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Heart Failure

Occupational, Commuting, and Leisure-Time Physical Activity in Relation to Heart Failure Among Finnish Men and Women

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Objectives The purpose of this study was to examine the association of different levels of occupational, commuting, and leisure-time physical activity and heart failure (HF) risk.

Background The role of different types of physical activity in explaining the risk of HF is not properly established.

Methods Study cohorts included 28,334 Finnish men and 29,874 women who were 25 to 74 years of age and free of HF at baseline. Baseline measurement of different types of physical activity was used to predict incident HF.

Results During a mean follow-up of 18.4 years, HF developed in 1,868 men and 1,640 women. The multivariate adjusted (age; smoking; education; alcohol consumption; body mass index; systolic blood pressure; total cholesterol; history of myocardial infarction, valvular heart disease, diabetes, lung disease, and use of antihypertensive drugs; and other types of physical activity) hazard ratios of HF associated with light, moderate, and active occupational activity were 1.00, 0.90, and 0.83 ($p = 0.005$, for trend) for men and 1.00, 0.80, and 0.92 ($p = 0.007$, for trend) for women, respectively. The multivariate adjusted hazard ratios of HF associated with low, moderate, and high leisure-time physical activity were 1.00, 0.83, and 0.65 ($p < 0.001$, for trend) for men and 1.00, 0.84, and 0.75 ($p < 0.001$, for trend) for women, respectively. Active commuting had a significant inverse association with HF risk in women, but not in men, before adjustment for occupational and leisure-time physical activity. The joint effects of any 2 types of physical activity on HF risk were even greater.

Conclusions Moderate and high levels of occupational or leisure-time physical activity are associated with a reduced risk of HF. (J Am Coll Cardiol 2010;56:1140–8) © 2010 by the American College of Cardiology Foundation

Heart failure (HF) has emerged as a scourge throughout the developed and developing regions of the world (1,2). According to the American Heart Association, 550,000 new cases occur in the U.S. each year, and more than 5 million Americans have HF (1). Although there is strong evidence that regular physical activity has a protective effect against coronary heart disease (CHD) and stroke (3), studies related to regular physical activity and HF are sparse, and the results of these studies are inconsistent (4–6). Furthermore, physical activity has always been represented by leisure-time physical activity in studies related to the association between physical activity and HF (4–6), whereas the relationship of HF with occupational or commuting physical activity remains unclear. The aim of this study was to examine whether occupational, commuting, or leisure-time physical activity are associated independently with a reduced HF risk, and moreover, how different combinations of physical activity affect the risk.

Methods

Subjects. Seven independent population surveys were carried out in 6 geographic areas of Finland in 1972, 1977, 1982, 1987, 1992, 1997, and 2002 (7). In 1972 and 1977, a

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randomly selected sample of 6.6% of the population born between 1913 and 1947 was drawn. Since 1982, the sample was stratified by area, gender, and 10-year age group according to the World Health Organization Monitoring Trends and Determinants of Cardiovascular Disease protocol (8). The participation rate varied by year from 65% to 88% (7). The subjects included in the 7 surveys were 25 to 64 years of age, and the 1997 and 2002 surveys also included subjects age 65 to 74 years. Subjects who participated in more than 1 survey were included only in the first survey cohort in which they appeared. The total sample size of the 7 surveys was 62,013. After excluding 998 subjects with a history of HF at baseline and 2,807 subjects with incomplete data on any required variables, the present analyses include 28,334 men and 29,874 women. The participants provided informed consent (verbal from 1972 through 1992 and written in 1997 and 2002). These surveys were conducted according to the ethical rules of the National Institute for Health and Welfare, and the investigations were performed in accordance with the Declaration of Helsinki.

Assessment of physical activity. Occupational, commuting, and leisure-time physical activity levels were assessed using a self-administered questionnaire only at baseline. A detailed description of the questions has been presented elsewhere (9–12). The questionnaire used for the assessment of physical activity has been used successfully elsewhere, and it has shown a high correlation with physical fitness, as measured by maximal oxygen uptake (13,14). The subjects reported their occupational physical activity according to the following 3 categories: 1) low was defined as physically very easy, sitting office work (e.g., secretary); 2) moderate was defined as work including standing and walking (e.g., store assistant, light industrial worker); and 3) high was defined as work including walking and lifting or heavy manual labor (e.g., industrial or farm work). Daily commuting (return journey) was divided into 3 categories: 1) motorized transportation or no physical work (no walking or cycling); 2) walking or bicycling 1 to 29 min/day; and 3) walking or bicycling more than 30 min/day. Self-reported leisure-time physical activity was divided into 3 categories: 1) low was defined as almost completely inactive, such as reading, watching TV, or doing some minor physical activity, but not of moderate or high level; 2) moderate was doing some physical activity more than 4 h/week, such as walking, cycling, or light gardening, excluding travel to work; and 3) high was defined as performing vigorous physical activity more than 3 h/week, such as running, jogging, swimming, or heavy gardening, or competitive sports several times a week.

