Leisure-Time Physical Activity and Ischemic Stroke Risk
The Northern Manhattan Stroke Study

Ralph L. Sacco, MD, MS; Robert Gan, MD; Bernadette Boden-Albala, MPH; I-Feng Lin, MS; Douglas E. Kargman, MS, MD; W. Allen Hauser, MD; Steven Shea, MD, MS; Myunghee C. Paik, PhD

Background and Purpose—Physical activity reduces the risk of premature death and cardiovascular disease, but the relationship to stroke is less well studied. The objective of this study was to investigate the association between leisure-time physical activity and ischemic stroke in an urban, elderly, multiethnic population.

Methods—The Northern Manhattan Stroke Study is a population-based incidence and case-control study. Case subjects had first ischemic stroke, and control subjects were derived through random-digit dialing with 1:2 matching for age, sex, and race/ethnicity. Physical activity was recorded through a standardized in-person interview regarding the frequency and duration of 14 activities over the 2 prior weeks. Conditional logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals after adjustment for medical and socioeconomic confounders.

Results—Over 30 months, 369 case subjects and 678 control subjects were enrolled. Mean age was 69.9±12 years; 57% were women, 18% whites, 30% blacks, and 52% Hispanics. Leisure-time physical activity was significantly protective for stroke after adjustment for cardiac disease, peripheral vascular disease, hypertension, diabetes, smoking, alcohol use, obesity, medical reasons for limited activity, education, and season of enrollment (OR=0.37; 95% confidence interval=0.25 to 0.55). The protective effect of physical activity was detected in both younger and older groups, in men and women, and in whites, blacks, and Hispanics. A dose-response relationship was shown for both intensity (light-moderate activity OR=0.39; heavy OR=0.23) and duration (<2 h/wk OR=0.42; 2 to <5 h/wk OR=0.35; ≥5 h/wk OR=0.31) of physical activity.

Conclusions—Leisure-time physical activity was related to a decreased occurrence of ischemic stroke in our elderly, multiethnic, urban subjects. More emphasis on physical activity in stroke prevention campaigns is needed among the elderly. (Stroke. 1998;29:380-387.)

Key Words: cerebrovascular disorders ▪ elderly ▪ epidemiology ▪ ethnic groups ▪ racial differences ▪ risk factors

Regular exercise has well-established benefits for reducing the risk of premature death and many diseases, including cardiovascular disease. In Healthy People 2000, the US Department of Health and Human Services targeted physical activity in health objectives 1.3 to 1.7 for health promotion and disease prevention. The aim by the year 2000 is to increase the proportion of people who engage in regular physical activity and reduce the proportion of those who engage in no leisure-time physical activity, particularly among people aged 65 years and older.1 Current guidelines endorsed by the Centers for Disease Control and Prevention and the National Institutes of Health recommend that Americans should exercise for at least 30 minutes of moderately intense physical activity on most, and preferably all, days of the week.2,3

The relationship between physical activity and stroke is less well studied than for other cardiovascular diseases. Only a few previous studies have evaluated the association between physical activity and the risk of stroke.4-12 The beneficial effects have been predominately described among white populations, have been more apparent for men than women, and generally have been described for younger rather than older adults. The aim of this population-based case-control study was to investigate the relationship between leisure-time/recreational physical activity and ischemic stroke in an elderly, urban, multiethnic population.

