All-Cause Mortality Associated With Physical Activity During Leisure Time, Work, Sports, and Cycling to Work

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Background: Physical activity is associated with low mortality in men, but little is known about the association in women, different age groups, and everyday activity.

Objective: To evaluate the relationship between levels of physical activity during work, leisure time, cycling to work, and sports participation and all-cause mortality.

Design: Prospective study to assess different types of physical activity associated with risk of mortality during follow-up after the subsequent examination. Mean follow-up from examination was 14.5 years.

Setting: Copenhagen University Hospital, Copenhagen, Denmark.

Participants: Participants were 13375 women and 17265 men, 20 to 93 years of age, who were randomly selected. Physical activity was assessed by self-report, and health status, including blood pressure, total cholesterol level, triglyceride levels, body mass index, smoking, and educational level, was evaluated.

Main Outcome Measure: All-cause mortality.

Results: A total of 2881 women and 5668 men died. Compared with the sedentary, age- and sex-adjusted mortality rates in leisure time physical activity groups 2 to 4 were 0.68 (95% confidence interval, 0.64-0.71), 0.61 (95% confidence interval, 0.57-0.66), and 0.53 (95% confidence interval, 0.41-0.68), respectively, with no difference between sexes and age groups. Within the moderately and highly active persons, sports participants experienced only half the mortality of nonparticipants. Bicycling to work decreased risk of mortality in approximately 40% after multivariate adjustment, including leisure time physical activity.

Conclusions: Leisure time physical activity was inversely associated with all-cause mortality in both men and women in all age groups. Benefit was found from moderate leisure time physical activity, with further benefit from sports activity and bicycling as transportation.

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A NUMBER of prospective studies[1] have shown lower mortality rates in physically active men compared with sedentary men. Most studies[2-4] of men have focused on the amount of leisure time physical activity. Also, physical activity at work[5,6] and the intensity of physical activity have been shown to be associated with a lower risk of disease and death.[2] Less evidence exists for women. Lissner et al[7] examined the relation between all-cause mortality and physical activity in women. They reported that mortality was twice as high in the group with the lowest activity level compared with the more active groups. In contrast, Blair et al[8] found no difference in mortality between physical activity groups in women. They suggested that the physical activity assessment technique they used was less accurate in women than in men, since focus was on self-reported traditional sport and leisure time physical activities, omitting other activities pertinent to this group, such as housework and child care. Studies associating physical activity in daily living, such as cycling to work, to mortality are few.

The aim of this study was to analyze whether the risk from being physically inactive was consistent across age and sex groups. We examined the association of leisure time physical activity, physical activity at work, bicycling to work, and sports activities to mortality after adjustment for blood pressure, blood lipid levels, smoking, body mass index, and educational level.

SUBJECTS AND METHODS

STUDY POPULATION

This study is based on pooled data from 3 epidemiological surveys from the region of Copenhagen: The Copenhagen City Heart Study, The Glostrup Population Studies, and The Copenhagen Male Study.[9]

A total of 13 455 women and 17 441 men have been examined. Information on chronic disease that could influence physical activity level and risk of death was obtained at the examination and, after 1977, additionally from hospital records. In 2960 women and 3959 men, a chronic disease had been diagnosed before baseline. Chronic diseases diagnosed according to *International Classification of Diseases, Eighth Revision* included cancers (diagnoses 140-172, 174-209, 230-239), cardiovascular diseases (diagnoses 400-448), lung diseases (diagnoses 490-493), and musculoskeletal diseases (diagnoses 710-738).

DETAILS OF EACH COHORT

The Copenhagen City Heart Study

In 1976 and 1978, 19 329 individuals, 20 to 93 years of age, from central Copenhagen were invited to participate in a medical examination. The sample was randomly selected within age strata from a population of 90 000 inhabitants living in this area.[10] From 1981 to 1983, another 500 individuals, 20 to 25 years of age, were invited, and 1276 of the former nonparticipants participated this time. A total of 19 829 living subjects have been invited to at least one examination, and of these, 8489 women and 7188 men were included in this study.