Other assessments. Smoking, socioeconomic factors, alcohol consumption, and medical history also were assessed by using the self-administered questionnaire. Based on the questionnaire data, the participants were classified as never smokers, former smokers, and current smokers. Current smokers were categorized into those who smoked fewer than 20 or 20 or more cigarettes/day. Years of education were divided into birth cohort-specific tertiles. Because questions regarding alcohol consumption were different between the first 2 surveys (1972 and 1977) and the latter surveys, the participants were categorized into abstainers and alcohol users. Data on the initiation of antihypertensive drug treatment were obtained from the questionnaire and the records of a drug register. Subjects who reported having diabetes on the questionnaire, who had had a hospital discharge diagnosis of diabetes (including asymptomatic diabetes and known diabetes), or who received the approval of a physician for using diabetes medication (either oral glucose-lowering agents or insulin) before the baseline survey were classified as having history of diabetes at baseline (9). Data on the history of myocardial infarction at baseline were obtained from the questionnaire and were collected by hospital discharge diagnosis, and the overall sensitivity of the diagnosis of myocardial infarction in the Finnish Hospital Discharge Register was 83% (15). Data on the history of valvular heart disease at baseline were collected by hospital discharge register. Data on the history of lung disease (pulmonary emphysema, bronchitis, chronic bronchial catarrh) were collected from the questionnaire.

Abbreviations and Acronyms

CHD = coronary heart disease

CI = confidence interval

HF = heart failure

ICD = International Classification of Diseases

At the study site, trained research nurses measured height, weight, and blood pressure using a standardized protocol (8). Height was measured without shoes and weight was measured with light clothing. Body mass index was calculated by dividing weight in kilograms by the height in square meters. Blood pressure was measured from the right arm after 5 min of sitting. After blood pressure measurement, a venous blood specimen was obtained. Total cholesterol was determined using Lieberman Burchard method in 1972 and 1977 and by an enzymatic method (CHOD-PAP, Boehringer Mannheim, Mannheim, Germany) since 1982. Because the enzymatic method gave 2.4% lower values than the Lieberman Burchard method (based on the double measurements of serum samples during the change of laboratory method), the values measured in 1972 and 1977 were corrected by this percentage. All samples were analyzed in the same central laboratory.

Prospective follow-up. Follow-up information was obtained from the Finnish Hospital Discharge Register and the National Social Insurance Institution's register on special reimbursement for HF drugs for nonfatal outcomes and the Finnish Death Register for fatal outcomes by using social security numbers assigned to every citizen of Finland. The International Classification of Diseases (ICD) codes 427.00 and 427.10 (ICD-8th edition); 428, 4029B (hypertensive heart disease with HF), and 4148A-X (ischemic HF with chronic CHD) (ICD-9th edition); and I50, I11.0

(hypertensive heart disease with HF), I13.0, and I13.2 (hypertensive heart and renal disease with HF) (ICD-10th edition) were used to identify cases in the above national databases. An HF diagnosis was made by the treating physicians, based on a clinical assessment, X-ray examination, and to various extents, echocardiography. Follow-up of each cohort member continued until the date of the diagnosis of HF obtained from the Hospital Discharge Register, the National Social Insurance Institution's register or mortality, death resulting from causes other than HF, or December 31, 2006 (16). This diagnosed method has been used in other Scandinavian countries, such as Sweden. The accuracy of the HF cases in the Swedish hospital discharge was found to be more than 80% based on the European Society of Cardiology definition (17,18).

