Exercise Intensity and Subclinical Cardiovascular Disease in the Elderly

The Cardiovascular Health Study

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The authors assessed the cross-sectional association between intensity of exercise in later life and coronary heart disease risk factors and subclinical disease among 2,274 men and women, 65 years of age and older, who were participants in the Cardiovascular Health Study (CHS) during 1989–1990. Subjects were free of prior clinical cardiovascular disease or impairment of physical function. Exercise intensity was characterized as low, moderate, or high, based on highest intensity exercise reported over the 2 weeks prior to the CHS baseline examination. After adjustment for age, education, and postmenopausal hormone therapy (among women), there was an inverse dose-response relationship of exercise intensity with selected risk factors. By low, moderate, and high exercise intensity, respectively: fasting insulin—men, 15.6 μU/ml, 14.1 μU/ml, and 12.6 μU/ml, p for trend <0.001; women, 14.8 μU/ml, 13.8 μU/ml, and 12.0 μU/ml, p for trend = 0.01; serum fibrinogen—men, 316.2 mg/dl, 315.4 mg/dl, and 300.0 mg/dl, p for trend = 0.01; women, 327.3 mg/dl, 317.0 mg/dl, and 310.7 mg/dl, p for trend = 0.01; lower extremity arterial disease by percent with ankle-arm index <0.9—men, 18.3, 5.5, and 3.7, p for trend = 0.01; women, 10.0, 5.7, and 2.8, p for trend = 0.02; evidence of myocardial injury by cardiac infarction/injury score (CMS)—men, 8.0, 6.0, 3.9, p for trend <0.001; women, 4.6, 3.9, and 3.6, p for trend = 0.03. Adjustment for smoking, alcohol consumption, and total kilocalories expended in exercise altered the findings only slightly. The authors conclude that intensity of exercise in later life is associated with favorable coronary disease risk factor levels and a reduced prevalence of several markers of subclinical disease.


Regular exercise is associated with reductions in risk factors for coronary heart disease (1, 2), subclinical coronary disease (3, 4), and incident coronary disease and sudden cardiac death (5–9). The reduction in coronary disease risk attributable to regular exercise is particularly large among older persons (6–8). However, the intensity of exercise required to promote cardiovascular health among older persons has remained a source of controversy. Several cohort studies (5, 6) suggest that strenuous activity that results in a training effect, an enhanced capacity to perform physical work, may be necessary to reduce coronary disease risk. Other studies (10–14) suggest that less intense activity also may reduce risk of coronary disease. Because sedentary persons may be more likely to adopt non-strenuous exercise rather than strenuous exercise, it is particularly important to know whether non-strenuous exercise is associated with reduced coronary disease risk, and the extent to which strenuous exercise provides additional cardiovascular benefits.

To further assess the relation between exercise intensity and cardiovascular health among older men and women, we examined the cross-sectional associations between the intensity of regular exercise and both coronary disease risk factors and subclinical dis-
ease in the Cardiovascular Health Study (CHS), a cohort study of risk factors for coronary disease and stroke. Because of the broad range of risk factors and non-invasive measures included in the CHS baseline examination, we were able to examine simultaneously the relation between the intensity of exercise and multiple measures that reflect cardiovascular health among men and women aged 65 years and older.

MATERIALS AND METHODS

Study sample

During a 12-month period beginning in June 1989, four CHS field centers—located in Forsyth County, North Carolina; Sacramento County, California; Washington County, Maryland; and Pittsburgh, Pennsylvania—recruited a total of 5,201 participants. Each community sample was obtained randomly from the Medicare eligibility lists of the Health Care Financing Administration (HCFA). Eligible participants included all persons who were living in the household of each individual sampled from the HCFA lists and who were: 1) 65 years or older; 2) non-institutionalized; 3) expected to remain in the area for 3 years; and 4) able to give informed consent and did not require a proxy respondent. Participants were eligible for CHS whether or not they had a history of cardiovascular disease. However, we excluded persons who were wheelchair-bound, or were receiving hospice treatment or treatment for cancer. Details of the CHS design and recruitment are described elsewhere (15). Among the persons contacted and eligible, 57.6 percent were enrolled in CHS. Enrolled participants were younger, more educated, and more likely to be married than those who refused or who were ineligible (16).

