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Determinants of Walkability in Meeting Physical Activity Recommendations-An NHIS Study

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Determinants of Walkability in Meeting Physical Activity Recommendations-An NHIS Study

Abstract:

Objectives: To investigate which perceived neighborhood characteristics are most strongly linked with adequate physical activity (PA) in a nationally-representative sample of adults in the United States.

Design: Cross-sectional

Setting: United States via 2015 National Health Interview Survey Data.

Participants: A group of 28,703 non-institutionalized adults with complete data.

Primary Outcome Measures: Meeting PA was defined as 150 min/week of moderate to vigorous activity.

Results: The population had a mean age of 49.6(±18.3) years and was 51.3% female and 66.1% non-Hispanic white. In adjusted, weighted analysis, places to walk and relax was mostly strongly associated with meeting PA recommendations (OR=1.49[95%CI 1.36-1.63]). Other elements associated with meeting PA were bus or transit stops to walk to, movies, libraries or churches, and absence of crime causing safety concern (OR=1.11[95% CI 1.01-1.21], OR=1.20[95% CI 1.09-1.31], and OR=1.14[95%CI 1.00-1.29], respectively).

Conclusions: In this analysis, the characteristic most strongly associated with PA was presence of places to walk and relax. Identifying communities that may lack amenities such as this, like a park, may help direct community investment to enhance structures that encourage activity.

Key Words: Epidemiology, Exercise, Built Environment, Neighborhood

Strengths and Limitations of this study

- This study includes a large, nationally-representative sample of adults living in the United States.
- This study contained high quality data on physical activity.
- This study was limited by its cross-sectional nature.
- This study is limited as location and type of physical activity cannot be delineated by the standardized questions in the data set.

INTRODUCTION:

Many Americans do not meet physical activity recommendations of 150 minutes per week of moderate to vigorous physical activity (PA).[1][2] Sedentary lifestyle is associated with a myriad of health problems, including obesity, cardiovascular disease, diabetes, and osteoarthritis[3-6]. Increasingly the built environment, such as access to sidewalks, crime rates, public transit, have been identified as contributors to meeting PA recommendations.[7] A measure of built environment that contributes to PA is 'walkability'.

Walkability has been shown to be associated with likelihood of PA.[8] When determined objectively, walkability is measured as street connectivity, land use mix, crime rates, and population density through geospatial information systems (GIS) techniques.[9] For instance, greater presence of green spaces has been associated with increased PA.[8] In one longitudinal study, walkable destinations, street connectivity, and increased housing density were associated with greater gains in PA over time.[10] However, there is some evidence that perceived walkability may be more influential on activity than objectively measured elements.[11] In particular, Jack and McCormack found that around 30% of their respondents who lived in objectively determined highly walkable areas felt their neighborhood was not walkable. Existing research on perceived environmental barriers to walking has been limited by relatively small sample sizes, restricted geographic areas, and existing studies may not generalize to the United States.[7] In 2015, the National Health Interview Survey (NHIS) introduced walkability questions. Research studies of these items have yet to link responses to walkability to meeting PA recommendations.[12]

To overcome limitations of existing research, we determined which elements of perceived walkability are most highly associated with meeting PA recommendations in a nationally representative sample of US adults.

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METHODS:

Study Population: This cross-sectional study used self-reported data from the 2015 National Health Interview Survey (NHIS), which are collected through an in-person survey by trained representatives from the United States (US) Census Bureau. The NHIS is an annual population-based survey of the civilian, non-institutionalized US population used to monitor disease prevalence and disability as well as track progress towards goals stated by the Department of Health and Human Services. After applying sampling weights, the sample is representative of the US non-institutionalized population. The annual response rate for 2015 was 70.1% of eligible households.[13] Eligible participants for this analysis were at least 18 years old, had no missing data on walkability questions, physical activity outcomes, and demographic data (n=28703). Complete case analysis was undertaken to minimize bias. See Figure 1 for Flow of Inclusion.

Exposures of Interest-Perceiving Walkability and Safety Barriers to Walking: Perceived walkability and safety barriers were ascertained from nine questions pertaining to the participants' feelings about their neighborhood. These questions centered on destinations to which participants could walk, as well as amenities to allow for walking and safety, specifically asking about walking (see Table 1). These questions were answered as either "yes" or "no, with safety questions reverse-coded for negative answers as "1" and positive answers at "0". Coding for walkability questions ensured that perceptions of higher walkability were coded positively (i.e. as "1").

Table 1. Content of questions for walkability and social cohesion.

Walkability "Where you live…"
"…are there roads, sidewalks, paths or trails where you can walk?"
"…are there shops, stores, or markets that you can walk to?"
"…are there bus or transit stops that you can walk to?"
"…are there places like movies, libraries, or churches that you can walk to?"
"…are there places that you can walk to that help you relax, clear your mind, and reduce stress?"
"…do most streets have sidewalks?"
Social Cohesion "How much do you agree with the following statements about your neighborhood?"
"People in this neighborhood can be trusted."
"People in this neighborhood help each other out."
"This is a close-knit neighborhood."
"There are people I can count on in this neighborhood."

Outcome of Interest: Meeting physical activity recommendations was evaluated via a series of questions regarding participants' activity. Questions used to measure PA are shown in Appendix A. The duration spent in each level of activity was summed to measure amount of PA per week. No data are available on the means by which the participant is active.

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The sum was then converted into a bivariate variable of either meeting physical activity recommendations or not. Participants were categorized as meeting PA recommendations if they had greater than or equal to 150 minutes of PA/week and as not meeting if they had less than 150 minutes. The questions in the NHIS data reliably measure physical activity.[14]

Covariates: All covariates were previously found to be associated with the likelihood of meeting PA recommendations.[15-21] Covariates were self-reported and included gender, age (18-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years and ≥75), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic/Latino, or Other), household highest educational attainment (≤high school diploma/GED, > high school to bachelors, and post-bachelor advanced degree), household income-to-poverty threshold ratio (<1.00, 1.00 to 1.99, 2.00 to 2.99, 3.00 to 3.99, and ≥4.00), marital status (never married, widowed/separated/divorced, and married/living with partner), social cohesion, psychological distress measured through the K6, weather as a barrier to walking, and length of time living in the neighborhood. Perceived social cohesion was based on four questions regarding the social nature of the neighborhood (see Table 1). These questions were answered on a Likert scale ranging from "strongly agree" (1) to "strongly disagree" (4). Answers were tallied up with a maximum score of 16 (low social cohesion) and minimum score of four (high social cohesion). These totals were then categorized at a median split within the entire participant population to Low and High social cohesion. The use of these questions in this manner was previously described by Yi et al in a national sample of NHIS participants.[22] Internal validity was assessed via Cronbach's Alpha. A value of 0.893 was determined, supporting high internal validity. Psychological distress was measured via the K6 instrument, a validated questionnaire comprised of 6 questions regarding psychological symptoms in the 30 days previous to administration. The K6 was categorized as Low or High based on established cutoffs.[23] A single question asked how frequently weather served as a barrier to walking. The answers were categorized as never, a little or some of the time, most or all of the time. Length of residence in the neighborhood was included in the statistical models as this may affect the knowledge a participant has about their neighborhood, or the opportunity to interact with neighbors. Length of time was categorized as less than 1 year, 1-3 years, 4-10 years, 11-20 years, and greater than 20 years.

