

Walk score and risk of stroke and stroke subtypes among town residents

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Abstract

Background—Regular physical activity, including light-to-moderate activity, such as walking, has well-established benefits for reducing the risk of ischemic stroke. It remains unknown, however, whether the characteristics of cities themselves can influence the risk of stroke by promoting such activity.

Objectives—We tested the hypothesis that how walkable a city will be associated with the risk of ischemic stroke in persons residing in that city.

Methods—We calculated the age-adjusted annual incidence rates of ischemic stroke among residents in each of the 63 cities in Minnesota for which Walk Scores were available using 2011 Minnesota Hospital Association (MHA) data. Walk Score®, an online service, uses an exclusive algorithm to compute a walkability score between 0 and 100 for any location within the United States. The score is calculated based on the distance to amenities in nine categories (grocery, restaurants, shopping, coffee, banks, parks, schools, books, and entertainment) weighed according to their importance.

Results—There are 2,910,435 persons residing in the 63 Minnesota cities in our data (average population per town is 46,197). The average Walk Score of the 63 towns in Minnesota was 34, ranging from 14 to 69. The average median age of residents was similar in tertiles of towns based on Walk Score as follows: ≤ 25 ($n=9$) 36 years; 26–50 ($n=46$) 37 years; and 51–100 ($n=8$) 35 years. The age-adjusted incidence of ischemic stroke was similar in tertiles of towns based on Walk Score as follows: ≤ 25 ($n=9$) 341 per 100,000; 26–50 ($n=46$) 308 per 100,000; and 51–100 ($n=8$) 330 per 100,000 residents. The correlation between age-adjusted ischemic stroke incidence and Walk Score was low ($R^2=0.09$) within Minnesota.

Conclusions—The ready availability of indices such as Walk Score make them attractive options for ischemic stroke risk correlation. Despite the lack of relationship in our study, further studies are required to measure the magnitude and health benefits of light-to-moderate activities performed within a town.

Introduction

A meta-analysis reported that regular brisk walking decreased body weight, BMI, percent body fat, and resting diastolic blood pressure in previously sedentary adults [1]. The daily number of walking steps was positively associated with HDL cholesterol levels and negatively associated with triglyceride levels [2]. Another meta-analysis found that an increment of approximately 30 min of normal walking a day for 5 days/week was associated with 19% coronary heart disease risk reduction [3]. In another meta-analysis, self-reported walking time and walking distance were significantly associated with lower rates of cardiovascular and all-cause mortality [4]. Walking pace was a stronger independent predic-

tor of overall risk compared with walking volume (48% versus 26% risk reductions, respectively). The net direct healthcare cost savings in coronary heart disease prevention resulting from 30 min of normal walking per day for 5–7 days/week were estimated at \$126.73 million in 2004 [5].

We performed this study to determine whether communities that promote walking affect the rate of stroke. The study used a readily available measure known as Walk Score to quantify community walkability and determine its effect on stroke (a relatively understudied endpoint for therapeutic benefit of walking), if any.

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Methods

The population of the state of Minnesota (79,610.08 square miles) according to the 2010 Census was 5,303,925 persons [6]. Whites and African Americans form 85.3% and 5.2% of the population, respectively; 4.7% were categorized as persons of Hispanic or Latino origin. Minnesotans aged 65 years and over comprise 12.9% of the population, and 50.4% of the overall population is women [6]. The state has 169 cities with population greater than 5000 persons and 17 cities with populations above 50,000 (based on the 2010 census) [6].

Walk score: The Walk Score was developed in 2007 as an online database which provides a numerical walkability score for any location within the United States, Canada, Australia, and New Zealand. Walk Scores range between 0 and 100 and are derived from an algorithm that quantifies the walkability of a given location. Amenities are sorted into nine categories: grocery, restaurants, shopping, coffee, banks, parks, schools, books, and entertainment, then weighed according to importance. Walk Score assigns weights as follows:

Grocery: 3

Restaurants: .75, .45, .25, .25, .225, .225, .225, .225, .2, .2

Shopping: .5, .45, .4, .35, .3

Coffee: 1.25, .75

Banks: 1

Parks: 1

Schools: 1

Books: 1

Entertainment: 1

A distance decay function is included to determine what percentage of a full score that a category will receive based on the distance between the address being examined (the origin) and the amenity being scored. Amenities more than 1.5 miles from the origin receive no score. This base score is then normalized to a scale from 0 to 100. Finally, pedestrian friendliness is quantified using intersection density and average block length. A location may receive a penalty of up to 5% of the total score for each criterion, up to a total penalty of 10%.

Estimation of stroke events: We analyzed MHA public use data files for 2011. We used the International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) primary diagnosis codes to identify the

patients admitted with ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage. Diagnostic code fields were screened for specific codes to identify patients with ischemic stroke using ICD-9 codes 433, 434, 436, 437.0, and 437.1 as primary diagnoses. Similarly, intracerebral (codes 431, 432) or subarachnoid hemorrhage (code 430) were identified. The zip code of the patient's residence address was available and used to assign events to each of the 69 cities.

