.03)	<0.0001
Low neighbourhood SES	−0.25 (0.03)	<0.0001
Race		
White	0	–
Black	−0.12 (0.03)	<0.0001
Region		
Non-Belt	0	–
Belt	−0.02 (0.03)	0.3465
Education		
College graduate and above	0	–
Some college	−0.17 (0.03)	<0.0001
High school graduate	−0.19 (0.03)	<0.0001
Less than high school	−0.16 (0.05)	0.0036
Income		
US$75k and above	0	–
US$35k–US$74k	−0.17 (0.03)	<0.0001
US$20k–US$34k	−0.27 (0.04)	<0.0001
Less than US$20k	−0.51 (0.05)	<0.0001
Refused	−0.21 (0.05)	<0.0001
Marital status		
Married	0	–
Single	0.12 (0.06)	0.0307
Divorced	0 (0.04)	0.9263
Widowed	0.03 (0.04)	0.374
Other	0.01 (0.09)	0.9523
Self-rated health		
Excellent	0	–
Very good	−0.23 (0.03)	<0.0001
Good	−0.48 (0.03)	<0.0001
Fair	−0.64 (0.05)	<0.0001
Poor	−0.88 (0.11)	<0.0001
Urban group		
Urban	0	–
Mixed	0.05 (0.04)	0.1481
Rural	0.05 (0.04)	0.1593
Body mass index†		
Normal	0	–
Underweight	−0.24 (0.12)	0.046
Overweight	−0.18 (0.03)	<0.0001
Obese	−0.5 (0.03)	<0.0001

*Age centred at age 65 years.
†Normal weight: 18.5–24.9 kg/m^2; overweight: 25.0–29.9 kg/m^2; obese: >30.0 kg/m^2.
SES, socioeconomic status.

were recruited from the commercially available national list via mass mailing between January 2003 and October 2007 and are being followed by telephone every 6 months for incident medical events. Participants in the study met the following inclusion criteria: over the age of 45 years, self-identified as black or white, no recent history of a cancer diagnosis that required chemotherapy, English speaker and not on a waiting list to enter a nursing home.[22]

After verbal consent, study participants completed a computer-assisted telephone interview where demographic and medical information was obtained. Three to 4 weeks after the telephone interview, health professionals from the Examination Management Services, Inc. completed an in-home physical examination with study participants.[22 23] A total of 30 239 participants completed the initial interview and home visit.[22] The final sample comprised 56% from stroke belt, 42% black and 55% women.[22] Written informed consent was obtained at the in-home visit and the study was approved by all participating Institutional Review Boards.

From May 2009 to January 2013, screening and enrollment for an ancillary REGARDS study collecting accelerometry data was undertaken. Participants were eligible for the ancillary study if they were enrolled in REGARDS and answered 'yes' to the question "on a typical day, are you physically able to go outside where you live and walk, whether or not you actually do?" Eligible participants (N=20 076) were invited to participate, of whom 12 146 (60.5%) consented and enrolled in the ancillary study. After accounting for lost, defective or non-worn devices (n=2173), and excluding participants with device errors, missing log sheets or non-compliant wear time (n=1877), usable data were available from 8096 participants. Previous work has compared those in the accelerometer substudy with those who declined participation and those who consented to participate and did not provide usable data.[24] Participants included in the accelerometry study were of higher socioeconomic status than those excluded, but were clinically similar in other demographic characteristics such as age, body mass index (BMI) and self-rated health.[25] Among the 8096 participants, 43.97% were over the age of 65, 31.61% were black and 54.17% were women. Additional details on study design, sampling strategy, recruitment and study procedures have been previously described.[22 23 25]

Physical activity

Objective measures of PA were captured using the Actical accelerometer. Participants were asked to place the accelerometer over their right hip and complete a daily wear log indicating when the device was taken off for water activities or sleep. All Actical devices were staff initialised to collect data in 60 s epochs. Participants were classified as having usable accelerometer data if (1) device was worn for >10 hours per day on at least 4 days of the week, (2) legible dates and times were available from the daily wear logs, and (3) self-reported wear dates corresponded with valid Actical data. Activity cut-points of 1065 cpm and 50

Table 3 Multiple linear regression analysis examining the interaction between Walk Score and gender, Walk Score and age, Walk Score and race, and their effect on log-transformed moderate to vigorous physical activity adjusted for demographic and area-level characteristics

