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Walking Distance by Trip Purpose and Population Subgroups

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Abstract

Background—Walking distance is an important concept in the fields of transportation and public health. A distance of 0.25 miles is often used as an acceptable walking distance in U.S. research studies. Overall, research on the distance and duration of walking trips for different purposes and across different population groups remains limited.

Purpose—This study examines the prevalence of walking and distances and durations of walking trips for different purposes among U.S. residents.

Methods—The distances and durations of walking trips for different purposes across population groups were compared using nationally representative data from the 2009 National Household Travel Survey (NHTS). Distance decay functions were used to summarize the distribution of walking distances and durations for different purposes and population subgroups. Data were analyzed in 2011.

Results—Sixteen percent of respondents had at least one daily walking trip. The mean and median values for walking distance were 0.7 and 0.5 miles, respectively. For walking duration, the mean and median values were 14.9 and 10 minutes. About 65% of walking trips were more than 0.25 miles, and about 18% of walking trips were more than 1 mile. Large variations were found among various purposes for both distance and duration. The distances and durations of walking for recreation were substantially longer than those for other purposes. People with lower versus higher household income walked longer distances for work but shorter distances for recreation.

Conclusions—Only a small fraction of respondents walk, but trips longer than 0.25 miles are common. There is substantial variability in the distance and duration of walking trips by purpose and population subgroups. These differences have implications for developing strategies to increase physical activity through walking.

Introduction

Walking is associated with features of the built or social environment[1–5] including proximity to destinations[6, 7] as well as social features like safety or the presence of other walkers.[8, 9] In the U.S., over the past 2 decades, 400 meters (0.25 miles or a 5-minute walk) has sometimes been assumed to be the distance that "the average American will walk rather than drive",[10] and has been used as the value of acceptable walking distance in studies.[10–15] However,

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research has also suggested that walking trips longer than 400 meters may not be uncommon, and features of buffers larger than 400 meters have been linked to walking. For example, destinations within 1500 meters were found to be associated with transport-related walking.[12] The mean walking-trip length and duration in the U.S. population were estimated to be 0.62 miles and 16 minutes in 2001[16] and 0.61 miles and 12 minutes in 2009.[17, 18]

Despite the growth of research on the social and physical environmental features that may be associated with walking, there is little evidence on the amounts and durations of usual walking trips for different purposes among nationally representative samples of U.S. residents.[12, 19] Agrawal and Schimek[16] described variations in walking-trip distance by purposes and groups in a national U.S. sample in 2001. Pucher et al.[17, 18] compared the frequency, duration, and distance of walking trips for U.S. adults between 2001 and 2009. Several other existing studies[6, 20, 21] focused on specific areas, which restricts generalizability to other contexts.

It is difficult to obtain valid estimates of the distribution of walking distances from surveys due to the discrepancy between perceived distances and objective distances.[22–24] Walking duration is sometimes used as a proxy for walking distance,[22, 25] but this may introduce difficulties in estimating distances due to variations in walking speeds. Hence, comprehensive studies that describe variations in both distances and duration of walking trips are needed.[26]

Descriptive data on the distribution of the duration and distance of usual walking trips for various purposes are useful in identifying possible targets for interventions to increase daily walking. In addition, the variability observed across sociodemographic groups may provide clues regarding the most important drivers of walking in the population. The upper tail-ends of the distributions can also provide a sense of the walking distance and duration that are actually achievable under certain circumstances. The distributions of distance may also provide guidelines helpful in defining the geographic area (e.g., the maximum radius around each person's home) for which environmental features are most likely to be related to walking.

This study used data from the 2009 National Household Travel Survey (NHTS) to examine the prevalence of walking and distances and durations of walking trips for various purposes among U.S. residents. The current work builds on prior works[17, 18] describing person-level walking behavior by further examining the distribution of distance and duration for walking trips by purpose and person-level characteristics using distance decay functions.

Methods

The National Household Travel Survey (NHTS) is a survey of household transportation covering the civilian, non-institutionalized population of the U.S. aged ≥5 years. The 2009 NHTS was conducted from March 2008 through May 2009 using computer-assisted random-digit-dialing telephone interviewing technology. The overall response rate was 19.8%. The full NHTS contains data for 308,901 people in 150,147 households and 1,167,321 trips. Data on one-way trips were obtained during a designated 24-hour period. Trip information includes purpose, transportation mode, distance, and duration. Distances for trips less than 1 mile were reported in blocks and transformed into miles assuming that a block equals 1/9 mile. NHTS data were weighted by personal weights to adjust for the selection probabilities at the individual level and to make the sample nationally representative. Data were analyzed in 2011.