Subjects and Methods
The Northern Manhattan Stroke Study (NOMASS) is an ongoing, prospective, population-based incidence and case-control study designed to determine stroke incidence, risk factors, and prognosis in a multiethnic, urban population. Northern Manhattan consists of the area north of 145th Street and south of 218th Street, bordered on the west by the Hudson River, and separated from the Bronx on the east by the Harlem River. In 1990 nearly 260 000 people lived in the region, with 40% older than 39 years. The racial/ethnic distribution in this community is approximately 20% black, 63% Hispanic, and 15% white residents.
Selection of Case Subjects
Case subjects eligible for the case-control study were prospectively enrolled if they met the following criteria: (1) diagnosed with first cerebral infarction after July 1, 1993; (2) older than 39 years at onset of the stroke; and (3) resided in the Northern Manhattan community in a household with a telephone. Even patients who died from their initial stroke were enrolled by relying on surrogate data. Patients with TIA were excluded, ie, neurological deficits lasting less than 24 hours and no ischemic infarct found on brain imaging. Prospective case surveillance consisted of daily screening of all admissions, discharges, and head CT scan logs at the Presbyterian Hospital in the City of New York, the only hospital in the community where approximately 80% of all patients in Northern Manhattan with cerebral infarction are hospitalized.13-15 To ensure complete incident stroke enumeration in the region, cases with International Classification of Diseases, 9th revision codes 430 to 438, 446, and 447 were also identified through discharge lists from 14 hospitals outside the immediate region. Extensive ongoing community-based surveillance for nonhospitalized stroke was done through random household telephone surveys (Audit and Survey, Inc) and frequent interval contacts with community physicians, senior citizen centers, visiting nurse services, and other social and cultural community agencies. Direct community outreach strategies and the local media were also utilized to encourage self-referral of patients with stroke.

Patients diagnosed with stroke as well as a variety of other neurological syndromes (eg, aphasia, hemiparesis, weakness, coma, syncope) were screened by the research assistants, and the case was discussed with a study neurologist to confirm eligibility. After permission was received from the attending physician, written informed consent was obtained from the patient or the family. The study was approved by the institutional review boards at Columbia-Presbyterian Medical Center and the other primary hospitals.

Selection of Control Subjects
Community control subjects were eligible if they (1) had never been diagnosed with a stroke, (2) were older than 39 years, and (3) resided in Northern Manhattan for at least 3 months in a household with a telephone. Stroke-free subjects were identified by random-digit dialing with dual-frame sampling to identify both published and unpublished telephone. Stroke-free subjects were randomly selected from among the participants within the appropriate stratum and matched to each stroke case subject by age (within 5 years in either direction), sex, and race/ethnicity. The telephone survey response rate was 94%, and our in-person participation rate was 70% among the telephone respondents. At the time of the in-person visit, written informed consent was obtained.

Index Evaluation of Case and Control Subjects
Data were collected through interview of the case and control subjects by trained research assistants, review of the medical records, physical and neurological examination by the study physicians, in-person measurements, and fasting blood specimens for lipid and glucose measurements. Data were obtained directly from study subjects by means of standardized data collection instruments. When the subject was unable to answer questions because of death, aphasia, coma, dementia, or other conditions, a proxy who was knowledgeable about the patient’s history was interviewed (data were obtained from the study subject in 74% of case subjects). Stroke-free control subjects were interviewed in person and evaluated in the same manner as case subjects (data were obtained from the study subject in 99% of control subjects). Case subjects were interviewed as soon as possible after their stroke, within a median time of 4 days from stroke onset.

All assessments were conducted in English or Spanish depending on the primary language of the participant. Race/ethnicity was based on self-identification through a series of interview questions modeled after the US census. All participants responding affirmatively to being of Spanish origin or identifying themselves as Hispanic were classified as such. All participants classifying themselves as white without any Hispanic origin or black without any Hispanic origin were classified as white, non-Hispanic, or black, non-Hispanic, respectively.

Subjects were interviewed regarding sociodemographic characteristics, stroke risk factors, and other medical conditions. Standardized questions were adapted from the Behavioral Risk Factor Surveillance System by the Centers for Disease Control and Prevention regarding the following conditions: hypertension, diabetes, hypercholesterolemia, peripheral vascular disease, transient ischemic attack, cigarette smoking, alcohol use, and cardiac conditions such as myocardial infarction, coronary artery disease, angina, congestive heart failure, atrial fibrillation, other arrhythmias, and valvular heart disease.16 Subjects also completed a comprehensive functional status battery, which included the Barthel ADL, the QWB, and the Geriatric Social Readjustment Rating scales.17-19

