Risk Due to Inactivity in Physically Capable Older Adults

ABSTRACT

Objectives. This study examined the association between recreational physical activity among physically capable older adults and functional status, incidence of selected chronic conditions, and mortality over 3 and 6 years.

Methods. Data are from three sites of the Established Populations for Epidemiologic Studies of the Elderly.

Results. A high level of recreational physical activity reduced the likelihood of mortality over both 3 and 6 years. Moderate to high activity reduced the risk of physical impairments over 3 years; this effect diminishes after 6 years. A consistent relationship between activity and new myocardial infarction or stroke or the incidence of diabetes or angina was not found after 3 or 6 years.

Conclusions. Findings suggest that physical activity offers benefits to physically capable older adults, primarily in reducing the risk of functional decline and mortality. Future work must use more objective and quantifiable measures of activity and assess changes in activity levels over time. (*Am J Public Health.* 1993;83:1443–1450)

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Introduction

Several studies demonstrate the benefit of habitual physical activity for improved health, reduced incidence of coronary heart disease, and increased longevity in middle-aged men and women.[1–6] Comparable investigations relating habitual activity in older adults to morbidity and mortality are limited.[7–11] The few studies that include older adults do not exclude persons with disease or disabling conditions that restrict activity; thus, these studies do not permit evaluation of inactivity that is not a result of disease processes in predicting physical decline, chronic disease onset, acute events, and mortality. While some[8,10] control statistically for baseline health, many do not, and one study[10] measured activity as degree of slowing down rather than the actual level pursued. Only Mor et al.[11] excluded physically impaired persons in their study on the effect of an active life-style on the risk of physical decline.

Studies of older athletes indicate that continued physical training maintains lean body mass, bone density, muscle strength, and work capacity, among other dimensions of fitness,[12–15] and has a favorable association with cardiovascular disease risk factors such as glucose tolerance[16] and blood lipid levels.[12,17] Such studies, however, provide little insight regarding the effects of lower intensity activity on health and functioning in nonathletic persons.

Endurance and strength training studies of sedentary older adults demonstrate that regular exercise can improve work capacity, strength, and flexibility[18–20]; increase bone density[21,22]; lower blood pressure[23]; and improve glucose metabolism[24] and blood lipid levels.[18,25] A recent analysis[26] found a protective effect of stationary cycling on the development of cardiac arrhythmias. The training period in these studies is relatively short, ranging from 6 weeks to 12 months, and the training regimen is of an intensity rarely attained by even highly active older adults on a regular basis. Ample data demonstrate the fitness promoting and probable health benefits of vigorous exercise in older adults; the health benefits of more moderate activity, such as that routinely performed as part of an active life-style, are unknown.

Using data from three sites of the Established Populations for Epidemiologic Studies of the Elderly (EPESE), we examined the association between recreational physical activity among physically capable older adults and functional status, incidence of selected chronic conditions, and mortality over 3 and 6 years. We examined outcomes after 3 years to deter-

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TABLE 1—Interview and Physical Impairment Status: East Boston, New Haven, and Iowa, 1982

Site	Initial Sample Size	Total No. of Respondents	Status: Impaired	Status: Unimpaired	Status: Unknown[a]	Missing Data, No. of Respondents[b]	Study Sample Size
East Boston	4562	3809	1868	1897	44	23	1874
New Haven	3337	2812	1236	1500	76	12	1488
Iowa	4601	3673	1442	2115	116	300[c]	1815

Note. Impairment was defined as reporting an inability to do heavy work around the house, walk up and down a flight of stairs, or walk half a mile without help.
[a]Information was missing on one or more impairment items, with no reported inability on answered items.
[b]Nonresponse or "don't know" response to any physical activity item.
[c]Proxies were not asked the physical activity questions.

TABLE 2—Criteria Used to Designate Activity Levels among the Unimpaired Elderly: East Boston, New Haven, and Iowa, 1982

	No. Designated as Active[a]
East Boston	
Do vigorous exercise at least weekly[b]	314
Walk frequently	1006
Walk sometimes and do housework and garden frequently	52
None of the above	502
New Haven	
Play sports often[b]	103
Do physical exercise often[b]	283
Walk often	586
Play sports sometimes and walk sometimes	23
Play sports sometimes and do physical exercise sometimes	1
Walk sometimes and do physical exercise sometimes	76
Garden often and play sports or walk or do physical exercise sometimes	33
None of the above	383
Iowa	
Do vigorous exercise at least weekly[b]	286
Do moderate exercise at least weekly[b]	107
Walk at least several times per week	824
Walk weekly and garden at least several times per week and do housework at least several times per week	10
Walk weekly and do vigorous or moderate activity several times per month	1
None of the above	587

[a]After the first criterion, numbers given for subsequent criteria include only persons added to the active category.
[b]Used to distinguish highly active from moderately active.

mine the proximate risks associated with inactivity, particularly those related to physical functioning. We continued the follow-up for 6 years to observe differences in mortality, new myocardial infarction and stroke, and onset of diabetes and angina and to determine whether risks observed at 3 years were sustained.

