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Authors

LaCroix, AZ
Guralnik, JM
Berkman, LF
et al.

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Maintaining Mobility in Late Life

II. Smoking, Alcohol Consumption, Physical Activity, and Body Mass Index

Andrea Z. LaCroix,[1] Jack M. Guralnik,[2] Lisa F. Berkman,[3] Robert B. Wallace,[4] and Suzanne Satterfield[5]

While positive health behaviors have been shown to extend life, their association with extending active life has not been well investigated. In this report, several health behaviors were investigated in relation to maintaining mobility during 4 years of follow-up among 6,981 men and women aged 65 years and older with intact mobility at baseline between 1981 and 1983 who lived in one of three communities: East Boston, Massachusetts; Iowa and Washington counties, Iowa; and New Haven, Connecticut. Intact mobility, defined as the ability to climb up and down stairs and walk a half mile, was determined annually by interview, and study subjects were classified into one of three categories at the end of 4 years of follow-up: 1) maintained mobility (55.1%); 2) lost mobility (36.2%); or 3) died without evidence of having lost mobility prior to death (8.7%). After adjustment for age and all of the health behaviors, risk of losing mobility was significantly associated with current smoking, not consuming alcohol compared with small-to-moderate amounts of alcohol consumption, high (>80th percentile) compared with moderate (21–80th percentiles) body mass index, and low physical activity levels in both men and women. These findings suggest that positive health behaviors can not only extend longevity but also reduce the risk of losing mobility and independence in later life. *Am J Epidemiol* 1993;137:858–69.

activities of daily living; aged; alcohol drinking; body mass index; exercise; handicapped; prospective studies; smoking

The expansion of the nation's older population in an era of limited resources for health care has appropriately focused attention on maximizing and preserving the health status of older adults. Traditionally, efforts have been focused on developing improved methods for the prevention and treatment of the conditions most responsible for death with the goal of extending years of life. However, in recognition of the pivotal role that declining functional status plays in maintaining independence, the national health objectives for the year 2000 now target increasing years of healthy life and reducing the proportion of older adults with limitations in activities of daily living (1).

The relation of health behaviors to total and cause-specific mortality has been the focus of epidemiologic studies for several decades. Such studies have shown a clear association between cigarette smoking and excessive alcohol consumption with prema-

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Abbreviation: CI, confidence interval

[1] Center for Health Studies, Group Health Cooperative of Puget Sound and Department of Epidemiology, University of Washington, Seattle, WA

[2] Epidemiology, Demography, and Biometry Program, National Institute on Aging, Bethesda, MD.

[3] Department of Epidemiology, Yale University School of Medicine, New Haven, CT

[4] Department of Preventive Medicine and Environmental Health, University of Iowa, Iowa City, IA.

[5] Channing Laboratory, Department of Medicine, Harvard Medical School, and the East Boston Neighborhood Health Center, Boston, MA.

Reprint requests to Dr. Andrea Z. LaCroix, Center for Health Studies, Group Health Cooperative of Puget Sound, 1730 Minor Avenue, Suite 1600, Seattle, WA 98101–1448.

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ture death. Less consistent associations between extremes of body weight and physical inactivity have been demonstrated. Although the relations of health behaviors to mortality and disease incidence have been less well studied in older adults, the available evidence suggests that these risk factors have the same direction of association in later life as in middle age (2). While positive health behaviors have been shown to extend life, their ability to extend active life has not been well investigated. Nevertheless, some have postulated that the modification of risky health behaviors can result in successful aging (3) and compression of morbidity (4), in which the onset of disease and disability is delayed or prevented altogether.

In this report, we investigate whether several health behaviors, including smoking, alcohol consumption, overweight and underweight, and physical activity, are related to maintaining mobility during a 4-year prospective study of nearly 7,000 older adults residing in three communities.