Analyses of percentage walkers were based on the full NHTS sample. In trip-level analyses, trips were categorized by purpose. If a trip's destination was returning home, it was

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categorized based on the trip's origin. The seven purposes were work, study, shopping, social event, recreation, dog-walking, and meals.

The 2009 NHTS includes 100,405 walking trips reported by a total of 43,724 respondents. A total of 2213 trips were excluded because the value of the distance or duration was missing or reported as 0; in all, 9517 were excluded because the trip purpose was missing or could not be categorized into the seven purposes mentioned above; 8453 were excluded because they were missing data on key variables (5037 for household income level, 3410 for race/ethnicity and six for urbanization level), leaving a total of 80,222 walking trips available for analysis. The 20,183 excluded trips were similar to the 80,222 included trips in demographic characteristics of individuals and in trip purpose, distance and duration (when available). Results including all 98,192 trips with nonmissing values for distance and duration yielded very similar results.

Descriptive analyses summarized the percentage of people who walked, the distribution of number of trips, and distance and duration of walking trip, for various purposes and for selected population subgroups (gender, age, total household income, race/ethnicity, region and urbanization level of the place of residence, and season of the trip). Distributions of distances and durations were summarized using means and medians as well as distance decay functions. The cumulative distance walked per day was also examined.

Distance decay functions have been used in geography to mathematically describe how a given phenomenon varies as a function of distance.[27, 28] Specifically, the longer the distance to the destination, the less likely people are to travel to it by walking. Distance decay functions have been used to describe the distribution of walking as a function of distance for walking generally,[29] for different walking purposes,[20, 21] for transit walking,[30, 31] and for multimodal trips.[32]

A specific decay function fitted to a real data set presents a quantitatively precise description of the distribution of walking trips over distances. It also provides a continuous description of the probability of walking for different distances by estimating probabilities for values not represented in the data. Distance decay functions can easily be used to compare the distribution of walking distances among different groups or to describe changes over time for the same group.

It is generally well accepted that the exponential function is more appropriate for analyzing processes involving relatively short distances.[29, 33–35] Since walking involves relatively short distances, the negative exponential form was used in this study as it yielded a better fit than other forms such as power and Gaussian, as reflected in the R^2. The distance decay function is specified as:

$$P(d)=e^{-\beta d}, \quad (1)$$

where $P(d)$ denotes the cumulative percentage of walking trips with distance equal to or longer than the value of d (in miles), and β is the decay parameter to be estimated using empirical data.

For a specific distance d, smaller β leads to larger P, which indicates a larger percentage of walking trips with distance equal or longer than d. Similarly, d can be used to denote walking duration (in minutes). In this study, the value of β was estimated using nonlinear ordinary least-squares regression modeling (PROC MODEL in SAS 9.2) with the value of R^2 indicating the goodness of fit. Appendix A (available at www.ajpmonline.org) shows the related script.

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In addition to distance decay functions, linear regression models were also used to estimate adjusted mean differences in trip distance or duration associated with various characteristics of the respondent, the place of residence, and the trip in mutually adjusted models. Multiple trips nested within individuals were accounted for using generalized estimating equations.[36]

Results

Overall, 16.4% of respondents reported at least one valid walking trip per day, and 3.7% of respondents had three or more valid walking trips per day. Among those who took at least one walking trip per day, the mean number of walking trips was 2.25 and the mean cumulative distance walked was 1.64 miles. Table 1 shows the distribution of walking trips by distance and duration using the 2009 NHTS.

The mean and median values for walking distance (all purposes combined) were 0.7 (95% CI=0.11, 3.0) and 0.5 miles, respectively. For walking duration, the mean and median values were 14.9 (95% CI=1, 59) and 10 in minutes, respectively. The distance decay parameter β was estimated to be 1.71 for distance (R^2=0.98) and 0.073 (R^2=0.99) for duration; the corresponding fitted distance decay curves are presented in Figure 1.

Most walking trips were <2 miles in distance (97%) and <60 minutes in duration (99%). According to the distance decay function, about 65% of walking trips were >0.25 miles, and about 18% of walking trips were >1 mile. About 69% of walking trips lasted >5 minutes, and about 23% of walking trips lasted >20 minutes.

Table 2 shows the distribution of walking trips by purpose and groups. The probabilities of walking varied by purpose. Among people with at least one trip to work, 6.5% had at least one walking trip. The percentage of people with at least one walking trip (among those with at least one trip in the category) was much higher for recreation (40%) and pet-related activities (72%). The percentage of respondents who walked at least once a day varied by sociodemographic characteristics with the largest variation observed by place of residence (as high as 21% among urban residents and as low as 11.6% among town and country residents). There was also substantial regional variability (22% in the Northeast to 12.5% in the South). The number of total walking trips among those who walked at least once a day ranged from 2.0 to 2.4.

