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Abstract

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Objective: This study examines the association between incident mobility limitation and 4 lifestyle factors: smoking, alcohol intake, physical activity, and diet in well-functioning obese (n = 667) and non-obese (n = 2027) older adults.

Research Methods and Procedures: Data were from men and women, 70 to 79 years of age from Pittsburgh, PA and Memphis, TN, participating in the Health, Aging and Body Composition (Health ABC) study. In addition to individual lifestyle practices, a high-risk lifestyle score (0 to 4) was calculated indicating the total number of unhealthy lifestyle practices per person. Mobility limitation was defined as reported difficulty walking 1/4 mile or climbing 10 steps during two consecutive semiannual assessments over 6.5 years.

Results: In non-obese older persons, significant risk factors for incident mobility limitation after adjustment for sociodemographics and health-related variables were current and former smoking [hazard ratio (HR) = 1.51; 95% confidence interval (CI), 1.20 to 1.89; HR = 1.40; 95% CI, 1.12 to 1.74), former alcohol intake (HR = 1.30; 95% CI, 1.05 to 1.60), low and medium physical activity (HR = 1.78; 95% CI, 1.45 to 2.18; HR = 1.29, 95% CI, 1.07 to 1.54), and eating an unhealthy diet (HR = 1.57; 95% CI, 1.17 to 2.10). In the obese, only low physical activity was associated with a significantly increased risk of mobility limitation (HR = 1.44; 95% CI, 1.08 to 1.92). Having two or more unhealthy lifestyle factors was a strong predictor of mobility limitation in the non-obese only (HR = 1.98; 95% CI, 1.61 to 2.43). Overall, obese persons had a significantly higher risk of mobility limitation compared with non-obese persons, independent of lifestyle factors (HR = 1.73; 95% CI, 1.52 to 1.96).

Conclusions: These results underscore the importance of a healthy lifestyle for maintaining function among non-obese older adults. However, a healthy lifestyle cannot overcome the effect of obesity in obese older adults; this stresses the importance of preventing obesity to protect against mobility loss in older persons.

Key words: aging, lifestyles, smoking, physical activity

Introduction

The prevalence of obesity is increasing across the age spectrum even in the oldest age groups (1–3). Obesity is

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associated with an increased risk of diseases, such as diabetes, heart disease, arthritis, and certain cancers (4–6). Additionally, obesity has been found to predict functional decline and future disability in older persons (4,5,7). Obese persons with an unhealthy lifestyle may be at especially high risk for functional decline.

Unhealthy lifestyle practices, such as smoking and lack of physical activity, are related to increased morbidity and mortality (8–11). Unhealthy lifestyle factors are also related to poor functional outcomes (12–15), although few studies have specifically examined lifestyle factors in relation to the onset of functional problems (16,17). In older people, physical function is an important health outcome that provides insight into a person's overall health status. Poor physical function is associated with disability (difficulty doing activities of daily living) and, especially in older adults, has been shown to be an important predictor of mortality and institutionalization (18,19). Thus, determining risk factors of functional decline in older populations that would be amenable to preventive intervention, such as lifestyle practices, is of utmost importance. This may be especially important for obese persons because of their higher risk for declines in physical function (4,5,7).

Whether the effect of unhealthy lifestyle factors on functional problems is different in obese and non-obese persons is unclear. Because obesity alone is an important risk factor for functional decline, it may overwhelm the effect of other risk factors, such as unhealthy lifestyles. On the other hand, the detrimental effects of unhealthy lifestyle factors on mobility problems may be consistent for obese and non-obese older persons. Several studies have shown that physical inactivity is associated with various adverse health outcomes in both obese and non-obese persons (20–22). Whether the same holds for other lifestyle factors is unknown.

