Physical Activity Frequency and Risk of Incident Stroke in a National US Study of Blacks and Whites

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Background and Purpose—Regular physical activity (PA) is an important recommendation for stroke prevention. We compared the associations of self-reported PA with incident stroke in the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study.

Methods—REGARDS recruited 30 239 US blacks (42%) and whites, aged ≥45 years with follow-up every 6 months for stroke events. Excluding those with prior stroke, analysis involved 27 348 participants who reported their frequency of moderate to vigorous intensity PA at baseline according to 3 categories: none (physical inactivity), 1 to 3×, and ≥4× per week. Stroke and transient ischemic attack cases were identified during an average of 5.7 years of follow-up. Cox proportional hazards models were constructed to examine whether self-reported PA was associated with risk of incident stroke.

Results—Physical inactivity was reported by 33% of participants and was associated with a hazard ratio of 1.20 (95% confidence intervals, 1.02–1.42; *P*=0.035). Adjustment for demographic and socioeconomic factors did not affect hazard ratio, but further adjustment for traditional stroke risk factors (diabetes mellitus, hypertension, body mass index, alcohol use, and smoking) partially attenuated this risk (hazard ratio, 1.14 [0.95–1.37]; *P*=0.17). There was no significant association between PA frequency and risk of stroke by sex groups, although there was a trend toward increased risk for men reporting PA 0 to 3× a week compared with ≥4× a week.

Conclusions—Self-reported low PA frequency is associated with increased risk of incident stroke. Any effect of PA is likely to be mediated through reducing traditional risk factors. **(*Stroke*. 2013;44:00-00.)**

Key Words: exercise ■ stroke ■ stroke prevention

Stroke is a leading cause of disability in the United States and the fourth leading cause of mortality[1] with total incidence expected to escalate in the coming decades with the rapidly aging population.[2] Adults who make healthy lifestyle choices have an 80% lower risk of stroke when compared with those who do not,[3] indicating that advances can still be made in primary prevention of stroke. An important component of a healthy lifestyle is regular physical activity (PA), as recommended by the PA Guidelines for Americans,[4] which is associated with lower risk of stroke.[5,6] Recent data from the 2010 National Health Interview Survey revealed that 49% of Americans do not meet these PA Guidelines.[7] There is considerable evidence from prospective and case–controlled studies that higher self-reported PA levels are associated with a reduced risk of stroke.[1,8]

Physical inactivity has been identified as the second leading risk factor for stroke after hypertension in a multinational case–control study (INTERSTROKE), finding a population-attributable risk of 28.5%.[9] Although the precise amounts and type of exercise required to prevent stroke are unclear, meta-analyses conclude that regular PA reduces the risk of stroke by 25% to 30% when compared with the least active people.[8,10] Recent evidence is emerging that there may be differences between sexes with vigorous PA associated with decreased risk of stroke in men[11] but not in women.[12] Many large prospective studies investigating the association between PA and stroke have involved only women or men, and often only in limited locations or professions.[13–16] The aim of this study was to investigate the potential for PA to reduce incident stroke in a large, national multiracial prospective cohort study of men and women.

Materials and Methods

The Reasons for Geographic and Racial Differences in Stroke (REGARDS) study, a national, population-based, longitudinal study of 30 239 Americans, was designed to determine the causes for the excess stroke mortality in blacks and those living in the Southeastern United States.[17] Participants aged ≥45 years were recruited by mail and telephone between 2003 and 2007 from a commercially available list of residents with oversampling of blacks and residents of the southeastern Stroke Belt, an area with higher stroke mortality rates

