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Physical Activity and Coronary Heart Disease in Women

Is "No Pain, No Gain" Passé?

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CORONARY HEART DISEASE (CHD) is the leading cause of mortality among women in the United States.¹ Physical inactivity is among the risk factors for this disease. A 1990 meta-analysis concluded that physically active individuals had about half the CHD rates of those who were sedentary.² However, less than one fifth of the studies in the meta-analysis included women. Since then, additional studies have been conducted in women, and the available evidence clearly indicates that active women experience lower CHD rates than inactive women.³⁻²⁶

What is less clear are the kinds and intensity of physical activities that are associated with lower risk. It is important to clarify this issue in light of a recent physical activity recommendation that calls for at least 30 minutes of moderate-intensity physical activity (eg, brisk walking at 4.8-6.4 km/h [3.0-4.0 mph]) most days of the week.^{27,28} This contrasts with previous recommendations that advocated vigorous-intensity exercise (eg, jogging, running) for at least 20 minutes continuously, 3 times per week.²⁹ A major difference is the cur-

See also Patient Page.

Context Physically active women have lower coronary heart disease (CHD) rates than inactive women. However, whether the association differs by intensity of activity or in women at high risk for CHD is unclear.

Objective To examine the relation between physical activity, specifically investigating walking (a light-to-moderate activity depending on pace), and CHD among women, including those at high risk for CHD.

Design, Setting, and Participants Cohort study of 39372 healthy female health professionals aged 45 years or older, enrolled throughout the United States between September 1992 and May 1995, with follow-up to March 1999. Recreational activities, including walking and stair climbing, were reported at study entry.

Main Outcome Measure Correlation of CHD with energy expended on all activities, vigorous activities, and walking.

Results A total of 244 cases of CHD occurred. Adjusting for potential confounders, the relative risks (RRs) of CHD for less than 200, 200-599, 600-1499, and 1500 or more kcal/wk expended on all activities were 1.00 (referent), 0.79 (95% confidence interval [CI], 0.56-1.12), 0.55 (95% CI, 0.37-0.82), and 0.75 (95% CI, 0.50-1.12), respectively (*P* for linear trend = .03). Vigorous activities were associated with lower risk (RR, 0.63; 95% CI, 0.38-1.04 comparing highest and lowest categories). Walking also predicted lower risk among women without vigorous activities. Among these women, the multivariate RRs for walking 1 to 59 min/wk, 1.0 to 1.5 h/wk, and 2 or more h/wk, compared with no regular walking, were 0.86 (95% CI, 0.57-1.29), 0.49 (95% CI, 0.28-0.86), and 0.48 (95% CI, 0.29-0.78), respectively. For walking paces of less than 3.2 km/h (2.0 mph), 3.2 to 4.7 km/h (2.0-2.9 mph), and 4.8 km/h (3.0 mph) or more, compared with no regular walking, RRs were 0.56 (95% CI, 0.32-0.97), 0.71 (95% CI, 0.47-1.05), and 0.52 (95% CI, 0.30-0.90), respectively. When analyzed simultaneously, time spent walking (*P* for linear trend = .01) but not walking pace (*P* for linear trend = .55) predicted lower risk. The inverse association between physical activity and CHD risk did not differ by weight or cholesterol levels (*P* for interaction = .95 and .71, respectively), but there were significant interactions by smoking and hypertension status. Physical activity was inversely related to risk in current smokers but not hypertensive women (*P* for interaction = .01 and .001, respectively).

Conclusions These data indicate that even light-to-moderate activity is associated with lower CHD rates in women. At least 1 hour of walking per week predicted lower risk. The inverse association with physical activity was also present in women at high risk for CHD, including those who were overweight, had increased cholesterol levels, or were smokers.

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rent emphasis on moderate instead of vigorous activity. This concession was made partly to encourage physical activity among sedentary individuals because the previous, more difficult prescription was believed to pose a barrier.²⁸

Another issue on which few data exist is whether physical activity is inversely related to risk among healthy women at high risk for CHD (eg, smokers). This has important clinical implications because if an inverse relationship exists, physicians should strongly promote physical activity in these women.