The present study examines the association between incident mobility limitation and 4 lifestyle factors: cigarette smoking, alcohol intake, physical activity, and diet quality in both non-obese and obese well-functioning older adults, as single entities and in combination. Most previous studies have focused on individual lifestyle factors in relation to various health outcomes but the combined, potential cumulative effects of different lifestyle factors have yet to be studied extensively and diet has generally been overlooked. Furthermore, it is unknown whether lifestyle factors at baseline mainly have a short-term effect regarding the onset of mobility limitation or are also related to later onset of mobility limitation. Therefore, we also explored the effect of lifestyle factors on early onset of mobility limitation (within 2 years of follow-up), as well as late onset of mobility limitation (after 2 years of follow-up).

Research Methods and Procedures

Study Population

The Health, Aging and Body Composition (Health ABC) study is a longitudinal cohort study consisting of 3075 well-functioning, 70- to 79-year-old, black and white men and women. Participants were identified from a random sample of white Medicare beneficiaries and all age-eligible community-dwelling black residents in designated zip code areas surrounding Memphis, TN, and Pittsburgh, PA. Participants were eligible if they reported no difficulty in walking one-quarter of a mile, going up 10 steps without resting, or performing basic activities of daily living. Participants were excluded if they reported a history of active treatment for cancer in the prior 3 years, planned to move of the study area in the next 3 years, or were currently participating in a randomized trial of a lifestyle intervention. Baseline data, collected between April 1997 and June 1998, included an in-person interview and a clinic-based examination, with evaluation of body composition, clinical and subclinical diseases, and physical functioning. Six and a half years of follow-up were used for this study. Information on all independent measures was collected at baseline, except for dietary intake. This was collected at the first 12-month follow-up examination and was available for 2701 participants. Data on other lifestyle factors were missing for 7 participants, leaving 2694 participants for the present analyses. All participants signed informed written consent forms approved by the institutional review boards of the clinical sites.

Measures

Obesity. Obesity was defined as a BMI (weight in kilograms divided by height in meters squared) $\geq$30 kg/m^2.

Lifestyle Factors. Lifestyle factors were assessed using an interviewer-administered questionnaire and included smoking, alcohol consumption, physical activity, and dietary intake.

Smoking was categorized as current smoker, former smoker who stopped smoking within the past 15 years, former smoker who stopped smoking >15 years ago, and never smoker (23).

Alcohol intake was assessed by asking the participant how many alcoholic drinks he/she consumed in a typical week, during the past 12 months. Furthermore, it was asked whether a person ever drank more than what he/she typically drank in the past 12 months (24). The Dietary Guidelines for Americans recommended no more than one drink per day for women and no more than two drinks per day for men (25). Average weekly alcohol consumption was categorized as never, former, low (less than one drink per week), moderate (1 to 7 drinks per week for women and 1 to 14 drinks per week for men), and high (>7 drinks per week for women and >14 drinks per week for men).

Physical activity in the previous 7 days was defined as the sum of time spent on gardening, heavy household chores, light house work, grocery shopping, laundry, climbing stairs, walking for exercise, walking for other purposes, aerobics, weight or circuit training, high-intensity exercise activities, and moderate-intensity exercise activities. Information on the intensity level at which each activity was performed was also obtained. Approximate metabolic equivalent unit values were assigned to each of the activity categories to calculate a weekly energy expenditure estimate in kcal/kg per week (26). The overall physical activity score in non-obese and obese persons together was divided into quartiles where the highest quartile was considered as high physical activity (>106.5 kcal/kg per week) and the lowest quartile as low physical activity (<38.4 kcal/kg per week). The second and third quartiles were combined in the medium group.

A modified Block food frequency questionnaire was administered by a trained dietary interviewer at the first annual follow-up examination. The food frequency questionnaire was developed and modified by Block Dietary Data Systems (Berkeley, CA) based on age-appropriate intake data from the third National Health and Nutrition Examination Survey (27). A Healthy Eating Index (HEI)[1] was calculated to measure the amount of variety in the diet and compliance with specific dietary guidelines (28,29). The HEI consisted of 10 components: 5 measured conformity to the sex- and age-specific serving recommendations from the 1992 Food Guide Pyramid for grains, fruit, vegetables, dairy, and meat, and the other 5 assessed intakes of total fat consumption as a percentage of total food energy intake, saturated fat consumption as a percentage of total food energy intake, total cholesterol, total sodium, and dietary variety. Each component was scored from 0 to 10 with higher scores indicating better compliance with recommended intake range or amount. Total HEI score ranged from 0 to 100 and was grouped into 3 categories for analysis: good (>80), fair (51 to 80), and poor (<51) (28).