The distances and durations of walking for recreation were substantially longer than for other purposes. The shortest distances and durations were observed for trips for meals. After adjustment for covariates, recreation trips were on average 0.47 miles and 9.8 minutes longer than meal trips. These differences are also reflected in β values of the distance decay functions for distance and duration (1.15 and 0.053, respectively, for recreation and 2.48 and 0.1 for meals).

Walking trips to work were shorter in distance than recreation trips but longer than study and social event trips, which in turn were longer than shopping trips. Shopping and dog-walking trips were only slightly longer in distance than trips for meals. With respect to duration, work trips were shorter than study and social event trips but similar to dog-walking trips, possibly due to different walking speed for different purposes (e.g., faster to work and slower for dog-walking and for children walking to school).

The distance decay curves for selected purposes are displayed in Figure 2. More than 75% of walking trips for recreation were >0.25 miles and about 32% were >1 mile. More than 59% of walking trips for recreation were >10 minutes and about 20% were >30 minutes. In contrast, about 54% of walking trips for meals were >0.25 miles and 8.5% were >1 mile. About 36% of walking trips for meals were >10 minutes and 5% were >30 minutes.

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Walking-to-work trips were similar in duration to shopping trips but longer in distance (Figure 2) possibly reflecting variations in walking speed.

There were also differences in distance and duration by sociodemographic characteristics (Table 2). Men and boys walked longer distances and durations than women and girls, although the difference was small. Children aged <11 years walked the least both in distance and duration, and adults aged 18–64 years walked the longest distances. The elderly walked relatively short distances but for the longest duration, which may be explained by their relatively slower walking speed.

The group with highest total household income walked the longest distance, while the group with lowest total household income walked the longest duration. After adjustment, the two middle-income categories walked slightly less distance than the highest-income category, and the two lower-income categories walked longer duration. Blacks walked the longest distances and for the longest duration after adjustment. Respondents walked the longest distance and duration during summer and the shortest during winter. Those living in the West walked longer both in distance and duration than those in other regions. Residents of suburban areas walked slightly more in distance and duration, but the difference is minor.

The patterns for adjusted mean difference in cumulative distance walked per person per day were generally similar to the patterns observed for distance per trip. This is consistent with small variations in the number of walking trips per day among walkers. Exceptions include longer cumulative distance walked in the lowest compared to the highest SES group, longer cumulative distance walked in blacks and Asians than in Hispanics or whites, and longer cumulative distances in the Northeast than in the West.

Table 3 shows distance decay parameters for walking to work, for recreation, and for shopping and social events by total household income and urbanization level. Respondents with lower household income walked longer distances for work than respondents with higher household income (percentage of walking trips for work which were longer than 0.5 miles: 52% and 37% for the groups with the lowest and the highest total household income, respectively). By contrast, respondents with higher household income walked longer distances for recreation than respondents with lower household income (percentage of walking trips for recreation that were >0.5 mile: 47% and 60% for the groups with the lowest and the highest total household income, respectively). Respondents living in urban or second-city areas walked longest distances for work but shortest distances for recreation, and respondents living in town and country walked shortest distances for shopping and social events.

Discussion

Using a large nationally representative sample, this research shows that 65% of all walking trips cover more than 0.25 miles and nearly one fifth were over 1 mile. In addition, nearly one quarter lasted more than 15 minutes. These results highlight the fact that an important portion of the walking population does indeed walk substantial distances and durations as part of their daily activities. However, only 16% of respondents walked at all, and the median distance and duration of waking trips among walkers were 0.5 miles and 10 minutes, respectively, suggesting that there is substantial room for increases in walking in the population as a whole.

Walking varied by purpose with the lowest probability of walking observed for work and the highest observed for recreation and pet-related activities. Walking distances and durations also varied substantially by purpose: respondents walked much longer for recreation and shorter for other purposes. In addition, walking distances for different purposes varied by

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factors such as income and urbanization. Respondents with lower household income and those who lived in more-urban areas walked longer distances for work, shopping and social events, and shorter distances for recreation than respondents with higher household income and those who lived in less-urban areas.

The results regarding variations in walking distances for various purposes were consistent with one study in Minneapolis/St. Paul MN[20] which found that walking for entertainment, recreation, and fitness covers longer distances than that for other purposes, but inconsistent with a study in Montreal,[21] which found that people walk longer for work than for leisure activities. The discrepancy may result from differences in the definitions of entertainment, recreation, and leisure across both studies. In contrast, this study covered the entire U.S. The differences in walking distances and duration for different purposes may vary based on other demographic and area factors, and thus findings could be highly dependent on the sample utilized.