We therefore investigated the relationship between physical activity and CHD risk among women, including those at high risk, specifically exploring the association with walking.

METHODS

Participants

Subjects were selected from the Women's Health Study, a randomized, double-blind, placebo-controlled trial of low-dosage aspirin and vitamin E for primary prevention of cardiovascular disease and cancer.³⁰⁻³² Between September 1992 and May 1995, female health professionals throughout the United States and Puerto Rico were invited to participate. Women completed a mailed baseline questionnaire on sociodemographic characteristics, health habits, and medical history. Those who were eligible and willing to be in the trial were enrolled into a 3-month run-in phase during which women took their study pills (all placebos). At the end of the run-in phase, women completed the run-in questionnaire that ascertained compliance with pill taking, health habits, and recent medical history. Women with good compliance who were still eligible and willing to participate were then randomized into the trial and started taking their randomized pill assignment.

A total of 39876 women aged 45 years or older who were free of self-reported coronary heart disease, cerebrovascular disease, and cancer (other than nonmelanoma skin cancer) were

randomly assigned to the agents tested. For this study, we excluded 504 women with missing information on physical activity or weight or who provided post-randomization reports of CHD occurring before randomization, leaving 39372 women.

Assessment of Physical Activity

On the run-in questionnaire, we asked women to estimate the average time (0, 1-19 min/wk, 20-59 min/wk, 1 h/wk, 1.5 h/wk, 2-3 h/wk, 4-6 h/wk, or ≥ 7 h/wk) spent on 8 groups of recreational activities during the past year: walking or hiking; jogging (slower than 10-minute miles); running (10-minute miles or faster); bicycling, including use of stationary machines; aerobic exercise, aerobic dance, or use of exercise machines; lower-intensity exercise, including yoga, stretching, or toning; tennis, squash, or racquetball; and lap swimming. We also inquired about the usual pace of walking (do not walk regularly; < 3.2 km/h [2.0 mph; easy, casual pace], 3.2-4.7 km/h [2.0-2.9 mph; normal, average pace], 4.8-6.3 km/h [3.0-3.9 mph; brisk pace], or ≥ 6.4 km/h [4.0 mph; very brisk/striding pace]) and the number of flights of stairs climbed daily (0, 1-2, 3-4, 5-9, 10-14, or ≥ 15). Based on the energy cost of these activities, we assigned a multiple of resting metabolic rate (MET score) to each group of activities and stair climbing.³³ Since resting metabolic rate (1 MET) is approximately 1 kcal/kg of body weight per hour, we estimated energy expenditure by multiplying the assigned MET score by body weight and hours per week of participation using the midpoint of time categories.³⁴ We summed kilocalories per week from the 8 groups of recreational activities and stair climbing to estimate weekly energy expenditure.

This assessment of physical activity is reliable and valid.³⁵ In a random sample of nurses, the test-retest correlation coefficient over 2 years was 0.59. Questionnaire estimates of physical activity, compared with 4 past-week recalls of physical activity collected dur-

ing the year prior to questionnaire administration, had a correlation of 0.79; compared with activity diaries kept for 4 separate weeks during the same year, the correlation was 0.62.

Assessment of Other Predictors of CHD

Information on variables that could potentially influence the association between physical activity and CHD risk was ascertained from the baseline and run-in questionnaires. These variables were age, weight, height, cigarette smoking status, diet (including alcohol consumption), history of hypertension, history of elevated cholesterol level, history of diabetes mellitus, menopausal status, use of postmenopausal hormones, and parental history of CHD. We considered a history of hypertension to be positive if women reported this diagnosis or blood pressure of higher than 140/90 mm Hg. Women were classified as having an elevated cholesterol level if they reported this diagnosis or cholesterol levels of more than 240 mg/dL (6.21 mmol/L). A positive history of diabetes mellitus was based on self-report.

Ascertainment of CHD

Every 6 months during the first year and then annually, women completed brief mailed questionnaires that inquired about compliance to their assigned treatment, serious adverse effects of study agents, risk factors, and end points of interest to the trial. Women reported a diagnosis of myocardial infarction (MI) or coronary revascularization procedures (coronary artery bypass grafting [CABG] or percutaneous transluminal coronary angioplasty [PTCA]) on these questionnaires, or wrote or telephoned the study staff. Deaths were reported by family members or postal authorities. Follow-up in the trial is high: at 36 months, the latest follow-up point attained by all participants, morbidity/mortality follow-up was more than 99% complete.