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than the remaining United States.[18] Within the Stroke Belt, there is a region along the coastal plain of North Carolina, South Carolina, and Georgia that has even higher stroke mortality than the remainder of the Stroke Belt, and this area is identified as the Stroke Buckle.[19] Demographic information and medical history were obtained by telephone interview followed by an in-home visit to obtain physical measurements. Cerebrovascular disease risk factors were body mass index, smoking status (never versus past versus current use of cigarettes), alcohol use (heavy, ≥7 drinks/wk for women, ≥14 per week for men; moderate, 1–7 for women, 1–14 for men; and none), diabetes mellitus (fasting glucose, >126 mL/dL or nonfasting glucose >200 mL/dL, or self-reported use of oral hypoglycemic medications or insulin) and hypertension (systolic blood pressure, ≥140 mm Hg or diastolic blood pressure, ≥90 mm Hg or self-reported use of antihypertensive medications). Participants are contacted every 6 months by telephone to assess potential stroke, with retrieval and central physician adjudication of medical charts of suspected strokes. Consent was obtained verbally and later in writing. The institutional review boards of each participating center reviewed and approved the study methods.

Of the 30 239 REGARDS participants, follow-up data were available for 29 643. Of these, we excluded 1854 participants because of prevalent stroke, and 441 who had not answered the PA question.

Assessment of PA

At enrollment, participants reported their usual PA frequency using the following question: How many times per week do you engage in intense PA, enough to work up a sweat? PA, in this context, could involve leisure time, commuting, and occupational PA. Responses were categorized into 3 groups: 1=no times per week, 2=1 to 3 times per week, and 3=4 or more times per week. Although geographic region and season may influence the intensity of PA required to work up a sweat, this widely used measure of PA is well validated,[20,21] can include either aerobic or resistance training, and has been used in similar studies, such as the National Health And Nutrition Examination Survey,[22] and similar questions have been used in other longitudinal cohort studies.[13,23] The sweat question has been shown to correlate with measures of physical fitness, such as maximal oxygen uptake and treadmill time during a maximal exercise fitness test.[24,25] This categorization of PA is appropriate because the effects of PA on stroke risk are more pronounced with moderate to vigorous rather than light PA[8,11] and allows analysis of the dose–response relationship between PA frequency and risk of stroke.

Stroke Events

Incidence of stroke is confirmed in a 3-stage process which has been described previously.[26] Briefly, reports of possible stroke during follow-up result in the retrieval of medical records that are centrally adjudicated by ≥2 physician members of a committee of stroke experts to confirm that the case meets the World Health Organization definition.[27] Events not meeting this definition because of a duration of symptoms <24 hours and neuroimaging consistent with acute ischemia or hemorrhage were classified as clinical strokes, or probable strokes whether adjudicators agreed that event was likely a stroke or death related to stroke but information was incomplete for World Health Organization or clinical classification. Strokes were further classified as ischemic or hemorrhagic. Participants who reported a diagnosis of transient ischemic attack (TIA) were also included in this analysis as a stroke-event.

Statistical Analysis

Cox proportional hazards analysis was used to determine the hazard ratios (HRs) and 95% confidence intervals (CIs) for the association between PA and incident stroke/TIA. Models were initially adjusted for age, sex, race, and age–race interaction, then for socioeconomic factors (income and education). An additional model was adjusted for stroke risk factors (diabetes mellitus, hypertension, body mass index, alcohol use, and smoking status). A final model took into account the effect of physical health limitations on incident stroke for those people who answered yes to either 1 or both of the following questions: Does your health limit moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf? Does your health limit you climbing several flights of stairs?

The protective level of PA was defined as taking part in exercise ≥4× per week, in accordance with the INTERSTROKE study.[9]

Results

Table 1 shows the baseline characteristics of the REGARDS participants by PA category. Participants who were more physically active tended to be men, white, have higher levels of education, higher income, and had lower body mass index and prevalence of diabetes mellitus.

Participants were followed for a mean of 5.7 years, and there were 918 confirmed incident stroke and TIA cases. There was a significant association between PA and incident stroke/TIA as demonstrated in the Figure. After adjustment for age, sex, race, and age–race interaction, the HR for stroke/TIA for those undertaking no PA was 1.20 (95% CI, 1.02–1.42) and for PA 1 to 3× per week, the HR was 1.16 (95% CI, 0.98–1.42). After adjustment for region, urban/rural residence, and socioeconomic status, the significant association remained with similar HR of 1.20 (95% CI, 1.01–1.42) for no PA and 1.14 (95% CI, 0.96–1.35) for 1 to 3× per week. There was a dose-dependent relationship, with PA 1 to 3× per week offering less protection against stroke than ≥4× per week. Further adjustment for stroke risk factors attenuated the effect by 30% to 1.14 (95% CI, 0.95–1.37), making the association statistically insignificant. The final adjustment for physical limitations did not change the HRs further.