Methods

Study Population

In 1980, the National Institute on Aging initiated the EPESE to prospectively evaluate social, behavioral, and environmental factors related to morbidity and mortality. Baseline data collection took place between 1982 and 1983 in East Boston, Mass; New Haven, Conn; and Iowa and Washington counties, Iowa. A fourth site, north-central North Carolina, added in 1986, did not assess physical activity; thus, this study uses data from the original three sites only.

After the baseline interview, each participant was recontacted annually and administered a brief telephone interview in years 1, 2, 4, and 5 and a more detailed, in-person interview in years 3 and 6. We assessed outcomes at 3 and 6 years following baseline, making use of the more detailed interviews. Information obtained from telephone contacts in the interim years contributed to the determination of mortality, myocardial infarction, stroke, and diabetes.

Sampling procedures have been described in detail elsewhere.[27] In East Boston and the two counties in Iowa, the samples constitute total community surveys of persons 65 years of age and older. The East Boston population consists largely of low- to middle-income, working class Whites of predominantly Italian descent. The Iowa population is composed primarily of Whites residing in rural areas. In New Haven, the study population was drawn from a random sample stratified by housing type (public and private housing for the elderly and general community housing). Men and those residing in public or private elderly housing were oversampled. Approximately 18% of this urban population is Black. Table 1 presents the initial sample sizes and the total numbers of respondents by site.

To examine the risk of inactivity in physically capable persons, we excluded subjects who reported at baseline that they were unable to do heavy work around the house, walk up and down a flight of stairs, or walk a half mile without help. Items measuring these physical capabilities were taken from the Rosow-Breslau functional health scale[28] and were selected because they tap the capabilities required to perform the activities assessed. Persons with insufficient information to determine impairment status were also excluded, as were persons missing data on activity items or responding "don't know" to any item (Table 1).

Measures

Physical activity. Measurement of physical activity varied by site, both in the number and scope of activities assessed and in categories of participation frequency. Table 2 lists the items used to measure activity by site and outlines the criteria used to categorize activity levels. Walking was the most common activity, with virtually all active participants doing some walking. Information on walking intensity and distance was not available; the range of activity among walkers was believed to be broad, with many having low levels of exercise. To distinguish a group with a high probability of getting adequate exercise, we divided the active group into high and moderate subgroups by placing all persons participating in vigorous exercise or active sports in the highly active category. Of the individuals in this group, 75% to 95% also reported frequent walking. While we may have misclassified some participants as a result of this scheme, we are confident that the average activity level in the highly active group is significantly greater than the average level in the moderately active group. Activity levels represent recreational and home maintenance activities only; information on work activity was not available.

Between 16% and 26% of the individuals from each site were classified as highly active, and between 26% and 32% were inactive (Table 3). Within each site, the proportion who were highly active varied greatly by age and sex; older women constituted the lowest proportion of highly active individuals. There was less variation by age in the proportion who were inactive.

Control measures. Several factors known or suspected to be related to both physical activity and health and functional status were examined at baseline, including self-rated health, education, work status, smoking status, depressive symptomatology, and chronic conditions.

For analyses, we created three categories of self-rated health: excellent, good, and fair or worse health. We assessed depressive symptomatology with a modified version of the Center for Epidemiologic Studies Depression scale[29] that consisted of 10 items, listed in the Appendix, and two response categories indicating the presence or absence of the symptom in the past week. Scores on this modified scale, which can range from 0 to 10 (a high score is indicative of high depressive symptomatology), correlated .88 with scores on the full scale.[30]

The prevalence of diabetes, angina, stroke, myocardial infarction, and respiratory symptoms was assessed. Diabetes was measured as lifetime prevalence by the following question: "Have you ever been told by a doctor (or other health professional) that you had diabetes, sugar in the urine, or high blood sugar?" Similarly phrased questions assessed histories of stroke and myocardial infarction. The London School of Hygiene questionnaire[31] was used to determine the presence of angina. An adaptation of the British Medical Council questionnaire was used to ascertain respiratory symptoms.[32]

Health outcomes. We examined mortality, myocardial infarction, stroke, diabetes, angina, and physical impairment. Deaths were ascertained at annual follow-ups and through continual surveillance of obituaries. Vital status was 100% complete in East Boston and Iowa and 99.87% complete in New Haven.

For survivors, new occurrences of myocardial infarction and stroke were obtained through self-report and, in some cases, proxy report at follow-up interviews. In the case of decedents, incidence of myocardial infarction and stroke was obtained from follow-ups in which they were still alive and from death certificates. Incidence of diabetes and angina was determined by self-report. The same question used to ascertain diabetes at baseline was repeated at each follow-up. The angina battery was repeated at the third and sixth follow-ups in East Boston and New Haven and the third follow-up only in Iowa. For both conditions, new cases involved persons who reported the condition at follow-up and who did not report the condition at baseline.

