Physical Activity and 10-Year Mortality From Cardiovascular Diseases and All Causes

The Zutphen Elderly Study

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Background: Little is known about physical activity and mortality risk in the elderly. Therefore, we describe the associations between the physical activity pattern of elderly men and the mortality from cardiovascular diseases (CVDs), particularly coronary heart disease (CHD) and stroke, and all causes.

Methods: Self-reported physical activity was assessed with a validated questionnaire for retired men in a population-based sample of 802 Dutch men, aged 64 to 84 years at baseline. Relative risks were estimated for 10-year mortality from CVD (199 deaths), CHD (90), stroke (47), and all causes (373) for tertiles of time spent on physical activity (reference, lowest tertile). Adjustments were made for baseline age, relevant major chronic diseases, cigarette smoking, and alcohol consumption.

Results: Mortality risks from CVD and all causes decreased with increasing physical activity (*P* for trend = .04) with adjusted relative risks of 0.70 (95% confidence interval, 0.48-1.01) and 0.77 (95% confidence interval, 0.59-1.00) in the highest tertile of total physical activity, respectively. Except for CHD, time spent in more intense activities (≥4 kcal/kg per hour) was more strongly associated with all mortality outcomes than less intense activities, but no single type of activity was particularly protective. Walking or cycling at least 3 times per week for 20 minutes (our definition of activity based on general health recommendations) was associated with reduced mortality from CVD (adjusted relative risk, 0.69; 95% confidence interval, 0.50-0.88) and all causes (relative risk, 0.71; 95% confidence interval, 0.58-0.88). Additional adjustment for biological cardiovascular risk factors did not affect the strength of any association.

Conclusion: In a general population of elderly men, physical activity may protect against mortality from CVDs and all causes.

Arch Intern Med. 1998;158:1499-1505

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IN DEVELOPED countries, 80% of all deaths from cardiovascular diseases (CVDs) occur in people aged 65 years and older.[1] Both coronary heart disease (CHD) and stroke are major causes of death and disability among the elderly. In middle-aged people, physical activity is inversely associated with CHD.[2,3] Decreased levels of physical activity may therefore be associated with increased cardiovascular risk in the elderly. However, in contrast to several consistent reports[4-9] about an inverse association between physical activity and all-cause mortality among elderly people, limited data are available for risk of specific diseases, such as CVDs.

In a survey among 1219 noninstitutionalized Spanish elderly, 5-year CVD mortality risk was significantly reduced among nonsedentary individuals (age-adjusted relative risk [RR], 0.64 for men and 0.44 for women).[9] The results of a sample of 285 elderly men and women from the Framingham Heart Study[10] also point to an inverse association between physical activity and CVD mortality risk. However, statistical significance was not reached possibly due to the limited number of events. With respect to CHD specifically, the reports are equivocal for the elderly in contrast to the vast amount of epidemiological literature[2,3] supporting an inverse association between physical activity and CHD among middle-aged people. Although the incidence of CHD among physically active elderly men in the Honolulu Heart Program study[11] was less than half compared with more sedentary men, no clear association was observed in the Established Populations for Epidemiologic Studies of the Elderly study.[8] Concerning stroke, the association with physical activity has not been extensively examined for any age group.[12] However, available data[13-15] suggest an inverse association with physical activity, particularly among people of advanced age.

SUBJECTS AND METHODS

STUDY POPULATION

The Zutphen Study is a longitudinal investigation of chronic disease risk factors initiated in 1960 among middle-aged men as the Dutch contribution to the study[16] conducted in 7 countries. In 1985, the 555 survivors of the original cohort were invited for new examinations. In addition, a random sample (2 of 3) of all men of the same age living in the town of Zutphen, the Netherlands, who were not a part of the original cohort was invited. A total of 1266 men, aged 64 to 84 years, were invited in 1985 and the study was continued as the Zutphen Elderly Study with follow-up examinations in 1990 and 1995. In the spring of 1985, 939 men (74%) participated, of whom 892 (95%) were noninstitutionalized. A total of 109 men (9%) could not be examined because of serious illness; 156 men (12%) refused to participate or could not be reached; and 62 men (5%) had moved.