The association between PA frequency and incident stroke/TIA was further investigated by comparing the risk of incident stroke in those who report being physically active ≥4× per week to those reporting PA 0 to 3× per week. After adjustment for age, sex, race, and age–race interaction, the HR for stroke/TIA was 1.18 (95% CI, 1.01–1.36). This was partially attenuated after adjustment for region, urban/rural residence, and socioeconomic status (HR, 1.17; 95% CI, 0.99–1.36) and the associations were statistically insignificant after further adjustment.

Analyses were repeated separately for stroke type (ischemic versus hemorrhagic), with no difference in the results obtained (data not shown).

The protective effect of PA has been reported to differ between men and women,[28] but the interaction between sex and PA was not significant in this analysis (P=0.22), perhaps because of insufficient power. To investigate this further, we stratified our results by sex to investigate whether this revealed a difference in risk of incident stroke in our cohort (Table 2). Men who took part in PA 1 to 3× per week compared with ≥4× per week had greater incidence of stroke. This relationship was significant for the demographic model with a HR of 1.30 (95% CI, 1.05–1.61) and also for the socioeconomic status model with a HR of 1.26 (95% CI, 1.00–1.59). Further adjustment for stroke risk factors and physical limitations did not attenuate the effect for men (adjustment for physical limitations not shown, results are identical to the risk factor model for men). These findings contrast with those observed in women, with no significant association between PA and incident stroke, although there was a trend toward a similar

Table 1. Baseline Characteristics of Study Participants by Physical Activity Frequency

	All (N=27 348)	≥4× per wk (n=8187)	1–3× per wk (n=10 003)	None (n=9158)	*P* Value*
Age, mean (SD)	64.6 (9.39)	64.8 (9.13)	63.6 (9.22)	65.6 (9.71)	<0.0001
Black, %	40.4	36.1	40.5	44.2	<0.0001
Women, %	55.5	46.1	55.0	64.3	<0.0001
Region, %					
Belt	34.7	34.9	34.5	34.7	
Buckle	21.0	21.6	21.0	20.6	0.3899
Nonbelt	44.3	43.5	44.5	44.7	
Urban group, %					
Urban	78.1	75.1	78.7	80.1	
Mixed	11.0	12.2	10.8	10.2	<0.0001
Rural	10.9	12.7	10.5	9.7	
Annual income, %					
<20K	17.1	15.2	14.2	22.1	
20–34K	23.9	23.2	23.1	25.4	
35–74K	30.5	31.3	32.6	27.3	<0.0001
≥75K	16.5	18.2	19.2	12.1	
Refused	12.0	12.1	10.9	13.1	
Highest education, %					
Less than HS	11.6	11.0	9.5	14.6	
HS graduate	25.7	25.5	23.4	28.3	<0.0001
Some college	26.9	25.9	27.1	27.5	
College grad and above	35.8	37.6	40.0	29.6	
BMI, kg/m²; mean (SD)	29.3 (6.18)	28.2 (5.44)	29.3 (5.95)	30.3 (6.86)	<0.0001
Smoke, %					
Current	14.2	12.7	13.0	16.7	
Never	45.8	44.4	48.4	44.2	<0.0001
Past	40.0	42.9	38.6	39.1	
Alcohol use, %					
Heavy	4.1	5.2	3.7	3.6	
Moderate	34.1	36.8	36.6	28.8	<0.0001
None	61.8	58.0	59.7	67.6	
Diabetes mellitus, %	21.0	17.5	19.7	25.4	<0.0001
Hypertension, %	57.8	53.2	56.1	63.9	<0.0001

BMI indicates body mass index; and HS, high school.
**P* values based on ANOVA tests for mean differences and χ^2 tests for differences in proportions.

reduction in risk for PA 1 to 3× and ≥4× a week compared with none. Additional analysis was performed combining both 1 to 3× and ≥4× per week categories to compare any PA to none. This demonstrated a lack of association between PA frequency and incident stroke, with the demographic model demonstrating no effect of PA on stroke (women: HR, 1.15 (95% CI, 0.95–1.39); men: HR, 1.05 (95% CI, 0.86–1.29).