Impairment was assessed with the same items that had been used as exclusion criteria: inability to do heavy work around the house, walk up and down a flight of stairs, or walk a half mile without help.

TABLE 3—Physical Activity Levels of the Unimpaired Elderly: East Boston, New Haven, and Iowa, 1982

		Activity Level, %		
	No.	High	Moderate	Inactive
East Boston				
Male				
65–74 y	631	27.1	54.7	18.2
75 y or older	207	17.4	63.8	18.8
Total	838	24.7	56.9	18.4
Female				
65–74 y	802	11.9	55.2	32.9
75 y or older	234	5.1	59.0	35.9
Total	1036	10.3	56.1	33.6
Total	1874	16.8	56.5	26.8
New Haven				
Male				
65–74 y	456	28.7	51.5	19.7
75 y or older	246	29.3	46.8	24.0
Total	702	28.9	49.9	21.2
Female				
65–74 y	515	25.6	47.4	27.0
75 y or older	271	18.8	46.1	35.1
Total	786	23.3	47.0	29.8
Total	1488	25.9	48.3	25.7
Iowa				
Male				
65–74 y	495	31.5	38.6	29.9
75 y or older	229	20.1	43.2	36.7
Total	724	27.9	40.1	32.0
Female				
65–74 y	728	21.8	46.3	31.9
75 y or older	363	8.8	57.3	33.9
Total	1091	17.5	50.0	32.5
Total	1815	21.6	46.0	32.3

Note. Percentages across sites are not directly comparable because different items were used to determine activity levels.

Statistical Analysis

We computed sex- and age-adjusted percentages and means by the direct method for all baseline comparisons; the total sample available for analysis from each site served as the standard population. We conducted these analyses to account for the different age and sex distributions within activity categories and to preserve statistical power. For the longitudinal analyses, sex- and age-adjusted percentages were also computed. Odds ratios for experiencing a negative outcome were derived with logistic regression models including age, sex, education, work status, smoking, depressive symptomatology, self-rated health, respiratory symptoms, history of myocardial infarction and stroke, and diabetes and angina reported at baseline. The three-category physical activity measure was entered as two dummy variables representing high and moderate ac-

TABLE 4—Baseline Characteristics of Unimpaired Elderly Participants Who Were Highly and Moderately Active and Inactive, 1982

Site/Characteristic	Activity Level: High	Moderate	Inactive
East Boston			
Completed high school, %	37.2	29.2	25.9
Works full or part time, %	15.1	13.3	15.3
Smoking status, %			
Current smoker	14.0	22.3	26.3
Former smoker	35.2	29.2	28.4
Self-rated health, %			
Excellent	36.6	25.2	16.8
Fair or poor	16.0	21.6	30.6
Mean modified CESD score[a]	1.44	1.56	1.83
Diabetes, %	10.1	11.6	13.2
Angina,%	1.4	3.7	5.9
Respiratory symptoms,[b] %	12.8	20.0	28.5
Myocardial infarction, %	7.2	7.5	8.1
Stroke, %	2.7	1.4	2.9
New Haven			
Completed high school, %	51.8	32.0	36.8
Works full or part time, %	18.9	14.1	22.4
Smoking status, %			
Current smoker	13.7	18.8	23.9
Former smoker	32.7	27.0	33.3
Self-rated health, %			
Excellent	22.3	18.0	12.5
Fair or poor	17.1	26.9	33.2
Mean modified CESD score[a]	0.74	0.72	1.01
Diabetes, %	9.6	11.8	8.1
Angina, %	3.1	3.0	4.1
Respiratory symptoms,[b] %	17.4	18.6	29.1
Myocardial infarction, %	9.0	6.8	9.0
Stroke, %	3.2	3.4	3.2
Iowa			
Completed high school, %	66.7	52.3	46.9
Works full or part time, %	18.7	21.2	25.8
Smoking status, %			
Current smoker	5.7	8.5	11.5
Former smoker	23.2	21.2	17.9
Self-rated health, %			
Excellent	31.3	25.1	23.4
Fair or poor	12.2	16.6	16.8
Mean modified CESD score[a]	0.33	0.51	0.48
Diabetes, %	7.5	11.3	9.7
Angina, %	4.2	2.0	2.9
Respiratory symptoms,[b] %	18.5	20.3	22.4
Myocardial infarction, %	10.9	9.4	8.1
Stroke, %	3.9	4.9	3.0

Note. Age- and sex-adjusted percentages and means with sample weights were applied in New Haven. CESD = Center for Epidemiologic Studies Depression scale.
[a]Score on the CESD using 10 items, with presence of depressive symptom scored 1 and absence scored 0.
[b]Includes any of the following: chronic cough, phlegm, or wheezing or breathlessness.

tivity levels, with inactivity at baseline as the reference.