Blood pressure was measured with the use of a calibrated standard aneroid sphygmomanometer (Omron). After the subject had 5 minutes of relative immobility in a sitting position, two blood pressure measurements separated by 15 minutes were recorded. In subjects with blood pressure recordings discrepant by >10 mm Hg, a third measurement was obtained by the study physician and entered into the database along with the closer blood pressure reading by the research assistant. Anthropometric measurements of height and weight were determined by the use of calibrated scales. Blood samples were sent for complete blood count on admission or enrollment. Fasting glucose was measured with a Hitachi 747 automated spectrometer (Boehringer). Fasting lipid panels (including total cholesterol, LDL, HDL, and triglyceride) were measured with a Hitachi 760 automated spectrometer (Boehringer).

Hypertension was defined as a systolic blood pressure recording \( \geq 160 \text{ mm Hg} \) or a diastolic blood pressure recording \( \geq 95 \text{ mm Hg} \) (based on the average of the two blood pressure measurements) or the patient’s self-report of a history of hypertension or antihypertensive use. Diabetes mellitus was defined by a fasting glucose \( >140 \text{ mg/dL} \) (7.7 mmol/L), the patient’s self-report of such a history, or insulin or hypoglycemic use. For this analysis, smoking was defined as currently smoking cigarettes, and heavy alcohol use was defined as current drinking of \( \geq 14 \) drinks per week. BMI was calculated as weight (kilograms) divided by height (meters) squared, and obesity was defined as BMI \( \geq 27.8 \) for men and \( \geq 27.3 \) for women.1

Physical Activity Assessment
A questionnaire adapted from the National Health Interview Survey of the National Center for Health Statistics was used to measure recent leisure-time/recreational physical activities.20 This survey form has been found to be reliable in evaluating elderly subjects.21 The questionnaire records the frequency and duration of 14 different recreational activities during the 2-week period before the interview. In light of the US Surgeon General’s report on physical activity and health,22 activities surveyed in our elderly population were classified as light-moderate (walking, calisthenics, dancing, golf, bowling,
horseback riding, and gardening) and heavy (hiking, tennis, swimming, bicycle riding, jogging, aerobic dancing, and handball or racquetball or squash). A series of yes/no responses were recorded for each of the questions, posed as “In the last 2 weeks, have you engaged in _______ for physical activity?” For stroke case subjects, the question was phrased as “In the last 2 weeks prior to your stroke . . . .” Each affirmative response was followed by two other questions: “On average, how many times did you perform this activity over the last 2 weeks?” and “On average, how many minutes each time?” From these responses the frequency and duration of each activity were computed.

Statistical Analyses
The crude frequency and mean duration of any physical activities, as well as the individual physical activities and their subgroups (light-moderate and heavy), were examined in the case and control subjects. Multivariate conditional logistic regression for matched data was used to calculate the ORs and 95% CIs for physical activity and stroke, with adjustment for potential stroke risk factors such as hypertension, diabetes, cardiac disease, smoking, heavy alcohol use, and obesity, education, and season (winter versus other seasons). The latter was done to control for any seasonal mismatch between the case and control subjects, since subjects enrolled in winter may be less physically active. Adjusted analyses were performed overall and stratified by age (<65 and ≥65 years), sex, and race/ethnicity. To examine for a dose-response relationship, physical activity was categorized by level of intensity into three groups (none, light-moderate, and heavy activities) and by duration of physical activity (none, <2 h/wk, 2 to <5 h/wk, and ≥5 h/wk). Subjects performing both light-moderate and heavy activities were classified as heavy. We assessed for a linear trend in duration as a continuous variable by testing whether the coefficient of the quadratic term was zero. Interactions between any physical activity and other stroke risk factors were assessed in the multivariate model.

Subgroup analyses were performed to evaluate for any confounding due to recent infection or TIA preceding the stroke. Proxy reliability of the physical activity questionnaire was assessed among 26 stroke case subjects and their proxies. After historical information from the patient was obtained in the usual manner, a surrogate familiar with the patient’s medical history and habits, but not aware of his/her responses to the questionnaire, was interviewed with the same instrument. To evaluate whether using the proxy variable led to any bias in estimates of the ORs, a subgroup analysis was done restricting the data to only nonproxy physical activity data.