Baseline examination

The baseline examination consisted of a home interview and a clinic examination. During the home interview, information was collected on prior medical history, medication use, and physical activity. Information also was obtained regarding the presence of impairments of physical functioning. The clinic examination included a fasting blood draw, seated blood pressure and resting heart rate, anthropometric measurements, ankle-brachial systolic blood pressure index (ABI), resting electrocardiograph, carotid ultrasonography, M-mode and 2-D echocardiograph, and Doppler measurements of trans-mitral flow velocities. Details of the examination procedures have been described elsewhere (15).

Analysis sample

We sought to minimize potential confounding from prior morbidity by excluding CHS participants who had clinical cardiovascular disease (n = 1,968) at the time of the baseline examination. We excluded CHS participants with a prior clinical history of the following: myocardial infarction; angina pectoris; congestive heart failure; coronary artery bypass and graft (CABG); coronary angioplasty; atrial fibrillation; pacemaker insertion; valvular disease; heart surgery other than CABG; carotid endarterectomy; lower extremity vascular surgery or angioplasty; aortic aneurysm repair; prior stroke; prior transient ischemic attack; intermittent claudication; Rose angina or claudication (17); and digoxin, nitroglycerin, or antiarrhythmic medication use.

Additionally, we excluded participants who reported impairment of physical function (n = 920) at the time of the baseline examination. Impairment of physical function was defined by reported difficulty in the performance of one or more activities related to exercise tolerance and physical functioning, including walking one-half mile (0.8 km), climbing 10 steps, performing heavy housework, and lifting and carrying groceries. We also excluded 39 participants who reported one or more bed days during the prior 2 weeks.

The CHS participants included in the current analysis sample (n = 2,274) rated their overall general health as excellent or very good (55.0 percent), good (36.0 percent), fair (8.6 percent), or poor (0.4 percent). Similarly, 67.9 percent rated their health as better compared with other people of their age, 31.5 percent as the same, and 0.6 percent as worse. In short, the analysis sample included a “healthy,” physically able subset of CHS participants.

Measurement of variables

We assessed participation in leisure-time physical activity using an instrument adapted from the Health Interview Survey that has been utilized in other epidemiologic studies (11). Participants were asked if they engaged in any of 15 leisure-time activities over the prior 2 weeks. For each activity, information also was obtained on the frequency and duration of participation (time spent) in the activity; this information was used to estimate the kilocalories of energy expended and the time spent per week in leisure-time physical activity (18). Participants also were asked the usual pace of walking outside the home. Based on the highest intensity leisure-time activity reported over the prior 2 weeks, participants were categorized as having engaged in high-intensity, moderate-intensity, or low-intensity activity, where high-intensity activi-
ties were estimated to require a work metabolic rate/resting metabolic rate of >6 METs.

Participants who engaged in one or more of six high-intensity activities, including swimming, hiking, aerobics, tennis, jogging, or racquetball, or who walked for exercise at a brisk (>4 mph (6.4 kmph)) pace were categorized as having engaged in high-intensity activity (>6 METs). Participants who engaged in one or more of nine light- or moderate-intensity activities (<6 METs) including gardening, mowing, raking, golf, bowling, biking, dancing, calisthenics, or exercise cycle, or who walked for exercise at an average pace (>2–3 mph (>3.2–4.8 kmph)) or fairly brisk pace (>3–4 mph (>4.8–6.4 kmph)) were categorized as having engaged in moderate-intensity activity. Participants who did not report participating in any of the 15 leisure-time activities or who walked for exercise at a casual or strolling pace (<2 mph (<3.2 kmph)) were categorized as having engaged in low-intensity activity.

Several measures of subclinical disease were obtained during the baseline examination. Carotid sonography was performed using Toshiba SSA-270A sonographic units (Toshiba America Medical Systems, Tustin, California). A single longitudinal view of the distal 10 mm of the right and left common carotid arteries and three longitudinal views in different imaging planes of each internal carotid artery were recorded and sent to the Ultrasound Reading Center for standardized readings. Measurements of lumen and wall (combined intima-media) thickness were made using a specially designed computer program. The maximal wall thickness (the average of the maximum from each side) for both the common carotid and internal carotid arteries were calculated. In addition, the percent diameter stenosis for each internal carotid artery was estimated using both image and Doppler data. Measurements were made at a single reading center as described elsewhere (19).