Statistical analyses: The event rate was derived from MHA as described below. We calculated the incidence rates for all strokes, ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage (per 100,000 persons) for 3 years. For the denominator, total persons in each year were categorized in 10-year age intervals (<25 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years, 65–74 years, 75–84 years, and ≥85 years). Persons aged less than 25 years were grouped as one owing to the small number of stroke events and persons aged ≥85 years were classified as one, because the census does not provide further differentiation. The distribution for age and sex in the residing population in Minnesota State was derived from the population Census of 2010. The incidence was averaged across all age strata to provide age-adjusted incidence. We also calculated the risk ratio with 95% confidence interval (CI) for incidence of various events for strata defined by Walk Score: ≤25 ($n=9$); 26–50 ($n=46$); and 51–100 ($n=8$). The Pearson correlation coefficient was determined to measure the strength and direction of the linear relationship between Walk Score and incidence per town (both entered as continuous variables). Analyses were performed using SAS version 9.3 (SAS Institute).

Results

There are 2,910,435 persons residing in 63 towns in Minnesota (the average population per town is 46,197). A total of 8737 all strokes occurred in the 69 cities: further characterized as ischemic stroke (7156), intracerebral hemorrhage (1169), and subarachnoid hemorrhage (412). The crude incidence and age-adjusted incidence of stroke per city was 287 per 100,000 and 397 per 100,000, respectively. The mean (\pm SD) Walk Score for the 69 cities was 37.4 (\pm 11.6) with a range from 14 to 69. The average Walk Score of the 63 towns in Minnesota was 34, ranging from 14 to 69. The average median age of residents was similar in tertiles of towns based on Walk Score as follows: ≤25 ($n=9$) 36 years; 26–50 ($n=46$) 37 years; and 51–100 ($n=8$) 35 years. Table 1 demonstrates the age-adjusted incidences of stroke, ischemic stroke, and intracerebral and subarachnoid

Table 1. Incidences of stroke, ischemic stroke, and intracerebral and subarachnoid hemorrhages according to strata defined by Walk Score.

	≤25 (n=9)	26–50(n=46)	51–100(n=8)
Average Walk Score	21.3	37.0	58.4
Median age	36	37	35
Men (%)	50	49	49
All strokes			
Crude incidence	205	287	373
Age incidence	401	372	537
Risk ratio (95% CI)	Reference	0.9 (0.8–1.0)	1.3 (1.2–1.4)
Ischemic stroke			
Crude incidence	171	238	308
Age incidence	341	308	444
Risk ratio (95% CI)	Reference	0.9 (0.8–1.0)	1.3 (1.1–1.4)
Intracerebral hemorrhage			
Crude incidence	22	39	46
Age incidence	39	50	66
Risk ratio (95% CI)	Reference	1.3 (1.0–1.6)	1.7 (1.3–2.1)
Subarachnoid hemorrhage			
Crude incidence	13	15	18
Age incidence	22	19	26
Risk ratio (95% CI)	Reference	0.8 (0.5–1.3)	1.2 (0.8–1.7)

CI: confidence interval.

hemorrhages according to these strata. Compared with cities with Walk Scores ≤ 25 , the age-adjusted risk of stroke was similar for cities with scores of 26–50 [0.9, 95% CI (0.8–1.0)] and scores of 51–100 [1.3, 95% CI (1.2–1.4)]. Likewise, the risk ratio of age-adjusted risk of ischemic stroke was similar for cities with scores of 26–50 [0.9, 95% CI (0.8–1.0)] and scores of 51–100 [1.3, 95% CI (1.1–1.4)]. The correlation between age-adjusted stroke incidence ($R^2=0.07$) and ischemic stroke ($R^2=0.09$) with Walk Score was low within Minnesota. The correlation between age-adjusted intracerebral hemorrhage incidence ($R^2=0.09$) and subarachnoid hemorrhage ($R^2=0.1$) with Walk Score was also low.

Discussion

Previous studies have examined the effects of other environmental factors upon various health measures in a community-at-large. Access to urban green space, as defined by Landsat satellite retrievals with the Normalized Difference Vegetation Index, was associated with long-term reduction in mortality [7]. In another study, exposure to air pollution at residence based on long-term average concentrations of black smoke, nitric dioxide, and $PM_{2.5}$ were related to mortality [8]. Traffic intensity near the home was also related to natural-cause mortality. The American Cancer Society Cancer Prevention Study II also found that long-term exposure to $PM_{2.5}$ increased mortality and ischemic heart disease related mortality in the general population [9].