MATERIALS AND METHODS

The study populations and data collection procedures at baseline and during 4 years of follow-up are presented in the accompanying paper (5). Briefly, the data in this report come from three communities of the Established Populations for Epidemiologic Studies of the Elderly. Community-dwelling men and women aged 65 years and older were enumerated and interviewed between 1981 and 1983 in East Boston, Massachusetts; New Haven, Connecticut; and Iowa and Washington counties in rural Iowa. Mobility status at baseline was classified as intact for those who reported the ability to walk a half mile and walk up and down stairs without help. Mobility status was classified as impaired for those who reported the inability to do one or both of these activities at baseline. During 4 years of follow-up, interviews were conducted annually to ascertain current mobility status using the same criteria. The study populations for this report were limited to 6,981 subjects with intact mobility at baseline (96.6 percent of all those with intact mobility at baseline) who provided sufficient follow-up information to be classified at the end of 4 years as having: 1) maintained mobility (55.1 percent); 2) lost mobility (36.2 percent); or 3) died without evidence of having lost mobility prior to death (8.7 percent). As described in the paper by Guralnik et al. (5), the utility of this mobility classification as an epidemiologic endpoint in the Established Populations for Epidemiologic Studies of the Elderly is supported by its strong associations at baseline with dependence in activities of daily living and the presence of multiple chronic conditions. Further details regarding the classification of mobility status are also described in this accompanying paper (5).

Risk factors for maintaining mobility

Smoking status was classified as current, former, or never using two questions from the initial interview: "Do you smoke cigarettes regularly now?" and "Did you ever smoke cigarettes regularly?" Alcohol intake was ascertained from a series of questions concerning frequency and quantity of drinking beer, wine, or liquor during the previous month. An estimate of average daily intake of alcohol in ounces per day was derived from this information, using the Framingham classification (6). For the purposes of this report, alcohol consumption was classified as none in the past month, 1 ounce (28.35 g) or less per day, or more than 1 ounce per day. Physical activity was measured using three items concerning the frequency of taking walks, gardening, and doing vigorous exercise. For each activity, subjects were classified into three categories: frequently (three or more times per week), sometimes (weekly or several times per month), and rarely or never. For the multivariate analysis, a composite indicator of physical activity was created by summing the frequency of walking, gardening, and vigorous exercise. For this measure, a value of three was assigned when the activity was performed frequently, two when the activity was performed sometimes, and one when the activity was performed rarely or never.

The score on the summed scale was divided by three so that the scale ranged from one to three, and relative risks were calculated comparing a high level of physical activity with a low level (score, three vs. one). Body mass index was calculated from self-reported height and weight as weight (kg)/height $(m)^2$. Subjects were categorized into sex-specific quintiles of body mass index; those in the lowest and the highest quintiles were compared with subjects in the middle three quintiles. Demographic characteristics and history of chronic conditions at baseline were ascertained during the baseline interview and classified using the same criteria as described previously.

Information from blood, saliva, or other physical or laboratory examinations was not available to investigate the accuracy of the self-reported risk factors. However, the predictive validity of these measures is supported by previous studies of the Established Populations for Epidemiologic Studies of the Elderly, in which smoking history and current alcohol consumption have shown the expected associations with risks of total and cause-specific mortality (7, 8). In addition, body mass index in these populations was shown to be strongly and inversely associated with risk of hip fracture, as expected (9).

Statistical methods

Prevalence rates for each life-style risk factor were examined by sex and age group. Many of the health behaviors varied markedly between men and women; therefore, all subsequent analyses were conducted for men and women separately. Age-adjusted rates of maintaining mobility were calculated for categories of each life-style risk factor by using analysis of covariance techniques in conjunction with logistic regression models (10). Rates were adjusted to the age distribution of the three study populations combined. The independent association of each risk factor with loss of mobility was evaluated by using proportional hazards regression models adjusted for age and all of the other risk factors simultaneously. In these models, time to loss of mobility was the outcome under investigation, and survival time for each study subject was calculated as the time between the initial interview and loss of mobility, death, or the end of follow-up, whichever came first. All analyses were first conducted separately for each community cohort. In the presence of consistent associations between risk factors and loss of mobility, an overall estimate of risk was calculated stratified (or blocked) by community (11). Relative risks and corresponding 95 percent confidence intervals were calculated from these models.