A high-risk lifestyle score was created as the number of unhealthy lifestyle factors per person. Unhealthy lifestyle factors were current or recent (quit within the past 15 years) smoking, high alcohol intake, low physical activity, and a poor HEI score. The high-risk lifestyle score ranged from 0 (no unhealthy lifestyle factors) to 4 (unhealthy for all lifestyle factors); 3 categories were created: 0, 1, and 2 or more unhealthy lifestyle factors. Because of the small number of persons (≤1%) in the group with 3 or 4 unhealthy lifestyle factors, these groups were combined with the group who had 2 unhealthy lifestyle factors.

Incident Persistent Mobility Limitation. The occurrence of mobility limitation over 6.5 years of follow-up was determined every 6 months, at study assessment visits (12, 24, 36, 48, 60, and 72 months after baseline) or during telephone follow-up assessments (6, 18, 30, 42, 54, 66, and 78 months after baseline). Incident persistent mobility limitation was considered to be present when a person reported any difficulty walking one quarter of a mile or climbing 10 steps at 2 consecutive semiannual follow-up assessments. The requirement that mobility limitation needed to be present at 2 consecutive assessments selected more participants with chronic functional limitation; therefore, this outcome was thought to be a more reliable indicator of a clinically relevant change in functional status than an indicator based on one assessment only. Early onset of mobility limitation was defined as mobility limitation within 2 years of follow-up and late onset after 2 years of follow-up. The median for the number of days until people developed mobility limitation was 700 days, which is close to 2 years and, therefore, chosen as the cut-off point here.

Covariates. Sociodemographics included age, sex, race (black or white), study site (Memphis or Pittsburgh), marital status (never married, previously married, or married), and educational level (<12 years, 12 years, or >12 years). Different health-related variables were included. Although no participants reported mobility limitation at baseline, there was some variation in baseline functional performance (30). To adjust for this, the Established Population for Epidemiological studies of the Elderly performance score was included (19). This performance score summarizes, on a scale from 0 (poor) to 12 (good), a person's performance on a 6-minute walk test, a standing balance test, and 5 repetitions of chair rises. Presence of lung, heart, and cerebrovascular disease, diabetes mellitus, osteoarthritis, and cancer was determined using standardized algorithms considering self-report, use of specific medications, and clinical assessments. Depressed mood was assessed with the Center for Epidemiological Studies Depression scale. A cutoff score of 16 was used as a criterion for major depressive symptoms (31). Cognitive impairment was defined as a Modified Mini-Mental State Examination score <78 (32).

Statistical Analyses

Differences in baseline characteristics between non-obese and obese persons were determined using χ^2 tests for categorical variables and t test statistics for continuous variables. Cox proportional hazard regression models were fitted to study the association of different lifestyle factors on time to incident mobility limitation in non-obese and obese persons separately. Persons surviving with no evidence of incident mobility limitation were censored at the last study visit. Persons dying with no evidence of incident mobility limitation were censored at time of death, and those lost to follow-up were censored at their last interview. Two models were fitted; the first was adjusted for sociodemographics and in the second model the health-related variables were added. Additionally, the effect of lifestyle factors on early onset (within 2 years of follow-up) and late onset (after 2 years of follow-up) of mobility limitation was examined. Interactions between each single lifestyle factor and obesity

[1] Nonstandard abbreviations: HEI, Healthy Eating Index; HR, hazard ratio; CI, confidence interval.

were formally tested in the model that adjusted for sociodemographics. The proportional hazards assumption was investigated by testing the constancy of the log hazard ratio (HR) over time by means of log-minus-log survival plots and interactions with time (log transformed). According to the tests, the proportional hazard assumption was not violated. Analyses were performed using SPSS, version 14.0 (SPSS, Inc., Chicago, IL).