We sought medical records and other relevant information, including death certificates and autopsy reports, for

women reporting MI, CABG, or PTCA, and for decedents. Reported diagnoses of CHD or death from CHD were considered confirmed only after examination of all available information by an end-points committee of physicians. Myocardial infarction was confirmed using World Health Organization criteria (ie, symptoms plus either typical electrocardiographic changes or elevated cardiac enzyme levels).³⁶ Fatal CHD was documented from convincing evidence of a cardiovascular mechanism from all available sources, including death certificates, hospital records, and, for deaths occurring outside the hospital, observers' impressions. CABG and PTCA were confirmed by hospital records. This report includes data as of March 1999.

Statistical Analysis

The following dimensions of physical activity were considered: (1) energy expended on all activities assessed, (2) energy expended on vigorous recreational activities, and (3) walking. Recreational activities requiring at least 6 METs (ie, jogging, running, aerobic exercise, aerobic dance, use of exercise machines, tennis, squash, racquetball, and lap swimming) were categorized as vigorous.^{33,34}

Women were first categorized into approximate quartiles of energy expended on all activities: less than 200, 200 to 599, 600 to 1499, and 1500 or more kcal/wk. Proportional hazards regression³⁷ was used to estimate hazard ratios (relative risks [RRs]) of CHD as a function of these 4 categories of physical activity, and both age (in years) and randomization to treatment assignment were controlled for. Post hoc power calculations revealed 80% power to detect an RR of between 0.6 and 0.7, comparing highest and lowest categories. To test for a linear trend across categories of physical activity, the 4 categories of physical activity were treated as a single ordinal variable. A multivariable model was then used that additionally adjusted for other potential confounders, including smoking status (never, past, or current smoker of

<15 or \geq 15 cigarettes/d); alcohol consumption (rarely, 1-3 drinks/mo, 1-6 drinks/wk, or \geq 1 drink/d); saturated fat intake, fiber intake, and consumption of fruits and vegetables (in quintiles); menopausal status (premenopausal or postmenopausal); postmenopausal hormone use (never, past, or current use); and parental history of MI before age 60 years (no or yes). In the main analyses, no adjustment was made for body mass index or history of hypertension, elevated cholesterol level, or diabetes mellitus because these are biological intermediates in the pathway between physical activity and decreased CHD risk. In secondary analyses, adjustments were made for these intermediates.

For energy expended on vigorous recreational activities of at least 6 METs, women were categorized into 5 groups: no vigorous recreational activity plus less than 200 kcal/wk expended on other activities, no vigorous recreational activity plus at least 200 kcal/wk expended on other activities, and 1 to 199, 200 to 499, and 500 or more kcal/wk expended on vigorous recreational activities. The cut points were chosen so that women who participated in any vigorous recreational activities were divided into approximate thirds. Relative risks for CHD were estimated in parallel fashion to that described herein.

Because walking is the most popular leisure activity among women,²⁸ this activity was specifically examined in relation to CHD risk. To prevent confounding by vigorous activities, analyses of walking were conducted among the 22865 women (58%) who reported no vigorous recreational activity. A priori, some response categories were combined on the run-in questionnaire for a more even distribution of women by time spent walking (no regular walking, 1-59 min/wk, 1.0-1.5 h/wk, or \geq 2.0 h/wk) and usual walking pace (no regular walking, <3.2 km/h [2.0 mph], 3.2-4.7 km/h [2.0-2.9 mph], or \geq 4.8 km/h [3.0 mph]). Relative risks of CHD were estimated in separate models for time spent walking and walking pace. To ascertain which was more predictive, terms

for both were then simultaneously included in a single model.

Finally, we investigated whether the association of physical activity with CHD rates differed among women without and with the following CHD risk factors: body mass index (<25 kg/m² or \geq 25 kg/m²), cigarette smoking (never, past, or current), and history of hypertension or elevated cholesterol level (no or yes). To test whether the association differed, an interaction term between physical activity (energy expended on all activities) and each risk factor was added in 4 separate multivariable models.

