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Which aspects of neighbourhood environment are most associated with meeting physical activity recommendations in American adults: an NHIS study

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ABSTRACT

Objectives To investigate which perceived neighbourhood characteristics are most strongly linked with adequate physical activity (PA) in a nationally representative sample of adults in the USA.

Design Cross-sectional.

Setting USA via 2015 National Health Interview Survey Data.

Participants A group of 28 697 non-institutionalised 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 to 1.54)). Other elements associated with meeting PA were presence of bus or transit stops to walk to and presence of movies, libraries or churches to walk to (OR=1.12 (95% CI 1.03 to 1.23) and OR=1.19 (95% CI 1.08 to 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.

Strengths and limitations of this study

► This study includes a large, nationally representative sample of adults living in the USA.
► 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 standardised questions in the data set.

INTRODUCTION

Many Americans do not meet physical activity (PA) recommendations of 150 min per week of moderate to vigorous 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 and public transit, has 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 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 neighbourhood was not walkable.

Existing research on perceived environmental barriers to walking has been limited by relatively small sample sizes and restricted geographic areas, and existing studies may not generalise to the USA.[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
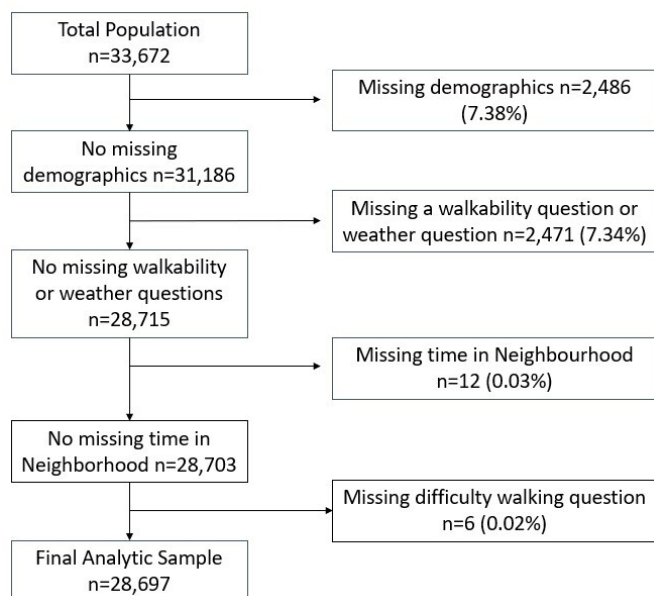
Figure 1 Flow of inclusion.

walkability are most highly associated with meeting PA recommendations in a large, nationally representative sample of US adults, collected from across the country.

METHODS

Study population

This cross-sectional study used self-reported data from the 2015 NHIS, which are collected through an in-person survey by trained representatives from the US Census Bureau. The NHIS is an annual population-based survey of the civilian, non-institutionalised 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 uses 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-institutionalised 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, PA outcomes and demographic data (n=28 697). Complete case analysis was undertaken to minimise 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 neighbourhood. These questions centred on destinations to which participants could walk, as well as amenities to allow for walking and safety, specifically asking about walking (see Box 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 (ie, as '1').

Outcome of interest

Meeting PA recommendations was evaluated via a series of questions regarding participants' activity. Questions used to measure PA are shown in online supplemental 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.

The sum was then converted into a bivariate variable of either meeting PA recommendations or not. Participants were categorised as meeting PA recommendations if they had greater than or equal to 150 min of PA/week and as not meeting if they had less than 150 min. The questions in the NHIS data reliably measure PA.[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 and 65 plus years), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic/Latino or other), household highest educational attainment (≤high school diploma/General Educational Development (GED), >high school to bachelors and postbachelor advanced degree), household income-to-poverty threshold ratio (<1.00, 1.00–1.99, 2.00–2.99, 3.00–3.99 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 neighbourhood. Difficulty walking was assessed via a single question regarding how difficult the participant finds it to walk a quarter of a mile (roughly 402 metres) 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 neighbourhood. 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 categorised 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 composed of six questions regarding psychological symptoms in the 30 days previous to administration. The K6 was categorised as low or high based on established cut-offs.[23] A single question asked how frequently weather served as a barrier to walking. The answers were categorised as never, a little or some of the time and most or all of the time. Length of residence in the neighbourhood was included in the statistical models as this may affect the knowledge a participant has about their neighbourhood or the opportunity to interact with neighbours. Length of time was categorised 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 used a domain statement to preserve integrity of the weights.[24] No cases were eliminated from the sample. Analyses were coded with SAS V.9.4 using an alpha of 0.05.

Overall observed frequencies and weighted prevalence estimates for walkability, PA and covariates were calculated. Bivariate analyses using χ^2 tests assessed the association of each covariate as well as each walkability question with meeting PA recommendations. Additionally, for each walkability question, standardised 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, an 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.[27] To assess for any relationships and/or multicollinearity among walkability questions, variance inflation factor and diagnostics were run with Variance Inflation Factor (VIF) >10 indicating multicollinearity.[28] A fully adjusted logistic regression model included each walkability question with SMD >10 and all covariates to calculate ORs and 95% CIs.