Results

Table 1 shows the distribution of the main characteristics for non-obese and obese persons. Obese persons were more often women, black, unmarried, and had less education. The non-obese group consisted of more current smokers, more moderate and high alcohol consumers, and persons with high physical activity levels compared with obese persons. In the obese group, 66% developed mobility limitation compared with 41% in the non-obese group ($p < 0.01$). Obese persons also had a worse functional performance score at baseline. The prevalence of diabetes mellitus was significantly higher in obese persons.

Incidence rates of mobility limitation were highest in people who were currently smoking (only in the non-obese), were former alcohol drinkers, had low physical activity, had a poor HEI score (only in the non-obese), or had 2 or more unhealthy lifestyle factors (Table 2). Overall, incidence rates of mobility limitation were significantly higher in obese persons compared with non-obese persons. Using the total study population, the incidence rate of mobility limitation according to obesity status itself was calculated. The incidence rate per 100 persons was 9 in the non-obese group and 19 in the obese group ($p < 0.01$) (not tabulated).

Non-obese persons with unhealthy lifestyle factors had a significantly increased risk of incident mobility limitation compared with those with healthy lifestyle factors (Table 2). For example, HRs of incident mobility limitation, adjusted for sociodemographics, were significantly higher in current smokers (HR = 1.68; 95% confidence interval (CI): 1.35 to 2.10), former alcohol drinkers (HR = 1.46; 95% CI, 1.19 to 1.81), people with low physical activity levels (HR = 1.97; 95% CI, 1.61 to 2.41), and people with a poor HEI score (HR = 1.52; 95% CI, 1.13 to 2.03) (Table 2, model 1). These HRs remained statistically significant after adjustment for all health-related variables (model 2). In the obese group, the association between lifestyle factors and incidence of mobility limitation seemed to be less strong. Only low physical activity levels were significantly related to a higher mobility limitation incidence (HR = 1.44; 95% CI, 1.08 to 1.92). In the fully adjusted model, having two or more unhealthy lifestyle factors remained a strong predictor of mobility limitation in the non-obese (HR = 1.98; 95% CI, 1.61 to 2.43) only. In a fully adjusted model, using the total study population, with obesity and all four lifestyle factors, obesity was a strong predictor of mobility limitation (HR = 1.73; 95% CI, 1.52 to 1.96).

We formally tested the interactions between each single lifestyle factor and obesity and the high-risk lifestyle score and obesity (Table 2). The significant interactions indicated that the effect of smoking, alcohol intake, healthy eating, and the number of unhealthy lifestyle factors on mobility limitation was different for non-obese and obese persons. Interactions between lifestyle factors and gender, lifestyle factors and race, and between individual lifestyle factors were not statistically significant (all $p > 0.10$).

In the non-obese group, 22% developed mobility limitation within 2 years of follow-up and 19% after 2 years of follow-up compared with 41% and 25% in the obese group ($p < 0.01$). In the non-obese, current smoking had a stronger effect on late onset of mobility limitation than on the early onset of mobility limitation (Table 3). In the obese, low physical activity was only significantly associated with early onset of mobility limitation. The effect of an unhealthy diet was only significantly related to early onset of mobility limitation in the non-obese group. Obesity itself was a strong risk factor for both early onset of mobility limitation (HR = 1.72; 95% CI, 1.45 to 2.03) and late onset of mobility limitation (HR = 1.81; 95% CI, 1.50 to 2.20). The joint effects of obesity and the number of unhealthy lifestyle factors on early and late onset of mobility limitation are shown in Figure 1. Compared with non-obese persons without unhealthy lifestyle factors, non-obese persons with two or more unhealthy lifestyle factors had an about 2 times higher risk of both early and late onset of mobility limitation. Obese persons without unhealthy lifestyle factors had a similar increased risk of mobility limitation. The additional detrimental effect of unhealthy lifestyle factors in the obese was not as strong as in the non-obese.