Life-style risk factors may exert an independent effect on mobility status or an effect on mobility that operates through their effects on risk of major chronic conditions. Likewise, the occurrence of major chronic conditions can influence levels of behavioral risk factors. Several analytic approaches were used to determine whether the life-style risk factors had the same association with loss of mobility in persons with and those without prevalent and incident chronic conditions. First, multivariate Cox proportional hazards models were used to adjust for the number of chronic conditions present at baseline (up to eight conditions found to be associated with loss of mobility in the accompanying paper). Second, proportional hazards regression models adjusted for age and all of the life-style risk factors were examined separately for those with no conditions present at baseline and those with one or more condition present at baseline. Finally, indicator variables for the occurrence of a new chronic disease event (heart attack, stroke, hip fracture, cancer, and diabetes) were added individually to models adjusted for age and all life-style risk factors.

RESULTS

The prevalence at baseline of current smoking was lower among women than among men and lower among older (age 75 years or more) than among younger (65–74 years) subjects in each community (table 1). A higher proportion of women than of men had never smoked, and men were more

TABLE 1. Prevalence of behavioral risk factors by age and sex, Established Populations for Epidemiologic Studies of the Elderly cohorts, 1981–1983

Risk factors	Age (years)											
	East Boston, MA				Iowa				New Haven, CT			
	Men		Women		Men		Women		Men		Women	
	65–74 (*n* = 743)	≥75 (*n* = 334)	65–74 (*n* = 1,011)	≥75 (*n* = 396)	65–74 (*n* = 697)	≥75 (*n* = 388)	65–74 (*n* = 932)	≥75 (*n* = 612)	65–74 (*n* = 540)	≥75 (*n* = 344)	65–74 (*n* = 601)	≥75 (*n* = 383)
Smoking (%)												
Never	27.6	33.2	59.7	78.0	39.2	51.0	83.2	93.1	29.6	36.6	58.3	75.2
Former	44.6	52.1	17.3	13.4	45.4	39.1	8.3	4.9	42.2	48.3	20.2	14.1
Current	27.9	14.7	22.9	8.6	15.4	9.8	8.5	2.0	28.1	15.1	21.5	10.7
Alcohol (ounces/day)* (%)												
None	28.9	31.2	45.9	52.4	47.3	65.9	69.3	84.9	34.2	35.6	52.0	60.8
≤1.0	45.0	45.5	50.0	43.5	37.0	28.4	28.5	13.5	43.1	45.5	42.8	35.8
>1.0	26.1	23.3	4.1	4.1	15.7	5.6	2.1	1.6	22.7	19.0	5.2	3.4
Walking (%)												
Frequently	73.2	71.6	59.7	50.6	61.3	57.4	60.6	64.5	61.2	59.1	53.7	48.3
Sometimes	17.9	15.1	27.3	30.0	8.5	9.9	10.4	8.6	26.0	27.1	30.1	34.5
Never	8.9	13.3	13.0	19.3	30.3	32.7	29.0	26.8	12.8	13.8	16.1	17.2
Gardening (%)												
Frequently	33.4	23.8	17.7	12.8	67.3	58.5	64.0	49.9	24.1	17.4	13.0	7.2
Sometimes	15.8	16.6	13.9	8.4	21.7	22.2	16.7	13.9	12.8	9.7	10.5	10.3
Never	50.8	59.6	68.4	78.8	11.0	19.4	19.3	36.2	63.2	72.9	76.5	82.5
Vigorous exercise (%)												
Frequently	16.0	7.2	5.4	2.0	15.7	8.6	15.5	6.4	20.9	23.5	22.0	18.6
Sometimes	7.8	6.0	5.0	3.0	5.8	2.5	2.9	1.5	19.1	11.8	20.6	21.8
Never	76.2	86.8	89.5	94.9	78.5	88.9	81.6	92.1	60.0	64.7	57.4	59.7
Body mass index (kg/m^2) (percentile)												
20th	23.5	22.5	22.9	21.9	23.2	21.9	21.9	20.1	22.9	22.2	21.8	20.8
80th	29.6	28.7	30.9	29.5	28.7	27.1	28.7	25.8	28.3	27.5	30.1	27.6
Mean	26.8	25.7	27.0	25.9	26.0	24.6	25.5	23.3	25.9	25.1	26.1	24.5