Results

Table 4 presents sex- and age-adjusted percentage distributions and means of the control measures and health status indicators by baseline activity level and site. At all three sites, those who were highly active were most likely to have completed high school and least likely to smoke. With the exception of those who were highly active having the lowest frequency of respiratory symptoms, disease conditions were not consistently associated with activity level. Yet, the highly active had better self-rated health and the lowest mean depression scores.

Outcomes after 3 Years

Table 5 presents health outcomes after 3 years by baseline activity level. For these and all subsequent analyses, comparisons involving mortality include all persons, comparisons of myocardial infarction and stroke include all persons except those lost to follow-up, comparisons involving impairment include interviewed survivors and those with proxy information, and comparisons of diabetes and angina include interviewed survivors at risk for the condition examined.

Individuals who were highly active had one half to two thirds the mortality after 3 years of those who were inactive. In Iowa, this difference attained statistical significance. Those who were moderately active experienced mortality similar to that of the inactive. While the participants who were highly active exhibited significantly lower rates and risk of angina in East Boston and stroke in Iowa, no consistent associations emerged between activity level and occurrence of myocardial infarction or stroke or onset of new chronic conditions. The data, however, reveal a strong association between inactivity and the development of physical impairment, particularly for walking a half mile. All odds ratios associated with the impairment measures were less than one for those participants who were most active. In addition, the data consistently show a graded response between activity level and impairment.

Outcomes after 6 Years

Table 6 presents outcomes after 6 years by baseline activity level. In all sites, participants who were highly active had significantly lower rates and about two thirds the risk of mortality of those who were inactive. Those who were highly active had significantly lower rates of myocardial infarction in East Boston and stroke in Iowa. In East Boston and New Haven, participants who were highly active showed lower rates and risk of angina and diabetes than did participants who were inactive.

Baseline activity and development of physical impairment showed a weaker relationship than that observed after 3 years. Only ability to walk a half mile had a strong and consistent association with activity, particularly in New Haven and Iowa, where a graded response was evident. Adjustment for baseline differences in demographic characteristics, smoking, and health status substantially diminishes the risk associated with inactivity; the only remaining differences in risk of mortality involved highly active participants in New Haven and Iowa.

We performed sex-stratified analyses using the fully adjusted logistic regression

TABLE 5—Health and Functional Outcomes of Highly and Moderately Active and Inactive Participants after 3 Years

Outcome	n	Activity Level, % High	Moderate	Inactive	n	Highly Active vs Inactive: Odds Ratio	95% Confidence Interval	Moderately Active vs Inactive: Odds Ratio	95% Confidence Interval
East Boston									
Mortality	1874	5.1	8.0	7.8	1809	0.77	0.40, 1.48	1.17	0.75, 1.82
Myocardial infarction	1753	4.5	5.4	5.6	1697	1.21	0.58, 2.51	1.23	0.70, 2.13
Stroke	1753	1.8	2.7	3.2	1697	0.58	0.17, 1.95	1.08	0.52, 2.27
Diabetes	1429[a]	3.1	4.1	4.3	1392	0.89	0.35, 2.28	1.05	0.55, 2.00
Angina	1543[a]	0.3**	2.5	4.0	1503	0.10	0.01, 0.80	0.65	0.32, 1.31
Walk a half mile	1586[b]	7.2***	9.0***	20.5	1543	0.34	0.18, 0.63	0.45	0.32, 0.64
Climb stairs	1603[b]	2.1**	3.5**	7.1	1560	0.28	0.10, 0.79	0.47	0.27, 0.82
Do heavy housework	1600[b]	16.8***	22.6*	28.0	1558	0.64	0.41, 1.00	0.88	0.66, 1.17
New Haven									
Mortality	1488	9.5	13.5	12.6	1437	0.77	0.46, 1.29	1.21	0.79, 1.84
Myocardial infarction	1400	4.6	5.1	3.7	1354	1.43	0.64, 3.19	1.55	0.78, 3.10
Stroke	1400	2.3	3.0	2.7	1354	1.06	0.38, 2.95	1.26	0.54, 2.92
Diabetes	1093[a]	1.8	3.3	2.4	1061	0.94	0.27, 3.25	1.52	0.57, 4.06
Angina	1131[a]	2.8	4.4*	1.6	1103	1.91	0.56, 6.53	3.52	1.16, 10.7
Walk a half mile	1171[b]	11.8***	14.7***	23.2	1135	0.48	0.30, 0.79	0.58	0.39, 0.86
Climb stairs	1201[b]	6.3**	8.0*	12.3	1163	0.50	0.27, 0.94	0.66	0.40, 1.09
Do heavy housework	1185[b]	18.7*	20.1	25.2	1148	0.75	0.49, 1.14	0.75	0.52, 1.07
Iowa									
Mortality	1815	2.8*	5.6	6.3	1768	0.45	0.22, 0.92	0.96	0.61, 1.52
Myocardial infarction	1763	3.9	4.7	4.4	1716	0.96	0.48, 1.89	1.04	0.60, 1.78
Stroke	1763	1.8	4.3	4.1	1716	0.22	0.08, 0.61	1.05	0.60, 1.84
Diabetes	1504[a]	3.9	1.9	3.6	1463	0.82	0.55, 1.83	0.44	0.20, 0.96
Angina	1562[a]	3.4	3.6	2.3	1519	1.84	0.76, 4.46	1.87	0.87, 3.99
Walk a half mile	1659[b]	8.5***	10.4***	16.4	1612	0.50	0.30, 0.83	0.56	0.40, 0.80
Climb stairs	1666[b]	1.9	2.6	3.5	1619	0.63	0.22, 1.81	0.75	0.38, 1.48
Do heavy housework	1667[b]	13.1*	17.4	18.9	1620	0.63	0.41, 0.97	0.91	0.67, 1.25