Statistical analyses. Differences in risk factors between groups with different physical activity levels were tested using a univariate analysis of variance after adjustment for age and study year. Cox proportional hazards regression models were used to analyze the association of physical activity with the risk of HF. Physical activity categories were included in the models as dummy and categorical variables, and the significance of the trend over different categories of physical activity was tested in the same models by giving an ordinal numeric value for each dummy variable. The proportional hazards assumption in the Cox model was assessed with graphical methods and with models including time-by-covariate interactions (19). In general, all proportionality assumptions were appropriate. The analyses were carried out first adjusting for age and study year, and further for smoking, education, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, history of using antihypertensive drugs, history of lung disease, body mass index, systolic blood pressure, total cholesterol, and further for other 2 types of physical activity. To avoid a potential bias resulting from severe disease at baseline, additional analyses were carried out excluding the subjects who died during the first 2 years of follow-up ($n = 408$). Statistical significance was considered to be $p < 0.05$. Statistical package SPSS for Windows software version 17.0 (SPSS, Inc., Chicago, Illinois) was used for statistical analysis.

Results

During a mean follow-up of 18.4 years, HF developed in 1868 men and 1640 women. General characteristics of the study population by different types of physical activity at baseline are presented in Table 1. Age- and study year-adjusted partial correlations were 0.23 in men ($p < 0.001$) and 0.20 in women ($p < 0.001$) for occupational and commuting physical activity, −0.08 in men ($p < 0.001$) and −0.04 in women ($p < 0.001$) for occupational and leisure-time physical activity, and 0.03 in men ($p < 0.001$) and 0.06 in women ($p < 0.001$) for commuting and leisure-time physical activity.

Age- and study year-adjusted hazard ratios of HF associated with low, moderate, and high occupational physical activity were 1.00, 0.75, and 0.74 ($p < 0.001$ for trend) for men and 1.00, 0.67, and 0.87 ($p < 0.001$ for trend) for women, respectively (Table 2). In multivariate analyses, after further adjustment for other risk factors (smoking, education, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, history of using antihypertensive drugs, history of lung disease, body mass index, systolic blood pressure, and total cholesterol) and for commuting and leisure-time physical activity, these inverse associations still were statistically significant for men ($p = 0.005$, for trend) and women ($p = 0.007$, for trend).

Daily commuting physical activity on foot or by bicycle was associated significantly and inversely with the risk of HF among men ($p < 0.001$, for trend) and women ($p < 0.001$, for trend) after adjustment for age and study year (Table 3). The inverse relationship remained significant among women ($p = 0.008$, for trend), but not among men ($p = 0.374$, for trend), after further adjustment for other risk factors. Women spending daily 1 to 29 min in walking or cycling to and from work had a significantly reduced risk of HF than women who had no commuting activity after additional adjustment for occupational and leisure-time physical activity.

Age- and study year-adjusted hazard ratios of HF associated with low, moderate, and high leisure-time physical activity were 1.00, 0.81, and 0.53 ($p < 0.001$, for trend) in men and 1.00, 0.71, and 0.56 ($p < 0.001$, for trend) in women, respectively (Table 4). These inverse associations weakened to some extent, but remained statistically significant, after further adjustment for other risk factors and occupational and commuting physical activity (both $p < 0.001$, for trend).

The joint effects of different types of physical activity on the risk of HF are presented in Figure 1. We dichotomized the level of occupational and leisure-time physical activity at low versus moderate to high and the level of commuting physical activity as any versus none. Among men, both moderate or high levels of leisure-time physical activity and moderate or high levels of occupational physical activity had inverse associations with HF risk. The combination of any 2 types of physical activity made this favorable effect even greater. Among women, none of the 3 types of physical activity alone is associated significantly with a reduced risk of HF. However, the risk of HF significantly reduced among women with more than 1 type of physical activity. After adjustment for age, study year, and other risk factors, men with high levels of all 3 types of physical activity had a 31% lower risk of HF as compared with the least active men. In women, the risk reduction was 34%.

Exclusion of the participants who died during the first 2 years of follow-up did not appreciably change the results above (Online Appendix).