* 1 ounce = 28.35 g.

likely to have stopped smoking than were women. Similarly, alcohol consumption in the previous month was more common among men than among women, and a greater quantity of alcohol was consumed by men than by women drinkers. Both alcohol consumption and current smoking were less common in Iowa than in the East Boston or New Haven cohorts. Of the three physical activities examined, walking was the most commonly reported frequent activity in both sexes and in all three communities, while vigorous activity was the least commonly reported frequent activity. For all three activities, those aged 75 years and older were more likely to report never doing the activity and less likely to report frequently engaging in the activity than were those aged 65–74. The distribution of body mass index was similar in men and women, and mean body mass index was somewhat lower in those aged 75 years and older than in those aged 65–74.

Age-adjusted rates of maintaining mobility according to categories of each behavioral risk factor are shown in table 2. Rates were highest among never smokers, lowest among current smokers, and intermediate among former smokers in each community and for both sexes. The differences between age-adjusted rates of maintaining mobility in current and never smokers were statistically significant in five of the six community-sex groups. The differences between age-adjusted rates of maintaining mobility in former and never smokers were statistically significant in three of the six community-sex groups. Age-adjusted rates of maintaining mobility were highest in moderate alcohol drinkers (e.g., those who drank 1 ounce

TABLE 2. Age-adjusted percentage remaining mobile over 4 years according to behavioral risk factors at baseline, Established Populations for Epidemiologic Studies of the Elderly cohorts (n = 6,981), 1981–1987

Risk factors	East Boston, MA		Iowa		New Haven, CT	
	Men	Women	Men	Women	Men	Women
Smoking						
Never†	62.4	56.8	68.1	63.8	52.9	45.1
Former	55.8*	50.9*	61.9*	58.1	46.0	39.2
Current	46.0*	48.4	52.4*	55.6*	36.4*	36.8*
Alcohol consumption (ounces/day)‡						
None	52.7*	49.7*	63.1	61.6*	43.0	38.3*
≤1†	58.2	59.2	68.2	70.1	48.7	47.6
>1	54.0	56.5	64.3*	67.8	44.4	44.9
Walking						
Frequently	57.4*	58.8*	67.9	68.6*	48.7	47.3*
Sometimes	50.8*	50.3*	61.8	60.8	42.0	38.8
Never†	48.6	45.0	59.7	55.6	39.9	33.8
Gardening						
Frequently	62.9*	64.5*	67.2*	68.0*	55.0*	53.5*
Sometimes	60.2*	61.7*	64.7	65.3	52.1*	50.5*
Never†	49.7	51.1	54.5	55.0	41.5	39.7
Vigorous exercise						
Frequently	64.8*	62.4*	73.5	71.0*	53.9*	47.5
Sometimes	59.6*	63.0	69.0	71.5	48.4	48.1*
Never†	53.5	53.6	63.5	63.0	42.1	38.5
Body mass index (kg/m^2) (percentile)						
≤20th	51.4	57.2	60.6	64.6	41.9	44.5
21–80th†	57.2	57.8	66.0	65.2	47.7	45.0
>80th	53.1	47.1*	62.2	54.9*	43.6	34.6

* $p < 0.05$.
† Reference group for statistical tests.
‡ 1 ounce = 28.35 g.

(28.35 g) or less per day) and somewhat lower in nondrinkers and those who drank more than 1 ounce per day. Nondrinkers had significantly lower age-adjusted rates of maintaining mobility than did moderate drinkers in four of the six community-sex groups. For each physical activity, age-adjusted rates of maintaining mobility were highest in those who frequently engaged in the activity and lowest in those who never engaged in the activity. The benefits of frequent activity in terms of preserving mobility appeared to be approximately equal for walking, gardening, and vigorous exercise; none was clearly superior to the others in maximizing rates of maintaining mobility. The differences in age-adjusted rates of maintaining mobility for those who engaged in the activity frequently compared with rarely or never were statistically significant in all six community-sex groups for gardening and in four of the six community-sex groups for walking and vigorous exercise. Older adults in the middle three quintiles of the body mass index distribution had the highest age-adjusted rates of maintaining mobility. Rates of maintaining mobility were lower among men in the bottom quintile of body mass index compared with the middle three quintiles, but the differences were not statistically significant in any community. Women in the lowest quintile of body mass index did not differ from those in the middle three quintiles in the age-adjusted rate of maintaining mobility. In men and women, age-adjusted rates of maintaining mobility were lower among those in the top quintile of body mass index compared with the those in the middle three quintiles; the differences were statistically significant among women in two of the three communities, but were not statistically significant for men.