RESULTS

During the study, participants were observed for an average of 5 years, and 244 confirmed incidents of CHD occurred (nonfatal MI or fatal CHD, n=125; CABG or PTCA, n=199; women could have had more than 1 event). TABLE 1 shows the characteristics of the participants. More active women had a lower mean body mass index than less active women. Women with higher levels of physical activity were less likely to smoke cigarettes but more likely to consume alcohol. They also had a healthier diet, consuming less saturated fat, more fiber, and more fruits and vegetables. More active women were more likely to use postmenopausal hormones. At higher levels of physical activity, prevalences of hypertension, elevated cholesterol level, and diabetes mellitus were lower. The least active women were somewhat more likely to have had a parent with MI prior to age 60 years.

In analyses that were adjusted for age and randomized treatment assignment, there was a strong inverse association (*P* for linear trend <.001) with energy expended on all activities in relation to CHD rates (TABLE 2). The inverse association persisted after further adjustment for smoking status, diet, alcohol use, menopausal status, postmenopausal hormone use, and parental history of MI before age 60 years (*P* for linear trend=.03). Women who expended 600 to 1499 kcal/wk were at significantly lower risk of subsequently de-

veloping CHD than less active women (RR, 0.55; 95% confidence interval [CI], 0.37-0.82). At higher levels of energy expenditure, no additional risk reduction was observed.

When biological intermediates (body mass index, hypertension, elevated cholesterol level, and diabetes mellitus) were controlled for in secondary analy-

ses, the inverse relationship was attenuated. The RRs associated with the 4 categories of energy expended on all activities were 1.00 (referent), 0.79, 0.62, and 0.84, respectively (*P* for linear trend=.14).

Nonfatal MI or fatal CHD and CABG or PTCA were then investigated separately. Significant inverse associations

were observed for each end point. The multivariable RRs for nonfatal MI or fatal CHD associated with the 4 categories of energy expended on all activities were 1.00 (referent), 0.68, 0.57, and 0.65, respectively (*P* for linear trend=.05). For coronary revascularization procedures, they were 1.00 (referent), 0.78, 0.49, and 0.74, respectively (*P* linear trend=.03).

Table 1. Characteristics of Participants at Study Entry According to Physical Activity*

Characteristics	Physical Activity, kcal/wk				P Value†
	<200 (n = 10 239)	200-599 (n = 9877)	600-1499 (n = 10 913)	≥1500 (n = 8343)	
Age, mean (SD), y	54.0 (7.0)	53.7 (7.0)	54.0 (7.1)	53.9 (7.0)	.01
Body mass index, mean (SD), kg/m ²	27.0 (5.8)	26.0 (4.9)	25.5 (4.6)	25.6 (4.8)	.001
Smoking status, %					.001
Never	48.8	52.7	53.0	49.8	
Past	31.7	34.1	37.0	41.8	
Current, <15 cigarettes/d	5.9	4.9	4.1	4.3	
Current, ≥15 cigarettes/d	13.7	8.4	5.9	4.2	
Alcohol consumption, %					.001
Rarely	52.9	45.5	41.6	39.3	
1-3 drinks/mo	12.5	13.6	13.4	13.3	
1-6 drinks/wk	25.4	30.7	34.4	36.3	
≥1 drinks/d	9.2	10.2	10.6	11.1	
Saturated fat intake, mean (SD), g/d	21.1 (5.0)	20.0 (4.6)	19.2 (4.6)	18.3 (4.8)	.001
Fiber intake, mean (SD), g/d	17.1 (5.5)	18.5 (5.5)	19.6 (5.8)	21.0 (6.4)	.001
Fruit and vegetable consumption, mean (SD), servings/d	5.2 (3.5)	5.9 (3.2)	6.4 (3.5)	7.3 (4.0)	.001
Postmenopausal hormone use, %					.001
Never	48.9	48.0	47.7	47.0	
Past	11.5	10.2	9.4	10.0	
Current	39.5	41.8	42.9	43.0	
History of hypertension, %	29.7	25.9	24.6	24.2	.001
History of elevated cholesterol level, %	29.2	27.5	26.8	24.6	.001
History of diabetes mellitus, %	3.4	2.3	2.5	2.1	.001
Parental history of myocardial infarction <60 years of age, %	15.5	14.2	14.6	14.8	.06

*Physical activity levels were estimated from assessment of all recreational activities plus stair climbing.