Results
From July 1, 1993, to December 31, 1995, 369 case subjects with first cerebral infarction and 678 age-, sex-, and race/ethnicity-matched control subjects were enrolled in the case-control study. Among the case subjects, 7% died within 30 days of the stroke, and both fatal and nonfatal strokes were included in the analyses. Overall, there were 18% whites, 30% blacks, and 52% Hispanics. Mean age was 69.9 ± 12 years, and women constituted 57%. Hypertension, diabetes, peripheral vascular disease, smoking, and cardiac disease were more common among the case subjects, while obesity was more prevalent among the control subjects. The control subjects were slightly more educated and were enrolled slightly more frequently during nonwinter months than the case subjects (Table 1). Only 16% of the case and control subjects were working >10 h/wk at the time of enrollment. Based on the recruitment telephone-interview data, our nonresponse analysis showed that control subjects who participated in person had a similar frequency of hypertension, diabetes, and cardiac disease but were more likely to be overweight and smoke cigarettes than subjects who did not participate.

Construct validity of our physical activity assessment was demonstrated within our cohort. Physical activity duration measurement correlated inversely with BMI among the control subjects (Pearson’s r = −.125; P < .001) and directly with ADL scores (Pearson’s r = .157; P < .0001) and other activity questions on the QWB scale (Pearson’s r = .182; P < .0001). A seasonal variation in the performance of physical activity was observed. Our control subjects were more active during nonwinter (March 21 to December 20) than winter months (December 21 to March 20) (P < .0005). The physical activity assessment was reasonably reliable when obtained from proxies, with a crude concordance rate of 0.69 for engaging in any physical activity in our proxy reliability study.

During the 2 weeks before study enrollment, 49% of case subjects and 25% of control subjects reported no leisure-time recreational physical activity (Table 2). Among those who performed any physical activity, walking was the most frequently reported form of exercise in both case and control subjects, followed by calisthenics. The mean duration for any activity was 4.0 ± 4.4 h/wk for case subjects and 4.7 ± 4.8 h/wk

**TABLE 1. Demographics and Vascular Risk Factors**

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Case Subjects (n=369)</th>
<th>Control Subjects (n=678)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>63 (17%)</td>
<td>121 (18%)</td>
</tr>
<tr>
<td>Black</td>
<td>106 (29%)</td>
<td>204 (30%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>196 (53%)</td>
<td>349 (51%)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>206 (56%)</td>
<td>394 (58%)</td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>70.0±12.4</td>
<td>69.8±11.8</td>
</tr>
<tr>
<td>Age ≥65</td>
<td>254 (69%)</td>
<td>472 (70%)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥HS graduate</td>
<td>116 (32%)</td>
<td>307 (45%)</td>
</tr>
<tr>
<td>Season of enrollment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonwinter*</td>
<td>295 (80%)</td>
<td>584 (86%)</td>
</tr>
<tr>
<td>Risk factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension†</td>
<td>264 (72%)</td>
<td>393 (58%)</td>
</tr>
<tr>
<td>Diabetes‡</td>
<td>140 (38%)</td>
<td>131 (19%)</td>
</tr>
<tr>
<td>PVD</td>
<td>85 (23%)</td>
<td>89 (13%)</td>
</tr>
<tr>
<td>Smoking§</td>
<td>81 (23%)</td>
<td>117 (18%)</td>
</tr>
<tr>
<td>Cardiac disease¶</td>
<td>141 (39%)</td>
<td>158 (23%)</td>
</tr>
<tr>
<td>Obesity¶¶</td>
<td>128 (37%)</td>
<td>286 (42%)</td>
</tr>
<tr>
<td>Heavy alcohol intake#</td>
<td>33 (9%)</td>
<td>43 (7%)</td>
</tr>
</tbody>
</table>