	Model 1*		Model 2*		Model 3*		Model 4*	
	B (SE)	P value	B (SE)	P value	B (SE)	P value	B (SE)	P value
Walk Score								
Very Walkable/Walker's Paradise	Ref	–	Ref	–	Ref	–	Ref	–
Somewhat Walkable	−0.2 (0.06)	0.0003	−0.18 (0.09)	0.04	−0.19 (0.07)	0.013	−0.27 (0.08)	0.0012
Car-Dependent	−0.2 (0.05)	0.0001	−0.2 (0.08)	0.0171	−0.13 (0.07)	0.0532	−0.28 (0.08)	0.0003
Very Car-Dependent	−0.19 (0.05)	0.0005	−0.15 (0.08)	0.0596	−0.18 (0.07)	0.0066	−0.27 (0.08)	0.0004
Female	−0.35 (0.03)	<0.0001	−0.31 (0.09)	0.0008	−0.35 (0.03)	<0.0001	−0.35 (0.03)	<0.0001
Age 65+ years	−0.8 (0.03)	<0.0001	−0.81 (0.03)	<0.0001	−0.77 (0.09)	<0.0001	−0.81 (0.03)	<0.0001
Black	−0.1 (0.03)	0.0011	−0.09 (0.03)	0.0021	−0.09 (0.03)	0.0026	−0.23 (0.09)	0.0143
Female×Somewhat Walkable	–	–	−0.02 (0.11)	0.8775	–	–	–	–
Female×Car-Dependent	–	–	0 (0.1)	0.9621	–	–	–	–
Female×Very Car-Dependent	–	–	−0.06 (0.1)	0.5563	–	–	–	–
Age 65+ years×Somewhat Walkable	–	–	–	–	−0.02 (0.11)	0.8316	–	–
Age 65+ years×Car-Dependent	–	–	–	–	−0.15 (0.1)	0.1541	–	–
Age 65+ years×Very Car-Dependent	–	–	–	–	0 (0.1)	0.9892	–	–
Black×Somewhat Walkable	–	–	–	–	–	–	0.13 (0.11)	0.2438
Black×Car-Dependent	–	–	–	–	–	–	0.13 (0.1)	0.2034
Black×Very Car-Dependent	–	–	–	–	–	–	0.17 (0.1)	0.0987

*Models adjusted for neighbourhood socioeconomic status, race, region, education, income, relationship status, self-rated health, urban group and body mass index.

cpm were used to indicate moderate to vigorous PA (MVPA) and total PA (light, moderate and vigorous PA), respectively.[23 26] Daily minutes in MPVA and total PA were summed across valid wear days and divided by the number of valid days to compute the average daily minutes of MVPA and total PA.

Walk Score

Walk Score calculates neighbourhood walkability using a proprietary algorithm. The Walk Score algorithm analyses hundreds of walking routes from a specific address to nearby amenities within the neighbourhood (eg, restaurants, parks, schools), weighted based on the network distance to each amenity.[13] To obtain each participant's Walk Score, his/her baseline geocoded address was used, based on neighbourhood attributes in the year 2018. Walk Score captures pedestrian friendliness surrounding a particular address to provide a score ranging from 0 to 100, where higher scores are indicative of more walkable areas.[13] Amenities within a 5 min walk (0.25 mi) are given the maximum number of points. A decay function is used to give points to more distant amenities, with no points given after a 30 min walk. Walk Score was categorised into four groups where 0–24.9 represents 'Very Car-Dependent', 25–49.9 represents 'Car-Dependent', 50–69.9 represents 'Somewhat Walkable' and 70–100 represents 'Very Walkable/Walker's Paradise'.[13]

Demographic characteristics

Age, race, sex, marital status, annual household income, education level and self-rated health were classified according to self-report. Neighbourhood socioeconomic status (nSES) and urbanicity were calculated at the census tract for the 2000 US Census. A summary of nSES was created using six items representing wealth/income, education and occupation.[27] Urban group is defined as the size of census tract where the participant lived, where rural is defined as ≤25% urban, mixed is defined as >25% and<75% urban, and urban is ≥75% urban. The region in which a participant lived was dichotomised as within the stroke belt region or not. Lastly, BMI was calculated from height and weight measured during the in-home examination.

Statistical analysis

All participants included in the current study analysis needed to have usable accelerometer data, a calculated Walk Score, not suffered a stroke prior to accelerometry data collection and all demographic variables of interest. Differences in demographic characteristics and MVPA or total PA across the four Walk Score groups were examined using ANOVA χ^2 tests. Mean MVPA had a right skewed distribution; therefore, MVPA was log transformed for use in regression models. Linear regression models were used to estimate the association between Walk Score and log-transformed mean MVPA and mean total PA while adjusting for demographic characteristics. All models were adjusted for age (centred at age 65), sex, nSES, race, region, education, income, marital status, self-rated health, urbanicity and BMI. Separate linear regression models were used to investigate the interaction effects of categorical age (<65 years, ≥65 years), sex and race on the association between Walk Score and log-transformed MVPA or mean total PA. Statistical significance was assessed with a two-tailed alpha of p value <0.05, and all analyses were conducted using SAS V.9.4 (SAS Institute, Cary, North Carolina, USA).