Note. Rates are sex- and age-adjusted. Odds ratios were derived from logistic regression models including age, sex, education, work status, smoking, respiratory symptoms, myocardial infarction, stroke, diabetes, angina, self-rated health, and modified depression score. Sample sizes differ for the rates and adjusted odds ratios because of missing data on variables in the multivariate analyses.
[a]No. of persons at risk.
[b]Percentage reporting any difficulty among survivors only.
*$P < .05$; **$P < .01$; ***$P < .001$ (compared with inactive participants).

models and found that the risk associated with inactivity was basically the same for men and women. In a few instances, when no association was present in one gender, the overall observed association masked a significant association in the other gender; however, none of these were consistent across sites.

Discussion

A high level of recreational physical activity characterized by performing vigorous exercise often or at least weekly and, in most cases, frequent walking appears to reduce the likelihood of mortality over both 3 and 6 years in physically capable older adults. Moderate to high activity appears to reduce the likelihood of developing limitations in physical functioning over 3 years, particularly in the areas of walking and doing heavy housework. The relationship between activity and functional decline diminished over time; the odds ratios increased toward one between 3 and 6 years. Differential mortality across activity groups did not completely explain this finding. Applying the criteria used at baseline to define impairment and including persons who died among the impaired, we reran the analyses. The odds ratios were still closer to one after 6 years. Another explanation is that those who were highly active became less active over the study period. Because we had limited information on activity at follow-up, we were not able to test this possibility.

A consistent relationship between high or moderate activity and new myocardial infarction or stroke or incident diabetes or angina was not found over 3 or 6 years. Several methodological problems related to these end points, however, may have limited our ability to identify more consistent relationships. Stroke, diabetes, and angina were rare events; thus, estimates of risk associated with inactivity were highly unstable. Reliance on self-report of outcomes may have led to undercounting of some conditions differentially across groups. For instance, those who are inactive may underreport angina because they exert themselves less than do those who are most active. In addition, because physical activity is often used to treat cardiovascular risk factors and conditions, some of the active participants may have been in poorer health than the inactive participants. For example, in Iowa, those who were highly active had the highest rate of previous myocardial infarction and may have initiated an exercise program as part of their cardiac rehabilitation. Therapeutic use of physical activity may explain why, in some cases, those who were moderately active seemed to have an increased risk of poor health

TABLE 6—Health and Functional Outcomes of Highly and Moderately Active and Inactive Participants after 6 Years