The present analyses include the 802 men for whom complete information was available with respect to baseline physical activity, age, major chronic diseases, lifestyle factors (cigarette smoking, alcohol consumption, and saturated fat intake), potential intermediate factors (body mass index [BMI; calculated as weight in kilograms divided by the square of the height in meters], serum total and high-density lipoprotein [HDL] cholesterol levels, and systolic blood pressure), and mortality follow-up.

EXAMINATIONS

Data were collected according to a standardized protocol. Clinical examinations were conducted by trained medical staff at a local survey site. The participants completed the questionnaires at home, and trained research assistants checked the questionnaires for missing values and inconsistencies.

Physical activity was assessed with a questionnaire originally designed for retired men that was translated into Dutch and validated in a sample of the Zutphen Elderly Study population.[17,18] The questionnaire asked about the frequency and duration of walking and bicycling in the previous week; the average amount of time spent weekly on hobbies and gardening in both summer and winter; and the average amount of time spent monthly on odd jobs and sports. Time estimates were converted to minutes per week for each type of activity and summed to yield total physical activity.[19] Time spent on total physical activity was also fractionated into time spent on heavy-intensity physical activities requiring an energy expenditure of at least 4 kcal/kg per hour (eg, brisk walking, cycling at normal or high speed, and gardening) and nonheavy-intensity activities (<4 kcal/kg per hour).[17] Finally, the men were categorized as having a sedentary or an active lifestyle according to whether they were walking or bicycling at least 3 times per week for 20 minutes or more (our definition of activity based on the assumption that regular physical activity using large muscle groups is beneficial for maintaining health).[19,20]

Information about cigarette smoking was collected by a standardized questionnaire, and participants were categorized as smokers or nonsmokers. Information about intake of dietary saturated fat (percentage of energy intake) and alcohol consumption during the month preceding the interview was obtained by trained dietitians using the cross-check dietary history method during a home visit.[21] Alcohol consumption was categorized as 0 g/d, less than 20 g/d, and 20 g/d or more.

Height and body weight were measured with the men in underwear only. Body mass index was calculated. At the end of the physical examination, systolic blood pressure was measured twice using a random-zero sphygmomanometer on the right biceps of the men in a supine position. The mean value was used in data analyses. Nonfasting venous blood samples were used for cholesterol determinations, which were conducted in a standardized

To gain more insight into the association between physical activity and mortality among elderly people, we investigated physical activity and 10-year mortality risk from CVDs, in particular CHD and stroke, and all causes among a random sample of elderly Dutch men. To support physical activity recommendations, the effect of specific components of the physical activity pattern on mortality risk are described.

RESULTS

The study population (mean [± SD] age, 71.4 ± 5.2 years) spent a mean (± SD) of 85 ± 77 min/d on total physical activity. Baseline characteristics for the participants according to tertiles of total physical activity are presented in **Table 1**. Mean total time spent in physical activity was about 15 min/d, 1 h/d, and 3 h/d in the respective tertiles. Time spent on each type of activity was higher in the higher tertiles of total activity. Compared with the lowest tertile, men in the highest physical activity tertile were younger, consumed more alcohol, had higher levels of total and HDL cholesterol, and a smaller proportion of men had a history of diagnosed CHD, stroke, chronic nonspecific lung diseases, and diabetes mellitus. They did not significantly differ regarding the proportion of men with diagnosed cancer at baseline, current smokers, or with respect to the intake of saturated fat, BMI, or systolic blood pressure.

A total of 373 participants (46.5%) died between the surveys of 1985 and January 1995; 199 (53%) of the deaths were due to CVDs, 90 (24%) were due to CHD, and 47 (13%) were due to stroke. The primary cause of death was CVD (170 men), CHD (84 men), and stroke (36 men). Three men died of both CHD (all primary cause of death) and stroke.