Table 1 General Characteristics of Study Subjects at Baseline*

Occupational Physical Activity

	Men			p Value (for Trend)	Women			p Value (for Trend)
	Low	Moderate	High		Low	Moderate	High	
n	11,069	6,032	11,233		13,115	9,266	7,493	
Age at baseline (yrs)	48.5	42.2	43.0	<0.001	46.8	42.4	44.2	<0.001
Body mass index (kg/m^2)	26.5	26.4	26.3	0.003	26.0	25.7	26.6	<0.001
Diastolic blood pressure (mm Hg)	87	87	86	0.002	83	83	84	<0.001
Systolic blood pressure (mm Hg)	143	142	143	<0.001	138	137	140	<0.001
Serum cholesterol (mmol/l)	6.01	6.04	6.19	<0.001	5.96	5.89	6.09	<0.001
Education (yrs)	10.4	10.6	8.3	<0.001	10.3	10.6	9.1	<0.001
Alcohol drinker (%)	66.3	77.1	63.6	<0.001	40.6	43.4	32.0	<0.001
Current smoker (%)	41.8	36.6	43.2	<0.001	19.3	18.7	16.3	<0.001
History of myocardial infarction (%)	5.5	2.8	1.9	<0.001	1.6	0.6	0.4	<0.001
History of valvular heart disease (%)	0.1	0.2	0.1	0.36	0.1	0.1	0.0	0.013
History of diabetes (%)	3.3	2.4	1.7	<0.001	2.6	1.4	1.7	<0.001
History of using antihypertensive drugs (%)	12.3	9.5	7.9	<0.001	13.6	9.5	9.9	<0.001
History of lung disease (%)	7.5	4.5	5.3	<0.001	5.1	4.6	4.9	0.261

Commuting Physical Activity (Walking or Cycling to and From Work [Min/Day])

	Men			p Value (for Trend)	Women			p Value (for Trend)
	0	1 to 29	≥30		0	1 to 29	≥30	
n	15,288	8,565	4,481		13,650	9,609	6,615	
Age at baseline (yrs)	46.2	42.2	46.0	<0.001	47.1	42.1	43.9	<0.001
Body mass index (kg/m^2)	26.5	26.3	26.1	<0.001	26.5	25.8	25.6	<0.001
Diastolic blood pressure (mm Hg)	87	87	87	0.63	83	83	83	0.33
Systolic blood pressure (mm Hg)	143	142	142	<0.001	139	137	137	<0.001
Serum cholesterol (mmol/l)	6.10	6.09	6.07	0.22	6.02	5.92	5.94	<0.001
Education (yrs)	9.4	10.0	9.6	<0.001	9.6	10.5	10.4	<0.001
Alcohol drinker (%)	65.7	67.5	65.8	0.012	35.0	44.0	41.5	<0.001
Current smoker (%)	43.5	38.1	39.6	<0.001	18.3	19.0	17.7	0.093
History of myocardial infarction (%)	4.6	2.2	2.1	<0.001	1.5	0.6	0.5	<0.001
History of valvular heart disease (%)	0.1	0.2	0.1	0.46	0.1	0.0	0.1	0.049
History of diabetes (%)	2.7	2.1	2.5	0.009	2.5	1.6	1.2	<0.001
History of using antihypertensive drugs (%)	10.9	9.2	8.7	<0.001	13.1	10.3	9.5	<0.001
History of lung disease (%)	6.9	4.9	4.9	<0.001	5.1	4.6	4.9	0.158

Leisure-Time Physical Activity

	Men			p Value (for Trend)	Women			p Value (for Trend)
	Low	Moderate	High		Low	Moderate	High	
n	7,849	14,761	5,724		10,564	15,032	4,278	
Age at baseline (yrs)	45.5	46.3	41.0	<0.001	45.7	45.2	41.3	<0.001
Body mass index (kg/m^2)	26.7	26.5	25.7	<0.001	26.9	25.8	25.0	<0.001
Diastolic blood pressure (mm Hg)	87	87	85	<0.001	84	83	82	<0.001
Systolic blood pressure (mm Hg)	143	143	141	<0.001	139	138	136	<0.001
Serum cholesterol (mmol/l)	6.15	6.14	5.88	<0.001	6.01	5.96	5.90	<0.001
Education (yrs)	9.1	9.5	10.6	<0.001	9.7	10.2	10.7	<0.001
Alcohol drinker (%)	63.1	66.8	69.3	<0.001	36.5	39.8	44.6	<0.001
Current smoker (%)	50.0	41.8	27.8	<0.001	21.6	17.8	12.4	<0.001
History of myocardial infarction (%)	3.9	3.7	2.5	<0.001	1.4	0.9	0.5	<0.001
History of valvular heart disease (%)	0.1	0.2	0.1	0.060	0.1	0.1	0.1	0.74
History of diabetes (%)	3.2	2.3	1.8	<0.001	2.3	1.9	1.1	<0.001
History of using antihypertensive drugs (%)	10.7	10.4	7.7	<0.001	13.1	11.0	8.1	<0.001
History of lung disease (%)	7.7	5.6	4.6	<0.001	5.7	4.6	3.9	<0.001

*Baseline characteristics represent mean or percentage; adjusted for age and study year.