This study focused on realized trips (i.e., walking trips actually taken). Obviously, the distance people empirically walk is different from the distance people are willing to walk. The number, duration, and distance of realized walking trips is itself a function of social and environmental features; thus, the patterns observed by sociodemographic factors may largely reflect the environmental constraints from where diverse groups live.

One limitation of this study is the low response rate of the NHTS, although the use of weights may have corrected for some of the nonresponse bias. Another limitation pertains to the validity of the self-reported data. Self-reported distance and duration for trip in NHTS may limit their precisions, especially for shorter trips as walking.[19] Generally, it is believed that short distances are likely to be overestimated and longer distances overestimated in self-reports.[22, 23, 37] In addition, the rounding that occurs in self-reports of distance or duration introduces additional measurement error (reported distances are more concentrated in several discrete values such as 0.25, 0.5, and 1 mile).

The 2009 NHTS used block as the recording unit if the distance was less than 1 mile. This creates another problem since the length of a block varies among different built environments. An alternative is to calculate distances using GIS based on street-network data.[22, 24, 38] However, most travel data provide the start and end locations of each trip instead of the route. Respondents can be asked to draw the route on a map[19] or carry a hand-held GPS device,[39] but this is difficult to implement in large surveys.

These results suggest that the conventional wisdom of using 0.25 miles as a walking distance understates the distance that some people commonly walk. Features of areas beyond 0.25 miles may affect the probability, distance and duration of walking. Decay functions can also be used to develop weights to differentially weight various features of the built environment (depending on the percentage of people who walk a given distance) when studying the impact of the built environment on walking, although with the caveat that these distance decay functions are based on realized walking rather than potential for walking.

Better understanding of the population distribution of walking trips for different purposes may also provide implications for policy. For example, specific policies may be needed to encourage lower-SES people to walk more for recreation (for example, by providing green space in their neighborhoods) and to encourage walking for transportation among people living in non-urban areas (for example, increasing land mix and providing shopping areas within residential zones). Continued national monitoring of walking trips among U.S. representative samples may also help assess the impact of various environmental changes and could help guide research on the best strategies to increase walking in the population as a whole.

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Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Riva M, Gauvin L, Apparicio P, Brodeur J-M. Disentangling the relative influence of built and socioeconomic environments on walking: The contribution of areas homogenous along exposures of interest. Social Science & Medicine. 2009; 69(9):1296–1305. [PubMed: 19733426]
2. Nagel C, Michael Y, Carlson N, Bosworth M. The relationship between neighborhood built environment and walking activity among older adults. American Journal of Epidemiology. 2008; 168:461–468. [PubMed: 18567638]
3. Saelens BE, Handy SL. Built Environment Correlates of Walking: A Review. Medicine & Science in Sports & Exercise. 2008; 40(S1)(7):S550–S566. [PubMed: 18562973]
4. Forsyth A, Oakes JM, Lee B, Schmitz KH. The built environment, walking, and physical activity: Is the environment more important to some people than others? Transportation Research Part D: Transport and Environment. 2009; 14(1):42–49.
5. Giles-Corti B, Donovan RJ. Relative influences of individual, social environmental, and physical environmental correlates of walking. Am J Public Health. 2003; 93(9):1583–1589. [PubMed: 12948984]
6. Moudon A, Lee C, Cheadle A, et al. Operational definitions of walkable neighborhood: theoretical and empirical insights. J Physical Activity and Health. 2006; 3(S1):S99–S117.
7. Sallis JF. Angels in the details: comment on "The relationship between destination proximity, destination mix and physical activity behaviors". Preventive Medicine. 2008; 46(1):6–7. [PubMed: 17467781]
8. Loukaitou-Sideris A. Is it Safe to Walk? Neighborhood Safety and Security Considerations and Their Effects on Walking. Journal of Planning Literature. 2006; 20(3):219–232.
9. Bennett GG, McNeill LH, Wolin KY, Duncan DT, Puleo E, Emmons KM. Safe to walk? Neighborhood safety and physical activity among public housing residents. PLoS Medicine. 2007; 4(10):1599–1606. [PubMed: 17958465]
10. Atash F. Redesigning suburbia for walking and transit: emerging concepts. Journal of Urban Planning and Development. 1994; 120(1):48–57.
11. Aultman-Hall L, Roorda M, Baetz B. Using GIS for evaluation of neighbourhoods pedestrian accessibility. Journal of Urban Planning and Development. 1997; 123(1):10–17.
12. McCormack GR, Giles-Corti B, Bulsara M. The relationship between destination proximity, destination mix and physical activity behaviors. Preventive Medicine. 2008; 46(1):33–40. [PubMed: 17481721]
13. Hoehner C, Brennan Ramirez L, Elliot M. Perceived and objective environmental measures and physical activity among urban adults. American Journal of Preventive Medicine. 2005; 28(S2): 105–116. [PubMed: 15694518]
14. Pikora T, Bull F, Jamrozik J. Developing a reliable audit instrument to measure the physical environment for physical activity. American Journal of Preventive Medicine. 2002; 23:187–194. [PubMed: 12350451]
15. Krizek KJ. Neighborhood Services, Trip Purpose, and Tour-based Travel. Transportation. 2003; 30(4):387–410.
16. Agrawal AW, Schimek P. Extent and correlates of walking in the USA. Transportation Research Part D: Transport and Environment. 2007; 12(8):548–563.