Outcome	n	Activity Level, %: High	Moderate	Inactive	n	Highly Active vs Inactive: Odds Ratio	95% Confidence Interval	Moderately Active vs Inactive: Odds Ratio	95% Confidence Interval
East Boston									
Mortality	1874	14.2*	18.1	21.0	1809	0.73	0.48, 1.11	0.85	0.63, 1.15
Myocardial infarction	1728	9.4*	10.9*	15.0	1667	0.69	0.42, 1.16	0.76	0.53, 1.09
Stroke	1728	5.3	6.4	4.7	1667	1.21	0.56, 2.61	1.73	0.98, 3.06
Diabetes	1234[a]	7.6	6.4	8.1	1199	1.11	0.53, 2.30	0.85	0.50, 1.45
Angina	1329[a]	1.7	2.3	2.6	1292	0.79	0.22, 2.89	1.02	0.41, 2.46
Walk a half mile	1387[b]	19.9*	20.6**	28.2	1326	0.82	0.51, 1.32	0.77	0.56, 1.06
Climb stairs	1376[b]	6.4	9.9	10.1	1335	0.65	0.31, 1.37	1.12	0.72, 1.74
Do heavy housework	1373[b]	27.0*	32.4	35.8	1332	0.82	0.53, 1.25	0.94	0.71, 1.26
New Haven									
Mortality	1488	19.1**	24.0	26.7	1437	0.66	0.45, 0.95	0.81	0.60, 1.11
Myocardial infarction	1387	9.2	9.7	10.9	1341	0.83	0.47, 1.46	1.23	0.78, 1.95
Stroke	1387	4.9	5.2	4.1	1341	1.05	0.52, 2.12	1.29	0.72, 2.32
Diabetes	906[a]	1.4	5.5	3.3	983	0.59	0.20, 1.77	1.54	0.68, 3.49
Angina	955[a]	0.4*	5.7	3.8	929	0.33	0.08, 1.32	1.71	0.72, 4.03
Walk a half mile	968[b]	24.3**	29.0*	37.9	942	0.63	0.40, 0.98	0.74	0.51, 1.08
Climb stairs	974[b]	11.9*	15.6	18.0	947	0.86	0.50, 1.45	0.97	0.62, 1.51
Do heavy housework	977[b]	27.5	30.0	28.3	950	0.87	0.56, 1.35	0.94	0.65, 1.38
Iowa									
Mortality	1815	9.1**	14.9	15.0	1768	0.59	0.37, 0.92	1.06	0.77, 1.46
Myocardial infarction	1725	8.7	9.9	7.1	1681	1.21	0.72, 2.04	1.41	0.93, 2.14
Stroke	1725	5.0*	7.9	8.6	1681	0.56	0.31, 1.03	0.97	0.64, 1.48
Diabetes	1348[a]	9.2*	4.5	5.5	1310	1.51	0.83, 2.75	0.76	0.42, 1.38
Walk a half mile	1471[b]	17.5*	20.5	23.4	1429	0.70	0.46, 1.05	0.82	0.60, 1.12
Climb stairs	1475[b]	7.3	6.9	6.4	1433	1.23	0.64, 2.35	1.07	0.64, 1.79
Do heavy housework	1477[b]	24.2	25.7	22.3	1435	1.15	0.78, 1.70	1.22	0.89, 1.66

Note. Rates are sex- and age-adjusted. Odds ratios were derived from logistic regression models including age, sex, education, work status, smoking, respiratory symptoms, myocardial infarction, stroke, diabetes, angina, self-rated health, and modified depression score. Sample sizes differ for the rates and adjusted odds ratios because of missing data on variables in the multivariate analyses.
[a]No. of persons at risk.
[b]Percentage reporting any difficulty among survivors only.
*$P < .05$; **$P < .01$; ***$P < .001$ (compared with inactive participants).

outcomes relative to those who were inactive.

Statistical adjustment of factors known or suspected to be related to activity level and health and functional status in the logistic regression analyses tended to reduce the association between activity and most outcomes, particularly after 6 years. Adjustments for group differences at baseline are common in longitudinal analyses; however, in instances in which the independent variable might affect some of these group differences, adjustment may be inappropriate and may obscure true associations. In this study, the inactive had more depressive symptomatology and lower self-rated health. Because physical activity has been found to influence the development of depressive symptomatology,[33,34] which in turn is associated with self-rated health,[35] controlling for these factors in the analyses may have erroneously reduced the observed associations between activity and health outcomes.

In Iowa, inactive participants were more likely to work. Because farming is a major occupation in Iowa, persons who were working may have been highly active even though they engaged in little recreational activity. To examine this possibility, we reassigned the 36 persons who reported farm work and who had moderate or no recreational activity to the group of highly active participants. Because poor outcomes were rare in these farmers, the revised analyses did not greatly alter the original findings. Rates of poor outcome in highly active individuals decreased marginally, and the significantly higher rate of diabetes in these individuals after 6 years became insignificant.

The relationship between activity and physical impairment in older adults has not been widely examined. Mor et al.[11] found that healthy elderly people 70 to 74 years of age who were inactive experienced 1.5 times the rate of disability over 2 years of persons who reported regular exercise or walked 1 mile. Our findings are comparable with a more physically capable population, a broader age range, and longer follow-up. Branch[36] found that reported slowing down of activity among nondisabled persons 65 years of age and older predicted incident disability over 15 months. Our results support these findings with a measure of physical activity less confounded with the measurement of disability than that available to Branch.[36]

Previous longitudinal studies of physical activity and mortality that have included sufficient numbers of adults over 65 years of age have examined the relationship in persons younger on average when they entered the study and followed them for a longer period. Kaplan and others[8] followed persons 60 to 94 years of age for 17 years and found an increased relative risk of mortality of 1.38 for inactivity in both the young-old and the old-old, which compares favorably with our findings. Over 26 years, Lindsted et al.[37] found only a small risk associated with inactivity on mortality in Seventh-Day Adventist men 65 to 75 years of age. The activity, however, was largely work related and unlikely to have been pursued much beyond baseline.