Echocardiographic examinations were performed with the Toshiba SSH-160A echocardiographic recorder (Toshiba America Medical Systems, Tustin, California). M-mode echocardiography was performed to measure left ventricular mass. In addition, Doppler measurements of trans-mitral early and late flow velocities were obtained to assess left ventricular filling, a marker of diastolic function. Details of the protocol for making echocardiographic measurements in CHS are summarized elsewhere (20).

Twelve-lead resting electrocardiograms (ECGs) were obtained with the MAC PC-DT ECG recorder (Marquette Electronics Inc., Milwaukee, Wisconsin). The ECG Reading Center used the NOVACODE ECG measurement and classification system (21). ECG measurements included a calculated cardiac injury infarction score (CIIS) (22).

Lower extremity arterial disease was assessed non-invasively using the ABI. Measurements were made in both legs with the participant at rest using a standard protocol administered by trained technicians. The ABI was calculated as the ratio of the average of two measurements obtained from the right arm and each lower extremity. The lower of the left or right ABI was used to categorize participants. Details of the ABI measurement protocol are described elsewhere (23).

Blood specimens were obtained early in the clinic visit after a 12-hour fast and were sent to the Central Blood Analysis Laboratory. At the laboratory, testing included: 1) fasting lipids (total cholesterol, high density lipoprotein (HDL) cholesterol, and triglycerides; low density lipoprotein (LDL) cholesterol was estimated using the Friedenwald formula; 2) measures of glucose metabolism (fasting and 2-hour post-glucose load glucose and insulin levels); and 3) coagulation factors (factor VII, factor VIII, and fibrinogen). Details related to the collection, processing, storage, and testing of blood specimens in CHS have been summarized elsewhere (24).

Statistical methods

To examine the relation of exercise intensity with both coronary disease risk factors and subclinical disease, we used contingency tables for categorical variables and analysis of covariance for continuous variables. When distributions of continuous variables were skewed, we used the log function to normalize the distribution. Because these transformations did not affect the statistical significance of our findings, we present the results of statistical tests (and associated p values) from untransformed data. The reported p values represent the result of a test for trend in the means or proportions across exercise-intensity categories, after adjustment for other characteristics, and are not adjusted for multiple comparisons.

We assessed the relation of exercise intensity with risk factors and subclinical disease, after adjustment for potential determinants of exercise, including age, education (high school graduate vs. less than high school graduate), and treatment with postmenopausal hormone therapy (for women). Analyses related to blood pressure and glucose and insulin levels were restricted to participants who were not treated for hypertension or diabetes mellitus, respectively. We also assessed the effect of further adjustment for cigarette smoking (current, former, never), alcohol consumption (number of drinks per day), and total kilocalories expended in leisure-time physical activity (as a continuous variable) using linear and logistic regres-
sion. Because the effects on risk factor levels might mediate the association of exercise intensity with subclinical disease, we did not adjust for risk factor levels in our assessment of the relation of exercise intensity with subclinical disease.

To explore further the relation between non-strenuous exercise and cardiovascular health, we conducted similar analyses to assess the relation of the kilocalories expended and time spent in moderate-intensity exercise with coronary disease risk factors and markers of subclinical disease among persons who did not engage in high-intensity exercise during the prior 2 weeks. However, because few persons who engaged in high-intensity activity reported that they spent less than 90 minutes per week engaged in exercise, we did not explore the impact of the duration of exercise among persons who engaged in high-intensity activity.

Analyses were conducted separately for men and women; because of the small number of nonwhite participants who were eligible for our analyses (n = 104), nonwhites were combined with whites in these analyses. Twelve participants with missing data related to physical activity were excluded from the analyses. Statistical analysis was performed using SPSS/PC plus V4.0 (SPSS Inc., Chicago, Illinois, 1990) and EGRET software (Statistical and Epidemiology Research Corp., Seattle, Washington, 1990) with default settings.