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17. Buehler R, Pucher J, Merom D, Bauman A. Active Travel in Germany and the U.S.: Contributions of Daily Walking and Cycling to Physical Activity. American Journal of Preventive Medicine. 2011; 41(3):241–250. [PubMed: 21855737]
18. Pucher J, Buehler R, Merom D, Bauman A. Walking and Cycling in the U.S., 2001–2009: Evidence From the National Household Travel Surveys. Am J Public Health. 2011 AJPH. 2010.300067.
19. Agrawal AW, Schlossberg M, Irvin K. How Far, by Which Route and Why? A Spatial Analysis of Pedestrian Preference. Journal of Urban Design. 2008; 13(1):81–98.
20. Iacono, M.; Krizek, K.; El-Geneidy, A. Estimating Accurate Distance Decay Functions for Multiple Modes and Different Purposes. Twin Cities: Center for Transportation Studies, University of Minnesota; 2008. Access to Destinations: How Close is Close Enough?.
21. Larsen J, El-Geneidy A, Yasmin F. Beyond the quarter mile: Re-examining travel distances by active transportation. Canadian Journal of Urban Research: Canadian Planning and Policy. 2010; 19(1s):70–88.
22. McCormack GR, Cerin E, Leslie E, Toit LD, Owen N. Objective Versus Perceived Walking Distances to Destinations Correspondence and Predictive Validity. Environment and Behavior. 2008; 40(3):401–425.
23. Horning, J.; El-Geneidy, A.; Krizek, KJ. Perceptions of walking distance to neighborhood retail and other public services. the 87th meeting of the Transportation Research Board; Washington, DC. 2008.
24. Badland H, Schofield G, Schluter P. Objectively measured commute distance: Associations with actual travel modes and perceptions to place of work or study in Auckland, New Zealand. Journal of Physical Activity and Health. 2007; 4:80–86. [PubMed: 17489009]
25. Colabianchi N, Dowda M, Pfeiffer K, Porter D, Almeida M, Pate R. Towards an understanding of salient neighborhood boundaries: adolescent reports of an easy walking distance and convenient driving distance. International Journal of Behavioral Nutrition and Physical Activity. 2007; 4(1): 66. [PubMed: 18088416]
26. Clifton, K.; Krizek, KJ. The Utility of the NHTS in Understanding Bicycle and Pedestrian Travel. National Household Travel Survey Conference: Understanding our Nation's Travel; Washington DC. 2004.
27. Fortheringham AS. Spatial structure and distance-decay parameters. Annals of the Association of American Geographers. 1981; 71(3):425–436.
28. Elridge J, Jones J. Warped Space: A Geography of Distance Decay. Professional Geographer. 1991; 43(4):500–511.
29. Iacono M, Krizek K, El-Geneidy A. Measuring non-motorized accessibility: Issues, alternatives, and execution. Journal of Transport Geography. 2010; (18):133–140.
30. Kimpel TJ, Dueker KJ, El-Geneidy AM. Using GIS to Measure the Effect of Overlapping Service Areas on Passenger Boardings at Bus Stops. Journal of the Urban and Regional Information Systems Association. 2007; 19(1):5–11.
31. Zhao F, Chow L-F, Li M-T, Ubaka I, Gan A. Forecasting Transit Walk Accessibility: Regression Model Alternative to Buffer. Transportation Research Record. 2003; (1835):34–41.
32. Krygsman S, Dijst M. Multimodal Trips in the Netherlands: Microlevel Individual Attributes and Residential Context. Transportation Research Record. 2001; (1753)
33. Fotheringham, AS.; O'Kelly, ME. Spatial interaction models: formulations and applications. London: Kluwer; 1989.
34. De Vries JJ, Nijkamp P, Rietveld P. Exponential or power distance-decay for commuting? An alternative specification. Environment and Planning A. 2009; 41(2):461–480.
35. Signorino G, Pasetto R, Gatto E, Mucciardi M, La Rocca M, Mudu P. Gravity models to classify commuting vs. resident workers. An application to the analysis of residential risk in a contaminated area. International Journal of Health Geographics. 2011; 10(1):11. [PubMed: 21272299]
36. Liang K-Y, Zeger S. Longitudinal data analysis using generalized linear models. Biometrika. 1986; 73(1):13–22.