There was no significant interaction between race and PA; therefore, results were not stratified for race.

Discussion

The results of this large, population-based prospective cohort study confirm that regular PA is associated with a decreased risk of incident stroke and TIA. This effect was seen for ≥4× per week compared with no PA, with 1× to 3× per wk showing a trend toward being less protective than ≥4× per week, although not significantly different. This confirms previous reports suggesting that exercising 4× a week is associated with a reduced risk of stroke[9] and other meta-analyses, which suggest that moderate intensity PA reduces the risk of stroke.[8,11] To the best of our knowledge, this is the first study to quantify the protective effect of PA on incident stroke in such a large multiracial cohort with equal representation of men and women in the United States.

The association between PA and incident stroke was present after adjustment for demographic and socioeconomic status factors, but further adjustment for stroke risk factors attenuated the relationship somewhat. This suggests that PA interacts with stroke risk factors, such as diabetes mellitus, hypertension, body mass index, alcohol use, and smoking status. In our cohort, there was an unexpected finding in the prevalence of risk factors among the groups: those who regularly

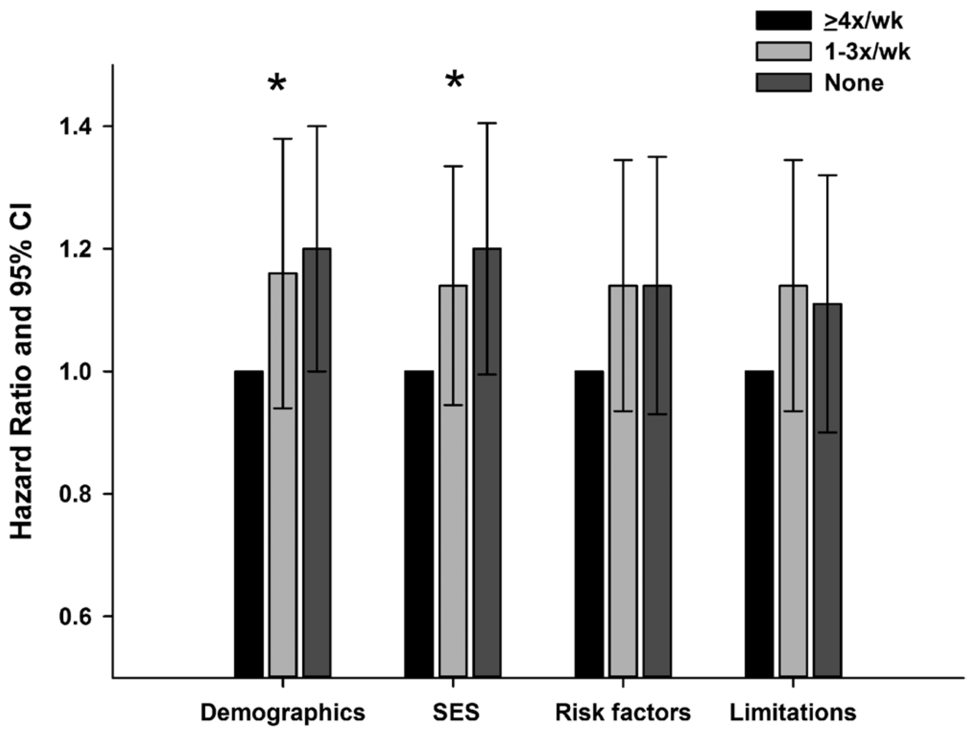

Figure. Physical activity (PA) frequency and risk of incident stroke/transient ischemic attack. The initial regression model included adjustment for demographics (age, sex, race, and age–race interaction) and then further adjustments were performed for 3 additional models: socioeconomic status (SES; including region, urban/rural residence), stroke risk factors (diabetes mellitus, hypertension, body mass index, alcohol use, smoking), presence of physical limitations (unable to climb stairs, perform moderate physical activities). *Significant association between PA and stroke (P_{trend}<0.05). CI indicates confidence interval.