Relative risks from proportional hazards models using time to loss of mobility as the outcome are shown in table 3. The relative risks were adjusted for age and all life-style risk factors. Current smoking was consistently associated with a small increased risk of losing mobility, with relative risks ranging from 1.1 to 1.5 in the six community-sex groups. The overall community-stratified relative risks were 1.3 (95 percent confidence interval (CI) 1.1–1.6) for men and 1.2 (95 percent CI 1.0–1.4) for women. Former smoking was consistently associated with a small increased risk of losing mobility in women but not in men. Similarly, not consuming alcohol was consistently associated with a small but statistically significant increased risk of losing mobility in both sexes; the community-stratified relative risks for men and women were identical at 1.2 (95 percent CI 1.1–1.4). High physical activity levels (based on the composite index of physical activity) were associated with a substantial reduction in the risk of losing mobility for men and women in each community. Relative risks ranged from 0.4 to 0.7, and all were statistically significant. The community-stratified summary relative risks for men and women were both 0.6 (95 percent CI 0.5–0.7). High compared with moderate body mass index was associated with an increased risk of losing mobility in both sexes; in men, the community-stratified relative risk for high body mass index was 1.2 (95 percent CI 1.0–1.5) and in women, it was 1.4 (95 percent CI 1.2–1.6). Low body mass index was not independently associated with the risk of losing mobility.

The relative risks presented here were not substantially altered by the addition to the multivariate model of a health status variable indicating the number of chronic conditions present at baseline (table 4). Additional adjustment for education also did not alter the relative risks presented in table 4. However, when the survival models were repeated for older adults with and those without chronic conditions at baseline, some differences in relative risks between these groups emerged. For women, current smoking was associated with loss of mobility only among those with prevalent chronic conditions at baseline. In both sexes, not consuming alcohol was only associated with loss of mobility among those with chronic conditions present at baseline. High levels of physical activity were associated with a reduced risk of losing mobility in older adults with and those without prevalent chronic condi-

TABLE 3. Relative risks relating behavioral risk factors to loss of mobility, adjusted for age and all behavioral risk factors, Established Populations for Epidemiologic Studies of the Elderly cohorts (n = 6,981), 1981–1987

Risk factors	East Boston, MA				Iowa				New Haven, CT				Community-stratified summary			
	Men		Women		Men		Women		Men		Women		Men		Women	
	RR*	95% CI*	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Smoking																
Current vs. never	1.4	1.0–1.9	1.1	0.8–1.4	1.5	1.0–2.2	1.3	0.9–2.0	1.1	0.9–1.5	1.2	0.9–1.5	1.3	1.1–1.6	1.2	1.0–1.4
Former vs. never	1.0	0.8–1.3	1.2	1.0–1.6	1.2	0.9–1.6	1.3	1.0–1.9	0.9	0.7–1.1	1.1	0.8–1.4	1.0	0.9–1.2	1.2	1.0–1.4
Alcohol consumption (ounces/day)†																
None vs. ≤1	1.3	1.0–1.7	1.1	1.0–1.4	1.1	0.8–1.5	1.4	1.0–1.7	1.2	1.0–1.6	1.3	1.1–1.5	1.2	1.1–1.4	1.2	1.1–1.4
>1 vs. ≤1	1.1	0.8–1.5	1.2	0.8–1.9	1.6	1.1–2.5	1.2	0.6–2.4	1.2	0.9–1.5	0.8	0.5–1.3	1.2	1.0–1.4	1.0	0.7–1.4
Physical activity (high vs. low)	0.6	0.4–0.7	0.4	0.3–0.5	0.6	0.4–0.8	0.7	0.5–0.8	0.6	0.5–0.8	0.6	0.5–0.8	0.6	0.5–0.7	0.6	0.5–0.7
Body mass index (kg/m^2) (percentile)																
≤20th vs. 21–80th	1.0	0.7–1.4	0.9	0.7–1.2	1.0	0.7–1.4	0.9	0.7–1.2	1.1	0.8–1.4	1.1	0.9–1.4	1.0	0.9–1.2	1.0	0.9–1.1
>80th vs. 21–80th	1.2	0.9–1.6	1.5	1.2–1.8	1.4	1.0–2.0	1.4	1.0–1.9	1.2	0.9–1.6	1.3	1.0–1.7	1.2	1.0–1.5	1.4	1.2–1.6