The Glostrup Population Studies

Since 1964, cohorts from the suburbs of the western part of Copenhagen County have been invited to participate in a health examination.[11] The cohorts comprise men and women in the age range of 20 to 75 years at entry. A total of 13 122 people have been invited, of whom 4966 women and 5026 men participated. All cohorts were randomly selected. The present study includes the following cohorts. (1) *The 1897 Birth Cohort*. The first examination was performed in 1967 and included 636 subjects, of whom 440 participated (69%). Thirty-nine of the former nonparticipants were examined in 1977. (2) *The 1914 Birth Cohort*. The first examination was performed in 1964, and the cohort was expanded in 1984 and 1989. A total of 663 men (85%) and 589 women (76%) have been examined. (3) *The 1936 Birth Cohort*. In the first examination in 1976, 1052 individuals (88%) of the 1199 invited participated. Twenty-six of the nonparticipants from the first examination were examined in 1981 and another 29 in 1987. A total of 520 men (90%) and 587 women (95%) have been examined. (4) *The MONICA (Monitoring of Trends and Determinants of Cardiovascular Disease) 1 Cohorts*. Four cohorts, comprising 4807 subjects aged 30, 40, 50, and 60 years, were invited to participate in a medical examination in 1982. A total of 1915 men (81%) and 1842 women (77%) have been examined. (5) The MONICA 2 Cohorts. Four cohorts, including 2000 subjects, were invited to take part in a medical examination in 1986. Participants were 702 women (71%) and 695 men (70%) aged 30, 40, 50, and 60 years. (6) *The MONICA 3 Cohorts*. Five cohorts, comprising 2912 subjects, were invited to participate in a health examination in 1992. Participants were 1015 women (70%) and 994 men (70%) aged 30, 40, 50, 60, and 70 years.

The Copenhagen Male Study

In 1970 and 1971, all men aged 40 to 59 years who were employed at 1 of 14 major work sites in Copenhagen were invited to participate in a health examination.[12] A total of 6125 men were invited, and 5227 men (86%) participated.

In both The Glostrup Population Studies and The Copenhagen City Heart Study, subjects were randomly selected from The Danish Central Population Registry. The Copenhagen Male Study included all middle-aged male employees in 14 randomly selected public and private companies, and the mortality rate among these men was lower compared with the total male population of Copenhagen because of a healthy worker effect.[9]

EXAMINATIONS

Information regarding physical activity, smoking, and number of years of education was collected from questionnaires.

Physical activity of work and leisure time was classified into 4 levels based on questions originally constructed and evaluated by Saltin and Grimby.[13] The physical activity level

RESULTS

The analyses included 13 375 women and 17 265 men followed up for an average of 14.5 years (range, 0-28 years), corresponding to 433 000 person-years. Data are presented as mean (±SD) or relative risks.

LEISURE TIME PHYSICAL ACTIVITY

Leisure time physical activity was assessed in 13 116 women. During 13.8 (±5.0) years of follow-up, 2738 died. Leisure time physical activity was also assessed in 14 776 men, who were followed up for 15.1 (±6.6) years, and among these 4672 died. Four levels of leisure time physical activity were assessed. Compared with the sedentary, age- and sex-adjusted mortality rates in leisure time physical activity groups 2 to 4 were 0.68 (95% CI, 0.64-0.71), 0.61 (95% CI, 0.57-0.66), and 0.53 (95% CI, 0.41-0.68), respectively. Baseline data were collected during a long time span, which might affect the relative risk between exposure groups, because mortality rates, physical activity, and confounder levels have changed. After adjustment for time of entry, the relative risks in leisure time physical activity levels 2 to 4 were 0.68 (95% CI, 0.64-0.72), 0.64 (95% CI, 0.60-0.66), and 0.53 (95% CI, 0.42-0.69), respectively. The frequency distribution and the mean (SD) values of the key variables used for adjustment in the survival analyses are shown for each level of leisure

was assessed as the mean level during the last year. Small differences existed in the words used in the questions among the cohorts, but 4 categories were used in all cohorts, and the age-specific distributions of leisure time physical activity were similar in the different cohorts.

Most of the subjects answered the following question: "(1) Is your work primarily sitting, ie, at a desk, housewife without children and with house aid; (2) sitting or standing and now and then walking, ie, teacher, housewife (you do the cleaning yourself and do not have small children); (3) walking, now and then lifts, ie, postman, housewife with small children; and (4) heavy manual work, ie, furniture remover, road construction worker."

In one of the cohorts, the frequency of heavy work was used instead. No differences were found in the distribution of subjects or mortality between groups using this question; therefore, the data were pooled.

In most cohorts, leisure time physical activity was assessed by responses to the following statements: "(1) You are almost entirely sedentary or perform light physical activity less than 2 hours per week, ie, reading, TV, cinema; (2) You perform light physical activity 2-4 hours per week, ie, walking, cycling, light gardening; (3) You perform light physical activity more than 4 hours per week or more vigorous activity 2-4 hours per week, ie, brisk walking, fast cycling, heavy gardening, sports where you get sweaty or exhausted; (4) You perform highly vigorous physical activity more than 4 hours per week or regular exercise or competitive sports several times per week."

A few cohorts used other phrases in these statements, but the distribution of subjects between groups was similar. Since the number of subjects and deaths among the most physically active in leisure time was limited (**Table 1** and **Table 2**), levels 3 and 4 were analyzed together in the analysis of age subgroups.

In addition, 14 727 subjects indicated whether they took part in sports activity (yes or no), and 6954 were asked if they used a bicycle as transportation to work (yes or no).