Patient and Public Involvement: There was no patient or public involvement in the development or design of the study.

Analysis: All analyses take into account the complex sampling scheme by accounting for clustering, stratification, and final sampling weight. Analysis of the included subpopulation

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utilized a Domain Statement to preserve integrity of the weights[24]. No cases were eliminated from the sample. Analyses were coded with SAS v9.4 (SAS Institute, Cary, NC) using an alpha of 0.05.

Overall observed frequencies and weighted prevalence estimates for walkability, PA, and covariates were calculated. Bivariate analyses using chi-square tests assessed the association of each covariate as well as each walkability question with meeting PA recommendations. Additionally, for each walkability question, standardized mean difference (SMD) was used as an effect size measure. SMD is a measure of distance or imbalance between two group means or prevalence estimates.[25] For walkability questions, a SMD of greater than 10 was used as the criterion for inclusion in the adjusted logistic regression model.[26] To assess for any relationships and/or multi-collinearity among walkability questions, variance inflation factor and diagnostics were run with VIF >10 indicating multi-collinearity.[27] A fully adjusted logistic regression model included each walkability question with SMD >10 and all covariates to calculate odds ratios and 95% confidence intervals.

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RESULTS:

Demographics: The final unweighted analytic sample included 28,703 participants. The average age was 49.6 years (SD=18.3). The study population was 51.3% female and 66.1% non-Hispanic white. Among this study population, 48.9% (n=13528, 95%CI 48.0-49.7) met PA recommendations.

Univariate Analysis of Demographics and Covariates with Activity: Chi-squared analysis revealed that age, sex, race/ethnicity, level of education, marital status, ratio household income to poverty threshold, perceived social cohesion, K6 psychological distress measure, weather, and time in neighborhood were all significantly associated with whether participants met PA recommendations (all p<0.0001) (Table 2).

Table 2. Descriptive analysis of included population and univariate associations with physical activity

Variable	Overall, n=28703 (%)	Meeting Physical Activity, n=13528 (%)	Not Meeting Physical Activity, n=15175 (%)	p-value
Age				<0.0001
18-44 yrs	12100 (47.1%)	6780 (54.3%)	5320 (40.37%)	
45-64 yrs	9657 (34.4%)	4303 (31.9%)	5354 (36.8%)	
65+ yrs	6946 (18.5%)	2445 (13.9%)	4501 (22.8%)	
Sex				<0.0001
Female	15754 (51.3%)	6898 (48.0%)	8856 (54.5%)	
Male	12949 (48.7%)	6630 (52.0%)	6319 (45.5%)	
Race/Ethnicity				<0.0001
Non-Hispanic White	18152 (66.1%)	9044 (68.6%)	9108 (63.8%)	
Non-Hispanic Black	3836 (11.9%)	1514 (10.3%)	2322 (13.4%)	
Other	1866 (6.2%)	939 (6.64%)	927 (5.82%)	
Hispanic	4849 (15.7%)	2031 (14.4%)	2818 (17.0%)	
Level of Education				<0.0001
HS Diploma/GED or Less	8627 (25.0%)	2787 (17.1%)	5840 (32.6%)	
Some College-AA/Bachelors	15471 (56.3%)	7778 (58.4%)	7693 (54.3%)	
Masters, Professional, Doctoral	4605 (18.7%)	2963 (24.4%)	1642 (13.1%)	
Marital Status				<0.0001
Married/Living with Partner	14432 (60.4%)	7064 (61.5%)	7368 (59.4%)	
Widowed/Divorced/Separated	7652 (17.4%)	2898 (13.5%)	4754 (21.1%)	
Never Married	6619 (22.1%)	3566 (25.0%)	3053 (19.4%)	
Ratio Household Income to Poverty Threshold				<0.0001
<1.00	4596 (13.0%)	1632 (9.78%)	2964 (14.9%)	
1.00-1.99	6035 (18.7%)	2199 (14.1%)	3836 (23.1%)	
2.00-3.99	8268 (28.8%)	3854 (27.2%)	4414 (30.2%)	
4.00 or More	9804 (40.1%)	5843 (48.9%)	3961 (31.8%)	

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Social Cohesion			<0.0001
Low	9856 (33.7%)	4263 (30.4%)	5593 (36.9%)
High	18847 (65.4%)	9265 (69.6%)	9582 (63.1%)
K6 Psychological Distress			<0.0001
Distressed	1656 (5.6%)	471 (3.44%)	1185 (7.62%)
No Distress	27407 (94.4%)	13057 (96.6%)	13990 (92.4%)
Weather as a Barrier			<0.0001
All or Most of the Time	10052 (34.1%)	3922 (28.7%)	6130 (39.3%)
Some or a Little of the Time	11707 (41.5%)	6575 (48.6%)	5132 (34.8%)
Never	6944 (24.4%)	3031 (22.8%)	3913 (25.9%)
Time in Neighborhood			<0.0001
<1 year	3940 (12.9%)	2047 (13.8%)	1893 (12.0%)
1-3 years	6010 (20.7%)	3078 (22.1%)	2932 (19.2%)
4-10 years	7472 (26.5%)	3608 (27.3%)	3864 (25.8%)
11-20 years	4962 (19.4%)	2314 (19.3%)	2648 (19.4%)
>20 years	6319 (20.6%)	2481 (17.6%)	3838 (23.5%)

Univariate Analysis Aspects of Neighborhood and Activity: Chi-squared analysis found that all aspects of perceived neighborhood conditions were associated with PA (p<0.0001). Standard mean difference (SMD) analysis (Table 3) found that places to walk or relax was associated with the largest SMD of 31.8, while presence of sidewalks on streets was associated with the smallest SMD of 9.43. As such, presence of sidewalks on streets was not included in the adjusted model. Multi-collinearity assessment found no multi-collinearity was present between any of the walkability variables (VIF <2.00 for all variables).