*Nonwinter = December 21 to December 20.
†History of hypertension or systolic blood pressure ≥160 mm Hg or diastolic blood pressure ≥95 mm Hg.
‡History of diabetes or glucose ≥140 mg/dL (7.7 mmol/L).
§Currently smoking.
¶History of myocardial infarction, coronary artery disease, congestive heart failure, atrial fibrillation, or valvular heart disease.
¶¶BMI ≥27.8 for men and ≥27.3 for women.
#≥2 drinks per day.
for control subjects. As expected in this elderly sample, the mean duration of the heavy types of physical activity was less than the light-moderate forms of activity.

Engaging in any physical activity (light-moderate or heavy) was independently related to a reduced risk of stroke (OR = 0.37; 95% CI = 0.25 to 0.55) after adjustment for hypertension, diabetes, cardiac disease, peripheral vascular disease, smoking, obesity, heavy alcohol use, medical reasons for limited activity, education, and season of enrollment. The protective effect of exercise for stroke was demonstrated in all subgroups after stratification by age, sex, and race/ethnicity (Fig 1). Our smaller white subgroup had the widest CI in the adjusted multivariate analyses; however, the point estimate of the OR for physical activity was still in the protective direction.

To assess for other confounding factors that may have affected the level of physical activity in our study subjects, we performed several analyses. The effect of physical activity was similar in our subgroup analysis restricted to nonproxy data (OR = 0.40). After exclusion of case subjects who experienced TIA during the preceding 30 days, the adjusted OR for physical activity was comparable to our original model (OR = 0.42; 95% CI = 0.28 to 0.63). Symptoms of infection were reported in only 9% of our case subjects and 6% of our control subjects and were not statistically different, and the association between physical activity and stroke remained even after adjustment for admission white blood cell count (OR = 0.36; 95% CI = 0.22 to 0.60). The median prestroke or preenrollment Barthel ADL scores were 100 for both our case and control subjects, and the mean QWB scores were similar between case subjects (0.7±0.16) and control subjects (0.7±0.15) (Table 1). With the use of the Geriatric Social Readjustment Rating Scale to survey recent changes in the subjects’ life events that may affect physical activity, the case and control groups were identical when we compared “stressful physical illness” (painful arthritis, eyesight failure, hearing failure, or feeling of slowing down) and “impactful acute loss events” (death of spouse, death of close friend, death of relative, or loss of job).

When we used the no-exercise group as a reference, heavy activity (OR = 0.23; CI = 0.10 to 0.54) appeared slightly more protective than light-moderate activity (OR = 0.39; CI = 0.26