The subjects classified themselves as never smokers, previous smokers, or current smokers, and the number of cigarettes, cheroots, or cigars or weight of pipe tobacco smoked daily was recorded. Many smokers in Denmark smoke pipes and cheroots, and some smoke a mixture of different types. Therefore, smoking was recoded into grams of tobacco, where 1 cigarette equals 1 g of tobacco. Socioeconomic status was assessed as years of education. Three categories were used: fewer than 8 years of school, between 8 and 11 years, and more than 12 years. Height and body mass were measured with the subject lightly dressed, and body mass index calculated as weight in kilograms divided by the square of height in meters.[2]

Blood pressure was measured on the upper arm using a mercury sphygmomanometer, with subjects in the sitting position having rested for at least 5 minutes. A venous blood sample was drawn following a 12-hour fast and analyzed for serum triglyceride and total serum cholesterol levels by conventional methods.[14] In The Copenhagen City Heart Study, subjects were nonfasting, and blood lipid levels were analyzed from plasma.

END POINTS

Information on mortality in the period from baseline examination to December 31, 1994, was obtained. All subjects were traced by means of The Danish Central Population Registry. Person-years were calculated from the date of the first examination to December 31, 1994, or to the date of emigration, death, or disappearance.

STATISTICAL ANALYSIS

All data were analyzed using Intercooled Stata (version 5).[15] Relative risks were calculated from Cox proportional hazards models.[16] Men and women were analyzed separately. Categorized risk factors were entered into Cox models, since a nonlinear relationship was found between mortality and the risk factors body mass index and serum cholesterol level. The categories used are described in **Table 3**. Linear regression with adjustment for age was used in the calculation of trends in risk factor levels between categories of leisure time physical activity. In all analyses, $P<.05$ was used as the significance level.

All mortality analyses were initially conducted separately for those free of disease and those with disease. Those who had a diagnosed disease had a sex- and age-adjusted relative risk of death of 1.74 (95% confidence interval [CI], 1.65-1.82) compared with the initially healthy, but the relative risk between physical activity groups was the same in both sexes in the healthy and the chronically ill subjects. In the analyses of physical activity, adjustment for chronic disease did not change the estimates when the whole group was analyzed. Therefore, data are presented for the whole group throughout the article.

time physical activity (Tables 1 and 2). In both women and men, younger age was associated with higher level of physical activity. Accordingly, other risk factors were age adjusted before calculation of trends across physical activity levels. The mean educational level of the participants was positively associated with the level of leisure time physical activity ($P<.001$). Body mass index, cholesterol level, triglyceride levels, and percentage of smokers were negatively related to leisure time physical activity ($P<.001$). Systolic blood pressure was negatively associated with leisure time physical activity ($P<.01$); after adjustment for age, the difference between the groups was not significant. The age- and sex-adjusted association between confounders and mortality are described in Table 3 and **Table 4**.

RELATIVE RISK OF MORTALITY IN THE PHYSICALLY INACTIVE IN THE 2 SEXES

The age-adjusted relative risks of mortality between different levels of leisure time physical activity were calculated for men and women. Adjustment for other coronary heart disease (CHD) risk factors did not substantially change the estimates (**Figure 1** and **Figure 2**). Adjustment for one risk factor at a time did not substantially change the relative risks in men or women. After multiple adjustment for the categorized variables of systolic

Table 1. Association of Baseline Characteristics With Level of Leisure Time Physical Activity in Women

Characteristic	Leisure Time Physical Activity Level				*P* for Trend*	All Women†
	1	2	3	4		
No. (%)	3235 (24.7)	7437 (56.7)	2350 (17.9)	94 (0.7)	. . .	13 375
Deaths, No. (%)	919 (33.6)	1413 (51.6)	396 (14.4)	10 (0.4)	. . .	2881
Age at baseline, mean ± SD, y	51.0 ± 12.8	50.2 ± 12.2	49.3 ± 12.9	42.4 ± 12.9	<.001	50.4 ± 12.7
Body mass index, mean ± SD, kg/m^2	25.0 ± 5.0	24.5 ± 4.4	23.9 ± 3.9	23.1 ± 3.4	<.001	24.5 ± 4.5
Systolic blood pressure, mean ± SD, mm Hg	131.8 ± 24.1	131.2 ± 22.6	130.8 ± 21.9	124.6 ± 19.4	.20	131.5 ± 23.0
Cholesterol, mean ± SD, mmol/L‡	6.00 ± 1.65	6.23 ± 1.33	6.08 ± 1.32	5.62 ± 1.20	<.001	6.10 ± 1.49
Triglyceride, mean ± SD, mmol/L‡	1.41 ± 0.90	1.35 ± 0.79	1.30 ± 0.85	1.27 ± 0.73	<.001	1.36 ± 0.83
Years in school, mean ± SD§	1.53 ± 0.61	1.67 ± 0.65	1.75 ± 0.68	1.93 ± 0.72	<.001	1.64 ± 0.65
Smokers, %	60.5	53.9	53.2	54.3	<.001	55.3
Years of observation, mean ± SD	12.9 ± 5.3	14.0 ± 4.9	14.8 ± 4.3	15.0 ± 4.1	<.001	13.8 ± 5.0