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37. Witlox F. Evaluating the reliability of reported distance data in urban travel behaviour analysis. Journal of Transport Geography. 2007; 15(3):172–183.

38. Badland HM, Schofield GM, Garrett N. Travel behavior and objectively measured urban design variables: Associations for adults traveling to work. Health & Place. 2008; 14(1):85–95. [PubMed: 17590378]

39. Chen C, Gong H, Lawson C, Bialostozky E. Evaluating the feasibility of a passive travel survey collection in a complex urban environment: Lessons learned from the New York City case study. Transportation Research Part A: Policy and Practice. 2010; 44(10):830–840.

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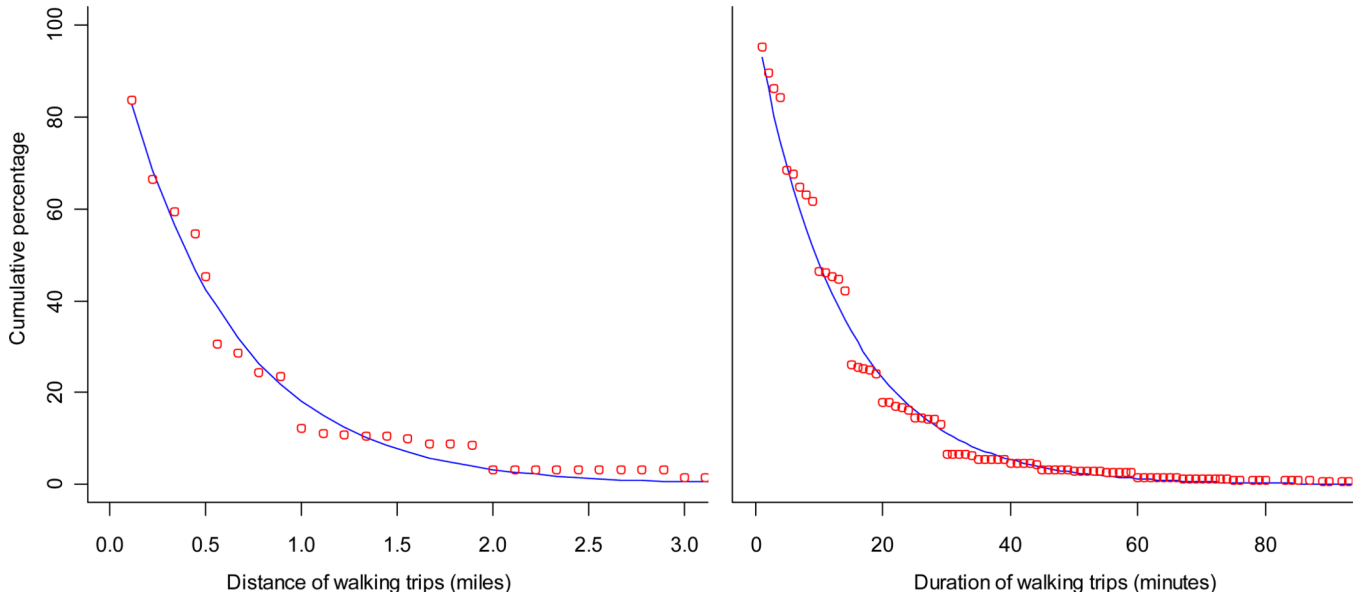

Figure 1.

Cumulative percentages of walking trips by distance and duration

Note: Left panel shows fitted distance decay curve (β=1.71, R^2=0.98); right panel shows fitted distance decay curve (β=0.073, R^2=0.99), both based on 2009 National Household Travel Survey data.