<table>
<thead>
<tr>
<th>Activity</th>
<th>Case Subjects</th>
<th></th>
<th></th>
<th>Control Subjects</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Hours/Week</td>
<td></td>
<td></td>
<td>n</td>
<td>Hours/Week</td>
</tr>
<tr>
<td>Never</td>
<td>179 (49%)</td>
<td>0</td>
<td></td>
<td>174 (25%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Any activities</td>
<td>190 (51%)</td>
<td>4.0±4.4</td>
<td></td>
<td>504 (75%)</td>
<td>4.7±4.8</td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>186 (50%)</td>
<td>3.8±4.4</td>
<td></td>
<td>489 (72%)</td>
<td>4.5±4.6</td>
<td></td>
</tr>
<tr>
<td>Walking</td>
<td>174 (47%)</td>
<td>3.6±3.5</td>
<td></td>
<td>468 (69%)</td>
<td>4.2±4.4</td>
<td></td>
</tr>
<tr>
<td>Calisthenics</td>
<td>20 (5%)</td>
<td>1.5±1.5</td>
<td></td>
<td>106 (16%)</td>
<td>1.5±1.4</td>
<td></td>
</tr>
<tr>
<td>Dancing</td>
<td>3 (1%)</td>
<td>5.3±8.4</td>
<td></td>
<td>13 (2.0%)</td>
<td>1.7±1.7</td>
<td></td>
</tr>
<tr>
<td>Golf</td>
<td>2 (1%)</td>
<td>18.5±23.3</td>
<td></td>
<td>4 (1%)</td>
<td>10±9.7</td>
<td></td>
</tr>
<tr>
<td>Gardening</td>
<td>1 (0.3%)</td>
<td>3.3±0</td>
<td></td>
<td>6 (1%)</td>
<td>2.4±3.7</td>
<td></td>
</tr>
<tr>
<td>Bowling</td>
<td>0 (0%)</td>
<td>0</td>
<td></td>
<td>2 (0.3%)</td>
<td>1.8±0.4</td>
<td></td>
</tr>
<tr>
<td>Horseback riding</td>
<td>0 (0%)</td>
<td>0</td>
<td></td>
<td>0 (0%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Moderate/heavy</td>
<td>16 (4%)</td>
<td>2.2±1.8</td>
<td></td>
<td>64 (9%)</td>
<td>2.4±3.4</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicycle</td>
<td>6 (2%)</td>
<td>2.2±1.5</td>
<td></td>
<td>17 (3%)</td>
<td>2.5±3.7</td>
<td></td>
</tr>
<tr>
<td>Swimming</td>
<td>0 (0%)</td>
<td>0</td>
<td></td>
<td>13 (2%)</td>
<td>1.6±1.3</td>
<td></td>
</tr>
<tr>
<td>Hiking</td>
<td>0 (0%)</td>
<td>0</td>
<td></td>
<td>3 (0.4%)</td>
<td>1.8±1.0</td>
<td></td>
</tr>
<tr>
<td>Tennis</td>
<td>0 (0%)</td>
<td>0</td>
<td></td>
<td>2 (0.3%)</td>
<td>0.75±1.7</td>
<td></td>
</tr>
<tr>
<td>Heavy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerobic dance</td>
<td>8 (2%)</td>
<td>2.3±1.1</td>
<td></td>
<td>28 (4%)</td>
<td>2.1±3.9</td>
<td></td>
</tr>
<tr>
<td>Jogging</td>
<td>4 (1%)</td>
<td>0.8±0.6</td>
<td></td>
<td>9 (1.3%)</td>
<td>2.2±2.75</td>
<td></td>
</tr>
<tr>
<td>Handball</td>
<td>0 (0%)</td>
<td>0</td>
<td></td>
<td>0 (0%)</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Association between physical activity and stroke. Adjusted ORs and 95% CIs from multivariate conditional logistic regression analysis of the association between ischemic stroke and physical activity are shown overall and stratified by age, sex, and race/ethnicity. No physical activity is the reference category within each stratum.
The cardiovascular benefits of physical activity have been emphasized by numerous organizations, including the Centers for Disease Control, National Institutes of Health, and the American Heart Association. Recent guidelines recommended that individuals perform moderate exercise for approximately 3.5 h/wk. This suggestion arose from accumulating data regarding the beneficial effects of physical activity in reducing the incidence of heart disease. The benefits for stroke, however, have not always been consistent across age and sex subgroups. Furthermore, little is known about physical activity in different nonwhite race/ethnic groups, in whom the stroke burden has been reported to be greater.23,24

In our study we detected a beneficial relationship between leisure-time physical activity and stroke. The protective effects were found after adjustment for medical and socioeconomic confounders, season of recruitment, and smoking and alcohol use. Similar benefits were observed for those younger and older than 65 years, both men and women, and among whites, blacks, and Hispanics. The mean duration of leisure-time physical activity in our population approximated that recommended by the Centers for Disease Control and National Institutes of Health, with much less participation in heavy forms of activity. In our relatively older cohort, walking was the most common form of recreational physical activity reported, which is consistent with observations in other comparably aged populations.21,25 The finding of an overall protective effect for leisure-time physical activity suggests that even light-moderate forms of activity may confer some benefits for the elderly. Our results are particularly relevant in the more sedentary and older population who have a greater risk of stroke and more prevalent cardiovascular risk factors and whose physical activity pattern may comprise mainly light to moderate activity of shorter duration.