Age distribution differed between groups. Therefore, the P *values for trend were calculated after adjustment for age. Ellipses indicate data not applicable.*
†*This category includes those women in whom leisure time physical activity is missing but excludes those who had chronic disease at baseline.*
‡*To convert cholesterol from millimoles per liter to milligrams per deciliter, divide by 0.02586. To convert triglyceride from millimoles per liter to milligrams per deciliter, divide by 0.01129.*
§*Three educational levels: level 1, 0 to 7 years; level 2, 8 to 11 years; and level 3, more than 11 years of school education.*

Table 2. Association of Baseline Characteristics With Level of Leisure Time Physical Activity in Men

Characteristic	Leisure Time Physical Activity Level				*P* for Trend*	All Men†
	1	2	3	4		
No. (%)	3024 (20.5)	7909 (53.5)	3506 (23.7)	337 (2.3)	. . .	17 265
Deaths, No. (%)	1190 (25.5)	2448 (52.4)	980 (21.0)	54 (1.2)	. . .	5668
Age at baseline, mean ± SD, y	51.7 ± 12.2	50.1 ± 10.9	48.7 ± 12.3	41.8 ± 12.6	<.001	49.7 ± 11.2
Body mass index, mean ± SD, kg/m^2	26.0 ± 4.0	25.6 ± 3.4	25.3 ± 3.4	24.9 ± 3.3	<.001	25.6 ± 3.4
Systolic blood pressure, mean ± SD, mm Hg	136.5 ± 21.3	136.2 ± 20.4	135.1 ± 19.9	132.6 ± 18.0	.51	135.9 ± 20.5
Cholesterol, mean ± SD, mmol/L‡	5.91 ± 1.56	6.05 ± 1.19	5.96 ± 1.19	5.54 ± 1.17	<.001	5.91 ± 1.43
Triglyceride, mean ± SD, mmol/L‡	1.96 ± 1.56	1.83 ± 1.30	1.74 ± 1.34	1.59 ± 1.06	<.001	1.82 ± 1.37
Years in school, mean ± SD§	1.59 ± 0.67	1.70 ± 0.68	1.74 ± 0.70	1.82 ± 0.70	<.001	1.68 ± 0.69
Smokers, %	73.4	67.8	62.3	54.3	<.001	68.2
Years of observation, mean ± SD	12.9 ± 6.3	15.0 ± 6.6	13.9 ± 5.5	14.3 ± 5.0	<.001	15.1 ± 6.6

Age distribution differed between groups. Therefore, the P *values for trend were calculated after adjustment for age. Ellipses indicate data not applicable.*
†*This category includes those men in whom leisure time physical activity is missing but excludes those who had chronic disease at baseline.*
‡*To convert cholesterol and triglyceride values to conventional units, see the third footnote to Table 1.*
§*Three educational levels: level 1, 0 to 7 years; level 2, 8 to 11 years; and level 3, more than 11 years of school education.*

blood pressure, total cholesterol level, triglyceride levels, body mass index, smoking, educational level, and age, the relative risks of physical activity levels 2, 3, and 4 were 0.65, 0.59 (both $P<.001$), and 0.64 ($P=.20$) in women, respectively, and 0.72, 0.72 (both $P<.001$), and 0.65 ($P<.01$) in men.

RELATIVE RISK OF PHYSICAL INACTIVITY IN 3 SEPARATE AGE GROUPS

In all stratified analyses, leisure time physical activity levels 3 and 4 were analyzed together.

To elucidate age-specific differences, mortality rates were calculated according to levels of leisure time physical activity in 3 separate age groups: 20 through 44 years, 45 through 64 years, and 65 years or older. Calculations were conducted for women and men separately (**Table 5** and **Table 6**). There was a trend toward increased benefit of physical activity with increasing age. No difference was found between sexes. The relative risk did not attain statistical significance in the youngest group in women, where the number of deaths was small (n=192). Multivariate adjustment for CHD risk factors did not change the relative risks substantially.

When the 2 sexes were analyzed together, with adjustment for age and sex, all estimates of relative risk became significant.