Table 3. Univariate associations between walking promoting neighborhood built environment, safety perception, and meeting physical activity recommendations using standardized mean difference (SMD)

Variable	Overall n=28703 (%)	Meeting Physical Activity n=13528 (%)	Not Meeting Physical Activity n=15175 (%)
Places to walk to relax	20778 (71.8%)	10926 (79.1%)	9852 (64.9%)
Roads, SW, paths or trails to walk	24584 (85.0%)	12054 (88.2%)	12530 (82.1%)
Shops, stores, markets to walk to	17249 (58.1%)	8675 (61.9%)	8574 (54.4%)
Do streets have sidewalks	18438 (62.6%)	9013 (64.9%)	9425 (60.4%)
Bus or transit stops to walk to	15935 (53.1%)	8023 (56.9%)	7912 (49.5%)
Movies, libraries, or churches	14362 (47.6%)	7414 (52.4%)	6948 (42.9%)
Crime does not make it unsafe	24728 (87.6%)	12011 (90.0%)	12717 (85.4%)
Animals do not make it unsafe	25415 (89.4%)	12192 (91.0%)	13223 (87.8%)
Traffic does not make it unsafe to walk	21820 (76.5%)	10634 (78.9%)	11186 (74.2%)

Multivariate Analysis: Unadjusted and adjusted associations between each neighborhood element and meeting PA recommendations are shown in Table 4. Model 1 indicated that places

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to walk and relax, presence of roads, sidewalks, paths or trail to walk, presence of bus or transit stops, and presence of movie theaters, libraries, or churches were all positively associated with meeting PA recommendations, while presence of sidewalks on streets was inversely associated with meeting PA recommendations (all $p<0.01$). Lack of crime was also positively associated with meeting PA recommendations (OR=1.46[95%CI 1.30-1.64]). After adjusting for covariates, reporting a presence vs. absence of places to walk to relax was associated with 49% increased odds of meeting PA recommendations (OR=1.49[95%CI 1.36-1.63]). Similarly, the presence vs. absence of bus or transit stops to walk to, and movie theaters, libraries or churches to walk to, remained positively associated with meeting PA recommendations (OR=1.11[95%CI 1.01-1.21] and OR=1.20[95%CI 1.09-1.31], respectively). Lack of crime also remained positively associated with meeting PA recommendations (OR=1.14[95%CI 1.00-1.29]). Low neighborhood social cohesion was negatively associated with meeting PA recommendations (OR=0.84[95%CI 0.78-0.91]).

Table 4. Unadjusted and Adjusted binomial logistic regression for odds of meeting physical activity recommendations

Variables	Model 1			Model 2		
	OR	95% CI	p-value	OR	95% CI	p-value
Neighborhood Questions						
Places to walk to relax	**1.76**	**1.62-1.92**	**<0.0001**	**1.49**	**1.36-1.63**	**<0.0001**
Roads, SW, paths or trails to walk	**1.25**	**1.12-1.41**	**0.0001**	1.09	0.97-1.21	0.1493
Shops, stores, markets to walk to	0.99	0.90-1.09	0.8601	0.99	0.89-1.10	0.8844
Do streets have sidewalks	**0.86**	**0.78-0.94**	**0.0019**			
Bus or transit stops to walk to	**1.16**	**1.07-1.27**	**0.0006**	**1.11**	**1.01-1.21**	**0.0264**
Movies, libraries, or churches	**1.20**	**1.10-1.31**	**<0.0001**	**1.20**	**1.09-1.31**	**0.0002**
Crime does not make it unsafe	1.46	1.3-1.64	<0.0001	**1.14**	**1.00-1.29**	**0.0432**
Animals do not make it unsafe	1.12	0.99-1.28	0.0722	0.97	0.85-1.10	0.6221
Traffic does not make it unsafe to walk	1.04	0.94-1.14	0.4569	0.97	0.88-1.06	0.4658
Age						**<0.0001**
18-44 yrs				1.00(ref)		
45-64 yrs				**0.65**	**0.59-0.71**	
65+ yrs				**0.53**	**0.47-0.59**	
Sex						**<0.0001**
Female				**0.83**	**0.78-0.89**	
Male				1.00(ref)		
Race/Ethnicity						**0.0002**
Non-Hispanic White				1.00(ref)		
Non-Hispanic Black				**0.80**	**0.72-0.88**	
Other				0.89	0.76-1.05	
Hispanic/Latino				0.90	0.81-1.00	
Level of Education						**<0.0001**

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HS Diploma/GED or Less	**0.46**	**0.41-0.52**	
Some College-AA/Bachelors	**0.71**	**0.64-0.78**	
Masters, Professional, Doctoral	1.00 ref)		
Marital Status			**0.0007**
Married/Living with Partner	1.00(ref)		
Widowed/Divorced/Separated	1.01	0.93-1.11	
Never Married	**1.23**	**1.10-1.37**	
Ratio Household Income to Poverty Threshold			**<0.0001**
<1.00	**0.56**	**0.50-0.63**	
1.00-1.99	**0.54**	**0.48-0.60**	
2.00-3.99	**0.70**	**0.64-0.77**	
4.00 or More	1.00(ref)		
Social Cohesion			**<0.0001**
Low	**0.84**	**0.78-0.91**	
High	1.00(ref)		
K6 Psychological Distress			**<0.0001**
Distressed	**0.58**	**0.49-0.69**	
No Distress	1.00(ref)		
Weather as a Barrier			**<0.0001**
All or Most of the Time	**0.85**	**0.78-0.93**	
Some or a Little of the Time	**1.39**	**1.27-1.51**	
Never	1.00(ref)		
Time in Neighborhood			0.1453
<1 year	1.11	0.97-1.26	
1-3 years	**1.17**	**1.04-1.32**	
4-10 years	1.10	0.99-1.22	
11-20 years	1.05	0.94-1.18	
>20 years	1.00(ref)		

DISCUSSION:

In this cross-sectional study examining what neighborhood aspects of walkability most influenced meeting PA recommendations, presence of places to walk and relax was most strongly associated with meeting physical activity recommendations. Presence of amenities and destinations were also positively associated with meeting PA recommendations. This study elucidates influential aspects of an individual's neighborhood on PA. Evidence suggests advice to increase physical activity from a clinician may be associated with increased activity.[28] However, clinicians should be sensitive to the socioecologic factors that influence activity, including aspects of neighborhood environment.[29] Clinicians who identify specific amenities for their patients may have more success in counseling their patients to increase their activity.

This study's findings are consistent with a growing body of evidence that environmental attributes are associated with physical activity.[30 31] Addy et al found that the presence of amenities was associated with increased physical activity.[30] Similarly, Tuckel & Milczarski found that perception of walkability and availability of amenities was positively associated with walking for leisure and total walking.[31]

This study has several strengths, including the large sample size, nationally-representative nature, strong validity to social cohesion index, and standardized methods for data collection. Its cross-sectional design and results do not support conclusions about causality. All data was self-reported data, however evidence suggests that self-reported data on health and exercise are highly valid.[14] Further, meeting physical activity recommendations does not necessarily mean that the physical activity occurs in the neighborhood.