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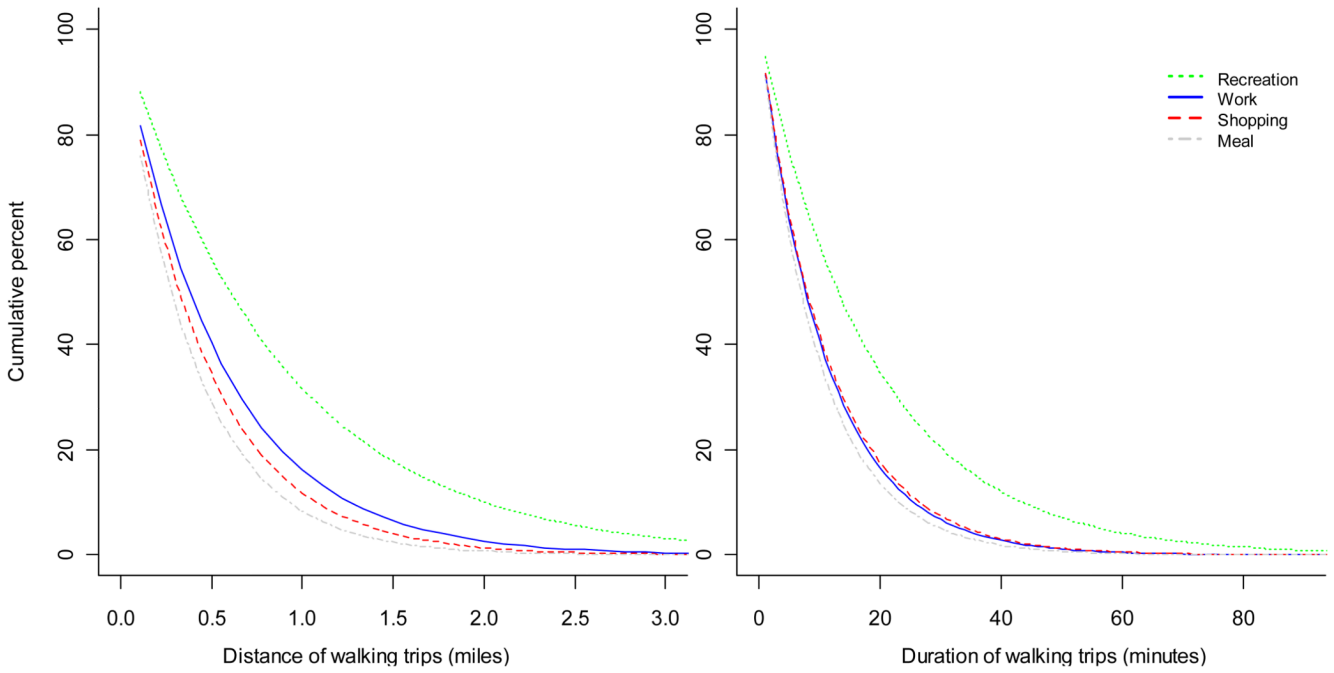

Figure 2.
Fitted distance decay curves of walking for work, shopping, recreation and meals

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Table 1

Distribution of walking trips by distance and duration, 2009 National Household Travel Survey, % unless otherwise noted

Distance (1 block=1/9 mile)	Frequency	Cumulative percentage	Duration (minutes)	Frequency	Cumulative Percentage
Blocks					
1	16	16	< 5	16	16
2	17	33	5	16	32
3	7	40	6–9	7	39
4	5	45	10	15	54
5–8	32	77	11–14	4	58
Miles					
1	11	88	15	16	74
1.1–2	9	97	16–29	13	87
>2	3	100	30	6	93
			>30	7	100

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Table 2

Descriptive characteristics of distance and duration for walkers and walking trips, 2009 NHTS

		Walkers (%)[3]	Mean walking trips by walkers	Distance		Duration		Adjusted mean difference in accumulative distance (mile) per walkers
				β_1	Adjusted mean difference in distance (miles) per trip	β_2	Adjusted mean difference in duration (minutes) per trip	
All		16.4	2.25	1.71	0.47[4]	0.073	12.3[5]	1.45[6]
Purpose[1]	Work	6.5		1.82	0.30**	0.09	2.7*	
	Study	12.0		2.01	0.18**	0.076	4.4**	
	Shopping	10.2		2.14	0.08*	0.087	1	
	Social event	14.0		1.93	0.18**	0.088	4.3**	
	Recreation	40.2		1.15	0.47**	0.053	9.8**	
	Dog-walking	71.8		2.28	0.04	0.084	2.7**	
	Meals	10.6		2.48	ref	0.1	ref	
Gender	Male	16.3	2.3	1.68	0.03	0.073	0.6	0.06*
	Female	16.5	2.2	1.74	ref	0.073	ref	ref
Age, years	5–10	17.0	2.0	2.39	−0.13**	0.095	−4.8**	−0.43**
	11–17	21.3	2.1	1.71	0.05	0.076	−0.9	0.01
	18–64	16.5	2.3	1.65	0.09**	0.071	−0.5	0.28**
	>=65	11.8	2.3	1.78	ref	0.067	ref	ref
Total household income	<20 k	18.9	2.4	1.85	−0.01	0.066	3.0**	0.10*
	20–40 k	15.7	2.2	1.84	−0.03	0.074	0.7	−0.08*
	40–80 k	15.0	2.2	1.72	−0.06**	0.075	−0.6	−0.13**
	>80 k	17.5	2.2	1.57	ref	0.076	ref	ref
Race/ethnicity	White	15.6	2.3	1.69	0.01	0.075	−1	0.09*
	Black	17.5	2.2	1.78	0.11	0.069	2	0.34**
	Asian	18.6	2.1	1.66	0.05	0.072	−1.5	0.72**