SPORTS PARTICIPATION

A question regarding sports participation (yes or no) was answered by 4746 women and 9981 men, among whom 624 and 2740 deaths were registered, respectively. Because a close relationship was expected between the 4-category question of leisure time physical activity and the sports participation question, the relative risk for sports participation was calculated with and without adjustment for leisure time physical activity. This adjustment changed the age-adjusted relative risk from 0.42 (95% CI, 0.32-0.55) to 0.48 (95% CI, 0.37-0.64) in women and from 0.80 (95% CI, 0.73-0.87) to 0.84 (95% CI, 0.75-0.93) in men.

Sports participation was unequally distributed among groups with different educational levels. In women, 18%

Table 3. Age-Adjusted Relative Risk (RR) and 95% Confidence Intervals (CIs) of Mortality in Risk Factors Other Than Physical Inactivity for Women

Risk Factor	No. of Women	No. of Deaths	RR (95% CI)
Smoking	13 205	2817	
Never smoked	3962	732	1 (Referent)
Ex-smokers	1946	356	1.03 (0.91-1.17)
Smoke 1-14 g/d	3874	925	1.57 (1.42-1.73)
Smoke 15-24 g/d	2947	655	2.01 (1.80-2.24)
Smoke ≥25 g/d	476	149	2.46 (2.07-2.94)
Body mass index, kg/m^2	13 188	2811	
<20	1537	322	1.65 (1.46-1.87)
20-25	6770	1175	1 (Referent)
25.01-27	1822	405	0.98 (0.89-1.11)
27.01-30	1607	424	1.1 (0.98-1.23)
>30	1452	485	1.43 (1.28-1.59)
Total cholesterol, mmol/L*	13 063	2782	
<5.25 (1st quartile)			1 (Referent)
5.25-6.02 (2nd quartile)			0.95 (0.83-1.09)
6.03-6.90 (3rd quartile)			0.89 (0.78-1.02)
>6.90 (4th quartile)			1.12 (0.99-1.27)
Triglycerides, mmol/L*	12 309	2618	
<0.92 (1st quartile)			1 (Referent)
0.92-1.27 (2nd quartile)			1.16 (1.03-1.31)
1.28-1.86 (3rd quartile)			1.3 (1.16-1.47)
>1.86 (4th quartile)			1.65 (1.46-1.86)
High-density lipoprotein cholesterol, mmol/L*	5775	628	
<1.08 (1st quartile)			1 (Referent)
1.08-1.33 (2nd quartile)			0.8 (0.63-1.01)
1.34-1.63 (3rd quartile)			0.65 (0.51-0.82)
>1.63 (4th quartile)			0.5 (0.40-0.62)
Systolic blood pressure, mm Hg	13 109	2791	
<120 (1st quartile)			1 (Referent)
120-130 (2nd quartile)			1.27 (1.10-1.46)
131-146 (3rd quartile)			1.22 (1.06-1.39)
>146 (4th quartile)			1.79 (1.57-2.03)

**To convert cholesterol and triglyceride values to conventional units, see the third footnote to Table 1.*

Table 4. Age-Adjusted Relative Risk (RR) and 95% Confidence Intervals (CIs) of Mortality in Risk Factors Other Than Physical Inactivity for Men

Risk Factor	No. of Men	No. of Deaths	RR (95% CI)
Smoking	17 116	5609	
Never smoked	2094	331	1 (Referent)
Ex-smokers	3332	942	1.25 (1.10-1.41)
Smoke 1-14 g/d	3705	1313	1.73 (1.53-1.95)
Smoke 15-24 g/d	5428	2034	2.21 (1.96-2.48)
Smoke ≥25 g/d	2557	989	2.36 (2.08-2.67)
Body mass index, kg/m^2	17 138	5603	
<20	600	248	1.69 (1.48-1.73)
20-25	7549	2204	1 (Referent)
25.01-27	3923	1240	0.93 (0.87-1.00)
27.01-30	3400	1248	1.06 (0.98-1.13)
>30	1666	663	1.21 (1.11-1.32)
Total cholesterol, mmol/L*	11 797	3739	
<5.25 (1st quartile)			1 (Referent)
5.25-6.02 (2nd quartile)			0.92 (0.84-1.01)
6.03-6.90 (3rd quartile)			0.92 (0.84-1.01)
>6.90 (4th quartile)			1.06 (0.96-1.16)
Triglycerides, mmol/L*	11 026	3515	
<0.92 (1st quartile)			1 (Referent)
0.92-1.27 (2nd quartile)			1.04 (0.93-1.18)
1.28-1.86 (3rd quartile)			1.09 (0.98-1.22)
>1.86 (4th quartile)			1.22 (1.10-1.35)
High-density lipoprotein cholesterol, mmol/L*	5532	920	
<1.08 (1st quartile)			1 (Referent)
1.08-1.33 (2nd quartile)			0.78 (0.67-0.92)
1.34-1.63 (3rd quartile)			0.76 (0.64-0.91)
>1.63 (4th quartile)			0.83 (0.68-1.02)
Systolic blood pressure, mm Hg	17 078	5584	
<120 (1st quartile)			1 (Referent)
120-130 (2nd quartile)			1.32 (1.19-1.47)
131-146 (3rd quartile)			1.48 (1.34-1.64)
>146 (4th quartile)			2 (1.81-2.21)