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Table 2 Hazard Ratios of Heart Failure According to Different Levels of Occupational Physical Activity

	Occupational Physical Activity			p Value (for Trend)
	Low	Moderate	High	
Men	11,069	6,032	11,233	
No. of incidence cases	777	340	751	
Person-yrs	160,376	117,247	225,292	
Age and study years adjusted HR	1.00	0.75 (0.66–0.85)	0.74 (0.67–0.82)	<0.001
Multivariate adjusted HR*	1.00	0.88 (0.77–1.01)	0.84 (0.75–0.94)	0.006
Multivariate adjusted HR†	1.00	0.90 (0.78–1.03)	0.83 (0.73–0.93)	0.005
Women	13,115	9,266	7,493	
No. of incidence cases	759	358	523	
Person-years	216,737	189,921	159,959	
Age and study years adjusted HR	1.00	0.67 (0.59–0.76)	0.87 (0.78–0.97)	<0.001
Multivariate adjusted HR*	1.00	0.77 (0.67–0.87)	0.90 (0.80–1.01)	<0.001
Multivariate adjusted HR†	1.00	0.80 (0.70–0.92)	0.92 (0.82–1.05)	0.007
Men and women combined‡	24,184	15,298	18,726	
No. of incidence cases	1,536	698	1,274	
Person-years	377,113	307,168	385,251	
Age and study years adjusted HR	1.00	0.70 (0.64–0.77)	0.79 (0.74–0.85)	<0.001
Multivariate adjusted HR*	1.00	0.82 (0.74–0.90)	0.86 (0.79–0.93)	<0.001
Multivariate adjusted HR†	1.00	0.85 (0.77–0.93)	0.87 (0.80–0.94)	<0.001

Values are n or HR (95% confidence interval). *Adjusted for age, study year, education, smoking, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, systolic blood pressure, total cholesterol, history of using antihypertension drugs, history of lung disease, and body mass index. †Adjusted for age, study year, education, smoking, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, systolic blood pressure, total cholesterol, history of using antihypertensive drugs, history of lung disease, body mass index, and other 2 types of physical activity. ‡Adjusted also for sex.

HR = hazard ratio.

Table 3 Hazard Ratios of Heart Failure According to Different Levels of Commuting Physical Activity

	Walking or Cycling to and From Work (Min/Day)			p Value (for Trend)
	0	1 to 29	≥30	
Men	15,288	8,565	4,481	
No. of incidence cases	984	499	385	
Person-yrs	243,541	167,513	91,861	
Age and study years adjusted HR	1.00	0.83 (0.74–0.92)	0.81 (0.72–0.91)	<0.001
Multivariate adjusted HR*	1.00	0.96 (0.86–1.07)	0.92 (0.81–1.04)	0.374
Multivariate adjusted HR†	1.00	1.01 (0.90–1.13)	0.99 (0.87–1.12)	0.954
Women	13,650	9,609	6,615	
No. of incidence cases	959	351	330	
Person-yrs	237,004	192,706	136,906	
Age and study years adjusted HR	1.00	0.73 (0.64–0.82)	0.76 (0.67–0.86)	<0.001
Multivariate adjustment HR*	1.00	0.83 (0.73–0.94)	0.89 (0.78–1.01)	0.008
Multivariate adjustment HR†	1.00	0.87 (0.76–0.99)	0.94 (0.82–1.07)	0.108
Men and women combined‡	28,938	18,174	11,096	
No. of incidence cases	1,943	850	715	
Person-yrs	480,545	360,220	228,767	
Age and study years adjusted HR	1.00	0.77 (0.71–0.83)	0.76 (0.70–0.83)	<0.001
Multivariate adjusted HR*	1.00	0.88 (0.81–0.96)	0.88 (0.80–0.96)	0.001
Multivariate adjusted HR†	1.00	0.93 (0.85–1.01)	0.93 (0.85–1.02)	0.159

Values are n or HR (95% confidence interval). *Adjusted for age, study year, education, smoking, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, systolic blood pressure, total cholesterol, history of using antihypertension drugs, history of lung disease, and body mass index. †Adjusted for age, study year, education, smoking, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, systolic blood pressure, total cholesterol, history of using antihypertensive drugs, history of lung disease, body mass index, and other 2 types of physical activity. ‡Adjusted also for sex.

Abbreviations as in Table 2.