†P values were calculated by the test for trend in means across physical activity categories for continuous variables and by the χ^2 test for categorical variables. Dietary variables (saturated fat, fiber, and fruits and vegetables) were classified by quintile when testing for differences.

Table 2. Relative Risk (RR) of Coronary Heart Disease (CHD) According to Physical Activity

	Physical Activity, kcal/wk										
	Energy Expended on All Activities				P Value for Trend	Energy Expended on Vigorous Recreational Activities*					P Value for Trend
	<200	200-599	600-1499	≥1500		0 + <200 in Other Activities	0 + ≥200 in Other Activities	1-199	200-499	≥500	
No. of women	10 239	9877	10 913	8343		9329	13 536	5912	4612	5983	
No. of cases of CHD	101	56	46	41		91	69	37	24	23	
Age- and treatment-adjusted RR (95% confidence interval)	1.00 (Referent)	0.59 (0.42-0.81)	0.42 (0.30-0.60)	0.51 (0.35-0.73)	<.001	1.00 (Referent)	0.49 (0.36-0.67)	0.75 (0.51-1.10)	0.60 (0.38-0.94)	0.41 (0.26-0.65)	<.001
Multivariable RR (95% confidence interval)†	1.00 (Referent)	0.79 (0.56-1.12)	0.55 (0.37-0.82)	0.75 (0.50-1.12)	.03	1.00 (Referent)	0.65 (0.46-0.91)	1.18 (0.79-1.78)	0.96 (0.60-1.55)	0.63 (0.38-1.04)	.45

*Vigorous activities requiring ≥6 METs (resting metabolic rate = 1 MET).

†Multivariable RRs are adjusted for age; randomized treatment assignment; smoking status; consumption of alcohol, saturated fat, fiber, and fruits and vegetables; menopausal status; use of postmenopausal hormones; and parental history of myocardial infarction at <60 years of age.

Next, the energy expended on vigorous recreational activities of at least 6 METs was examined. When highest and lowest categories of women were compared, there was a lower risk of CHD among the most active women that was of borderline significance (RR, 0.63; 95% CI, 0.38-1.04).

Whether walking is inversely related to risk of subsequent CHD among women who did not engage in vigorous activities was also assessed. Among participants, 22865 women (58%) reported no vigorous recreational activity; any activity these women (75% of the 22865) carried out consisted primarily of walking. In this subgroup, both time spent walking and usual walking pace were inversely related to CHD risk when analyzed separately (TABLE 3). Women who walked at least 1 hour per week or whose usual walking pace was at least 4.8 km/h (3.0 mph) experienced about half the CHD risk of women who did not walk regularly. To ascertain which of the 2 walking parameters was more important, variables for both were entered in a single multivariable model. In doing so, time spent walking (*P* for linear trend=.01) but not usual pace of walking (*P* for linear trend=.55) was significantly related to lower CHD rates, indicating that time but not pace independently predicted lower risk.

Finally, whether the association of physical activity with CHD risk differed among women without and with CHD risk factors was examined

(FIGURE). There was no evidence that the inverse association differed between women of normal weight and overweight women (*P* for interaction=.95). There also was no evidence that the inverse relationship differed between women without and with elevated cholesterol level (*P* for interaction=.71). However, there were significant interactions by smoking status and history of hypertension (*P* for interaction=.01 and .001, respectively). Physical activity was inversely associated with CHD rates in current and past smokers, but not in women who had never smoked (*P* for linear trend=.005, .10, and .75, respectively). Among nonhypertensive women, an inverse association with physical activity (*P* for linear trend=.001) was observed; among hypertensive women, a u-shaped relationship (*P* for quadratic trend=.07) was observed.