Increased physical activity was associated with reduced CVD mortality (**Table 2**). The CVD mortality rate ranged from 47.6 per 1000 person-years for the lowest activity tertile to 22.7 per 1000 person-years for the highest activity tertile. After adjustment for age, CVDs, and the lifestyle factors, such as cigarette smoking and alcohol consumption, at baseline, men in the highest activity tertile had a 30% lower risk compared with men in the lowest activity tertile (*P* for trend = .04). Concerning the 2 main components of CVDs, CHD and stroke, crude inverse associations were also observed, but stalipid laboratory (Department of Human Nutrition, Agricultural University, Wageningen, the Netherlands). Serum cholesterol concentration was determined enzymatically (CHOD-PAP mono-test kit, Boehringer Mannheim, Mannheim, Germany).[22,23] High-density lipoproteins were isolated after precipitation of apolipoprotein B–containing particles using dextran sulfate-Mg^{2+}.[24]

BASELINE DISEASE AND MORTALITY

Information on a history of myocardial infarction, angina pectoris, and intermittent claudication was obtained during the medical examination using the Dutch translation of the questionnaire by Rose and Blackburn.[25] Information on a history of stroke, diabetes mellitus, chronic nonspecific lung diseases, and cancer was also obtained using a standardized medical questionnaire. Myocardial infarction was verified with information from electrocardiograms and levels of specific enzymes.[26]

Municipal registries provided information on the vital status of the participants until January 1995. Three men were unavailable for follow-up. Information on the causes of death was obtained from Statistics Netherlands, Voorburg, the Netherlands, between baseline assessment and June 1990 and from the subjects' general practitioner for deaths occurring thereafter. Coding the causes of death followed the *International Classification of Diseases, Ninth Revision (ICD-9)*[27] codes: CVD (402-444), CHD (410-414), cerebrovascular accidents (430-438; stroke), and all other causes of death (remaining *ICD-9* codes). Because the underlying cause of death in the elderly is often difficult to determine, both the primary and the secondary cause of death were considered in the analyses.

All diagnoses were verified with hospital discharge data and written information from the subject's general practitioner. All information was uniformly coded by 3 physicians.

STATISTICAL ANALYSES

A statistical analysis computer package was used for all analyses (version 6.11, SAS Institute Inc, Cary, NC). Two-sided *P* values less than .05 were considered statistically significant.

Differences in baseline characteristics across tertiles of physical activity were evaluated using analysis of variance for normally distributed variables, the Kruskal-Wallis test for variables with a skewed distribution, and an overall χ^2 test for categorical variables. Cox proportional hazards model was used to investigate the associations between physical activity variables and mortality. Relative risks, 95% confidence intervals (CIs), and *P* values for linear trend of mortality are presented according to minutes per week engaged in physical activity using the lowest tertile as the reference category. The observed Spearman rank correlation coefficients between time spent walking, cycling, gardening, and other activities ranged between 0.06 (walking and gardening) and 0.24 (gardening and other activities), which allowed the 4 types of activities to be simultaneously entered as dummy variables in the statistical models. This correlation coefficient also applied for heavy- and nonheavy-intensity activities ($r = 0.14$).

No interaction was observed between baseline disease and physical activity with respect to cardiovascular mortality end points ($P = .27$ [CVD]; $P = .66$ [CHD]; and $P = .48$ [stroke]). To preserve the power of the statistical analyses, we primarily adjusted for potential confounding by baseline disease through adding the history of relevant diseases to the multivariate models rather than excluding men with diseases from the mortality analyses. When examining all-cause mortality, we adjusted for CVDs, cancer, chronic nonspecific lung diseases, and diabetes mellitus.

The extent to which the observed mortality could be attributed to a sedentary lifestyle was calculated by means of the attributable risk of the adjusted population.[28]

tistical significance was not reached after adjustment for baseline age, disease, and lifestyle factors. For CHD, the lowest risk was observed in the middle activity tertile, but additional analyses showed that a quadratic model did not fit the data. An inverse trend ($P = .12$) was more clear for stroke with an adjusted RR of 0.55 (95% CI, 0.24-1.26) in the highest activity tertile.

Similar to CVD mortality, an inverse association was also observed between physical activity and all-cause mortality after adjustment for age, diseases, and lifestyle factors at baseline (Table 2). Men in the highest activity tertile experienced a 23% lower risk compared with men in the lowest activity tertile. Men in the more active tertiles also experienced a reduced adjusted non-CVD mortality risk, but statistical significance was not reached (Table 2).

Additional adjustments for BMI, total and HDL cholesterol levels, systolic blood pressure, and the use of antihypertensive medication did not affect the strength of any association studied (data not shown).