Table 4 Hazard Ratios of Heart Failure According to Different Levels of Leisure Time Physical Activity

	Leisure Time Physical Activity			p Value (for Trend)
	Low	Moderate	High	
Men	7,849	14,761	5,724	
No. of incidence cases	707	995	166	
Person-yrs	140,606	260,215	102,094	
Age and study years adjusted HR	1.00	0.81 (0.73–0.88)	0.53 (0.45–0.62)	<0.001
Multivariate adjusted HR*	1.00	0.84 (0.76–0.93)	0.66 (0.55–0.79)	<0.001
Multivariate adjusted HR†	1.00	0.83 (0.76–0.92)	0.65 (0.54–0.77)	<0.001
Women	10,564	15,032	4,278	
No. of incidence cases	940	608	92	
Person-yrs	219,722	273,837	73,058	
Age and study years adjusted HR	1.00	0.71 (0.65–0.79)	0.56 (0.46–0.69)	<0.001
Multivariate adjusted HR*	1.00	0.83 (0.74–0.92)	0.74 (0.59–0.92)	<0.001
Multivariate adjusted HR†	1.00	0.84 (0.75–0.94)	0.75 (0.60–0.94)	0.001
Men and women combined‡	18,413	29,793	10,002	
No. of incidence cases	1,647	1,603	258	
Person-yrs	360,328	534,052	175,151	
Age and study years adjusted HR	1.00	0.75 (0.70–0.81)	0.54 (0.48–0.61)	<0.001
Multivariate adjusted HR*	1.00	0.83 (0.77–0.89)	0.69 (0.60–0.79)	<0.001
Multivariate adjusted HR†	1.00	0.83 (0.77–0.89)	0.69 (0.60–0.79)	<0.001

Values are n or HR (95% confidence interval). *Adjusted for age, study year, education, smoking, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, systolic blood pressure, total cholesterol, history of using antihypertension drugs, history of lung disease, and body mass index. †Adjusted for age, study year, education, smoking, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, systolic blood pressure, total cholesterol, history of using antihypertensive drugs, history of lung disease, body mass index, and other 2 types of physical activity. ‡Adjusted also for sex.

Abbreviations as in Table 2.

Discussion

Moderate and high levels of occupational or leisure-time physical activity are associated with a reduced risk of HF in both sexes. Commuting activity seemed to be associated inversely with HF risk among women before adjustment for occupational and leisure-time physical activity. A simultaneous engagement in 2 or 3 types of physical activity showed a slightly stronger protective effect than participation in only 1 type of physical activity.

To the best of our knowledge, only 3 studies have assessed the association between physical activity and the risk of HF (4–6,16), and only 1 of them included both men and women (4). Moreover, the results of the 3 studies were inconsistent (4–6,16). Physical activity was found to be a protective factor against HF among men in the Physicians' Health Study (5,6). However, in the First National Health and Nutrition Examination Survey, the significant inverse association between leisure-time physical activity and HF risk was found only in women but not in men (4). In the present study, for the first time, moderate or high physical activity levels were found to be associated with a decreased risk of HF in both men and women.

All of the previous studies focused on leisure-time activity (4–6). However, the present study shows for the first time that moderate or high occupational physical activity also has the same protective effect on the risk of HF as leisure-time physical activity, especially in men. If this finding represents a causal relation, this approach is highly relevant to the improvement of health and longevity among working-aged people, because the increase in computerization and mechanization during the last decades has resulted in ever-increasing numbers of people being sedentary for most of their working time. Occupational physical activity largely has been ignored in epidemiologic surveys. The National Institutes of Health Consensus Development Conference on Physical Activity and Cardiovascular Health concluded that intermittent or shorter bouts of physical activity (at least 10 min), including occupational and nonoccupational activity and tasks of daily living, have similar HF preventive effects and other health benefits if performed at a level of moderate intensity (such as brisk walking, cycling, swimming, home repair, and yard work) with an accumulated duration of at least 30 min/day (20).

The present study also is the first study that observed an association between commuting physical activity and the risk of HF. We observed a significant inverse association between active commuting with the risk of HF events in women before adjustment for occupational and leisure-time physical activity. Although we did not establish a significant association between the risk of HF and commuting physical activity alone in both men and women, we confirmed that an individual with moderate or high leisure-time or occupational physical activity experienced further reduced risk of HF when the individual also was engaged in commuting physical activity. This is an important finding because daily active commuting is a major source of total physical activity