COMMENT

This study clearly indicates that physically active women have lower CHD rates. It is encouraging to observe that vigorous activities were not necessary for lower CHD rates. Among women who did not engage in vigorous activities, walking (a light- to moderate-intensity activity, depending on pace³³) was associated with lower risk. These data suggest that walking need not be fast-paced for benefit; time spent walking was more important than walking pace. Additionally, we observed inverse associations between physical ac-

tivity and CHD risk among those who were overweight, smokers, and women with elevated cholesterol levels. Among hypertensive women, there was a u-shaped association between physical activity and CHD risk.

These findings support recent guidelines recommending moderate-intensity physical activity for at least 30 minutes most days of the week (generating energy expenditure of about 1000 kcal/wk).^{27,28} Moreover, they raise the possibility that even lesser degrees of activity may decrease CHD risk. We found that time spent walking but not walking pace independently predicted lower risk, implying that walking slower than 4.8 to 6.4 km/h (3-4 mph; ie, a light-intensity activity) may be beneficial. Women who walked at least 1 h/wk had about half the CHD rates of women who did not walk regularly. Assuming that walking 5 d/wk satisfies the definition of "most days of the week," the recent guidelines recommend brisk walking for at least 2.5 h/wk.^{27,28}

Limitations in the assessment of walking should be considered when interpreting our findings. Based on data from another study, women probably reported walking pace validly; when asked to walk at a pace they gauged to be of at least moderate intensity, both unfit and fit participants correctly walked more than 4.8 km/h (3 mph; Isabelle M. T. Bohlmann, MSc, written communication, August 2000).

Table 3. Relative Risks (RRs) of Coronary Heart Disease (CHD) According to Walking Parameters*

	Walking Parameter									
	Time Spent Walking per wk					Usual Walking Pace, km/h†				
	Do Not Walk Regularly	1-59 min	1.0-1.5 h	≥2 h	<i>P</i> Value for Trend	Do Not Walk Regularly	<3.2	3.2-4.7	≥4.8	<i>P</i> Value for Trend
No. of women	5826	6034	4406	6599		5826	2958	8356	5725	
No. of cases of CHD	68	45	19	28		68	21	50	21	
Age- and treatment-adjusted RR (95% confidence interval)	1.00 (Referent)	0.68 (0.46-0.99)	0.37 (0.22-0.62)	0.33 (0.21-0.52)	<.001	1.00 (Referent)	0.57 (0.35-0.93)	0.50 (0.35-0.72)	0.33 (0.20-0.54)	<.0001
Multivariable RR (95% confidence interval)‡	1.00 (Referent)	0.86 (0.57-1.29)	0.49 (0.28-0.86)	0.48 (0.29-0.78)	<.001	1.00 (Referent)	0.56 (0.32-0.97)	0.71 (0.47-1.05)	0.52 (0.30-0.90)	.02

*Data are shown for women who reported no vigorous recreational activities requiring ≥6 METs (resting metabolic rate = 1 MET).

†To convert kilometers to miles, divide by 1.6.

‡Multivariable RRs are adjusted for age; randomized treatment assignment; smoking status; consumption of alcohol, saturated fat, fiber, and fruits and vegetables; menopausal status; use of postmenopausal hormones; and parental history of myocardial infarction at <60 years of age.