### RESULTS

The relations of demographic characteristics, lifestyle habits, and self-reported cardiovascular risk factors and treatments with exercise intensity by sex are shown in Table 1. As expected, younger age, higher educational attainment and income, and the total kilocalories expended in activity were associated with higher exercise intensity, and nonwhite race was associated with lower exercise intensity. Higher exercise intensity also was associated with a lower prevalence of treatment with antihypertensive medications and a higher prevalence of treatment with postmenopausal hormones (among women). Among women, alcohol consumption also was directly related to exercise intensity. However, there was only a weak relation between cigarette smoking and exercise intensity.

The relations of exercise intensity with both physiologic and metabolic coronary disease risk factors by sex are shown in Table 2. Among both men and women, exercise intensity was directly related to pulmonary function (forced expiratory volume in one second (FEV$_1$) and forced expiratory vital capacity (FVC)) and inversely related to resting heart rate, obesity (waist girth, hip girth, and weight), and hyperinsulinemia (fasting 2-hour post-glucose load insulin levels). In general, persons who engaged in moderate-intensity activity had more favorable levels of these risk factors than those who were sedentary, and those who engaged in high-intensity exercise had even...
more favorable levels than those who engaged in moderate-intensity exercise. There was little evidence of an association of exercise intensity with systolic and diastolic blood pressure.

The relations of exercise intensity with lipids and lipoproteins differed somewhat for men and women. Among women, there was an inverse dose-response relationship of exercise intensity with serum lipids. Across exercise-intensity categories, there was little difference in the mean factor VIII. Among women, there also was an inverse relation of exercise intensity with fibrinogen and a weak inverse relation with factor VII (p = 0.09), but there was little difference in the mean factor VIII levels among more active women (p = 0.04). Among men, there was no evidence of a dose-response relationship between exercise intensity and serum fibrinogen and the activity levels of factor VII and factor VIII. Among women, there also was an inverse relation of exercise intensity with fibrinogen and a weak inverse relation with factor VII (p = 0.09), but there was little difference in the mean factor VIII levels across exercise-intensity categories.

The relations of exercise intensity with measures of subclinical cardiovascular disease are shown in Table 3. Among both men and women, there was an inverse relation between exercise intensity and the prevalence of a low ABI (<0.9). In men, the cardiac infarction/injury score, a measure of myocardial damage, and, in women, the Doppler trans-mitral late flow velocity, a measure of left ventricular diastolic filling, were inversely related to exercise intensity. (A higher Doppler trans-mitral late flow velocity may reflect impaired left ventricular filling and diastolic dysfunction (25)).

There was little evidence of a dose-response relationship between exercise intensity and the maximal common carotid artery and maximal internal carotid artery intimal-medial thicknesses for either men or women, and the prevalences of carotid stenosis ≥50 percent were not related to exercise intensity. Although there was a modest trend in the mean left ventricular mass across exercise intensity categories, these differences did not achieve conventional levels of statistical significance, in part because of the reduced sample size available for this comparison.