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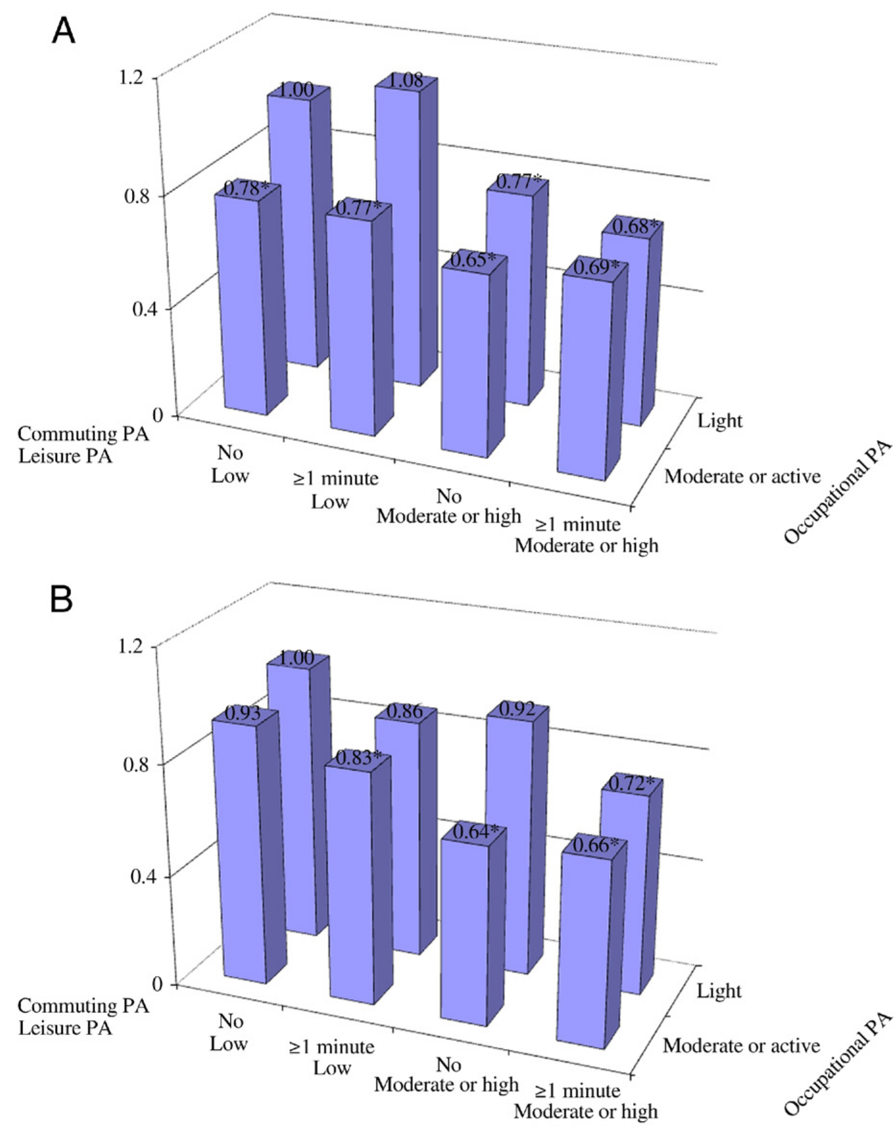

Figure 1 **Hazard Ratios of Heart Failure**

Bar graphs showing hazard ratios of heart failure according to joint categories of occupational, commuting, and leisure-time physical activity (PA) among **(A)** men and **(B)** women, adjusted for age, study year, education, smoking, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, history of using antihypertensive drugs, history of lung disease, body mass index, systolic blood pressure, and total cholesterol. *$p < 0.05$.

in some populations, can be implemented virtually everywhere, and is inexpensive. For example, in urban China, more than 90% of people walk or cycle to and from work daily (21). In our study, 54% of women and 46% of men reported walking or cycling to work daily, and 22% of women and 16% of men reported more than a half hour of walking or cycling to work daily. Several studies have shown that regular walking or cycling to and from work is related to lower levels of cardiovascular risk factors (9,21,22); as well as a reduced risk of type 2 diabetes (9), stroke (11), and CHD incidences (12); and mortality in general populations and patients with diabetes (10,13). In many Western studies, commuting physical activity was measured indirectly by asking for the frequency and duration of walking or cycling. Our results emphasize commuting as a separate component of physical activity to prevent HF in women.