Conclusions:

In this nationally-representative study of adults, places to relax and the presence of amenities and destinations were associated with increase odds of meeting physical activity recommendations. Though certain factors may influence activity in a general population, further studies may investigate whether particular populations are influenced differentially. Some disease states, such as arthritis or cardiovascular disease, may favor different amenities compared to an unaffected population.[32] For example, Timmermans et al found that retail outlets were more associated with PA among older adults with osteoarthritis compared to a general population.[32] Various age demographics may also benefit from different amenities, such one study demonstrated that older adults tend to be more connected to their neighborhood amenities than younger adults.[33] Further studies measuring walking behavior may help understand which elements are most closely connected to measured activity to allow for informed neighborhood design and policy change around urban planning.

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Foot Notes

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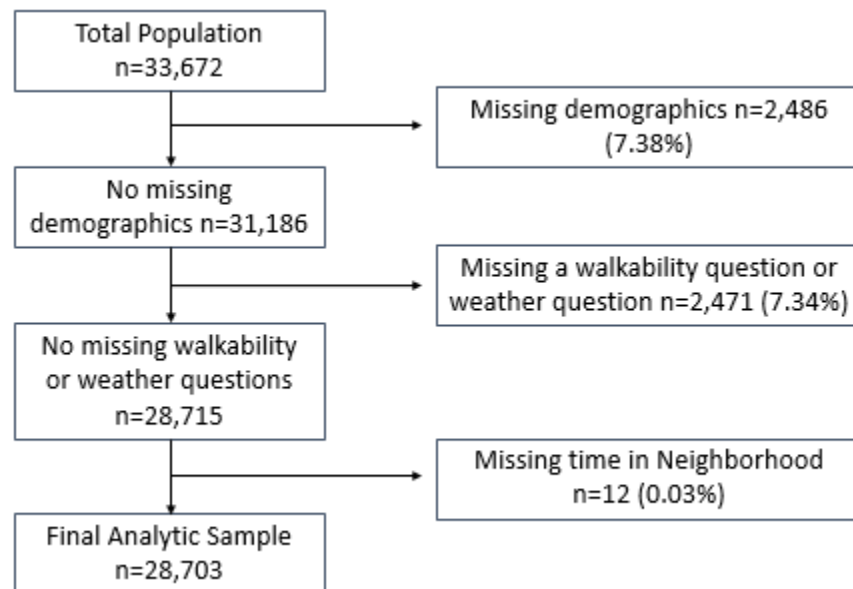
Competing Interests: None Declared

Patient Consent for publication: None required

Ethics Approval: This research was considered non-human subjects research by the Saint Louis University Institutional Review Board

Data availability statement: The National Health Interview Survey Data are publically available at the following URL https://www.cdc.gov/nchs/nhis/nhis_2015_data_release.htm Statistical code is available upon reasonable request.

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Figure 1. Flow of inclusion

Appendix A

Questions Regarding Physical Activity

How often do you do VIGOROUS leisure-time physical activities for AT LEAST 10 MINUTES that cause HEAVY sweating or LARGE increases in breathing or heart rate?

Number of units
Never
1-999 times
Unable to do this type of activity
Refused
Not Ascertained
Don't Know

How often do you do VIGOROUS leisure-time physical activities for AT LEAST 10 MINUTES that cause HEAVY sweating or LARGE increases in breathing or heart rate?

Time Units
Never
Per day
Per week
Per month
Per year
Refused
Not Ascertained
Don't Know

About how long do you do these vigorous leisure-time physical activities each time?

Number Time Units
1-995
Refused
Not Ascertained
Don't Know

About how long do you do these vigorous leisure-time physical activities each time?

Time Units
Minutes
Hours
Refused
Not Ascertained
Don't Know

How often do you do LIGHT OR MODERATE leisure-time physical activities for AT LEAST 10 MINUTES that cause ONLY LIGHT sweating or a SLIGHT to MODERATE increase in breathing or heart rate?

Number Units
Never
1-995 times
Unable to do this type of activity
Refused
Not Ascertained
Don't Know

How often do you do LIGHT OR MODERATE leisure-time physical activities for AT LEAST 10 MINUTES that cause ONLY LIGHT sweating or a SLIGHT to MODERATE increase in breathing or heart rate?

Time Units
Never
Per day
Per week
Per month
Per year
Refused
Not Ascertained
Don't Know

About how long do you do these light or moderate leisure-time physical activities each time?

Time Units
1-995
Unable to do this type of activity
Refused
Not Ascertained
Don't Know

About how long do you do these light or moderate leisure-time physical activities each time?

Time Units
Minutes
Hours
Refused
Not Ascertained
Don't Know

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-5*
Bias	9	Describe any efforts to address potential sources of bias	4-6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	5-6

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		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7, figure 1
		(b) Give reasons for non-participation at each stage	See CDC
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	Complete Case, Figure 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8
		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5 (social cohesion index)
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11-12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Which Aspects of Neighborhood Environment are Most Associated with Meeting Physical Activity Recommendations in American Adults-An NHIS Study

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Which Aspects of Neighborhood Environment are Most Associated with Meeting Physical Activity Recommendations in American Adults-An NHIS Study

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Which Aspects of Neighborhood Environment are Most Associated with Meeting Physical Activity Recommendations in American Adults-An NHIS Study

Abstract:

Objectives: To investigate which perceived neighborhood characteristics are most strongly linked with adequate physical activity (PA) in a nationally-representative sample of adults in the United States.

Design: Cross-sectional

Setting: United States via 2015 National Health Interview Survey Data.

Participants: A group of 28,697 non-institutionalized adults with complete data.

Primary Outcome Measures: Meeting PA was defined as 150 min/week of moderate to vigorous activity.

Results: The population had a mean age of 49.6(±18.3) years and was 51.3% female and 66.2% non-Hispanic white. In adjusted, weighted analysis, places to walk and relax was mostly strongly associated with meeting PA recommendations (OR=1.40[95%CI 1.27-1.54]). Other elements associated with meeting PA were presence of bus or transit stops to walk to, and presence movies, libraries or churches to walk to (OR=1.12[95% CI 1.03-1.23], and OR=1.19[95% CI 1.08-1.31], respectively).

Conclusions: In this analysis, the characteristic most strongly associated with PA was presence of places to walk and relax. Identifying communities that may lack amenities such as this, like a park, may help direct community investment to enhance structures that encourage activity.

Key Words: Epidemiology, Exercise, Built Environment, Neighborhood

Strengths and Limitations of this study

- This study includes a large, nationally-representative sample of adults living in the United States.
- This study contained high quality data on physical activity.
- This study was limited by its cross-sectional nature.
- This study is limited as location and type of physical activity cannot be delineated by the standardized questions in the data set.