The risks for CVD and all-cause mortality were also investigated with respect to other components of the physical activity pattern. With few exceptions, an RR below 1 was observed in the highest tertiles of time spent on each of the major types of physical activity (walking, cycling, gardening, and other activities), but statistical significance was not reached (data not shown). However, when time spent on all activities was grouped according to intensity, clear inverse associations were observed between time spent on activities requiring at least 4 kcal/kg per hour and all mortality end points, except for CHD (**Table 3**). The inverse association with stroke mortality was notably pronounced with an adjusted RR of 0.35 (95% CI, 0.15-0.79) in the highest activity tertile. No clear associations between less intense activities and mortality were observed.

Finally, the men were categorized according to whether they were walking or bicycling at least 3 times per week for 20 minutes or more. The physically active men (66%) showed a significantly reduced mortality risk from CVDs and all causes compared with sedentary men (**Table 4**). Compared with stroke, a trend toward reduced risk was also observed for CHD mortality (RR, 0.69; 95% CI, 0.45-1.05). Based on this classification, it was estimated that 15% of the CVD mortality and 12% of the all-cause mortality could be attributed to a sedentary lifestyle.

Table 1. Baseline Characteristics of 802 Elderly Men by Tertiles of Physical Activity

Characteristics	Total (N = 802)	Total Leisure Physical Activity Tertile: Lowest (n = 258)	Middle (n = 279)	Highest (n = 265)	*P*
	Mean (SD)				
Physical activity, min/wk					
Total	598 (542)	122 (86)	448 (119)	1217 (488)	
Walking	133 (189)	44 (55)	134 (123)	219 (272)	<.01
Bicycling	128 (183)	30 (47)	122 (118)	230 (255)	<.01
Gardening	139 (254)	26 (40)	96 (107)	295 (379)	<.01
Odd jobs	104 (248)	13 (31)	58 (92)	240 (384)	<.01
Hobbies	80 (243)	4 (25)	30 (83)	205 (384)	<.01
Sports	14 (68)	5 (22)	8 (35)	29 (110)	<.01
Age, y	71.4 (5.2)	72.8 (5.4)	71.5 (5.2)	69.7 (4.6)	<.01
Body mass index, kg/m^2	25.5 (3.1)	25.5 (3.2)	25.4 (3.0)	25.5 (3.2)	.82
Total cholesterol level, mmol/L (mg/dL)	6.12 (1.11) (236 [42])	6.03 (1.15) (233 [44])	6.01 (1.08) (232 [41])	6.31 (1.09) (244 [42])	<.01
High-density lipoprotein cholesterol, mmol/L (mg/dL)	1.12 (0.29) (43 [11])	1.09 (0.30) (42 [11])	1.12 (0.29) (43 [11])	1.16 (0.29) (44 [11])	.01
Systolic blood pressure, mm Hg	150.8 (21.2)	151.9 (21.9)	151.0 (21.2)	149.6 (20.5)	.45
Alcohol intake, g/d	13.2 (17.0)	12.8 (18.3)	12.5 (16.0)	14.4 (16.9)	.02
Saturated fat intake, % of energy intake	17.2 (3.5)	17.4 (3.6)	17.1 (3.4)	17.2 (3.5)	.69
	% (No.)				
Sedentary	34.3 (275)	64.0 (165)	18.6 (52)	21.9 (58)	<.01
Current cigarette smoking	30.1 (241)	30.2 (78)	29.0 (81)	30.9 (82)	.89
Using antihypertensive drugs	11.9 (95)	13.2 (34)	11.8 (33)	10.6 (28)	.65
History of diagnosed					
Cardiovascular disease	30.5 (245)	42.6 (110)	28.0 (78)	21.5 (57)	<.01
Coronary heart disease	20.6 (165)	27.1 (70)	18.6 (52)	16.2 (43)	<.01
Myocardial infarction	14.2 (114)	17.4 (45)	13.3 (37)	12.1 (32)	.18
Angina pectoris	13.6 (109)	19.8 (51)	12.9 (36)	8.3 (22)	<.01
Stroke	4.9 (39)	9.3 (24)	4.3 (12)	1.1 (3)	<.01
Cancer	7.9 (63)	8.9 (23)	6.8 (19)	7.9 (21)	.66
Chronic nonspecific lung diseases	15.2 (122)	23.3 (60)	10.8 (30)	12.1 (32)	<.01
Diabetes mellitus	6.1 (49)	7.8 (20)	7.5 (21)	3.0 (8)	.04

COMMENT

Reported total time spent on physical activity was associated with reduced risk for CVD and all-cause mortality in a population-based cohort of elderly men. The observed associations were more pronounced for time spent in activities requiring at least 4 kcal/kg per hour than time spent in activities of lower intensity. This was most striking for stroke mortality, in which the risk was about 60% lower in the 2 highest tertiles of time spent in heavy activities. However, no single type of activity was particularly protective. When men were categorized according to whether they were walking or bicycling at least 3 times per week for 20 minutes or more (our definition of activity based on health recommendations for adults),[19,20] clearly reduced mortality risks were observed among the active men.