The differences between the results of the present study and the previous studies may be explained partially by the relatively larger sample size of both men and women; the inclusion of physical activity during occupation, commuting, and leisure time; more incident HF cases; and different adjustment procedures in the present study. When assessing the joint effects of different types of physical activity, we observed a slightly higher risk of HF in those who participated in 3 types of physical activity. By our classification, it was possible that the level of the 3 types of physical activity in which those participants engaged were moderate levels of physical activity, whereas it is also possible for participants to take part in 2 types of physical activity that were of high levels of physical activity. This may account in part for the observed trend. Moreover, the present study indicated that the lowest hazard ratios occurred in women who performed moderate occupational and commuting physical activity. Older age and higher levels of cardiovascular disease risk factors in women with high occupational physical activity compared with women with moderate occupational physical activity may account in part for the observed trend, although we took these cardiovascular disease risk factors into account in the multivariate analyses. Except for older age, other possible reasons for the loss of dose effect between commuting physical activity and HF risk among women in our study was unknown.

The protective effect of physical activity from HF may be mediated in part by its effect on other risk factors for HF. Physical activity has a favorable effect on blood pressure, lipid profile, insulin sensitivity, body weight, blood coagulation, and fibrinolysis (12,21–25), and it also contributes to a decreased risk of developing hypertension, type 2 diabetes, the metabolic syndrome, and CHD (9,12,23,26–28). In our study population, it was shown previously that moderate or high levels of occupational or leisure-time physical activity were associated with a reduced risk of CHD, and daily walking or cycling to and from work was associated with a decreased risk of CHD among women (12,28). The current findings on the relationship between physical activity and the risk of HF are similar with the previous findings regarding the association between physical activity and the risk of CHD. In the present study, the inverse association between physical activity and the risk of HF remained after adjusting for major HF risk factors. However, given the temporal lag between the assessment of physical activity at baseline and the measurement of the outcome, it is not possible to determine the pathways by which physical activity resulted in a lower risk of HF.

Study limitations. First, a major strength of the study is the large number of both men and women from a homogeneous population who participated in the study. Second, the mean follow-up time was sufficiently long to ascertain a large number of HF end point events. Not only leisure-time physical activity, but also occupational and commuting physical activities, were included in the analysis. Finally, we also carried out additional analyses excluding the subjects who died during the first 2 years of follow-up to avoid a potential bias resulting from severe disease at baseline. Limitations of our study include the self-report of physical activity and that physical activity was recorded only once at baseline. Although no specific assessment of repeatability or validity of our questionnaire for physical activity has been carried out, similar questionnaires have been used in a large number of studies in Finland and other Nordic countries (9–13) where the patterns of physical activity are relatively similar. The method has been working in a large number of studies that can be considered as a validation in practice (13,14). We have no data on possible changes in physical activity during the follow-up. Misclassification, particularly over-reporting of the amount of physical activity at baseline and changes in the activity during the follow-up, probably underestimated the association between physical activity and the outcome. Because our data allowed for only a dichotomized measure of alcohol consumption in the entire sample, we may not be able to control fully for the effect of this variable on the risk of HF. To evaluate the impact of this shortcoming, we performed separate subgroup analyses (surveys of 1982, 1987, 1992, 1997, and 2002) in the multivariate-adjusted model of a dichotomized measure of alcohol consumption compared with another multivariate-adjusted model of 4 categories of alcohol consumption. In general, the associations between different types of physical activity and HF risk were not influenced substantially or systematically. Ascertainment of HF status was based on the National Hospital Discharge Registry, the National Social Insurance Institution's register on special reimbursement for HF drugs, and the Causes of Death Register. This diagnosis method has been used in other Scandinavian countries, such as Finland and Sweden (16–18,29). The accuracy of the HF cases in the Swedish hospital discharge was found to be more than 80% based on the European Society of Cardiology definition (17,18). Although accuracy of clinical HF diagnosis in our cohort is likely to be high, some diagnostic errors are inevitable. However, the misdiagnosis is most likely to be independent of the exposure status, and therefore tends to attenuate the underlying associations rather than causes spurious associations. We cannot exclude completely the effects of residual confounding resulting from measurement error in the assessment of confounding factors or some unmeasured factors, such as other chronic diseases (e.g., peripheral vascular disease, renal disease, and anemia), the extent or severity of the prior myocardial infarction, ischemic heart disease symptom burden, and some dietary factors.

Conclusions

This study confirms that moderate or high levels of occupational or leisure-time physical activity have a negative association with the risk of HF among men and women. Active commuting had a significant inverse association with the risk of HF events in women before adjustment for occupational and leisure-time physical activity.

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Key Words: heart failure ▪ incidence ▪ physical activity.

APPENDIX

For a supplemental table on the multivariate adjustment hazard ratios of heart failure according to different levels and different types of physical activity, please see the online version of this article.