RESULTS

Of the 8096 participants with useable accelerometer data, 131 were missing covariates of interest, 399 had a stroke prior to obtaining accelerometer data and 5 were missing Walk Score information. This resulted in a total of 7561 participants eligible for the current study.

Age of participants ranged from 45 to 94 years, with a mean of 63.4 years. As shown in table 1, more than half (54.6%) of the sample were women, with the proportion of women increasing as the neighbourhood became more walkable. Approximately one-third (31.5%) of the sample was black, and with increasing

Table 4 Multiple linear regression analysis examining the relationship between Walk Score and total physical activity (light physical activity, moderate physical activity and vigorous physical activity) adjusted for demographic and area-level characteristics

	B (SE)	P value
Intercept	230.77 (4.32)	<0.0001
Walk Score		
Very Walkable/Walker's Paradise	0	–
Somewhat Walkable	−0.79 (4.01)	0.843
Car-Dependent	6.09 (3.76)	0.1051
Very Car-Dependent	7.84 (3.79)	0.0385
Age (years)*	−4.52 (0.11)	<0.0001
Sex		
Male	0	–
Female	−6.07 (1.85)	0.0011
Neighbourhood SES		
High neighbourhood SES	0	–
Mid neighbourhood SES	−4.55 (2.23)	0.0409
Low neighbourhood SES	−3.86 (2.53)	0.126
Race		
White	0	–
Black	−5.42 (2.16)	0.012
Region		
Non-Belt	0	–
Belt	0.09 (1.92)	0.9644
Education		
College graduate and above	0	–
Some college	2.99 (2.18)	0.1703
High school graduate	7.63 (2.42)	0.0016
Less than high school	5.2 (4.04)	0.1983
Income		
US$75k and above	0	–
US$35k–US$74k	−1.1 (2.43)	0.6504
US$20k–US$34k	−6.65 (2.95)	0.0241
Less than US$20k	−23.16 (3.86)	<0.0001
Refused	−4.88 (3.45)	0.1577
Marital status		
Married	0	–
Single	−5.49 (4.28)	0.199
Divorced	−8.82 (2.79)	0.0016
Widowed	−6.54 (2.82)	0.0203
Other	4.26 (6.79)	0.53
Self-rated health		
Excellent	0	–
Very good	−11.39 (2.31)	<0.0001
Good	−23.69 (2.47)	<0.0001
Fair	−33.13 (3.65)	<0.0001
Poor	−54.11 (7.98)	<0.0001
Urban group		
Urban	0	–
Mixed	10.2 (2.78)	0.0002
Rural	10.92 (2.8)	<0.0001
Body mass index†		
Normal	0	–
Underweight	−3.7 (9)	0.6815
Overweight	−10.45 (2.17)	<0.0001
Obese	−33.22 (2.33)	<0.0001

*Age centred at age 65 years.
†Normal weight: 18.5–24.9 kg/m^2; overweight: 25.0–29.9 kg/m^2; obese: >30.0 kg/m^2.
SES, socioeconomic status.

neighbourhood walkability the percentage of black participants increased. On average, participants accumulated 13.6 (SD 17.9) min of MVPA each day. MVPA accumulation had a 'U'-shaped relationship with neighbourhood walkability in bivariate associations.

There were significantly (p<0.0001) lower levels of accumulated time in MVPA for those living in 'Somewhat Walkable', 'Car-Dependent' and 'Very Car-Dependent' neighbourhoods in comparison with those living in 'Very Walkable/Walker's Paradise', adjusted for all other covariates (table 2). Using the beta coefficient for each Walk Score category, the percentage change in accumulated daily time in MVPA was calculated by raising each coefficient to a power of *e* (~2.72). Accumulated daily time in MVPA was predicted to be 20% lower (0.80; 95% CI 0.72 to 0.89) for those living in 'Somewhat Walkable' neighbourhoods compared with 'Very Walkable/Walker's Paradise' neighbourhoods, independent of covariates. Living in a neighbourhood with a Walk Score of 'Car-Dependent' and 'Very Car-Dependent' was associated with 20% (0.80; 95% CI 0.73 to 0.89) and 19% (0.81; 95% CI 0.73 to 0.90) lower predicted minutes of MVPA per day, respectively, after adjustment for all other covariates. There was no evidence of statistical interactions between Walk Score and sex, age or race (table 3).