**To convert cholesterol and triglyceride values to conventional units, see third footnote to Table 1.*

of those attending school for fewer than 8 years participated in sports, whereas 33% and 31% from the groups with the higher educational levels participated. Adjustment for educational level or other single CHD risk factors did not affect the age-adjusted relative risk in women, with all estimates being between 0.42 and 0.45. After multivariate adjustment, a relative risk of 0.56 (95% CI, 0.42-0.75) was found for sports participants in women. In men, participation rates were 16%, 36%, and 37%, respectively. In men, the age-adjusted relative risk changed markedly from 0.80 to 0.58 (95% CI, 0.47-0.72) after adjustment for educational level. No change was found after additional adjustment for other single risk factors in men. After multivariate adjustment for CHD risk factors, the estimated relative risk for the men who participated in sports was 0.69 (95% CI, 0.55-0.87) compared with those who did not.

In the analysis of the 4-category leisure time physical activity variables, only small differences were found in mortality rates among groups 2 to 4. Therefore, an analysis of the relative risk in those who participated in sports was conducted after exclusion of the sedentary (leisure time physical activity group 1). After multiple adjustment, a relative risk of 0.47 (95% CI, 0.34-0.66) was found in women who participated in sports compared with the moderately active women and a relative risk of 0.63 (95% CI, 0.51-0.79) was found in men. So, even if the leisure time physical activity question could not discriminate in mortality among levels 2 to 4, great differences existed in mortality rates in relation to sports participation within this group.

PHYSICAL ACTIVITY AT WORK

Physical activity at work was assessed in 10 334 women and 9929 men, of whom 1688 and 2587, respectively, died during the follow-up. Differential associations were found for women and men in relation to physical activity at work. In women, a higher level of physical activity at work was associated with lower mortality rates. Age-adjusted relative risks in levels 2 to 4 compared with the lowest level of physical activity at work were 0.86 (95% CI, 0.77-0.96) and 0.86 (95% CI, 0.74-0.99), respectively, after adjustment for educational level. Adjust-

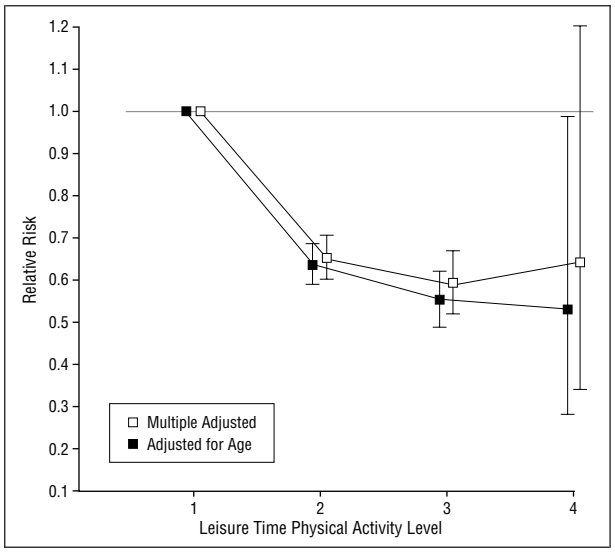

Figure 1. *The estimated relative risk in women for leisure time physical activity levels 2, 3, and 4 in relation to the inactive. The upper curve is adjusted for cholesterol level, triglyceride levels, body mass index, systolic blood pressure, educational level, smoking, and age at baseline.*

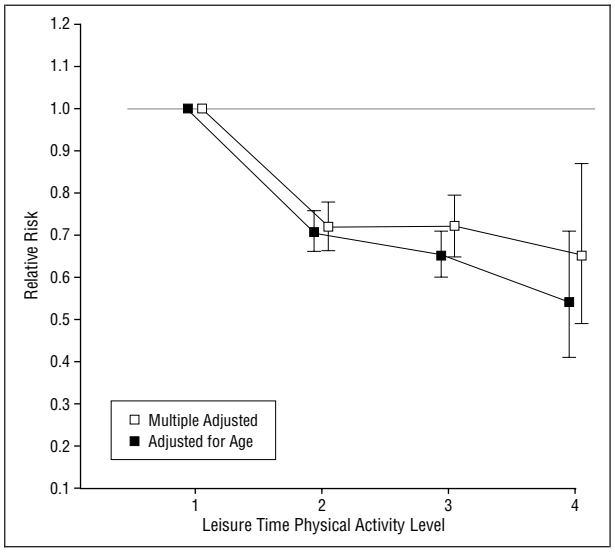

Figure 2. *The estimated relative risk in men for leisure time physical activity levels 2, 3, and 4 in relation to the inactive. The upper curve is adjusted for cholesterol level, triglyceride levels, body mass index, systolic blood pressure, educational level, smoking, and age at baseline.*