participated in PA were more likely to be moderate or heavy consumers of alcohol. Both PA groups were, however, less likely to smoke, have hypertension or have a high body mass index, and had significantly less diabetes mellitus than the nonexercisers. Thus, reduced stroke risk in the exercisers is likely to be explained for the most part by the positive effect that PA has on body mass index, hypertension, and diabetes mellitus, although PA also has the potential to reduce stroke risk because of other biological actions (eg, improving endothelial function[29] and reducing platelet activity).[30]

Consistent with a previous report,[28] we found a difference between PA and risk reduction when results were stratified according to sex. There was no protective effect of 1 to 3× per week or ≥4× per week on incident stroke/TIA in women, which was confirmed by collapsing both activity categories and still finding no association. The opposite was true for men, with increased HRs for 1 to 3× per week (but not 0× per week) compared with ≥4× per wk, although this trend was not significant (P=0.09). Combining both PA categories for men attenuated the association completely, confirming that PA ≥4× per week is required to reduce the risk of incident stroke in men.

Our PA measure enabled us to classify participants on the basis of frequency of moderate to vigorous PA rather than duration. Nevertheless, there was a significant difference in stroke risk between those individuals reporting PA 1 to 3× or ≥4× per week, confirming that regular moderate to heavy intensity PA is protective against stroke and TIA.[11] This was

Table 2. Association Between PA Frequency and Incident Stroke/TIA in Women and Men

	No. of Cases	Demographic Model	SES Model	Risk Factor Model
Women				
≥4× per wk (n=3777)	105	1	1	1
1–3× per wk (n=5498)	146	1.00 (0.78–1.28)	0.99 (0.76–1.29)	0.99 (0.75–1.30)
None (n=5890)	198	1.15 (0.91–1.46)	1.19 (0.93–1.52)	1.10 (0.85–1.43)
P value for trend	…	0.20	0.12	0.40
Men				
≥4× per wk (n=4410)	149	1	1	1
1–3× per wk (n=4505)	188	1.30 (1.05–1.61)	1.26 (1.00–1.59)	1.29 (1.02–1.64)
None (n=3268)	132	1.21 (0.95–1.53)	1.16 (0.90–1.49)	1.13 (0.87–1.47)
P value for trend	…	0.09	0.21	0.35

PA indicates physical activity; SES, socioeconomic status; and TIA, transient ischemic attack.

further substantiated with subsequent analysis, which compared PA ≥4× per week to 0 to 3× per week and found a significant association with a hours of 1.18; exercising intensely for ≥4× a week was required for PA to have a protective effect in this cohort, as previously reported.[11] Separate analyses by stroke subtype showed similar results. This is consistent with other reports that have considered risk of stroke separately for all stroke, as well as hemorrhagic and ischemic strokes with similar findings.[8,9,12,31]

An important consideration in the interpretation of these results is the potential limitation of our measurement of PA. Although the sweat question is a valid tool to assess PA in large cohort studies, such as REGARDS, it does not include certain key elements to consider when quantifying PA. First, asking specifically about intense PA which works up a sweat may prevent participants from including activities with a light or moderate intensity, such as walking or cycling, which may underestimate the amounts of PA actually performed. Second, our measure of PA does not quantify the duration or type of PA, or the precise number of sessions: responses for those who reported exercising once per week were included in the same category as those exercising 3× per week. It is possible that the inability to find an association between PA and incident stroke in women in our sample is because of the limitation of our PA measure to capture walking and other low-intensity PA; it has previously been reported that walking, but not vigorous PA, is associated with reduced stroke risk in women.[12] Future large-scale cohort studies should consider incorporating measures of PA that allow quantification of intensity, duration, and frequency, such as the International PA Questionnaire[32] or accelerometry.