INTRODUCTION:

Many Americans do not meet physical activity recommendations of 150 minutes per week of moderate to vigorous physical activity (PA).[1][2] Sedentary lifestyle is associated with a myriad of health problems, including obesity, cardiovascular disease, diabetes, and osteoarthritis[3-6]. Increasingly the built environment, such as access to sidewalks, crime rates, public transit, have been identified as contributors to meeting PA recommendations.[7] A measure of built environment that contributes to PA is 'walkability'.

Walkability has been shown to be associated with likelihood of PA.[8] When determined objectively, walkability is measured as street connectivity, land use mix, crime rates, and population density through geospatial information systems (GIS) techniques.[9] For instance, greater presence of green spaces has been associated with increased PA.[8] In one longitudinal study, walkable destinations, street connectivity, and increased housing density were associated with greater gains in PA over time.[10] However, there is some evidence that perceived walkability may be more influential on activity than objectively measured elements.[11] In particular, Jack and McCormack found that around 30% of their respondents who lived in objectively determined highly walkable areas felt their neighborhood was not walkable. Existing research on perceived environmental barriers to walking has been limited by relatively small sample sizes, restricted geographic areas, and existing studies may not generalize to the United States.[7] In 2015, the National Health Interview Survey (NHIS) introduced walkability questions. Research studies of these items have yet to link responses to walkability to meeting PA recommendations.[12]

To overcome limitations of existing research, particularly regarding small geographic areas and small sample sizes, we determined which elements of perceived walkability are most highly associated with meeting PA recommendations in a large, nationally representative sample of US adults, collected from across the country.

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METHODS:

Study Population: This cross-sectional study used self-reported data from the 2015 National Health Interview Survey (NHIS), which are collected through an in-person survey by trained representatives from the United States (US) Census Bureau. The NHIS is an annual population-based survey of the civilian, non-institutionalized US population used to monitor disease prevalence and disability as well as track progress towards goals stated by the Department of Health and Human Services. The NHIS utilizes multistage sampling techniques to partition the population into several nested levels of strata and clusters[13]. After applying sampling weights, the sample is representative of the US non-institutionalized population. The annual response rate for 2015 was 70.1% of eligible households.[13] Eligible participants for this analysis were at least 18 years old, had no missing data on walkability questions, physical activity outcomes, and demographic data (n=28697). Complete case analysis was undertaken to minimize bias. See Figure 1 for Flow of Inclusion.

Exposures of Interest-Perceiving Walkability and Safety Barriers to Walking: Perceived walkability and safety barriers were ascertained from nine questions pertaining to the participants' feelings about their neighborhood. These questions centered on destinations to which participants could walk, as well as amenities to allow for walking and safety, specifically asking about walking (see Table 1). These questions were answered as either "yes" or "no, with safety questions reverse-coded for negative answers as "1" and positive answers at "0". Coding for walkability questions ensured that perceptions of higher walkability were coded positively (i.e. as "1").

Table 1. Content of questions for walkability and safety.

Walkability "Where you live…"
"…are there roads, sidewalks, paths or trails where you can walk?"
"…are there shops, stores, or markets that you can walk to?"
"…are there bus or transit stops that you can walk to?"
"…are there places like movies, libraries, or churches that you can walk to?"
"…are there places that you can walk to that help you relax, clear your mind, and reduce stress?"
"…do most streets have sidewalks?"
Safety "Where you live…"
"Does crime make it unsafe for you to walk?"
"Does traffic make it unsafe to walk?"
"Do dogs or other animals make it unsafe to walk?"

Outcome of Interest: Meeting physical activity recommendations was evaluated via a series of questions regarding participants' activity. Questions used to measure PA are shown in Appendix A. The duration spent in each level of activity was summed to measure amount of PA per week. No data are available on the means by which the participant is active.

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 The sum was then converted into a bivariate variable of either meeting physical activity recommendations or not. Participants were categorized as meeting PA recommendations if they had greater than or equal to 150 minutes of PA/week and as not meeting if they had less than 150 minutes. The questions in the NHIS data reliably measure physical activity.[14]

Covariates: All covariates were previously found to be associated with the likelihood of meeting PA recommendations.[15-21] Covariates were self-reported and included gender, age (18-44 years, 45-64 years, 65 plus years), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic/Latino, or Other), household highest educational attainment (≤high school diploma/GED, > high school to bachelors, and post-bachelor advanced degree), household income-to-poverty threshold ratio (<1.00, 1.00 to 1.99, 2.00 to 2.99, 3.00 to 3.99, and ≥4.00), marital status (never married, widowed/separated/divorced, and married/living with partner), difficulty walking, social cohesion, psychological distress measured through the K6, weather as a barrier to walking, and length of time living in the neighborhood. Difficulty walking was assessed via a single question regarding how difficult the participant finds it to walk a quarter of a mile (rougly 402 meters) without an assistive device (not at all, only a little, somewhat, very, can't do or do not do this activity). Perceived social cohesion was based on four questions regarding the social nature of the neighborhood. These questions were answered on a Likert scale ranging from "strongly agree" (1) to "strongly disagree" (4). Answers were tallied up with a maximum score of 16 (low social cohesion) and minimum score of four (high social cohesion). These totals were then categorized at a median split within the entire participant population to Low and High social cohesion. The use of these questions in this manner was previously described by Yi et al in a national sample of NHIS participants.[22] Internal consistency was assessed via Cronbach's Alpha. A value of 0.893 was determined, supporting high internal validity. Psychological distress was measured via the K6 instrument, a validated questionnaire comprised of 6 questions regarding psychological symptoms in the 30 days previous to administration. The K6 was categorized as Low or High based on established cutoffs.[23] A single question asked how frequently weather served as a barrier to walking. The answers were categorized as never, a little or some of the time, most or all of the time. Length of residence in the neighborhood was included in the statistical models as this may affect the knowledge a participant has about their neighborhood, or the opportunity to interact with neighbors. Length of time was categorized as less than 1 year, 1-3 years, 4-10 years, 11-20 years, and greater than 20 years.

Patient and Public Involvement: There was no patient or public involvement in the development or design of the study.

Analysis: All analyses take into account the complex sampling scheme by accounting for clustering, stratification, and final sampling weight. Analysis of the included subpopulation utilized a Domain Statement to preserve integrity of the weights[24]. No cases were eliminated from the sample. Analyses were coded with SAS v9.4 (SAS Institute, Cary, NC) using an alpha of 0.05.

Overall observed frequencies and weighted prevalence estimates for walkability, PA, and covariates were calculated. Bivariate analyses using chi-square tests assessed the association of each covariate as well as each walkability question with meeting PA recommendations. Additionally, for each walkability question, standardized mean difference (SMD) was used as an effect size measure. SMD is a measure of distance or imbalance between two group means or prevalence estimates.[25] For walkability questions, a SMD of greater than 10 was used as the criterion for inclusion in the adjusted logistic regression model.[26] SMD was used as the large sample size of the NHIS dataset can identify differences that are small, but not meaningful. Measuring the effect size in this manner allows for more meaningful identification of variables in this situation. Its use in this manner for bivariate data is described by Austin et al[27]. To assess for any relationships and/or multi-collinearity among walkability questions, variance inflation factor and diagnostics were run with VIF >10 indicating multi-collinearity.[28] A fully adjusted logistic regression model included each walkability question with SMD >10 and all covariates to calculate odds ratios and 95% confidence intervals.