Table 5. Relative Risk of Mortality in Women in Leisure Time Physical Activity (LTPA) Group 2 (Moderate) and Groups 3 and 4 (High) vs Group 1 (Low)

Age Group	No. of Women	No. of Deaths	Relative Risk (95% Confidence Interval) Moderate vs Low LTPA	High vs Low LTPA
20-44 y				
Age-adjusted	4347	192	0.78 (0.57-1.07)	0.66 (0.43-1.03)
Multivariate*	4235	181	0.75 (0.54-1.04)	0.66 (0.42-1.05)
45-64 y				
Age-adjusted	6557	1527	0.67 (0.60-0.75)	0.59 (0.50-0.69)
Multivariate*	6339	1469	0.73 (0.65-0.83)	0.66 (0.56-0.77)
≥65 y				
Age-adjusted	1434	851	0.52 (0.45-0.60)	0.48 (0.39-0.60)
Multivariate*	1373	808	0.52 (0.45-0.61)	0.49 (0.39-0.61)
All age groups				
Age-adjusted	13 116	2738	0.64 (0.59-0.69)	0.55 (0.49-0.62)
Multivariate*	11 947	2458	0.65 (0.60-0.71)	0.59 (0.52-0.67)

**Relative risk adjusted for age, systolic blood pressure, serum cholesterol level, triglyceride levels, smoking status, and years of education.*

Table 6. Relative Risk of Mortality in Men in Leisure Time Physical Activity (LTPA) Group 2 (Moderate) and Groups 3 and 4 (High) vs Group 1 (Low)

Age Group	No. of Women	No. of Deaths	Relative Risk (95% Confidence Interval) Moderate vs Low LTPA	High vs Low LTPA
20-44 y				
Age-adjusted	5005	469	0.71 (0.57-0.88)	0.6 (0.46-0.78)
Multivariate*	4000	306	0.73 (0.56-0.96)	0.74 (0.55-1.01)
45-64 y				
Age-adjusted	7618	2956	0.75 (0.68-0.82)	0.69 (0.62-0.77)
Multivariate*	5332	1978	0.75 (0.67-0.84)	0.75 (0.67-0.85)
≥65 y				
Age-adjusted	1374	1021	0.6 (0.52-0.70)	0.59 (0.50-0.71)
Multivariate*	1318	975	0.62 (0.53-0.73)	0.6 (0.50-0.72)
All age groups				
Age-adjusted	14 776	4672	0.71 (0.66-0.76)	0.65 (0.59-0.70)
Multivariate*	10 650	3259	0.72 (0.66-0.78)	0.71 (0.65-0.78)

**Relative risk adjusted for age, systolic blood pressure, serum cholesterol level, triglyceride levels, smoking status, and years of education.*

ment for each single CHD risk factor did not change the estimates, and after multiple adjustment, estimates were 0.90 and 0.86, respectively. In the most physically active group at work, a significant protection after full adjustment was found ($P<.001$). In men, no difference was found in age-adjusted mortality rates between levels of physical activity at work, and even after adjustment for educational level, only a tendency toward a decrease in mortality with higher physical activity at work was seen.

BICYCLING TO WORK

Information on bicycling as transportation to work was available for 783 women and 6171 men. Among these 6954 subjects, 2291 died during follow-up. The same tendencies were found in men and women when mortality rates were compared between those who cycled to work and those who did not, but the estimates were not significant in women. The average time spent cycling in those who did cycle to work was 3 hours per week. The analyses are presented for the whole group, with adjustment for sex. Bicycling to work was inversely related to years of education. Among the less educated subjects (<8 years of school), 27.8% used the bicycle to work, in the middle group (8-12 years of school) 24.5% cycled, and in the most educated group (≥12 years of school) 20.3% cycled. After adjustment for age, sex, and educational level, the relative risk in those who cycled was 0.70 (95% CI, 0.55-0.89). After additional adjustment for leisure time physical activity, body mass index, blood lipid levels,

smoking, and blood pressure, the relative risk was 0.72 (95% CI, 0.57-0.91).

COMMENT

The present study analyzed self-reported physical activity at baseline and subsequent all-cause mortality. The major findings of this large-scale epidemiological study were that in both sexes and in all age groups there was a lower mortality in the physically active compared with the inactive. Those who used the bicycle as transportation to work experienced a lower mortality rate even after adjustment for leisure time physical activity, and sports participation discriminated mortality rates even among the more physically active subjects. Physical inactivity at work was only a risk factor in women.