### Table 2. Cardiovascular risk factor levels by exercise intensity and sex: the Cardiovascular Health Study, 1989–1990

<table>
<thead>
<tr>
<th>Variable</th>
<th>Exercise Intensity</th>
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<tr>
<td></td>
<td>Low (n=72)</td>
<td>Medium (n=761)</td>
<td>High (n=189)</td>
<td>p value*</td>
<td>Low (n=188)</td>
<td>Medium (n=876)</td>
<td>High (n=188)</td>
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<td>Anthropometric measures</td>
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<td>Waist (cm)</td>
<td>99.0 (8.1)</td>
<td>97.6 (0.3)</td>
<td>95.0 (0.7)</td>
<td>&lt;0.001</td>
<td>91.3 (0.9)</td>
<td>86.4 (0.4)</td>
<td>87.6 (1.0)</td>
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<td>Hip (cm)</td>
<td>102.4 (0.9)</td>
<td>100.9 (0.3)</td>
<td>98.5 (0.5)</td>
<td>&lt;0.001</td>
<td>102.1 (0.7)</td>
<td>101.0 (0.3)</td>
<td>99.7 (0.7)</td>
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<tr>
<td>Weight (kg)</td>
<td>80.8 (1.3)</td>
<td>79.4 (0.4)</td>
<td>77.3 (0.8)</td>
<td>0.01</td>
<td>87.8 (0.8)</td>
<td>85.8 (0.4)</td>
<td>65.0 (0.8)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>173.4 (0.7)</td>
<td>173.1 (0.2)</td>
<td>173.2 (0.5)</td>
<td>0.97</td>
<td>159.4 (0.4)</td>
<td>159.2 (0.2)</td>
<td>159.5 (0.4)</td>
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<td>Pulmonary function</td>
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<tr>
<td>FEV₆ (liters)</td>
<td>2.4 (0.1)</td>
<td>2.5 (0.0)</td>
<td>2.7 (0.1)</td>
<td>&lt;0.001</td>
<td>1.8 (0.0)</td>
<td>1.9 (0.0)</td>
<td>2.0 (0.0)</td>
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<tr>
<td>FVC₆ (liters)</td>
<td>3.5 (0.1)</td>
<td>3.7 (0.0)</td>
<td>3.6 (0.1)</td>
<td>0.01</td>
<td>2.6 (0.0)</td>
<td>2.6 (0.0)</td>
<td>2.7 (0.0)</td>
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<tr>
<td>Blood pressure/heart rate</td>
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<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>132.6 (2.3)</td>
<td>132.2 (0.7)</td>
<td>131.3 (1.4)</td>
<td>0.15</td>
<td>130.4 (1.5)</td>
<td>123.7 (0.7)</td>
<td>129.5 (1.5)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>71.8 (1.3)</td>
<td>71.6 (0.4)</td>
<td>70.9 (0.8)</td>
<td>0.5</td>
<td>68.9 (0.8)</td>
<td>69.2 (0.4)</td>
<td>68.7 (0.8)</td>
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<tr>
<td>Heart rate (beats/min)</td>
<td>68.3 (1.2)</td>
<td>66.0 (0.4)</td>
<td>64.2 (0.8)</td>
<td>0.01</td>
<td>69.0 (0.8)</td>
<td>69.4 (0.4)</td>
<td>67.4 (0.8)</td>
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<td>Glucose metabolism</td>
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<tr>
<td>Fasting glucose (mg/dl)</td>
<td>110.5 (2.6)</td>
<td>105.7 (0.8)</td>
<td>106.6 (1.6)</td>
<td>0.55</td>
<td>102.7 (1.5)</td>
<td>102.2 (0.7)</td>
<td>99.9 (0.9)</td>
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<tr>
<td>2-hour glucose (mg/dl)</td>
<td>142.3 (3.3)</td>
<td>141.1 (1.0)</td>
<td>133.8 (2.0)</td>
<td>0.12</td>
<td>139.9 (4.1)</td>
<td>134.9 (0.9)</td>
<td>135.1 (4.0)</td>
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<tr>
<td>Fasting insulin (μU/ml)</td>
<td>15.6 (0.8)</td>
<td>14.1 (0.3)</td>
<td>12.6 (0.5)</td>
<td>&lt;0.001</td>
<td>14.8 (0.6)</td>
<td>13.6 (0.4)</td>
<td>12.0 (0.8)</td>
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<tr>
<td>2-hour insulin (μU/ml)</td>
<td>82.2 (3.8)</td>
<td>79.6 (1.2)</td>
<td>59.7 (2.5)</td>
<td>&lt;0.001</td>
<td>87.5 (4.6)</td>
<td>85.1 (2.2)</td>
<td>86.0 (4.8)</td>
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<td>Lipids</td>
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<tr>
<td>Total cholesterol (mg/dl)</td>
<td>196.0 (3.8)</td>
<td>202.6 (1.2)</td>
<td>203.9 (2.4)</td>
<td>0.35</td>
<td>231.9 (2.7)</td>
<td>225.5 (1.3)</td>
<td>227.0 (2.7)</td>
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<tr>
<td>LDL cholesterol (mg/dl)</td>
<td>124.7 (3.8)</td>
<td>127.8 (1.1)</td>
<td>127.8 (2.2)</td>
<td>0.62</td>
<td>146.8 (2.6)</td>
<td>138.4 (1.2)</td>
<td>138.5 (2.6)</td>
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<td>HDL cholesterol (mg/dl)</td>
<td>48.5 (1.5)</td>
<td>47.0 (0.5)</td>
<td>50.9 (0.9)</td>
<td>0.03</td>
<td>57.7 (1.1)</td>
<td>60.4 (0.5)</td>
<td>63.5 (1.1)</td>
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<td>Triglycerides (mg/dl)</td>
<td>133.4 (8.9)</td>
<td>132.1 (2.7)</td>
<td>125.8 (5.5)</td>
<td>0.15</td>
<td>144.1 (4.0)</td>
<td>139.5 (2.3)</td>
<td>124.7 (4.0)</td>
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<td>Coagulation factors</td>
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<tr>
<td>Factor VII (% activity)</td>
<td>116.5 (3.2)</td>
<td>115.4 (1.0)</td>
<td>109.8 (2.0)</td>
<td>0.02</td>
<td>136.9 (2.6)</td>
<td>134.7 (1.2)</td>
<td>130.6 (2.6)</td>
</tr>
<tr>
<td>Factor VIII (% activity)</td>
<td>124.4 (4.0)</td>
<td>115.2 (1.2)</td>
<td>111.6 (2.9)</td>
<td>0.01</td>
<td>123.3 (2.6)</td>
<td>118.1 (1.2)</td>
<td>119.5 (2.6)</td>
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<tr>
<td>Fibrinogen (mg/dl)</td>
<td>316.2 (7.6)</td>
<td>315.4 (2.5)</td>
<td>330.0 (4.7)</td>
<td>0.01</td>
<td>327.3 (4.4)</td>
<td>317.0 (2.1)</td>
<td>317.0 (4.4)</td>
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</table>