Similarly, little comparable research has examined the risk of inactivity in older adults for cardiovascular disease. Donahue and colleagues[7] found that the rate of cardiovascular events over 12 years in active men 65 to 69 years of age was less than half that in inactive men. While we did not obtain a similar result, Donahue et al.[7] had a younger population, longer follow-up, more rigorous measure of activity, and more complete and objective ascertainment of coronary events. Studies with stronger designs generally show larger benefits associated with physical activity.[1] Posner et al.[26] found a lower occurrence and delayed onset of cardiovascular diagnoses in elderly participants in an exercise program vs nonexercising controls over 2 years; however, the major difference occurred in the development of arrhythmias. No differences were observed in rates of myocardial infarction or angina.

While we would like to conclude that this study provides evidence supporting the "use it or lose it" axiom, at least over 3 years, we must consider alternative explanations. Persons who reported that they were capable of walking a half mile without difficulty but who rarely walked may have been more likely to overestimate their capacity at baseline than persons who walked regularly. We also cannot be certain that inactivity did not result from an underlying condition that was not yet disabling (as defined and measured here) but nevertheless caused subjects to limit their activity. Higher rates of respiratory symptoms reported by inactive participants support this interpretation. On the other hand, national surveys of younger adults indicate that a sizable proportion are physically inactive despite low rates of chronic conditions. Given this evidence and the strict exclusion criteria used in this study, it seems reasonable to assume that the majority of those who were inactive were habitually sedentary by choice and not because of poor health.

Several aspects of the measurement of activity may have limited our ability to demonstrate a relationship between activity and morbidity. The assessment of activity level was highly subjective because quantitative measures of frequency, duration, and intensity were not available. Thus, the distinction between high and moderate activity had to be somewhat arbitrary. For instance, someone who walked a brisk 2 miles five times per week would be classified as moderately active, whereas someone who played doubles tennis 1 hour per week would be classified as highly active. We could not assess the duration participants had been active or inactive, nor could we assess the consistency of activity over follow-up. Clearly, persons who developed acute illness or who became disabled during the study reduced their baseline activity level, and persons who may have been recovering from an acute illness at baseline may have increased their activity.

In conclusion, our findings suggest that continued physical activity offers benefits to physically capable older adults, primarily in reducing the risk of physical impairment and mortality. More vigorous activity offers greater protection from impairment and mortality than does moderate activity. This is not to suggest that only fitness promoting levels of exercise are required to achieve benefits; in this study, highly active individuals, although more active than their peers, were pursuing activities well within the scope of a moderately active life-style. The gradient of effect for activity level for the functioning outcomes after 3 years and mortality after 6 years provides further evidence of a true association. Future work in this area must use more objective and quantifiable measures of activity and assess changes in activity levels over time. □

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References

1. Berlin JA, Colditz GA. A meta-analysis of physical activity in the prevention of coronary heart disease. *Am J Epidemiol.* 1990; 132:612–628.
2. Siscovick DS, LaPorte RE, Newman JM. The disease-specific benefits and risks of physical activity and exercise. *Public Health Rep.* 1985;100:180–188.
3. Paffenbarger RS, Hyde RT, Wing AL, et al. Physical activity, all-cause mortality, and longevity of college alumni. *N Engl J Med.* 1986;314:605–613.
4. Powell KE, Caspersen CJ, Koplan JP, Ford ES. Physical activity and chronic diseases. *Am J Clin Nutr.* 1989;49:999–1006.
5. Pekkanen J, Marti B, Nissinen A, Tuomilehto J, Punsar S, Karvonen MJ. Reduction of premature mortality by high physical activity: a 20-year follow-up of middle-aged Finnish men. *Lancet.* 1987;i:1473–1477.
6. Powell KE, Thompson PD, Caspersen CJ, Kendrick JS. Physical activity and the incidence of coronary heart disease. *Annu Rev Public Health.* 1987;8:253–287.
7. Donahue RP, Abbott RD, Reed DM, Yano K. Physical activity and coronary heart disease in middle-aged and elderly men: The Honolulu Heart Program. *Am J Public Health.* 1988;78:683–685.
8. Kaplan GA, Seeman TE, Cohen RD, Knudsen LP, Guralnik J. Mortality among the elderly in the Alameda County Study: behavioral and demographic risk factors. *Am J Public Health.* 1987;77:307–312.
9. Palmore E. Health practices and illness among the aged. *Gerontologist.* 1970;10: 313–316.
10. Branch LG, Jette AM. Personal health practices and mortality among the elderly. *Am J Public Health.* 1984;74:1126–1129.
11. Mor V, Murphy J, Masterson-Allen S, et al. Risk of functional decline among well elders. *J Clin Epidemiol.* 1989;42:895–904.
12. Goldberg AP, Hagberg JM. Physical exercise in the elderly. In: Schneider EL, Rowe JW, eds. *Handbook of the Biology of Aging.* 3rd ed. San Diego, Calif: Academic Press; 1990:407–428.
13. Heath GW, Hagberg JM, Ehsani AA, Holloszy JO. A physiological comparison of young and older endurance athletes. *J Appl Physiol.* 1981;51:634–640.
14. Pollock ML, Foster C, Knapp D, Rod JL, Schmidt DH. Effect of age and training on aerobic capacity and body composition of master athletes. *J Appl Physiol.* 1987;62: 725–731.
15. Lane NE, Bloch DA, Jones HH, Marshall WH, Wood PD, Fries JF. Long-distance running, bone density, and osteoarthritis. *JAMA.* 1986;255:1147–1151.
16. Seals DR, Hagberg JM, Allen WK, et al. Glucose tolerance in young and older athletes and sedentary men. *J Appl Physiol.* 1984;56:1521–1525.
17. Seals DR, Allen WK, Hurley BF, Dalsky GP, Ehsani AA, Hagberg JM. Elevated high-density lipoprotein cholesterol levels in older endurance athletes. *Am J Cardiol.* 1984;54:390–393.
18. Blumenthal JA, Emery CF, Madden DJ, et al. Cardiovascular and behavioral effects of aerobic exercise training in healthy older men and women. *J Gerontol.* 1989;44:M-147–M157.
19. Buskirk ER. Health maintenance and longevity: exercise. In: Finch CE, Schneider EL, eds. *Handbook of the Biology of Aging.* 2nd ed. New York, NY: Van Nostrand Reinhold; 1985:894–931.
20. Frontera WR, Meredith CN, O'Reilly KP, Evans WJ. Strength training determinants of VO_2MAX in older men. *J Appl Physiol.* 1990;68:329–333.
21. Smith EL, Reddan W, Smith PE. Physical activity and calcium modalities for bone mineral increase in aged women. *Med Sci Sports Exerc.* 1981;13:60–64.
22. Chow R, Harrison JE, Notarius C. Effect of two randomised exercise programmes on bone mass of healthy post-menopausal women. *Br Med J.* 1987;295:1141–1144.