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		Walkers (%)[3]	Mean walking trips by walkers	Distance		Duration		Adjusted mean difference in accumulative distance (mile) per walkers
				β_1	Adjusted mean difference in distance (miles) per trip	β_2	Adjusted mean difference in duration (minutes) per trip	
	Hispanic	20.2	2.2	1.91	ref	0.065	ref	ref
Season	Winter (Dec–Feb)	14.8	2.2	1.88	−0.08*	0.079	−1.4*	−0.29**
	Spring (Mar–May)	16.3	2.3	1.68	−0.01	0.072	−0.1	0.01
	Summer (Jun–Aug)	16.8	2.3	1.64	0.01	0.07	1.3	0.21**
	Autumn (Sep–Nov)	17.7	2.2	1.7	ref	0.072	ref	ref
Region	Northeast	22.0	2.4	1.85	−0.08*	0.077	−1.3	0.12**
	Midwest	14.7	2.3	1.65	−0.07	0.073	−1.4	−0.01
	South	12.5	2.2	1.76	−0.10**	0.076	−2.8**	−0.15**
	West	19.8	2.2	1.59	ref	0.066	ref	0.00
Urbanization level[2]	Town and country	11.6	2.2	1.68	−0.02	0.075	−0.9	−0.17**
	Suburban	16.6	2.2	1.63	0.02	0.072	0.4	−0.14
	Urban and second city	21.8	2.3	1.78	ref	0.072	ref	ref

*$p<0.05$;

**$p<0.001$

β_1 : value of the decay parameter of decay function for distance

β_2 : value of the decay parameters of decay function for duration

For all decay functions, the values of R^2 ranged between 0.95 and 0.99.

[1]Category of trip purpose (the number in the parenthesis is the code value of *WHYTO* in NHTS 2009):
Work: (10) work, (11) go to work and (12) return to work; Study: (21) go to school as student; Shopping: (40) shopping/errands, (41) buy goods: groceries/clothing/hardware store and (42) buy services: video rentals/dry cleaner/post office/car service/bank; Social event: (50) social/recreational, (53) visit friends/relatives, (54) go out/hang out: entertainment/theater/sports event/go to bar, (55) visit public place: historical site/museum/park/library, and (81) social event; Recreation: (51) go to gym/exercise/play sports, and (52) rest or relaxation/vacation; Dog-walking: (64) pet care: walk the dog/vet visits; Meals: (80) meals, (82) get/eat meal, and (83) coffee/ice cream/snacks.

[2]Category of urbanization level (the value in the parenthesis is the code value of *HBHUR* in NHTS 2009):
Town and country: (TC) town and country; Suburban: (S) suburban; urban and second city: (U) Urban, and (C) second City. Urbanization levels in NHTS 2009 were based on population density, and for more information, see [36].

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[3]For trip purposes, percentage is the percentage of people with at least one trip with that purpose and who have at least one walking trip; for other variables, percentage is the percentage of people in the category and who have at least one walking trip.

[4]The intercept for models of distance per trip was 0.47 miles.

[5]The intercept for models of duration per trip was 12.3 minutes.

[6]The intercept for models of cumulative distance was 1.45 miles.

NHTS, National Household Travel Survey

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Table 3

Distance decay functions for distance by trip purpose, income and urbanization, 2009 NHTS

		Trip purpose					
		Work		**Recreation**		**Shopping and social events**	
		Trips	**β**	**Trips**	**β**	**Trips**	**β**
Total household income	<20 k	411	1.29	3044	1.49	4762	1.93
	20–40 k	656	1.54	5336	1.37	4502	1.95
	40–80 k	1416	2.26	10,594	1.12	6632	2.22
	>80 k	2137	1.99	13,171	1.03	7692	2.06
Urbanization level	Town and Country	1780	1.97	13,326	1.10	8588	2.40
	Suburban	1051	1.87	8773	1.07	5006	1.86
	Urban and second city	1789	1.74	10,046	1.27	9994	1.96

β: value of the decay parameter of decay function for distance

For all decay functions, the values of R^2 range between 0.960 and 0.986