Generally, our results confirm previous reports about elderly people.[4-11,13-15] As in these studies, the observed inverse association with all-cause mortality is clear. Some of the results also point to an inverse association with CVD mortality, but the results are less clear regarding the specific CVD end points. If an association exists between physical activity and CHD, it appears from our study to be most notable for regularly walking or cycling for at least 20 minutes. The observed inverse association with time spent on heavy-intensity activities and stroke mortality also seems noteworthy, especially considering the limited number of stroke events in our study. Yet, these heavy-intensity activities did not necessarily include strenuous activities, which is illustrated by the fact that gardening and bicycling at normal speed according to the elderly were classified into this category. It cannot be excluded that mortality from other than CVDs also contributed to the inverse association with all-cause mortality, but the inverse association with total physical activity was statistically nonsignificant after adjustment for major confounders.

Past physical activity may have contributed to a history of disease, but the presence of disease may have caused decreased physical activity at baseline. The latter would mistakenly strengthen observed associations in the absence of a causal relationship. To overcome this bias, we statistically controlled for reported preexisting diseases after examining the interaction between baseline disease and physical activity with respect to CVD mortality outcomes. We repeated the analyses for CVD and all-cause mortality with additional adjustment for baseline subjective health. Because the associations were then somewhat weakened (RR in the highest activity tertile, 0.78 [CVD] and 0.85 [all cause]), we also repeated the analyses after excluding deaths within the first 2 years of observation to control for poten-

Table 2. Crude and Adjusted Relative Risks (RRs) of 10-year Mortality According to Tertiles of Physical Activity Among 802 Elderly Men (Aged 64-84 Years)*

	Tertile of Physical Activity			
	Lowest	Middle	Highest	
	No. of Deaths (Rate per 1000 Person-Years)			
CVD	83 (47.6)	67 (30.2)	49 (22.7)	
CHD	37 (21.2)	25 (11.3)	28 (13.0)	
Stroke	23 (13.2)	15 (6.8)	9 (4.2)	
All causes	153 (87.7)	121 (54.6)	99 (45.9)	
Non-CVD	70 (40.1)	54 (24.4)	50 (23.2)	
	RR (95% CI)			**P for Trend**
CVD mortality				
Crude	...	0.60 (0.45-0.85)	0.46 (0.32-0.65)	<.01
Age	...	0.67 (0.49-0.93)	0.57 (0.39-0.81)	<.01
Age and baseline CVD	...	0.74 (0.53-1.02)	0.67 (0.46-0.96)	.02
Age, baseline CVD, and lifestyle†	...	0.75 (0.54-1.04)	0.70 (0.48-1.01)	.04
CHD mortality				
Crude	...	0.52 (0.32-0.87)	0.60 (0.37-0.98)	.04
Age	...	0.56 (0.34-0.94)	0.72 (0.43-1.19)	.17
Age and baseline CHD	...	0.61 (0.37-1.02)	0.82 (0.49-1.37)	.39
Age, baseline CHD, and lifestyle†	...	0.63 (0.38-1.05)	0.85 (0.51-1.44)	.48
Stroke mortality				
Crude	...	0.50 (0.26-0.95)	0.30 (0.14-0.66)	<.01
Age	...	0.56 (0.29-1.07)	0.41 (0.18-0.89)	.02
Age and baseline stroke	...	0.65 (0.33-1.26)	0.53 (0.24-1.20)	.10
Age, baseline stroke, and lifestyle†	...	0.65 (0.33-1.25)	0.55 (0.24-1.26)	.12
All-cause mortality				
Crude	...	0.61 (0.48-0.77)	0.51 (0.39-0.65)	<.01
Age	...	0.67 (0.52-0.85)	0.64 (0.50-0.83)	<.01
Age and baseline diseases‡	...	0.78 (0.61-1.00)	0.74 (0.57-0.97)	.02
Age, baseline diseases, and lifestyle†	...	0.80 (0.63-1.02)	0.77 (0.59-1.00)	.04
Non-CVD mortality				
Crude	...	0.60 (0.42-0.85)	0.56 (0.39-0.81)	<.01
Age	...	0.66 (0.46-0.95)	0.74 (0.51-1.08)	.09
Age and baseline diseases‡	...	0.78 (0.54-1.12)	0.77 (0.52-1.12)	.15
Age, baseline diseases, and lifestyle†	...	0.80 (0.56-1.15)	0.79 (0.54-1.16)	.21