* RR, relative risk; CI, confidence interval
† 1 ounce = 28.35 g

TABLE 4. Relative risks relating behavioral risk factors to loss of mobility adjusted for and stratified by the presence of chronic conditions, Established Populations for Epidemiologic Studies of the Elderly cohorts (n = 6,981), 1981–1987

Risk factors	Men						Women					
	Adjusted for chronic conditions*,†		No chronic conditions		≥1 chronic conditions		Adjusted for chronic conditions*,†		No chronic conditions		≥1 chronic conditions	
	RR‡	95% CI‡	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Smoking												
Current vs. never	1.3	1.1–1.5	1.2	0.8–2.0	1.3	1.1–1.6	1.2	1.0–1.4	0.8	0.5–1.3	1.2	1.1–1.5
Former vs. never	0.9	0.8–1.1	0.9	0.6–1.3	1.0	0.8–1.2	1.2	1.0–1.3	0.8	0.5–1.3	1.2	1.1–1.5
Alcohol consumption (ounces/day)§												
None vs. ≤1	1.2	1.0–1.4	1.1	0.7–1.7	1.3	1.1–1.5	1.2	1.1–1.3	0.9	0.7–1.3	1.3	1.1–1.4
>1 vs. ≤1	1.2	1.0–1.4	1.1	0.7–1.8	1.2	1.0–1.5	1.0	0.7–1.3	1.3	0.6–2.7	1.0	0.7–1.4
Physical activity (high vs. low)	0.6	0.5–0.7	0.5	0.4–0.8	0.6	0.5–0.7	0.6	0.5–0.7	0.4	0.3–0.6	0.6	0.5–0.7
Body mass index (kg/m^2) (percentile)												
≤20th vs. 21–80th	1.1	0.9–1.3	1.4	0.9–2.2	1.0	0.8–1.2	1.1	0.9–1.2	1.3	0.9–1.8	1.0	0.8–1.2
>80th vs. 21–80th	1.2	1.0–1.4	1.7	1.0–2.8	1.1	0.9–1.4	1.3	1.1–1.5	1.1	0.7–1.9	1.4	1.2–1.6

* All models are adjusted for community (by stratification/blocking), age, and all behavioral risk factors.
† Model includes a summary variable for prevalent chronic conditions (number of conditions from a list of eight including myocardial infarction, stroke, exertional chest pain, diabetes, high blood pressure, dyspnea, joint pain, and leg pain).
‡ RR, relative risk; CI, confidence interval.
§ 1 ounce = 28.35 g.

tions at baseline. Patterns of association between body mass index and loss of mobility were inconsistent for men and women with and without prevalent chronic conditions at baseline. Finally, the addition of indicator variables for incident chronic conditions entered one at a time to the models summarized in table 4 did not alter the relative risks presented (data not shown).

DISCUSSION

In this prospective study of older adults with intact mobility at baseline, the probability of maintaining mobility during 4 years of follow-up was significantly associated with being a nonsmoker, consuming small amounts of alcohol, having a moderate relative body weight, and getting regular physical activity. These associations were independent of age and education. The increased risk of mobility loss associated with current smoking and not consuming alcohol was restricted to older adults with prevalent chronic conditions at baseline. Regular physical activity, in the form of walking, gardening, or vigorous exercise three or more times per week, was the health behavior most strongly and consistently associated with maintaining mobility.