The protective effects of physical activity for stroke risk noted in other studies were limited to certain age, sex, and risk factor subgroups. The Honolulu Heart Program, which investigated older middle-aged men of Japanese ancestry, showed a protective effect of habitual physical activity from thromboembolic stroke only among their nonsmoking group.5 The Framingham Study demonstrated the benefits of combined leisure and work physical activities for men but not for women.6 In the Oslo Study of men aged 40 to 49 years, increased leisure physical activity was related to a reduced stroke incidence.7 For women aged 40 to 65 years, the Nurses’ Health Study showed an inverse association between level of physical activity and the incidence of any stroke.8 For white, lower and middle class, urban women participating in the Copenhagen City Heart Study, lack of physical activity had an effect similar to that of cigarette smoking, with a relative risk of stroke of 1.4.9 In the National Health and Nutrition Examination Survey I follow-up study, low level of recreational or nonrecreational activities was slightly associated with an increased risk of stroke for both men and women and among blacks.10

The dose-response relationship between level and duration of leisure physical activity and protective effects from stroke was consistent in our study population and among each of the age, sex, and race/ethnic subgroups. Although performance of leisure-time physical activities conferred protection, more vigorous (heavy) forms of physical activities provided additional benefits compared with light-moderate activities. The same was true for duration of physical activity. Although the odds of stroke were reduced in the group performing <2 h/wk of physical activity, additional protection was observed with increasing duration of exercise. The beneficial effects of even small amounts of leisure-time physical activity in the older population have not been reported previously, and the dose-response relationship is encouraging for those individuals who can safely increase their level of physical activity.
The dose-response relationship between increasing amounts of physical activity and the reduction in the risk of stroke has not always been demonstrated. Wannamethee and Shaper\textsuperscript{11} found an inverse relationship between physical activity and risk of stroke, but the benefit of vigorous physical activity for stroke was offset by an increased risk of heart attack. In Framingham among the older cohort, the strongest protective effect was detected in the medium tertile physical activity subgroup, with no additional benefit gained from higher levels of physical activity.\textsuperscript{6} Among subjects in a case-control study in West Birmingham, UK, who were free of cardiac disease, peripheral vascular disease, and poor health, recent vigorous exercise was no more protective than walking.\textsuperscript{12}

The protective effect of physical activity may be partly mediated through its role in controlling various known risk factors for stroke. Exercise has been shown to lower blood pressure in certain groups.\textsuperscript{26–28} It is also associated with a lower incidence of cardiovascular disease.\textsuperscript{29–32} Improved diabetes control,\textsuperscript{33,34} better dietary habits, and lower body weight.\textsuperscript{35,36} Cigarette smokers are less likely to participate in exercise programs.\textsuperscript{37} Furthermore, people with a higher level of education participate in more leisure-time activity.\textsuperscript{38} The finding of an independent effect of physical activity after adjustment for these factors suggests that mechanisms other than the control of risk factors may be responsible for the protective effect of physical activity for stroke.

Other biological mechanisms are also associated with physical activity, including reductions in plasma fibrinogen and platelet activity and elevations in plasma tissue plasminogen activator concentration and HDL concentrations.\textsuperscript{39–42} In a preliminary analysis from our multiethnic population, we found HDL concentration to be inversely related to the risk of stroke.\textsuperscript{43} However, we found no significant differences in plasma HDL levels among our inactive, light-moderately active, and heavily active groups in either our case or control subjects, and the independent effect of physical activity remained after HDL and other lipid levels were added to our model in a subgroup analysis.