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RESULTS:

Demographics: The final unweighted analytic sample included 28,697 participants. The average age was 49.6 years (SD=18.3). The study population was 51.3% female and 66.1% non-Hispanic white. Among this study population, 48.9% (n=13526, 95%CI 48.0-49.7) met PA recommendations.

Univariate Analysis of Demographics and Covariates with Activity: Chi-squared analysis revealed that age, sex, race/ethnicity, level of education, marital status, ratio household income to poverty threshold, perceived social cohesion, K6 psychological distress measure, weather, and time in neighborhood were all significantly associated with whether participants met PA recommendations (all $p<0.0001$) (Table 2).

Table 2. Descriptive analysis of included population and univariate associations with physical activity, n=unweighted % weighted

Variable	Overall, n=28697 (%)	Meeting Physical Activity, n=13526 (%)	Not Meeting Physical Activity, n=15171 (%)	p-value
Age				<0.0001
18-44 yrs	12099 (47.1%)	6779 (54.3%)	5320 (40.4%)	
45-64 yrs	9652 (34.4%)	4302 (31.8%)	5350 (36.8%)	
65+ yrs	6946 (18.4%)	2445 (13.9%)	4501 (22.8%)	
Sex				<0.0001
Female	15750 (51.3%)	6897 (48.0%)	8853 (54.5%)	
Male	12947 (48.7%)	6629 (52.0%)	6318 (45.5%)	
Race/Ethnicity				<0.0001
Non-Hispanic White	18148 (66.2%)	9043 (68.7%)	9105 (63.8%)	
Non-Hispanic Black	3834 (11.9%)	1513 (10.3%)	2321 (13.4%)	
Other	1866 (6.2%)	939 (6.6%)	927 (5.8%)	
Hispanic	4849 (15.7%)	2031 (14.4%)	2818 (17.0%)	
Level of Education				<0.0001
HS Diploma/GED or Less	8626 (25.0%)	2786 (17.1%)	5840 (32.6%)	
Some College-AA/Bachelors	15466 (56.3%)	7777 (58.5%)	7689 (54.3%)	
Masters, Professional, Doctoral	4605 (18.7%)	2963 (24.4%)	1642 (13.1%)	
Marital Status				<0.0001
Married/Living with Partner	14432 (60.5%)	7064 (61.5%)	7368 (59.4%)	
Widowed/Divorced/Separated	7646 (17.4%)	2896 (13.5%)	4750 (21.1%)	
Never Married	6619 (22.1%)	3566 (25.0%)	3053 (19.5%)	
Ratio Household Income to Poverty Threshold				<0.0001
<1.00	4596 (12.4%)	1632 (9.8%)	2964 (14.9%)	
1.00-1.99	6034 (18.7%)	2199 (14.1%)	3835 (23.1%)	
2.00-3.99	8266 (28.8%)	3854 (27.2%)	4412 (30.2%)	

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4.00 or More	9801 (40.1%)	5841 (48.9%)	3960 (31.8%)	
Difficulty walking ¼ mile				<0.0001
Not at all difficult	22371 (81.3%)	12384 (92.9%)	9987 (70.3%)	
Only a little difficult	1587 (5.0%)	486 (3.1%)	1101 (6.8%)	
Somewhat difficult	1402 (4.3%)	313 (2.1%)	1089 (6.4%)	
Very Difficult	1068 (3.1%)	142 (0.7%)	926 (5.3%)	
Can't do at all	1561 (4.2%)	130 (0.7%)	1431 (7.6%)	
Do not do this activity	708 (2.1%)	71 (0.5%)	637 (3.6%)	
Social Cohesion				<0.0001
Low	9855 (33.7%)	4262 (30.4%)	5593 (36.9%)	
High	18842 (66.3%)	9264 (69.6%)	9578 (63.1%)	
K6 Psychological Distress				<0.0001
Distressed	1654 (5.6%)	470 (3.4%)	1184 (7.6%)	
No Distress	27043 (94.4%)	13056 (96.6%)	13987 (92.4%)	
Weather as a Barrier				<0.0001
All or Most of the Time	10049 (34.1%)	3921 (28.7%)	6128 (39.3%)	
Some or a Little of the Time	11705 (41.5%)	6575 (48.6%)	5130 (34.8%)	
Never	6943 (24.4%)	3030 (22.7%)	3913 (25.9%)	
Time in Neighborhood				<0.0001
<1 year	3940 (12.9%)	2047 (13.8%)	1893 (12.0%)	
1-3 years	6007 (20.6%)	3077 (22.0%)	2930 (19.2%)	
4-10 years	7471 (26.5%)	3608 (27.3%)	3863 (25.8%)	
11-20 years	4961 (19.4%)	2314 (19.3%)	2647 (19.5%)	
>20 years	6318 (20.6%)	2480 (17.6%)	3838 (23.5%)	

Univariate Analysis Aspects of Neighborhood and Activity: Chi-squared analysis found that all aspects of perceived neighborhood conditions were associated with PA (p<0.0001). Standard mean difference (SMD) analysis (Table 3) found that places to walk or relax was associated with the largest SMD of 31.8, while presence of sidewalks on streets was associated with the smallest SMD of 9.43. As such, presence of sidewalks on streets was not included in the adjusted model. Multi-collinearity assessment found no multi-collinearity was present between any of the walkability variables (VIF <2.00 for all variables).

Table 3. Univariate associations between walking promoting neighborhood built environment, safety perception, and meeting physical activity recommendations using standardized mean difference (SMD). n=unweighted %=weighted

Variable	Overall n=28697 (%)	Meeting Physical Activity n=13526 (%)	Not Meeting Physical Activity n=15171 (%)	Chi-squared p-value	SMD
Places to walk to relax	20778 (71.8%)	10925 (79.1%)	9849 (64.9%)	<0.0001	31.8
Roads, SW, paths or trails to walk	24579 (85.0%)	12052 (88.2%)	12527 (82.1%)	<0.0001	17.2
Shops, stores, markets to walk to	17247 (58.1%)	8675 (61.9%)	8572 (54.4%)	<0.0001	15.3
Do streets have sidewalks	18434 (62.6%)	9012 (64.9%)	9422 (60.4%)	<0.0001	9.43