RELATIVE RISK OF PHYSICAL INACTIVITY IN WOMEN

The benefit of physical activity in women seems to be controversial, mainly because only a few studies have included women and relatively few deaths were observed. The present study includes a large sample of women, in whom there were almost 3000 deaths during the follow-up. We found consistently lower mortality rates, in all age groups, with higher levels of physical activity of any kind in contrast to Blair et al.[8] In a 12-year prospective study of 1462 Swedish women, Lapidus and Bengtsson[17] found a relative risk of death of 1.9 (95% CI, 1.1-3.2) in the inactive group during leisure time compared with their more active counterparts. They used the same questionnaire as in the present study. The relative risk for being inactive at work was increased more than 5 times in their study (95% CI, 2.8-9.7). The study only included middle-aged women. After a further 8 years of follow-up of the same cohort of women, Lissner et al[7] found that those who were inactive during leisure time had a double risk of mortality. Even with only 147 deaths, the results were highly significant. The relative risk for inactivity at work was 4 times that of the most active group. Salonen et al[18] studied 3784 women and 4015 men from North Karelia and Kuopio. There were 75 deaths among women during the 7-year follow-up. The relative risk of low physical activity at work was 2.4 (90% CI, 1.6-3.5) in women. During leisure time, the relative risk for a low physical activity level was 1.6 (90% CI, 1.1-2.3) in women. All these Scandinavian studies used the same physical activity questions of leisure time and at work. The studies all showed a significant protection from a high level of physical activity in women.

DOSE-RESPONSE RELATIONSHIP IN LEISURE TIME PHYSICAL ACTIVITY

A dose-response relationship was found in both women and men, with the most striking difference in mortality between the inactive group compared with others. Could the small difference in mortality rate between the moderately and highly active participants be caused by the formulation of the questions? To elucidate this question, we excluded the sedentary and analyzed an additional question of sports participation in the remaining population. The mortality was less than half in the sports participants compared with nonparticipants. Therefore, the small difference in mortality rates between moderately active and highly active subjects found in the analysis of the 4-category leisure time physical activity question may be a bias from the formulation of the question. Recent recommendations of physical activity for health have focused on moderate-intensity exercise,[19] and it may be more feasible to make a sedentary person moderately active than vigorously active, although sports participants only experienced half the mortality rate of the moderately active.

RELATIVE RISK OF LEISURE TIME PHYSICAL INACTIVITY IN DIFFERENT AGE GROUPS

The present study showed a tendency toward increased benefit of physical activity associated with higher age. In women, the mortality rate in the most active group in the oldest age group was less than half the mortality rate in the sedentary group, whereas the relative risk between physical activity groups in the youngest group was 0.66. In men, no trend was observed. The relative risk between physical activity groups in the elderly was greater than seen in other studies. It has been proposed that physical activity prevents premature death but does not extend the life span.[20] In the Harvard Alumni Study,[3] the estimated number of added years gained by having an active lifestyle decreased with increasing age at entry. Other studies have found lower mortality rate with higher physical activity level in the elderly. Lindsted et al[21] studied older men up to the age of 90 years, and Kaplan et al[22] studied men and women older than 70 years. Both studies found lower mortality among the physically active. Simonsick et al[23] found a 23% to 55% lower mortality rate in highly active men and women older than 65 years, and in the Framingham studies a relative risk of 0.24 was found in physically active women older than 75 years, but no difference was found in men.[24]

It seems that most studies with a large number of older subjects find that a physically active lifestyle is beneficial in old age. To what extent mortality rates differ between activity groups among the elderly is still uncertain. The present study suggests that physical activity is as important in old age as it is in younger age in both sexes and may be even more important in older women.

PHYSICAL INACTIVITY AT WORK AND BICYCLING TO WORK

In women, the group with the highest physical activity level at work experienced a protective effect after adjustment for other risk factors and educational level. No benefit with increasing physical activity at work was found in men. Physical activity at work may have changed during the last decades with the introduction of labor-saving devices in the workplace. Powell et al[1] stated that the study of San Francisco longshoremen would not now be possible because the proportion of men in the highest energy category at work has fallen from 40% to 5%. In some studies,[5] where both physical activity at work and during leisure time have been assessed, researchers

have failed to show a benefit of job-related activity in men; most other Scandinavian studies[17,25] support the present findings in women.

To our knowledge, no other study has analyzed the independent benefit of bicycling to work, probably because it is rare in most countries. Morris[26] presented data on cycling and myocardial infarction from the study of civil servants at a 1-day conference in 1990. Seven percent reported cycling, and of those who cycled, most experienced only half the myocardial infarctions of those who reported no cycling. In Denmark, 46% of the 25-year-old men and women use the bicycle to travel to work every day throughout the year and about 70% in the summer.[27] Even after adjustment for other risk factors, including leisure time physical activity, those who did not cycle to work experienced a 39% higher mortality rate than those who did.

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