There are some limitations to our study. Our design was a case-control study and not a prospective cohort study. However, our subjects were population based, and selection bias is less likely than in hospital-based case-control studies. The OR more closely approximates a relative risk in population-based case-control studies, since the case and control subjects are derived from the same community and provide a close approximation of the prevalence of exposure in those with and without incident disease.\textsuperscript{44} Recall bias, a frequent source of bias in case-control studies, seems less likely since the case and control subjects were not aware of the hypotheses being tested. In addition, recall physical activity surveys like the instrument we used are less likely to influence a subject’s typical behavior than activity diaries or logs.\textsuperscript{22} There may have been some unmeasured confounders that led to a reduction in recent physical activity among the stroke case subjects or influenced the selection of control subjects who were more physically active. This could have resulted in an overestimation of the OR. However, we made a concerted effort to adjust for such confounders in our analyses and performed nonresponse analyses which showed that the control subjects who participated in the study had risk factor profiles similar to those who did not participate in person, except for greater BMI and smoking among the participants. Both of these conditions would lead to bias of the OR toward the null value, since such conditions would decrease the likelihood of engaging in physical activity. Some have argued that recent infections are more frequent in stroke patients,\textsuperscript{45,46} which could also confound the physical activity association. We found no direct association between clinical symptoms of infection and physical activity among our case subjects, and our findings were the same even after we controlled for admission white blood cell count. There was likewise no relationship between occurrence of TIA within 30 days before stroke and physical activity to suggest that TIA differentially reduced the level of physical activity in our case subjects. Furthermore, the prestroke or preenrollment median ADL scores, mean QWB scores, and Geriatric Social Readjustment Scale assessments were similar among our case and control subjects.

Physical activity questionnaires have differed in the time frame of assessment, and some have included occupational as well as leisure or recreational activities.\textsuperscript{47–53} The majority of our subjects were elderly, with only 16% working at the time of enrollment. Among those who were working, the job types infrequently involved strenuous physical activities. Our physical activity assessments were not designed to evaluate lifelong exercise practices, exercise patterns at younger ages, physical conditioning, or quantitative estimations of energy expenditure. Our instrument measured leisure physical activity during the preceding 2 weeks. The 2-week period of activity recall was deemed reliable, short enough to allow reasonably accurate recall in an elderly sample, yet long enough to represent the usual activity patterns of most people.\textsuperscript{54} The inverse correlation of physical activity with BMI in our study could suggest that our measurements being correlated with more sustained patterns of physical activity. It is not clear from our study whether the pattern of physical activity in the elderly correlated with a life-long pattern of physical activity that conferred the protective effect or whether recent physical activity, regardless of life-long patterns, can confer some benefits.

Our study demonstrates the importance of leisure-time physical activity in the prevention of stroke among the elderly, in men and women, and in all race/ethnic groups. While currently available methods of physical activity measurement may not be ideal, they have provided a means of demonstrating important benefits of physical activity.\textsuperscript{21} The benefits in stroke are apparent even for light-moderate activities, such as walking, and the data support additional benefits to be gained from increasing the level and duration of one’s recreational activity. The potential undesirable consequences of extreme exercise, such as alterations in hormonal levels in women, musculoskeletal injuries, loss of bone mineral content, and risk of acute myocardial infarction,\textsuperscript{55–62} should be considered when advising individual patients, particularly the elderly, to increase their physical activity. Nevertheless, physical activity is a modifiable behavior that requires greater emphasis in stroke prevention campaigns. As long as the adverse effects of high-intensity physical activity are minimized, leisure-time physical activity could translate into a cost-effective means of decreasing the
public health burden of stroke and other cardiovascular diseases among our rapidly aging population.

Acknowledgments

This study was supported by grants from the National Institute of Neurological Disorders and Stroke (R01 NS 27517, R01 NS 29993, and T32 NS 07153) and the General Clinical Research Center (2 M01 RR00645). We acknowledge the support of Dr J.P. Mohr, Director of Cerebrovascular Research; the statistical assistance of Qiong Gu; and the help provided by Drs J. Kirk Roberts and Mitchell S. Elkind, fellows in stroke and neuroepidemiology.

References


Leisure-Time Physical Activity and Ischemic Stroke Risk: The Northern Manhattan Stroke Study

Stroke. 1998;29:380-387
doi: 10.1161/01.STR.29.2.380
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1998 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/29/2/380