A meta-analysis of studies that evaluated the effectiveness of worksite physical activity programs found a positive effect on the risk of musculoskeletal disorders [10]. However, the evidence remained inconclusive for effect

on cardiovascular risk factors. Another meta-analysis evaluated the effectiveness of home-based versus center-based physical activity programs on the health of older adults [11]. There was essentially no difference in terms of treadmill performance or cardiovascular risk factors between groups. However, adherence to programs was low with an adherence rate of 36% in the center-based group as compared with 68% in the home-based program at 2-year followup. In another study, men with at least some difficulty walking a distance of 2 km had a higher relative risk of all-cause mortality when compared with those who had no functional difficulties [12].

Cigarette smoking prevalence varies by community. More walkable neighborhoods may harbor populations with measurably higher or lower rates of smoking, and this variation should be factored in to future analyses. Likewise, dependence upon motor vehicles for transportation varies by community regardless of Walk Score. For example, communities may regard walking as an activity brought about by the lack of access to motor vehicle transportation owing to low income. An examination of total area taken up by parking lots in a given community may help to reveal a preference for driving over walking, regardless of Walk Score. An analysis of smaller geographical units would reveal greater variation in Walk Scores as opposed to the 14–69 range used by this study, and increase resolution. The walkability of large cities such as Minneapolis is extremely varied and includes neighborhoods with very high Walk Scores as well as well as very low Walk Scores. It is therefore likely that considering Minneapolis as one data point conceals valuable information. Increasing the number of data points in an analysis such as this would also enable the division of data points into groupings more meaning-

ful than those used by this study. It is possible that the correlation between Walk Score and walking prevalence is nonlinear, with a greater correlation at the upper end of the scale.

The percentage of worldwide population located in urban areas continues to increase and the interest in any correlation between high Walk Scores and stroke incidence will increase apace. Future examinations of the correlation between stroke incidence and walkable neighborhoods would benefit from the consideration of additional cultural risk factors and a larger number of smaller geographic areas and the modified breakdown of community Walk Scores.

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References

1. Murphy MH, Nevill AM, Murtagh EM, Holder RL. 2007;The effect of walking on fitness, fatness and resting blood pressure: a meta-analysis of randomised, controlled trials. *Prev Med* 44:377–85.
2. Koba S, Tanaka H, Maruyama C, Tada N, Birou S, Teramoto T, Sasaki J. 2011;Physical activity in the japan population: Association with blood lipid levels and effects in reducing cardiovascular and all-cause mortality. *J Atheroscler Thromb* 18:833–45.
3. Zheng H, Orsini N, Amin J, Wolk A, Nguyen VT, Ehrlich F. 2009;Quantifying the dose-response of walking in reducing coronary heart disease risk: meta-analysis. *Eur J Epidemiol* 24:181–92.
4. Hamer M, Chida Y. 2008;Walking and primary prevention: a meta-analysis of prospective cohort studies. *Br J Sports Med* 42:238–43.
5. Zheng H, Ehrlich F, Amin J. 2010;Economic evaluation of the direct healthcare cost savings resulting from the use of walking interventions to prevent coronary heart disease in Australia. *Int J Health Care Finance Econ* 10:187–201.
6. Reich DL, Hossain S, Krol M, Baez B, Patel P, Bernstein A, Bodian CA. 2005;Predictors of hypotension after induction of general anesthesia. *Anesth Analg* 101:622–28.(table of contents)
7. Villeneuve PJ, Jerrett M, Su JG, Burnett RT, Chen H, Wheeler AJ, Goldberg MS. 2012;A cohort study relating urban green space with mortality in Ontario, Canada. *Environ Res* 115:51–8.
8. Brunekreef B, Beelen R, Hoek G, Schouten L, Bausch-Goldbohm S, Fischer P, Armstrong B, Hughes E, Jerrett M, van den Brandt P. 2009Effects of long-term exposure to traffic-related air pollution on respiratory and cardiovascular mortality in the Netherlands: the NLCS-air study. *Res Rep Health Eff Inst* :5–71.(discussion 73–89)
9. Krewski D, Jerrett M, Burnett RT, Ma R, Hughes E, Shi Y, Turner MC, Pope CA 3rd, Thurston G, Calle EE, Thun MJ, Beckerman B, DeLuca P, Finkelstein N, Ito K, Moore DK, Newbold KB, Ramsay T, Ross Z, Shin H, Tempalski B. 2009Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. *Res Rep Health Eff Inst* :5–114.(discussion 115–36)
10. Proper KI, Koning M, van der Beek AJ, Hildebrandt VH, Bosscher RJ, van Mechelen W. 2003;The effectiveness of worksite physical activity programs on physical activity, physical fitness, and health. *Clin J Sport Med* 13:106–17.
11. Ashworth NL, Chad KE, Harrison EL, Reeder BA, Marshall SC. 2005Home versus center based physical activity programs in older adults. *Cochrane Database Syst Rev* CD004017
12. Haapanen-Niemi N, Miilunpalo S, Pasanen M, Vuori I, Oja P, Malmberg J. 2000;Body mass index, physical inactivity and low level of physical fitness as determinants of all-cause and cardiovascular disease mortality--16 y follow-up of middle-aged and elderly men and women. *Int J Obes Relat Metab Disord* 24:1465–74.