There were significantly (p=0.0385) higher levels of accumulated time in total PA for those living in 'Very Car-Dependent' neighbourhoods in comparison with those living in 'Very Walkable/Walker's Paradise', adjusted for all other covariates (table 4). Daily minutes of total PA was predicted to be on average 7.84 higher for those living in 'Very Car-Dependent' neighbourhoods compared with 'Very Walkable/Walker's Paradise' neighbourhoods, independent of covariates. Living in a neighbourhood with a Walk Score of 'Somewhat Walkable' and 'Car-Dependent' was not significantly associated with average daily minutes of total PA.

As shown in table 5, there was no evidence of statistical interactions between Walk Score and sex, age or race.

DISCUSSION

The overall objective of this study was to examine the association between composite neighbourhood walkability and objectively measured PA in a diverse sample. This study showed that accumulated daily MVPA was greatest for participants living in 'Very Walkable/Walker's Paradise' neighbourhoods. The relationship between neighbourhood walkability and accumulated daily MVPA remained after further adjustment for demographic characteristics, nSES and urbanicity. However, there was no evidence of a differential relationship between Walk Score and MVPA between men and women, blacks and whites, or those older or younger than 65 years of age, as was hypothesised. Conversely, when examining the association between Walk Score and total PA, there appears to be an inverse association, where decreased walkability is associated with an increase in mean total PA. This may be because total PA captures movement occurring

Table 5 Multiple linear regression analysis examining the interaction between Walk Score and gender, Walk Score and age, Walk Score and race, and their effect on total physical activity (light physical activity, moderate physical activity and vigorous physical activity) adjusted for demographic and area-level characteristics

	Model 1*		Model 2*		Model 3*		Model 4*	
	B (SE)	P value	B (SE)	P value	B (SE)	P value	B (SE)	P value
Walk Score								
Very Walkable/Walker's Paradise	Ref	–	Ref	–	Ref	–	Ref	–
Somewhat Walkable	3.74 (3.82)	0.3267	0.13 (6.06)	0.9824	1.95 (5.04)	0.6991	0.34 (5.67)	0.9523
Car-Dependent	10.98 (3.58)	0.0022	6.64 (5.54)	0.2312	11.31 (4.7)	0.016	3.88 (5.23)	0.4575
Very Car-Dependent	13.14 (3.61)	0.0003	11.51 (5.39)	0.0328	8.9 (4.59)	0.0523	7.02 (5.11)	0.1695
Female	2.97 (1.76)	0.0911	−0.85 (6.35)	0.8932	3.7 (1.75)	0.0346	3.63 (1.75)	0.0379
Age 65+ years	−49.8 (1.76)	<0.0001	−50.9 (1.76)	<0.0001	−57.12 (6.21)	<0.0001	−50.7 (1.76)	<0.0001
Black	−2.3 (2.05)	0.2621	−1.72 (2.05)	0.4005	−1.52 (2.05)	0.4582	−12.18 (6.31)	0.0535
Female×Somewhat Walkable	–	–	7.04 (7.72)	0.3622	–	–	–	–
Female×Car-Dependent	–	–	7.71 (7.09)	0.2769	–	–	–	–
Female×Very Car-Dependent	–	–	2.72 (6.69)	0.6838	–	–	–	–
Age 65+ years×Somewhat Walkable	–	–	–	–	5.64 (7.57)	0.4567	–	–
Age 65+ years×Car-Dependent	–	–	–	–	−0.06 (6.96)	0.9935	–	–
Age 65+ years×Very Car-Dependent	–	–	–	–	10.21 (6.56)	0.1197	–	–
Black×Somewhat Walkable	–	–	–	–	–	–	6.39 (7.62)	0.4016
Black×Car-Dependent	–	–	–	–	–	–	13.75 (7.08)	0.0522
Black×Very Car-Dependent	–	–	–	–	–	–	11.92 (6.85)	0.0817

*Models adjusted for neighbourhood socioeconomic status, race, region, education, income, relationship status, self-rated health, urban group and body mass index.

throughout the day which is more likely to be indoors (eg, light housework, occupational activities) and therefore may not be influenced by the built environment.