* p value reflects a test for trend across exercise intensity categories, after adjustment for age, education, and estrogen use.
† Numbers in parentheses, standard deviation.
§ FEV₆, forced expiratory volume in one second; FVC, forced expiratory vital capacity; HDL, high density lipoprotein; LDL, low density lipoprotein.
time spent in exercise was inversely related to serum
men who engaged in moderate-intensity activity, the
load insulin and glucose levels (table 5) among women
related to heart rate, weight, and 2-hour post-glucose
who engaged in moderate-intensity exercise. Among
relationships of total kilocalories expended in exercise
further adjustment for differences across exercise in-
tensity categories in the total kilocalories expended in
the leisure-time physical activity (as a continuous vari-
able).
On the other hand, among women, the addition of
total kilocalories expended in leisure-time physical
activity (as a continuous variable) to multivariate mod-
els that included exercise intensity improved the fit of
the models for waist girth, 2-hour post-glucose load
insulin and glucose levels, and diastolic blood
pressure (table 4). Among men, our findings suggest that among physically able
older men and women the intensity of exercise in later
life is associated both with coronary disease risk factor
levels and subclinical disease. In general, the relation
of exercise intensity with markers of cardiovascular
health was graded: sedentary persons had the least
favorable risk factor levels and the most subclinical
disease, persons who reported moderate-intensity ex-
ercise had intermediate levels, and persons who en-
gaged in high-intensity exercise had the most favor-
able risk factor levels and the least subclinical disease.
For most risk factors, we observed similar relations
between exercise intensity and risk factor levels
among men and women. Obesity and hyperinsulin-
emia were inversely related to exercise intensity in
both sexes. On the other hand, the relation of exercise
intensity to lipids and lipoproteins differed for men
and women. For HDL cholesterol and triglycerides,
the relation between exercise intensity and the risk
factor level was particularly strong and graded among
women, even after adjustment for age, education, cig-
carette smoking, alcohol consumption, and treatment
with postmenopausal estrogens. Among men, our find-
ings for HDL cholesterol and triglycerides were con-
sistent with a threshold effect: men who reported high-
intensity exercise had more favorable levels of these
risk factors than less active men, but the levels among
men who engaged in moderate-intensity exercise did
not differ from those of men who engaged in only
low-intensity leisure-time physical activity. In con-
trast, there was an inverse dose-response relationship