Current cigarette smoking was associated with an increased risk of losing mobility in both men and women. The magnitude of the increased risk ranged from 10 to 50 percent among men and women in three different communities. These results are consistent with two previous prospective studies in which older nonsmokers had a higher level of physical function at the end of follow-up than did current smokers (12, 13). An effect of cigarette smoking on loss of mobility is biologically plausible because of its known association with several disabling chronic conditions, including heart disease, stroke, cancer, and chronic obstructive pulmonary disease (14, 15). In addition, evidence is mounting for a role of smoking in osteoporosis and hip fracture (16–20). Furthermore, smoking may lead to physiologic losses and symptomatology that, in turn, contribute to frailty and disability, such as smoking-related losses in pulmonary function (21, 22).

Although the magnitude of the association between current smoking and loss of mobility was modest, 20–30 percent increased risk in women and men, respectively, the impact of smoking on development of mobility impairments among the 4.5 million older adults who currently smoke (23) could be substantial. For example, among East Bos-

ton men, an excess of 16.4 cases of mobility loss or death per 100 men with initially intact mobility were attributable to cigarette smoking. The prospects for prevention of mobility loss by smoking cessation appear to be excellent for men in this study; former smokers were no more likely to lose mobility than were never smokers. Among women, former smokers remained at higher risk of losing mobility, and the level of increased risk was similar to that of current smokers. This may be explained by the greater prevalence of past smoking among men compared with women and the possibility that women more so than men had stopped in response to the presence of chronic disease. The accumulated evidence relating cigarette smoking to a number of serious and fatal chronic conditions combined with the many documented benefits of stopping are already a compelling basis for recommending smoking cessation in older adults, regardless of sex. These findings suggest that the consequences of persistent smoking in later life may extend to loss of mobility and raise the possibility that cessation may improve prospects for remaining mobile.

Older men and women who consumed small-to-moderate amounts of alcohol were more likely to maintain mobility than were nondrinkers. Moderate alcohol consumption has been related to a higher level of physical function in one previous prospective study of older adults (13). Several epidemiologic studies of predominantly middlehaged adults have related moderate alcohol consumption to a decreased risk of coronary heart disease that is most likely mediated through an effect of moderate alcohol on increasing high density lipoprotein cholesterol levels (24, 25). In other analyses of the Established Populations for Epidemiologic Studies of the Elderly, moderate alcohol consumption has been associated with a decreased risk of total and cardiovascular mortality (8). Therefore, it is possible that the benefits of moderate alcohol consumption in terms of preserving mobility in our study were mediated by a decreased risk of disabling coronary events among those consuming small-to-moderate amounts. Alternatively, the increased risk among nondrinkers was restricted to older adults who reported one or more chronic conditions at baseline. It is possible that older adults with prevalent chronic conditions had ceased their alcohol consumption as a result of having developed a disabling chronic condition prior to baseline. Unfortunately, information on the amount of alcohol consumed in the past by nondrinkers at baseline was not available. However, previous studies of older populations have shown that older adults consume less and less alcohol as they age (26) and that those who are under treatment for medical conditions consume less alcohol than do others (27). Our analytic strategy included adjustment for the effects of several prevalent and incident chronic diseases, including heart attack, and these adjustments did not change the relation of alcohol consumption to loss of mobility. However, our list of chronic conditions was not exhaustive, particularly for the occurrence of new events during follow-up, and therefore these adjustments cannot completely exclude the potential mediating effects of chronic conditions in explaining the relation of alcohol consumption to mobility loss.

Men who consumed more than 1 ounce (28.35 g) per day of alcohol on average had a small (20 percent) increased risk of losing mobility compared with those who consumed less alcohol. No such effect was seen among women. Heavy alcohol consumption has been related to loss of physical function in a recent prospective study of older women (28). In that study, high-risk consumers of alcohol were those who usually drank three or more alcoholic drinks per occasion in the previous month. It is possible that our measure of average daily alcohol consumption did not capture periodic heavy drinking patterns that may be associated with injuries such as falls and fractures.