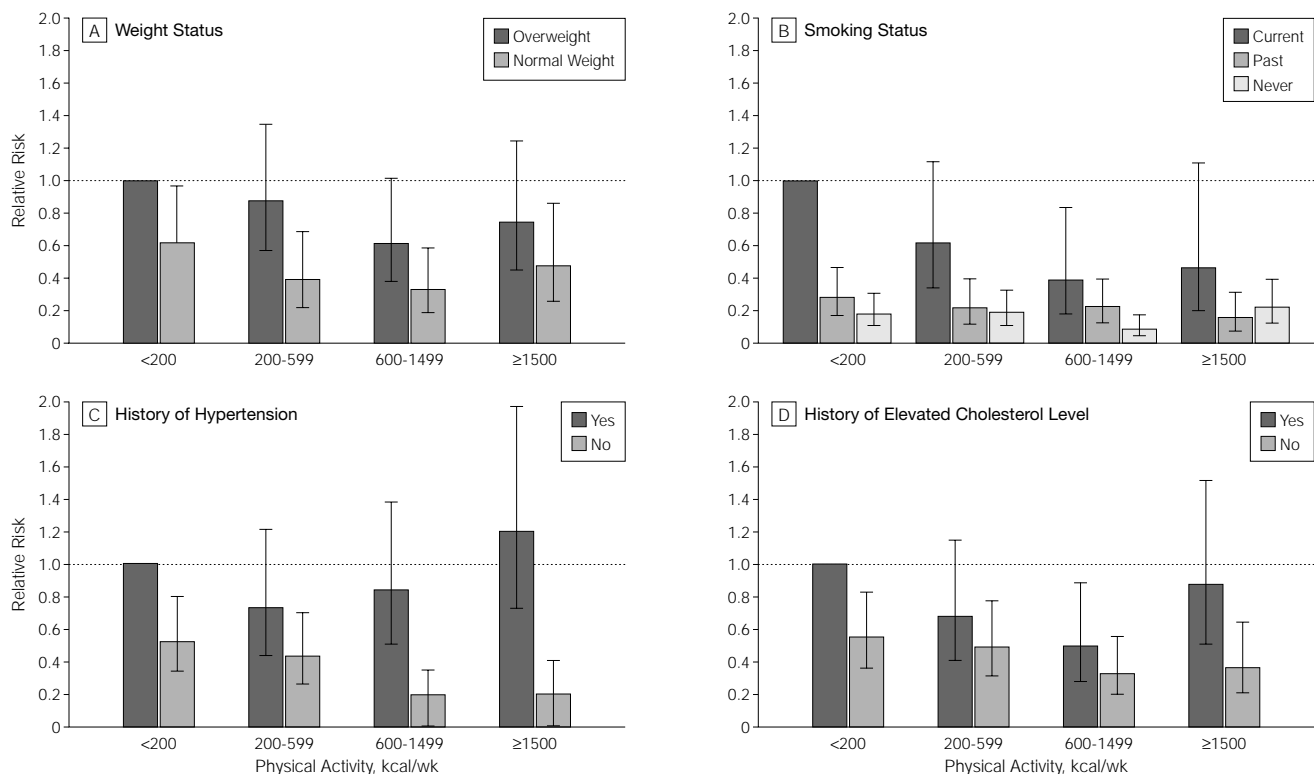
Time spent walking may be less validly reported. The questionnaire used probably measured purposeful walking (for transportation or exercise) only, rather than all walking (eg, walking around the home). A recent study compared walking reported on questionnaires and measured using pedometers.³⁸ Reported walking was only 0.34 times the distance measured by pedometers. It is unclear whether the recent activity guidelines refer to time spent on all walking or purposeful walking. If the former were intended, our findings probably are in accord with the recommended time. Women who reported walking at least 1 h/wk were at significantly reduced risk. If only purposeful walking was measured and was 0.34 of all walking, these women would actually have spent 2.9 h/wk on all walking.

Walking was specifically investigated in 3 previous studies of women. In the Nurses' Health Study, among women with no vigorous activities, those who expended at least 3.9 MET-hours/wk walking (approximately 1 h/wk at brisk pace) had lower CHD risk compared with those who expended no more than 0.5 MET-hours/wk.²⁵ In the College Alumni Health Study, walking at least 10 blocks/d (approximately 2 h/wk at brisk pace) lowered risk of cardiovascular disease in women compared with walking less than 4 blocks/d.²⁶ Among men and women aged 65 years or older, walking more than 4 h/wk reduced risk of hospitalization due to cardiovascular disease compared with walking less than 1 h/wk.¹⁷ The differences in the time required may be partly due to comparison with reference groups who were more active than the referent

in this study (no vigorous activity and no regular walking); the reference group in the Nurses' Health Study was most similar.