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<tr>
<td>Variable</td>
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<td>Carotid measurements</td>
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<tr>
<td>Common maxt (mm)</td>
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<td>Internal maxt (mm)</td>
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<td>Carotid stenosis ≥50% (%)</td>
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<td>Peripheral vascular disease</td>
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<td>Ankle-brachial index &lt;0.9 (%)</td>
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<td>Echocardiography/Doppler</td>
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<td>Mean LV mass (g)</td>
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<td>Doppler—early (m/sec)</td>
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<td>Doppler—late (m/sec)</td>
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<tr>
<td>Electrocardiography</td>
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<td>Cardiac infarction/injury score</td>
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</table>

* p value reflects a test for trend across exercise intensity categories, after adjustment for age, education, and estrogen use.
† Combined maximal intima-media thickness.
‡ Numbers in parentheses, standard deviation.
§ Also adjusted for weight; LV mass estimates were available from 671 of 1,022 men and 899 of 1,252 women.

The relations of exercise intensity with the risk factors and markers of subclinical cardiovascular dis-
ease noted above changed only slightly after further adjustment for cigarette smoking and alcohol con-
sumption. Additionally, the relations persisted after further adjustment for differences across exercise in-
tensity categories in the total kilocalories expended in
the leisure-time physical activity (as a continuous vari-
able).

Similarly, the time spent in exercise was inversely related to heart rate, weight, and 2-hour post-glucose
load insulin and glucose levels (table 5) among women
who engaged in moderate-intensity exercise. Among
women who engaged in moderate-intensity activity, the
time spent in exercise was inversely related to serum
triglycerides, directly related to HDL cholesterol, and
inversely related to the prevalence of a low ABI.

**DISCUSSION**

Our findings suggest that among physically able
older men and women the intensity of exercise in later
life is associated both with coronary disease risk factor
levels and subclinical disease. In general, the relation
of exercise intensity with markers of cardiovascular
health was graded: sedentary persons had the least
favorable risk factor levels and the most subclinical
disease, persons who reported moderate-intensity ex-
ercise had intermediate levels, and persons who en-
gaged in high-intensity exercise had the most favor-
able risk factor levels and the least subclinical disease.

For most risk factors, we observed similar relations
between exercise intensity and risk factor levels
among men and women. Obesity and hyperinsulin-
emia were inversely related to exercise intensity in
both sexes. On the other hand, the relation of exercise
intensity to lipids and lipoproteins differed for men
and women. For HDL cholesterol and triglycerides,
the relation between exercise intensity and the risk
factor level was particularly strong and graded among
women, even after adjustment for age, education, cig-
carette smoking, alcohol consumption, and treatment
with postmenopausal estrogens. Among men, our find-
ings for HDL cholesterol and triglycerides were con-
sistent with a threshold effect: men who reported high-
intensity exercise had more favorable levels of these
risk factors than less active men, but the levels among
men who engaged in moderate-intensity exercise did
not differ from those of men who engaged in only
low-intensity leisure-time physical activity. In con-
trast, there was an inverse dose-response relationship
of exercise intensity with fibrinogen, and factor VII and factor VIII activity levels among men, but only the inverse relation of fibrinogen with exercise intensity was statistically significant among women. Whether these findings reflect differences in measurement error, uncontrolled confounding factors, or sex-specific differences in the exercise intensity-risk factor relations remains unclear.

We also observed an inverse relation between exercise intensity and non-invasive measures of subclinical cardiovascular disease. Among both sexes, there was an inverse relation with the prevalences of a low ABI, a non-invasive measure of lower extremity arterial disease. In addition, there was an inverse dose-response relationship between exercise intensity and electrocardiographic evidence of myocardial scarring (for men), and an inverse dose-response relationship with Doppler evidence of diastolic dysfunction (for women).