Another limitation of the study was that the classification of PA category was performed at entry into the study, with stroke events occurring several years later. Although participants may have changed their PA habits during this time, the advantage of this method is that responses are not influenced by recall bias if they were asked to report their usual PA habits soon after diagnosis of stroke, which frequently leads to overestimating of PA.[5] Another potential limitation is that stroke cases could have been missed if participants did not seek medical care or report a suspected stroke. However, medical records were obtained for 89% of potential stroke events, including those instances where participants sought medical attention for stroke-like symptoms. It is possible that incident stroke may have been under-reported, but few stroke events are likely to have been missed. The strengths of this study include the rigorous confirmation of stroke incidence with review of medical records with stroke experts, and participation in follow-up interviews was very high. Furthermore, other strengths include the large sample size representative of blacks and whites, with greater representation of those in areas of high stroke mortality.

In conclusion, regular moderate to vigorous self-reported PA is associated with a reduced risk of stroke and TIA in this large multiracial prospective cohort study. When considering men, exercising at an intensity sufficient to work up a sweat ≥4× a week is more protective than exercising 1 to 3× per week. Any effect of PA is likely to be mediated through reduction of traditional risk factors, such as body mass index and diabetes mellitus.

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References

1. Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Borden WB, et al; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics–2013 update: a report from the American Heart Association. *Circulation*. 2013;127:e6–e245.
2. Howard G, Goff DC. Population shifts and the future of stroke: forecasts of the future burden of stroke. *Ann N Y Acad Sci*. 2012;1268:14–20.
3. Chiuve SE, Rexrode KM, Spiegelman D, Logroscino G, Manson JE, Rimm EB. Primary prevention of stroke by healthy lifestyle. *Circulation*. 2008;118:947–954.
4. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al; American College of Sports Medicine; American Heart Association. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*. 2007;116:1081–1093.
5. Stroud N, Mazwi TM, Case LD, Brown RD Jr, Brott TG, Worrall BB, et al; Ischemic Stroke Genetics Study Investigators. Prestroke physical activity and early functional status after stroke. *J Neurol Neurosurg Psychiatry*. 2009;80:1019–1022.
6. Win S, Parakh K, Eze-Nliam CM, Gottdiener JS, Kop WJ, Ziegelstein RC. Depressive symptoms, physical inactivity and risk of cardiovascular mortality in older adults: the Cardiovascular Health Study. *Heart*. 2011;97:500–505.
7. Schiller JS, Lucas JW, Ward BW, Peregoy JA. Summary health statistics for U.S. adults: National Health Interview Survey, 2010. *Vital Health Stat 10*. 2012:1-207.
8. Lee CD, Folsom AR, Blair SN. Physical activity and stroke risk: a meta-analysis. *Stroke*. 2003;34:2475–2481.
9. O'Donnell MJ, Xavier D, Liu L, Zhang H, Chin SL, Rao-Melacini P, et al; INTERSTROKE Investigators. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. *Lancet*. 2010;376:112–123.
10. Goldstein LB, Bushnell CD, Adams RJ, Appel LJ, Braun LT, Chaturvedi S, et al; American Heart Association Stroke Council; Council on Cardiovascular Nursing; Council on Epidemiology and Prevention; Council for High Blood Pressure Research, Council on Peripheral Vascular Disease, and Interdisciplinary Council on Quality of Care and Outcomes Research. Guidelines for the primary prevention of stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2011;42:517–584.
11. Willey JZ, Moon YP, Paik MC, Boden-Albala B, Sacco RL, Elkind MS. Physical activity and risk of ischemic stroke in the Northern Manhattan Study. *Neurology*. 2009;73:1774–1779.
12. Sattelmair JR, Kurth T, Buring JE, Lee IM. Physical activity and risk of stroke in women. *Stroke*. 2010;41:1243–1250.
13. Hu FB, Stampfer MJ, Colditz GA, Ascherio A, Rexrode KM, Willett WC, et al. Physical activity and risk of stroke in women. *JAMA*. 2000;283:2961–2967.