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=13 526, 95% CI 48.0 to 49.7) met PA recommendations.

Univariate analysis of demographics and covariates with activity

χ^2 analysis revealed that age, sex, race/ethnicity, level of education, marital status, ratio of household income to poverty threshold, perceived social cohesion, K6 psychological distress measure, weather and time in neighbourhood were all significantly associated with whether participants met PA recommendations (all p<0.0001) (table 1).

Univariate analysis aspects of neighbourhood and activity

χ^2 analysis found that all aspects of perceived neighbourhood conditions were associated with PA (p<0.0001). SMD analysis (table 2) 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. Multicollinearity assessment found no multicollinearity was present between any of the walkability variables (VIF <2.00 for all variables).

Multivariate analysis

Unadjusted and adjusted associations between each neighbourhood element and meeting PA recommendations are shown in table 3. 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 theatres, 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 to 1.64)). After adjusting for covariates, reporting a presence versus absence of places to walk to relax was associated with 40% increased odds of meeting PA recommendations (OR=1.40 (95% CI 1.27 to 1.54)). Similarly, the presence versus absence of bus or transit stops to walk to, and movie theatres, libraries or churches to walk to, remained positively associated with meeting PA recommendations (OR=1.12 (95% CI 1.03 to 1.23) and OR=1.19 (95% CI 1.08 to 1.31), respectively). Low neighbourhood social cohesion was negatively associated with meeting PA recommendations (OR=0.85 (95% CI 0.78 to 0.92)).

DISCUSSION

In this cross-sectional study examining what neighbourhood aspects of walkability most influenced meeting PA recommendations, presence of places to walk and relax

Table 1 Descriptive analysis of included population and univariate associations with physical activity, n=unweighted%=weighted

Variable	Overall n=28 697 (%)	Meeting physical activity n=13 526 (%)	Not meeting physical activity n=15 171 (%)	P value
Age (years)				<0.0001
18–44	12 099 (47.1)	6779 (54.3)	5320 (40.4)	
45–64	9652 (34.4)	4302 (31.8)	5350 (36.8)	
65+	6946 (18.4)	2445 (13.9)	4501 (22.8)	
Sex				<0.0001
Female	15 750 (51.3)	6897 (48.0)	8853 (54.5)	
Male	12 947 (48.7)	6629 (52.0)	6318 (45.5)	
Race/ethnicity				<0.0001
Non-Hispanic white	18 148 (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
High School diploma/GED or less	8626 (25.0)	2786 (17.1)	5840 (32.6)	
Some college-associates/bachelors	15 466 (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	14 432 (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)	
4.00 or more	9801 (40.1)	5841 (48.9)	3960 (31.8)	
Difficulty walking ¼ mile				<0.0001
Not at all difficult	22 371 (81.3)	12 384 (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	18 842 (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	27 043 (94.4)	13 056 (96.6)	13 987 (92.4)	
Weather as a barrier				<0.0001
All or most of the time	10 049 (34.1)	3921 (28.7)	6128 (39.3)	
Some or a little of the time	11 705 (41.5)	6575 (48.6)	5130 (34.8)	

Continued

Table 1 Continued

Variable	Overall n=28 697 (%)	Meeting physical activity n=13 526 (%)	Not meeting physical activity n=15 171 (%)	P value
Never	6943 (24.4)	3030 (22.7)	3913 (25.9)	
Time in neighbourhood (years)				<0.0001
<1	3940 (12.9)	2047 (13.8)	1893 (12.0)	
1–3	6007 (20.6)	3077 (22.0)	2930 (19.2)	
4–10	7471 (26.5)	3608 (27.3)	3863 (25.8)	
11–20	4961 (19.4)	2314 (19.3)	2647 (19.5)	
>20	6318 (20.6)	2480 (17.6)	3838 (23.5)	

GED, General Educational Development.

was most strongly associated with meeting PA 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 neighbourhood 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 neighbourhood on PA. Evidence suggests advice to increase PA from a clinician may be associated with increased activity.[31] However, clinicians should be sensitive to the socioecological factors that influence activity, including aspects of neighbourhood environment.[32] Clinicians who identify specific amenities for their patients may have more success in counselling their patients to increase their activity.

This study's findings are consistent with a growing body of evidence that environmental attributes are associated with PA.[8 33] Addy et al[33] found that the presence of amenities was associated with increased PA. 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 standardised methods for data collection. Its cross-sectional design and results do not support conclusions about causality. All data were 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 with any other perceived walkability scale, such as the Neighbourhood Environment Walkability Scale, possibly limiting validity, though in our previous published work, an index constructed from these questions demonstrated high internal validity.[34] Furthermore, meeting PA recommendations does not necessarily mean that the PA occurs in the neighbourhood. Additionally, residential self-selection, for example, individuals who are 'walkers' are more likely to choose to live in a walkable place, has been associated with walking in one's neighbourhood.[9] These data do not offer any ability to adjust for this potential bias.