As in any observational study, a major concern in the interpretation of our findings is that prior morbidity or other factors may have selected persons both for lower exercise intensity and higher risk factor and/or subclinical coronary disease levels. We sought to minimize potential confounding related to prior morbidity by restricting our analysis to persons who were physically able and without prior clinical cardiovascular disease. We not only excluded persons with self-reported cardiovascular disease, but we also excluded persons with symptoms consistent with angina or clau-
dication detected by the Rose questionnaire (17). We further excluded those persons without clinical cardiovascular disease, but who had a reported limitation of physical function—limitations that might influence exercise intensity. Adjustment for potential determinants of exercise-intensity did not alter the relation between exercise intensity and measures of subclinical disease.

Another concern is that the intensity of exercise reported later in life may reflect differences in physical activity during middle age. In this analysis, we could not assess the effects of recent changes in physical activity on cardiovascular health among the elderly. For these reasons, it is unclear whether older persons who increase the intensity of exercise will experience reductions in risk factors and subclinical disease.

Our cross-sectional findings among physically able older persons are consistent with previous reports from experimental and observational studies of middle-aged men and women. For example, exercise intervention trials have demonstrated favorable effects of exercise training on obesity, lipids and lipoproteins, blood pressure, and overall cardiovascular risk among moderately overweight, middle-aged men and women (25, 26). In addition, follow-up studies of male Harvard University alumni and female nurses suggest a potential role of exercise in the primary prevention of diabetes (27, 28). However, to our knowledge, few
Prospective follow-up of the CHS cohort is currently being conducted and should provide an opportunity to examine the impact of the intensity of regular exercise, the total kilocalories expended, and the time spent in exercise, assessed later in life, on incident coronary disease and stroke among older men and women. Given the limitations of the assessment of both the intensity and the time spent in exercise and the correlations of the different dimensions of exercise, short-term intervention trials will also be needed to explore further the relative importance of the intensity and time spent in exercise in promoting cardiovascular health through risk factor reduction among older persons.

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few large epidemiologic studies have included the range of measures included in CHS. Nevertheless, our findings of a relation between exercise and subclinical disease among physically able older persons are consistent with those of prior studies of middle-aged men. Morris and Crawford (29) suggested four decades ago that active busmen had fewer myocardial scars on autopsy than inactive conductors in London. Furthermore, vigorous exercise in leisure time was associated with a reduced prevalence of electrocardiographic abnormalities at rest among male British civil servants (3). In the Lipid Research Clinic Coronary Primary Prevention Trial (4), self-reported regular strenuous exercise or hard physical labor was associated with a reduced prevalence of treadmill exercise-induced electrocardiographic changes, suggesting transient myocardial ischemia among middle-aged men. In short, initial findings from the CHS regarding the relation of exercise to subclinical disease among older men and women are consistent with prior studies conducted among middle-aged persons.

We focused on the intensity of regular exercise because previous research had suggested that the intensity of exercise was more strongly related to the risk of coronary disease than the kilocalories expended or time spent in exercise (5, 6). However, the intensity of exercise was strongly associated with the total kilocalories expended and time spent in exercise in CHS. In this analysis, the intensity of exercise was associated with risk factors and subclinical disease, even after taking into account the estimated kilocalories expended in leisure-time physical activity.

On the other hand, the analyses reported here also suggest that among women and men who engage in moderate-intensity physical activity, the kilocalories expended and time spent in leisure-time activity are related to levels of selected risk factors and markers of subclinical disease. It is possible, however, that the misclassification of some high-intensity exercise as moderate-intensity exercise might have accounted for these findings.

Taken overall, our findings suggest that the intensity of regular exercise may be related to cardiovascular health among older persons. Compared with physical inactivity, moderate-intensity exercise is associated with favorable risk factor profiles; however, more intense exercise may provide additional cardiovascular benefits among older persons. Among persons who engage only in moderate-intensity activity, the total kilocalories expended and time spent in exercise also may be inversely related to selected risk factor levels. Prospective follow-up of the CHS cohort is currently being conducted and should provide an opportunity to examine the impact of the intensity of regular exercise, the total kilocalories expended, and the time spent in exercise, assessed later in life, on incident coronary disease and stroke among older men and women. Given the limitations of the assessment of both the intensity and the time spent in exercise and the correlations of the different dimensions of exercise, short-term intervention trials will also be needed to explore further the relative importance of the intensity and time spent in exercise in promoting cardiovascular health through risk factor reduction among older persons.
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