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Bus or transit stops to walk to	15933 (53.1%)	8023 (56.9%)	7910 (49.5%)	<0.0001	14.9
Movies, libraries, or churches	14359 (47.6%)	7413 (52.4%)	6946 (42.9%)	<0.0001	19.1
Crime does not make it unsafe	24723 (87.6%)	12009 (90.0%)	12714 (85.4%)	<0.0001	13.9
Animals do not make it unsafe	25409 (89.4%)	12190 (91.0%)	13219 (87.8%)	<0.0001	10.5
Traffic does not make it unsafe to walk	21816 (76.5%)	10633 (78.9%)	11183 (74.2%)	<0.0001	11.1

Multivariate Analysis: Unadjusted and adjusted associations between each neighborhood element and meeting PA recommendations are shown in Table 4. Model 1 indicated that places to walk and relax, presence of roads, sidewalks, paths or trail to walk, presence of bus or transit stops, and presence of movie theaters, libraries, or churches were all positively associated with meeting PA recommendations, while presence of sidewalks on streets was inversely associated with meeting PA recommendations (all p<0.01). Lack of crime was also positively associated with meeting PA recommendations (OR=1.46[95%CI 1.30-1.64]). After adjusting for covariates, reporting a presence vs. absence of places to walk to relax was associated with 40% increased odds of meeting PA recommendations (OR=1.40[95%CI 1.27-1.54]). Similarly, the presence vs. absence of bus or transit stops to walk to, and movie theaters, libraries or churches to walk to, remained positively associated with meeting PA recommendations (OR=1.12[95%CI 1.03-1.23] and OR=1.19[95%CI 1.08-1.31], respectively). Low neighborhood social cohesion was negatively associated with meeting PA recommendations (OR=0.85[95%CI 0.78-0.92]).

Table 4. Unadjusted and Adjusted binomial logistic regression for odds of meeting physical activity recommendations

	Model 1			Model 2		
Variables	OR	95% CI	p-value	OR	95% CI	p-value
Neighborhood Questions						
Places to walk to relax	**1.76**	**1.62-1.93**	**<0.0001**	**1.40**	**1.27-1.54**	**<0.0001**
Roads, SW, paths or trails to walk	**1.25**	**1.12-1.41**	**0.0001**	**1.09**	**0.97-1.22**	**0.1401**
Shops, stores, markets to walk to	0.99	0.90-1.09	0.8601	0.95	0.85-1.06	0.3607
Do streets have sidewalks	0.86	0.78-0.94	0.0019			
Bus or transit stops to walk to	**1.16**	**1.07-1.27**	**0.0006**	**1.12**	**1.03-1.23**	**0.0132**
Movies, libraries, or churches	**1.20**	**1.10-1.31**	**<0.0001**	**1.19**	**1.08-1.31**	**0.0004**
Crime does not make it unsafe	1.46	1.30-1.64	<0.0001	1.09	0.95-1.24	0.2145
Animals do not make it unsafe	1.12	0.99-1.28	0.0722	0.97	0.84-1.11	0.6212
Traffic does not make it unsafe to walk	1.04	0.94-1.14	0.4569	0.94	0.85-1.03	0.1745
Age						**<0.0001**
18-44 yrs				1.00(ref)		
45-64 yrs				**0.76**	**0.70-0.83**	
65+ yrs				**0.80**	**0.72-0.90**	
Sex						**<0.0001**

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Female	**0.86**	**0.80-0.92**
Male	1.00(ref)	
Race/Ethnicity		**<0.0001**
Non-Hispanic White	1.00(ref)	
Non-Hispanic Black	**0.80**	**0.72-0.89**
Other	0.85	0.72-1.00
Hispanic/Latino	0.83	0.75-0.93
Level of Education		**<0.0001**
HS Diploma/GED or Less	**0.47**	**0.42-0.54**
Some College-AA/Bachelors	**0.71**	**0.65-0.79**
Masters, Professional, Doctoral	1.00 ref)	
Marital Status		**0.0005**
Married/Living with Partner	1.00(ref)	
Widowed/Divorced/Separated	1.10	1.00-1.21
Never Married	**1.24**	**1.11-1.39**
Ratio Household Income to Poverty Threshold		**<0.0001**
<1.00	**0.66**	**0.58-0.74**
1.00-1.99	**0.61**	**0.54-0.68**
2.00-3.99	**0.76**	**0.69-0.83**
4.00 or More	1.00(ref)	
Difficulty walking ¼ mile		**<0.0001**
Not at all difficult	1.00(ref)	
Only a little difficult	0.45	0.38-0.54
Somewhat difficult	0.34	0.28-0.41
Very difficult	0.15	0.12-0.20
Can't do at all	0.11	0.08-0.14
Do not do this activity	0.18	0.13-0.26
Social Cohesion		**<0.0001**
Low	**0.85**	**0.78-0.92**
High	1.00(ref)	
K6 Psychological Distress		**0.0280**
Distressed	**0.81**	**0.68-0.98**
No Distress	1.00(ref)	
Weather as a Barrier		**<0.0001**
All or Most of the Time	**0.84**	**0.77-0.92**
Some or a Little of the Time	**1.28**	**1.17-1.40**
Never	1.00(ref)	
Time in Neighborhood		0.2896
<1 year	1.10	0.96-1.26
1-3 years	**1.14**	**1.01-1.28**
4-10 years	1.08	0.7-1.20
11-20 years	1.03	0.91-1.16

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>20 years	1.00(ref)	

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DISCUSSION:

In this cross-sectional study examining what neighborhood aspects of walkability most influenced meeting PA recommendations, presence of places to walk and relax was most strongly associated with meeting physical activity recommendations. Presence of amenities and destinations were also positively associated with meeting PA recommendations. The strength of association between places to walk and relax may reflect general preferences for walking for leisure as opposed to transport. These two types of activity appear to be differentially associated with certain neighborhood characteristics[29]. For example, WalkScore is more strongly associated with Active Transport, rather than leisure walking[30]. This study elucidates influential aspects of an individual's neighborhood on PA. Evidence suggests advice to increase physical activity from a clinician may be associated with increased activity.[31] However, clinicians should be sensitive to the socioecologic factors that influence activity, including aspects of neighborhood environment.[32] Clinicians who identify specific amenities for their patients may have more success in counseling their patients to increase their activity.

This study's findings are consistent with a growing body of evidence that environmental attributes are associated with physical activity.[8] [33] Addy et al found that the presence of amenities was associated with increased physical activity.[33] Smith et al similarly found that built environment is associated with increased active transport[8].

This study has several strengths, including the large sample size, nationally-representative nature, strong validity to social cohesion index, and standardized methods for data collection. Its cross-sectional design and results do not support conclusions about causality. All data was self-reported data, however evidence suggests that self-reported data on health and exercise are highly valid.[14] The walkability questions used are relatively new to the NHIS and have not been compared to any other perceived walkability scale, such as the Neighbourhood Environment Walkability Scale (NEWS), possibly limiting validity, though in our previous published work, an index constructed from these questions demonstrated high internal validity[34]. Further, meeting physical activity recommendations does not necessarily mean that the physical activity occurs in the neighborhood. Additionally, residential self-selection, e.g. individuals who are 'walkers' are more likely to choose to live in a walkable place, has been associated with walking in one's neighborhood[9]. These data do not offer any ability to adjust for this potential bias.