*CVD indicates cardiovascular disease; CHD, coronary heart disease; CI, confidence interval; and ellipses, 1.00.
†Lifestyle factors included cigarette smoking and alcohol consumption.
‡Baseline diseases included for mortality from all causes CVD, cancer, diabetes mellitus, and chronic nonspecific lung diseases; for non-CVD mortality, cancer, diabetes mellitus, and chronic nonspecific lung diseases.

tial effects of subclinical diseases. Similar results were then obtained (adjusted RR in the highest activity tertile, 0.70 [CVD]; 0.87 [CHD]; 0.58 [stroke]; and 0.78 [all cause]), indicating that residual confounding by health status was unlikely in our main analyses.

Apart from lower age and less disease at baseline, more physically active men might have had more favorable health behaviors that may account for the associations we noted. Therefore, we adjusted for lifestyle factors such as smoking status and alcohol consumption in the analyses. We investigated the effect of the intake of saturated fat as well, but the saturated fat consumption did not differ between activity tertiles. Adjusting for lifestyle factors affected the observed associations only marginally. We also examined the effect of confounding due to socioeconomic status, but this did not affect the strength of the observed associations (data not shown). Finally, we additionally adjusted for other variables that may have confounded or mediated the effect of physical activity, such as BMI, total and HDL cholesterol levels, systolic blood pressure, and the use of antihypertensive medication. This adjustment provides information about whether physical inactivity may be an independent risk factor for different end points and it also provides more insight as to the possible mechanism. However, with respect to public health purposes, adjusting for such intermediating factors may unnecessarily weaken associations of interest. Nevertheless, the effect of adding such factors was of limited importance to the observed strength of the associations (adjusted RR for the highest activity tertile, 0.70 [CVD]; 0.82 [CHD]; and 0.56 [stroke]). This limited impact is consistent with previously published cross-sectional findings regarding our cohort[17,19] and with reports by others,[13-15] for example with respect to stroke risk. This finding suggests that biological mechanisms other than an effect of physical activity on the established CVD risk factors are involved. For example, our results regarding stroke mortality are in line with the recently observed dose-response relationship between exercise intensity and hemostatic parameters, such as fibrinogen and factor VII, among elderly men and women in the Cardiovascular Health Study.[29]

Table 3. Relative Risks (RRs) of 10-year Mortality According to Tertile of Physical Activity of Heavy and Nonheavy Intensity Among 802 Elderly Men (Aged 64-84 Years)*

	Tertile of Physical Activity			
	Lowest	Middle	Highest	
	Mean (SD) Minutes per Week			
Heavy-intensity activities	8 (14)	132 (58)	600 (373)	
Nonheavy-intensity activities	39 (38)	215 (67)	790 (427)	
	RR (95% CI)			P for Trend
Heavy-intensity activities				
CVD	. . .	0.72 (0.52-1.01)	0.68 (0.47-0.98)	.03
CHD	. . .	0.87 (0.52-1.45)	1.01 (0.60-1.71)	.99
Stroke	. . .	0.40 (0.20-0.83)	0.35 (0.15-0.79)	<.01
All cause	. . .	0.82 (0.64-1.04)	0.65 (0.50-0.86)	<.01
Nonheavy-intensity activities				
CVD	. . .	0.67 (0.48-0.95)	0.79 (0.56-1.12)	.16
CHD	. . .	0.48 (0.28-0.83)	0.80 (0.49-1.30)	.33
Stroke	. . .	0.93 (0.48-1.82)	0.82 (0.38-1.76)	.62
All cause	. . .	0.86 (0.67-1.10)	0.93 (0.72-1.20)	.54