Table 2 Univariate associations between walking promoting neighbourhood built environment, safety perception and meeting physical activity recommendations using standardised mean difference (SMD)

Variable	Overall n=28 697 (%)	Meeting physical activity n=13 526 (%)	Not meeting physical activity n=15 171 (%)	χ^2 P value	SMD
Places to walk to relax	20 778 (71.8)	10 925 (79.1)	9849 (64.9)	<0.0001	31.8
Roads, Sidewalks, paths or trails to walk	24 579 (85.0)	12 052 (88.2)	12 527 (82.1)	<0.0001	17.2
Shops, stores and markets to walk to	17 247 (58.1)	8675 (61.9)	8572 (54.4)	<0.0001	15.3
Do streets have sidewalks	18 434 (62.6)	9012 (64.9)	9422 (60.4)	<0.0001	9.43
Bus or transit stops to walk to	15 933 (53.1)	8023 (56.9)	7910 (49.5)	<0.0001	14.9
Movies, libraries or churches	14 359 (47.6)	7413 (52.4)	6946 (42.9)	<0.0001	19.1
Crime does not make it unsafe	24 723 (87.6)	12 009 (90.0)	12 714 (85.4)	<0.0001	13.9
Animals do not make it unsafe	25 409 (89.4)	12 190 (91.0)	13 219 (87.8)	<0.0001	10.5
Traffic does not make it unsafe to walk	21 816 (76.5)	10 633 (78.9)	11 183 (74.2)	<0.0001	11.1

n=unweighted %=weighted.

Table 3 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
Neighbourhood questions						
Places to walk to relax	1.76	1.62 to 1.93	<0.0001	1.40	1.27 to 1.54	<0.0001
Roads, SW, paths or trails to walk	1.25	1.12 to 1.41	0.0001	1.09	0.97 to 1.22	0.1401
Shops, stores, markets to walk to	0.99	0.90 to 1.09	0.8601	0.95	0.85 to 1.06	0.3607
Do streets have sidewalks	0.86	0.78 to 0.94	0.0019			
Bus or transit stops to walk to	1.16	1.07 to 1.27	0.0006	1.12	1.03 to 1.23	0.0132
Movies, libraries or churches	1.20	1.10 to 1.31	<0.0001	1.19	1.08 to 1.31	0.0004
Crime does not make it unsafe	1.46	1.30 to 1.64	<0.0001	1.09	0.95 to 1.24	0.2145
Animals do not make it unsafe	1.12	0.99 to 1.28	0.0722	0.97	0.84 to 1.11	0.6212
Traffic does not make it unsafe to walk	1.04	0.94 to 1.14	0.4569	0.94	0.85 to 1.03	0.1745
Age (years)						<0.0001
18–44				1.00 (ref)		
45–64				0.76	0.70 to 0.83	
65+				0.80	0.72 to 0.90	
Sex						<0.0001
Female				0.86	0.80 to 0.92	
Male				1.00 (ref)		
Race/ethnicity						<0.0001
Non-Hispanic white				1.00 (ref)		
Non-Hispanic black				0.80	0.72 to 0.89	
Other				0.85	0.72 to 1.00	
Hispanic/Latino				0.83	0.75 to 0.93	
Level of education						<0.0001
HS diploma/GED or less				0.47	0.42 to 0.54	
Some college-Associates/bachelors				0.71	0.65 to 0.79	
Masters, professional and doctoral				1.00 (ref)		
Marital status						0.0005
Married/living with partner				1.00 (ref)		
Widowed/divorced/separated				1.10	1.00 to 1.21	
Never married				1.24	1.11 to 1.39	
Ratio household income to poverty threshold						<0.0001
<1.00				0.66	0.58 to 0.74	
1.00–1.99				0.61	0.54 to 0.68	
2.00–3.99				0.76	0.69 to 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 to 0.54	
Somewhat difficult				0.34	0.28 to 0.41	
Very difficult				0.15	0.12 to 0.20	
Can't do at all				0.11	0.08 to 0.14	
Do not do this activity				0.18	0.13 to 0.26	
Social cohesion						<0.0001
Low				0.85	0.78 to 0.92	

Continued

Table 3 Continued

Variables	Model 1			Model 2		
	OR	95% CI	P value	OR	95% CI	P value
High				1.00 (ref)		
K6 psychological distress						0.0280
Distressed				0.81	0.68 to 0.98	
No distress				1.00 (ref)		
Weather as a barrier						<0.0001
All or most of the time				0.84	0.77 to 0.92	
Some or a little of the time				1.28	1.17 to 1.40	
Never				1.00 (ref)		
Time in neighbourhood (years)						0.2896
<1				1.10	0.96 to 1.26	
1–3				1.14	1.01 to 1.28	
4–10				1.08	0.70 to 1.20	
11–20				1.03	0.91 to 1.16	
>20				1.00 (ref)		

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 PA 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 favour different amenities compared with an unaffected population.[35] For example, Timmermans et al[35] found that retail outlets were more associated with PA among older adults with osteoarthritis compared with a general population. Various age demographics may also benefit from different amenities. One such study demonstrated that older adults tend to be more connected to their neighbourhood amenities than younger adults.[36] Further studies measuring walking behaviour may help understand which elements are most closely connected to measured activity to allow for informed neighbourhood design and policy change around urban planning.

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