Obesity, defined as body mass index above the 80th percentile, was associated with a 20 percent increased risk of losing mobility among men and a 40 percent increased risk among women in this study. Low body mass

index (<20th percentile) was not significantly associated with loss of mobility in either sex. Moderate body weight has been related to overall health and higher functional status in previous prospective studies of older populations (13, 29–31). An effect of obesity on mobility loss has several potential biologically plausible mechanisms. First, obesity may increase the risk of cardiovascular disease events that, in turn, could lead to loss of mobility (32), although not all epidemiologic studies confirm such an association (33). Second, obesity has been consistently associated with osteoarthritis, a major cause of disability in older adults (34). Such an association may be explained by the increased mechanical stress on joints in those with greater body mass or by other factors. Third, obesity is associated with decreased levels of physical activity that can lead to deconditioning and increased frailty (35, 36). Such deconditioning could make obese older adults more vulnerable to developing long-term disabilities when confronted with episodes of acute and chronic illness.

Older men and women who engaged in physical activity three or more times per week were significantly less likely to lose mobility than were their sedentary counterparts. For both men and women, regular physical activity was associated with a 40 percent decreased risk of losing mobility. The association was present in older adults with and those without prevalent chronic conditions at baseline. Furthermore, the type of physical activity did not alter the strength of the association; walking and gardening conveyed a degree of benefit similar to that of more vigorous forms of exercise. Two previous prospective studies have shown a relation of inactivity to disability (37, 38). Branch (37) found that men and women aged 65 and older who reported having "slowed down" their physical activity level were more than twice as likely to have functional disabilities 5 years later. Mor et al. (38) studied a national sample of men and women aged 70–74 years who were functionally intact at baseline and found that inactivity, defined as lack of a regular exercise program or infrequent walking of a mile or more, was associated with a 50 percent greater risk of losing function during a 2-year follow-up period.

It is possible that physical activity levels at baseline were influenced by overall health and functional capabilities, even in this study population, which was restricted to older adults with intact mobility at baseline. If physical activity were simply a surrogate for good overall health and high functioning and not an independent protective factor for loss of mobility, then we would not expect to see an association in that segment of our population with the best overall health, those with none of the eight chronic conditions at baseline. In fact, the association between physical activity and mobility loss was as strong, if not stronger, in this group compared with those who had one or more chronic conditions. Furthermore, an effect of physical activity on mobility status is biologically plausible for several reasons. Regular physical activity, in its various forms, has been consistently associated with increased bone density; improved lipid profiles; increased strength, balance, and coordination; improved aerobic capacity; and decreased depression (35, 36). These benefits would be expected to translate into reduced risks of coronary events, osteoporotic fractures, and mortality. In fact, such expectations find support in many previous studies (36, 39–42). In addition to preventing disabling chronic diseases, the apparent benefits of physical activity in terms of improved physiologic and psychosocial function have been postulated to reduce frailty in older adults; frailty is defined as an increased susceptibility to disability resulting from diminished physiologic reserve (35, 36). Our findings support an important role for regular physical activity in preserving mobility and independence in older men and women.

Taken together, these two companion papers have joint implications for the prevention of mobility losses in older adults. First, we have identified subgroups of the older population living in the community who

have a relatively high level of function, but are at greater risk of losing mobility over time. Compared with those who already have substantial disability and with those functioning at a high level and without important risk factors for mobility loss, these individuals may have greater potential to benefit from preventive interventions. Second, the majority of older adults in this population with intact mobility had at least one major chronic condition, and the overall burden of morbidity clearly increased the risk of losing mobility. Nevertheless, these findings suggest the possibility that reversal of negative health behaviors may confer benefits in terms of preserving mobility, even among those with prevalent chronic conditions. Third, of the health behaviors investigated here, physical activity appears to have the greatest potential to reduce susceptibility to mobility losses, yet older adults tend to reduce their activity levels as they age (36). Older adults with prevalent chronic conditions and symptoms should not be excluded from intervention programs aimed at increasing activity; rather, we must develop activity programs than can be adapted to whole populations of older adults with a variety of capabilities and health concerns. The development of safe, practical, and cost-effective interventions aimed at prevention of mobility losses and other disabilities through modification of high-risk behaviors has the potential to extend active life expectancy, preserve independence, and curtail health care costs.

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