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Conclusions:

In this nationally-representative study of adults, places to relax and the presence of amenities and destinations were associated with increase odds of meeting physical activity recommendations. Though certain factors may influence activity in a general population, further studies may investigate whether particular populations are influenced differentially. Some disease states, such as arthritis or cardiovascular disease, may favor different amenities compared to an unaffected population.[35] For example, Timmermans et al found that retail outlets were more associated with PA among older adults with osteoarthritis compared to a general population.[35] Various age demographics may also benefit from different amenities. One such study demonstrated that older adults tend to be more connected to their neighborhood amenities than younger adults.[36] Further studies measuring walking behavior may help understand which elements are most closely connected to measured activity to allow for informed neighborhood design and policy change around urban planning.

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Figure Legend

Figure 1. Flow of Inclusion

Foot Notes

Contributors: SG, LC and JS designed the study. SG and JS analyzed and interpreted the data. SG, JS, and JFS wrote the article. SG, LC, JFS, and JS made critical revisions to the article. All authors have read and approved the final version of the manuscript.

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Patient Consent for publication: None required

Ethics Approval: This research was considered non-human subjects research by the Saint Louis University Institutional Review Board

Data availability statement: The National Health Interview Survey Data are publically available at the following URL https://www.cdc.gov/nchs/nhis/nhis_2015_data_release.htm Statistical code is available upon reasonable request.
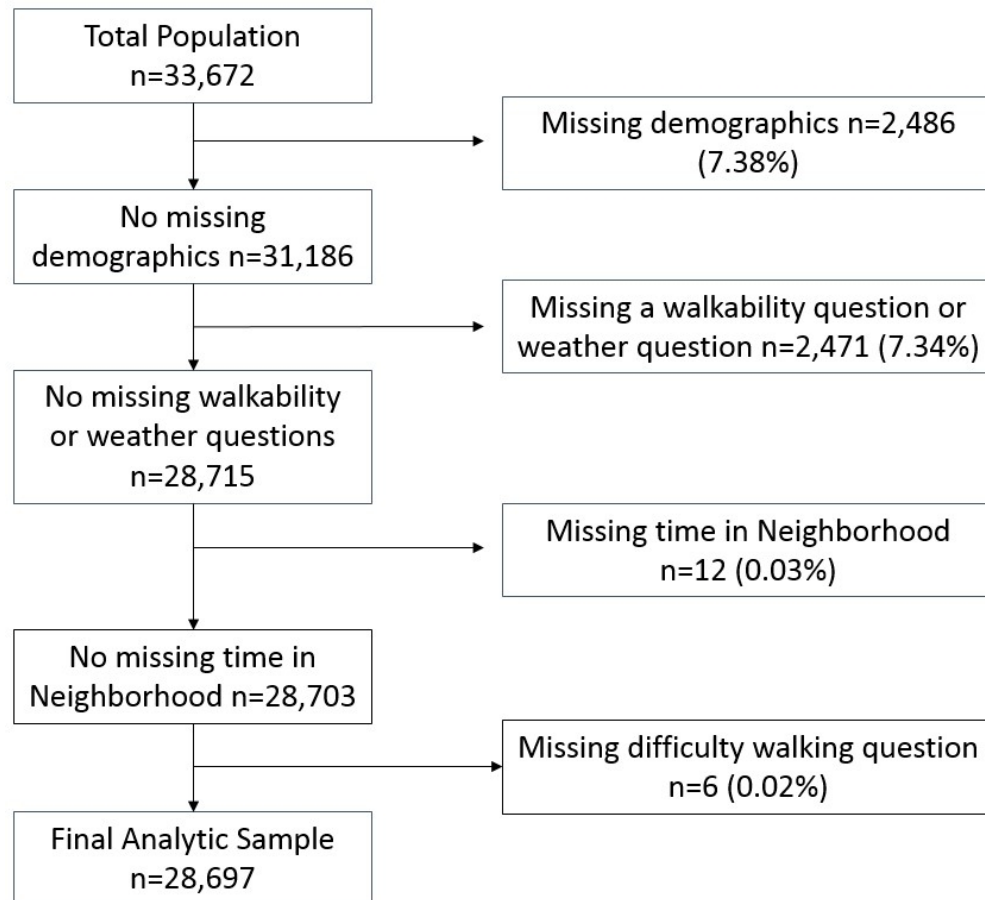
Figure 1: Flow of Inclusion

222x203mm (96 x 96 DPI)

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Appendix A

Questions Regarding Physical Activity

How often do you do VIGOROUS leisure-time physical activities for AT LEAST 10 MINUTES that cause HEAVY sweating or LARGE increases in breathing or heart rate?

Number of units
Never
1-999 times
Unable to do this type of activity
Refused
Not Ascertained
Don't Know

How often do you do VIGOROUS leisure-time physical activities for AT LEAST 10 MINUTES that cause HEAVY sweating or LARGE increases in breathing or heart rate?

Time Units
Never
Per day
Per week
Per month
Per year
Refused
Not Ascertained
Don't Know

About how long do you do these vigorous leisure-time physical activities each time?

Number Time Units
1-995
Refused
Not Ascertained
Don't Know

About how long do you do these vigorous leisure-time physical activities each time?

Time Units
Minutes
Hours
Refused
Not Ascertained
Don't Know

How often do you do LIGHT OR MODERATE leisure-time physical activities for AT LEAST 10 MINUTES that cause ONLY LIGHT sweating or a SLIGHT to MODERATE increase in breathing or heart rate?

Number Units
Never
1-995 times
Unable to do this type of activity
Refused
Not Ascertained
Don't Know

How often do you do LIGHT OR MODERATE leisure-time physical activities for AT LEAST 10 MINUTES that cause ONLY LIGHT sweating or a SLIGHT to MODERATE increase in breathing or heart rate?

Time Units
Never
Per day
Per week
Per month
Per year
Refused
Not Ascertained
Don't Know

About how long do you do these light or moderate leisure-time physical activities each time?

Time Units
1-995
Unable to do this type of activity
Refused
Not Ascertained
Don't Know

About how long do you do these light or moderate leisure-time physical activities each time?

Time Units
Minutes
Hours
Refused
Not Ascertained
Don't Know

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-5*
Bias	9	Describe any efforts to address potential sources of bias	4-6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	5-6

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7, figure 1
		(b) Give reasons for non-participation at each stage	See CDC
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	Complete Case, Figure 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8
		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	5 (social cohesion index)
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11-12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.