**Data are adjusted for age, disease (including cardiovascular diseases [CVDs], cancer, chronic nonspecific lung diseases, and diabetes mellitus for all-cause mortality), and lifestyle factors (cigarette smoking and alcohol consumption) at baseline and other subjects. Heavy-intensity activities use at least 4 kcal/kg per hour. Nonheavy-intensity activities are those activities that use less than 4 kcal/kg per hour. CI indicates confidence interval; CHD, coronary heart disease; and ellipses, 1.00.*

Table 4. Ten-year Mortality Risk for Elderly Men Who Are Sedentary Compared With Men Who Are Active*

	Men (N = 802)	
	Sedentary (n = 275)	Active (n = 527)
	No. of Deaths (Rate per 1000 Person-Years)	
CVD	83 (43.3)	116 (27.6)
CHD	38 (19.8)	52 (12.4)
Stroke	17 (8.9)	30 (7.1)
All causes	153 (79.8)	220 (52.3)
	RR (95% CI)	
CVD	. . .	0.66 (0.50-0.88)
CHD	. . .	0.69 (0.45-1.05)
Stroke	. . .	0.95 (0.52-1.74)
All causes	. . .	0.71 (0.58-0.88)

**Active men are those who walk or bicycle for 20 minutes at least 3 times per week. Sedentary men do not meet this criterion. Data are adjusted for age, disease (including cardiovascular diseases [CVDs], cancer, chronic nonspecific lung diseases, and diabetes mellitus for all-cause mortality), and lifestyle factors (cigarette smoking and alcohol consumption) at baseline. CHD indicates coronary heart disease; RR, relative risk; CI, confidence interval; and ellipses, 1.00.*

Several other potential biases and problems exist in any observational study of physical activity. Self-reported physical activity questionnaires are less precise than objective laboratory measures.[30] Few questionnaires have been confirmed to have acceptable reproducibility and validity, especially for use among elderly men or women.[31-34] Our results are based on a physical activity questionnaire specifically designed for elderly men that has good reproducibility (4-month test-retest correlation, 0.93), was validated against the doubly labeled water method ($r = 0.61$), and shows expected congruence with physiological indicators.[17-19,35] Another bias pertains to the common inability of a baseline measure of physical activity to reflect engaging in activity over time. On reaching retirement age, men more often engaged in certain types of physical activity in cross-sectional studies,[36-38] which invalidates the use of measures of preretirement physical activity for follow-up. Yet, at baseline our study population had generally reached retirement age.

The results indicate that guidelines[20] for maintaining health among adults, which we defined as walking or cycling for 20 minutes or more at least 3 times per week,[19] may also be applicable to elderly men with respect to mortality from CVDs and all causes. Presuming causal associations and practical feasibility, the attributable risks of the calculated population imply that a substantial amount of deaths due to CVDs (15%) and all causes (12%) during 10 years of follow-up may have been prevented among the elderly men when a sedentary lifestyle was changed to an active lifestyle. Reports[5-10,39] about physical activity and CVD and mortality risk among elderly women generally do not indicate that physical activity may be of less importance for elderly women. These reports suggest that our findings may also be extrapolated to elderly women.

In conclusion, the Zutphen Elderly Study is 1 of the few longitudinal studies that describes the impact of physical activity on specific risks of CVD and all-cause mortality among the elderly. Inverse associations were observed between total time spent in physical activity and both CVD and all-cause mortality during 10 years of follow-up. Although no single type of activity in particular showed a clear beneficial effect, time spent in more intense activities was generally more effective than time spent in less intense activities. Regularly walking or cycling for at least 20 minutes 3 times weekly was associated with reduced CVD and all-cause mortality risk. It was estimated that 15% of the deaths due to CVD and 12% of deaths due to all causes among the elderly men during 10 years of follow-up could have been avoided by a physically active lifestyle.

Accepted for publication December 18, 1997.

Supported by grant 92.356 from The Netherlands Heart Foundation, The Netherlands "Praeventiefonds," and The Netherlands Organization for Scientific Research, The Hague.

We are indebted to many people involved in this study, especially the fieldwork teams, the persons who coded the morbidity and mortality data, and the persons who critically reviewed the manuscript.

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