Few data, either in men or women, are available regarding whether walking time or pace is more predictive of lower risk. In the Nurses' Health Study, walking pace was associated with lower CHD risk after adjustment for MET-hours of walking (a combined measure of walking pace and time).²⁵ Our finding that time spent walking is more important—implying that total energy expenditure is the relevant parameter—requires confirmation. Some supporting evidence comes from an experiment in which sedentary women were randomized to a control group or 1 of 3 exercise groups that walked the same distances (4.8 km/d [3 miles/d], 5 d/wk) at 4.8, 6.4, or 8.0 km/h (3, 4, or 5 mph)

Figure. Multivariable Relative Risks of Coronary Heart Disease According to Physical Activity Among Subgroups of Women



Relative risks are adjusted for age; randomized treatment assignment; cigarette smoking (except B); consumption of alcohol, saturated fat, fiber, and fruits and vegetables; menopausal status; use of postmenopausal hormones; and parental history of myocardial infarction at younger than 60 years. Physical activity was estimated from recreational activities and stair climbing. Overweight is defined as body mass index ≥ 25 kg/m². Dotted lines indicate relative risk = 1. Error bars indicate 95% confidence intervals. Columns of data without error bars are the referents.

for 24 weeks.³⁹ All 3 exercise groups improved in fitness (measured by maximal oxygen uptake) compared with controls, with fitness improving in a dose-response fashion among exercisers. High-density lipoprotein cholesterol levels, however, increased significantly, to the same extent, among the 3 groups.

How can our findings be reconciled with those from other studies, primarily of men, that observed only vigorous-intensity activity to be associated with decreased CHD risk?⁴⁰ We believe the data represent a spectrum of responses to physical activity. Among persons with little activity, institution of even light-to-moderate activity is associated with benefit. Among persons who are more active and fit, vigorous activity is needed for additional health benefits. Our study participants, in whom light-to-moderate activity was associated with decreased CHD risk, were relatively inactive. The most active group (the most active 21%; Table 1) expended at least 1500 kcal/wk in recreational activities and stair climbing. In contrast, in a study of men in which physical activity was assessed in similar fashion to this study, subjects were much more active; the most active 20% expended at least 3129 kcal/wk.⁴¹ In that study, vigorous but not nonvigorous activity was associated with greater longevity.⁴¹

Few data exist regarding the role of physical activity in the primary prevention of CHD among high-risk women. As with this study, the Nurses' Health Study also observed inverse associations among overweight women and smokers.²⁵ Some investigators have postulated that overweight but active individuals have lower morbidity and mortality than normal-weight but sedentary individuals.⁴² In contrast, this study and the Nurses' Health Study²⁵ both indicate that inactivity and overweight adversely affect CHD risk in women to a similar extent. The observation of a u-shaped relationship among hypertensive persons also has been reported in Finnish men.²¹ Two^{43,44} of 3 randomized trials that tested exercise of varying intensities among hypertensive patients⁴³⁻⁴⁵ suggested that higher-

intensity physical activity is less effective in decreasing systolic blood pressure than lower-intensity activity. This could partly account for the u shape.

Strengths of this study include its large size, well-characterized participants, and careful documentation of CHD. Furthermore, strict health criteria were used for enrollment into the parent trial. Therefore, it is unlikely that underlying disease could have decreased physical activity at study entry, biasing results. It is also less likely that women who did not walk were limited by physical disability.

Limitations include self-reports of physical activity. While the questionnaire used is reliable and valid for large-scale studies,³⁵ it does not offer the precision of, say, electronic devices that measure movement. The latter, however, are impractical for large studies. Moreover, physical activity data were gathered in this study prior to CHD occurrence; thus, any misclassification is likely random, diluting the true association. While we did adjust for a large number of potential confounders, confounding by unmeasured factors is a concern in any observational study. Participants also were not representative of the general population. The proportions of women who were overweight or had elevated blood pressure or cholesterol levels were similar to the general population, but fewer smoked and more used postmenopausal hormones.³² However, it is unlikely that the biologic effects of physical activity would differ in the general population.

In conclusion, this study indicates that physical activity, easily within the ability of almost all women, is associated with lower CHD rates. At least 1 hour of walking per week, regardless of pace, was associated with lower CHD rates among relatively sedentary women. Because this is less than what current guidelines suggest, confirmation of these findings is desirable. Meanwhile, a conservative approach is to endorse current guidelines recommending moderate-intensity physical activity for 30 min/d most days of the week. In the present study, this level of physical ac-

tivity was associated with lower CHD rates, even among women who were overweight, smoked, or had elevated cholesterol levels.

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