23. Tipton CM. Exercise, training and hypertension. *Exerc Sport Sci Rev.* 1984;12:245–306.
24. Holloszy JO, Schultz J, Kusnierkiewicz J, Hagberg JM, Ehsani AA. Effects of exercise on glucose tolerance and insulin resistance. *Acta Med Scand.* 1986;711(suppl): 55–65.
25. Seals DR, Hagberg JM, Hurley BF, Ehsani AA, Holloszy JO. Effects of endurance training on glucose tolerance and plasma lipid levels in older men and women. *JAMA.* 1984;252:645–649.
26. Posner JD, Gorman KM, Gitlin LN, et al. Effects of exercise training in the elderly on the occurrence and time to onset of cardiovascular diagnoses. *J Am Geriatr Soc.* 1990;38:205–210.
27. Cornoni-Huntley J, Brock DB, Ostfeld AM, Taylor JO, Wallace RB. *Established Populations for Epidemiologic Studies of the Elderly: Resource Data Book. 1986.* Washington, DC: US Dept of Health and Human Services; 1986. NIH publication 86-2443.
28. Rosow I, Breslau N. A Guttman health scale for the aged. *J Gerontol.* 1966;21:556–559.
29. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977;1: 385–401.
30. Kohout FJ, Berkman LF, Evans DA, Cornoni-Huntley J. Two shorter forms of the CES-D depressive symptoms index. *J Aging Health.* 1993;5:179–193.
31. Rose GA. The diagnosis of ischaemic heart pain and intermittent claudication in field surveys. *Bull WHO.* 1962;27:645–658.
32. Medical Research Council Committee on the Aetiology of Chronic Bronchitis. Standardized questionnaire on respiratory symptoms. *Br Med J.* 1960;2:1665.
33. Camacho TC, Roberts RE, Lazarus NB, Kaplan GA, Cohen RD. Physical activity and depression: evidence from the Alameda County study. *Am J Epidemiol.* 1991;34:220–231.
34. Farmer ME, Locke BZ, Moscicki EK, Dannenberg AL, Larson DB, Radloff LS. Physical activity and depressive symptoms: The NHANES I Epidemiologic Follow-up Study. *Am J Epidemiol.* 1988;128: 1340–1351.
35. Maddox GL. Some correlates of differences in self-assessment of health status among the elderly. *J Gerontol.* 1962;17: 180–185.
36. Branch LG. Health practices and incident disability among the elderly. *Am J Public Health.* 1985;75:1436–1439.
37. Lindsted KD, Tonstad S, Kuzma JW. Self-report of physical activity and patterns of mortality in Seventh-Day Adventist men. *J Clin Epidemiol.* 1991;44:355–364.

APPENDIX—The 10 Items of the Modified Center for Epidemiologic Studies Depression Scale

I felt depressed.
I felt everything I did was an effort.
My sleep was restless.
I was happy.
I felt lonely.
People were unfriendly.
I enjoyed life.
I felt sad.
I felt that people disliked me.
I could not get going.