This study's findings are inconsistent with previous research finding no direct association between neighbourhood walkability and individual walking behaviour.[9 28] For example, Hajna *et al* found no association between Walk Score and daily steps among Canadian adults.[9] This may, in part, be due to the heterogeneity of neighbourhood design across countries and the limited ability of Walk Score to capture the within and between variability of spatial networks.[29] Additionally, longitudinal work completed by Brawn *et al* found no association between change in walkability, following residential relocation and self-reported walking.[30] Disagreement may be due to the differences in measurement of walking behaviour. Within Brawn *et al*, participants self-reported walking behaviour over the past 12 months, whereas in the current study PA was assessed through accelerometry.[31]

Findings from the current study also conflict with previous research that has reported neighbourhood walkability has a differential relationship on MVPA depending on sex and age of the participant.[20 21] Differences across studies may be due to study sample and measurement of environmental constructs. Within Richardson *et al*, participants were recruited from a single US city, where participants predominately self-identified as black (92%) and were less than 65 years of age (68%).[20] Van Dyck *et al* used a measure that collected built environment perceptions from participants.[21] Perceptions of built environments likely capture a different construct than Walk Score and may not be representative of the true physical environment surrounding study participants. Although these two studies contradict the current study findings, a systematic review concluded there was no evidence to suggest the association between built environmental characteristics and PA behaviour is different between men and women.[32]

Despite the disagreement discussed above, several studies have found a positive association between walkability and PA behaviour. Among these studies, a number have found evidence of a positive association between walkability of a neighbourhood and accumulated MVPA.[5 10 18 33] In addition, our findings are in agreement with research using self-reported PA levels.[2] Notably, our findings echo those from the Multi-Ethnic Study of Atherosclerosis (MESA), which used self-report measures of PA.[34] Using data from six cities across the USA, of different race-ethnic groups (41.1% white, 11.6% non-Hispanic Chinese, 26.3% non-Hispanic black, 21.0% Hispanic), the results suggested that a higher Walk Score was associated with lower odds of not walking for transport and with more minutes per week of transport walking among study participants.[34] The current study complements the MESA investigation, with REGARDS having greater variation in participants' geographical location and capturing objectively measured PA levels through accelerometry.[34] Lastly, our findings are in agreement with results from a longitudinal study examining the association between Walk Score and utilitarian walking.[35] Wasfi *et al* found that moderate utilitarian walking increased over the study period and was moderated by neighbourhood walkability, where those living in more walkable neighbourhoods had larger increases in moderate utilitarian walking.[35] This study, along with previous research, provides convincing evidence that the walkability of a neighbourhood is positively associated with PA behaviour.

There are many strengths to our study. This study used accelerometer data from a diverse sample of individuals across the continental USA, and participants within this sample had great variability in terms of socioeconomic status, urban and rural environment, age and sex. Therefore, this study was well suited to examine differential relationships between the built environment and PA among demographic groups. Other major strengths include a large sample size, the use of software that is publicly available for locations across the nation to characterise neighbourhood walkability, and inclusion of both black and white participants. These data also included a wide range of neighbourhoods and used measured height and weight to calculate BMI. However, there are also some limitations. Due to the temporality of data collection, there is no inference of causality between neighbourhood walkability and MVPA or total PA. Participants within the study provided PA data from 2009 to 2013, while Walk Score of a participant's neighbourhood was captured in 2018 based on their baseline address. Participants were instructed to wear the Actical device for all waking hours, but currently a 24-hour wear protocol is the standard practice.[25] It is possible that our minimum wear time criteria, which was set at 10 hours, may have resulted in measurement error in our PA measure, although the average wear time for participants in this study was 15 hours.[24 25 36] There may be other important unmeasured variables, such as neighbourhood crime or safety, which were not accounted for in our analysis. In addition, PA captured via accelerometry does not provide information on the form of activity undertaken (eg, participation in sports, walking on a treadmill vs outdoor environment), thus future studies that objectively measure form and location of PA can further specify the degree of association between Walk Score and specific types of PA. Lastly, our study results are limited in external validity. Participants included in the current study may not be representative of the full REGARDS cohort or of the whole US population. Therefore, our study is limited in its generalisability to only black and white adults over the age of 45 years who agreed to participate and provided usable accelerometer data.

In this national study of black and white older adults across the USA, increased Walk Score was associated with greater amounts of accumulated time in MVPA, for both men and women, blacks and whites, and across age groups. Increasing the walkability of the environment may facilitate higher levels of MVPA of residents. Future research should examine the influence that non–home-based environmental features have on accumulated MVPA and whether this association holds in populations outside of the USA.

What is already known on this subject?

- The association between neighbourhood environments and physical activity has been well studied.
- The majority of studies within this area have found a positive association between geographical information systems–derived walkability of a neighbourhood and objectively measured physical activity.
- To date, most studies have had limited geographical and demographic variability to explore moderating effects on this relationship.

What this study adds?

- This study found that Walk Score had a positive association with accumulated daily time spent in moderate to vigorous physical activity.
- There was no evidence of this association changing by sex, race or age within a national sample.

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