14. Kiely DK, Wolf PA, Cupples LA, Beiser AS, Kannel WB. Physical activity and stroke risk: the Framingham Study. *Am J Epidemiol*. 1994;140:608–620.
15. Lee IM, Hennekens CH, Berger K, Buring JE, Manson JE. Exercise and risk of stroke in male physicians. *Stroke*. 1999;30:1–6.
16. Folsom AR, Prineas RJ, Kaye SA, Munger RG. Incidence of hypertension and stroke in relation to body fat distribution and other risk factors in older women. *Stroke*. 1990;21:701–706.
17. Howard VJ, Cushman M, Pulley L, Gomez CR, Go RC, Prineas RJ, et al. The reasons for geographic and racial differences in stroke study: objectives and design. *Neuroepidemiology*. 2005;25:135–143.
18. Borhani NO. Changes and geographic distribution of mortality from cerebrovascular disease. *Am J Public Health Nations Health*. 1965;55:673–681.
19. Howard G, Anderson R, Johnson NJ, Sorlie P, Russell G, Howard VJ. Evaluation of social status as a contributing factor to the stroke belt region of the United States. *Stroke*. 1997;28:936–940.
20. Washburn RA, Adams LL, Haile GT. Physical activity assessment for epidemiologic research: the utility of two simplified approaches. *Prev Med*. 1987;16:636–646.
21. Washburn RA, Goldfield SR, Smith KW, McKinlay JB. The validity of self-reported exercise-induced sweating as a measure of physical activity. *Am J Epidemiol*. 1990;132:107–113.
22. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey Questionnaire: physical activity and physical fitness - PAQ. 2007 - 2008 Data Documentation, Codebook, and Frequencies Centers for Disease Control and Prevention; Available at: http://www.cdc.gov/nchs/nhanes/nhanes2007-2008/PAQ_E.htm#PAQ620. Accessed June 20, 2012 2009.
23. Duvernoy CS, Martin JW, Briesmiester K, Muzik O, Mosca L. Self-reported physical activity and myocardial flow reserve in postmenopausal women at risk for cardiovascular disease. *J Womens Health (Larchmt)*. 2006;15:45–50.
24. Siconolfi SF, Lasater TM, Snow RC, Carleton RA. Self-reported physical activity compared with maximal oxygen uptake. *Am J Epidemiol*. 1985;122:101–105.
25. Kohl HW, Blair SN, Paffenbarger RS Jr, Macera CA, Kronenfeld JJ. A mail survey of physical activity habits as related to measured physical fitness. *Am J Epidemiol*. 1988;127:1228–1239.
26. Howard VJ, Kleindorfer DO, Judd SE, McClure LA, Safford MM, Rhodes JD, et al. Disparities in stroke incidence contributing to disparities in stroke mortality. *Ann Neurol*. 2011;69:619–627.
27. Aho K, Harmsen P, Hatano S, Marquardsen J, Smirnov VE, Strasser T. Cerebrovascular disease in the community: results of a WHO collaborative study. *Bull World Health Organ*. 1980;58:113–130.
28. Diep L, Kwagyan J, Kurantsin-Mills J, Weir R, Jayam-Trouth A. Association of physical activity level and stroke outcomes in men and women: a meta-analysis. *J Womens Health (Larchmt)*. 2010;19:1815–1822.
29. Sherman DL. Exercise and endothelial function. *Coron Artery Dis*. 2000;11:117–122.
30. Rauramaa R, Salonen JT, Seppänen K, Salonen R, Venäläinen JM, Ihanainen M, et al. Inhibition of platelet aggregability by moderate-intensity physical exercise: a randomized clinical trial in overweight men. *Circulation*. 1986;74:939–944.
31. Wendel-Vos GC, Schuit AJ, Feskens EJ, Boshuizen HC, Verschuren WM, Saris WH, et al. Physical activity and stroke. A meta-analysis of observational data. *Int J Epidemiol*. 2004;33:787–798.
32. Hagströmer M, Oja P, Sjöström M. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. *Public Health Nutr*. 2006;9:755–762.

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