Discussion

In non-obese older persons, current and former smoking, former alcohol intake, low physical activity, and eating an unhealthy diet were significant risk factors for incident mobility limitation. In obese older persons, only low physical activity was associated with a significantly increased risk of mobility limitation. The individual lifestyle factors were more strongly related to mobility limitation in non-obese persons than in obese persons. Having two or more unhealthy lifestyle factors was a particularly strong predictor of mobility limitation in the non-obese only. It seems that the effect of obesity partly overwhelms the effect of other lifestyle factors in obese older adults. Overall, obese persons were at higher risk of mobility limitation compared with non-obese persons, independent of lifestyle factors.

Regarding the early and late onset of mobility limitation, the general pattern remained similar; lifestyle factors were more strongly associated with mobility limitation in the non-obese than in the obese. In the non-obese, smoking was

Table 1. Distribution of main characteristics for non-obese and obese persons

	Non-obese (n = 2027)	Obese (n = 667)	p
Age [mean (SD)]	74.3 (2.9)	73.8 (2.8)	<0.01
Women (%)	48.5	58.8	<0.01
Black (%)	33.0	56.1	<0.01
Memphis site (%)	50.0	53.8	0.05
Married (%)	61.0	51.1	<0.01
Education			
<12 years	21.1	30.1	<0.01
12 years	31.3	35.0	
>12 years	47.6	34.9	
Smoking (%)			
Never	44.1	45.0	<0.01
Former, stopped >15 years ago	33.8	34.9	
Former, stopped ≤15 years ago	11.5	14.5	
Current	10.6	5.5	
Alcohol intake (%)			
Never	26.5	32.2	<0.01
Former	20.4	24.9	
Low	21.1	20.4	
Moderate	27.1	19.6	
High	4.9	2.8	
Total physical activity (%)			
High	26.2	23.2	0.14
Medium	50.7	50.5	
Low	23.0	26.2	
Healthy Eating Index (%)			
Good	20.3	18.9	0.72
Fair	72.4	73.6	
Poor	7.3	7.5	
Number of unhealthful lifestyle factors (%)			
0	55.8	54.1	0.33
1	32.8	35.7	
2 or more	11.4	10.2	
Incident mobility limitation (%)	41.2	66.3	<0.01
EPESE performance score [mean (SD)]	10.2 (1.5)	9.7 (1.7)	<0.01
Lung disease (%)	18.2	18.2	0.99
Heart disease (%)	16.9	17.8	0.57
Cerebrovascular disease (%)	7.2	5.6	0.16
Peripheral arterial disease (%)	5.1	4.5	0.51
Diabetes mellitus (%)	14.3	28.7	<0.01
Osteoarthritis (%)	14.3	17.2	0.07
Depression (%)	4.6	4.8	0.81
Cognitively impaired (%)	6.1	7.7	0.14

SD, standard deviation; EPESE, Established Population for Epidemiological Studies of the Elderly.

Table 2. Number of incident cases, incidence rates per 100 person-years, and HRs (95% CI) of incident mobility limitation according to lifestyle factors for non-obese and obese persons

	Incident mobility limitation					Model 1†				Model 2‡			
	Non-obese		Obese			Non-obese		Obese		Non-obese		Obese	
Lifestyle factor	*n* (%)	Incidence rate	*n* (%)	Incidence rate	*p* value for interaction with obesity*	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Smoking													
Never	329 (37)	7	212 (71)	30	0.03	1.00		1.00		1.00		1.00	
Former, stopped >15 years ago	273 (40)	8	131 (56)	23		1.26	1.06 to 1.48	0.91	0.72 to 1.16	1.17	0.99 to 1.38	0.86	0.67 to 1.09
Former, stopped ≤15 years ago	118 (50)	12	72 (74)	31		1.62	1.30 to 2.00	1.29	0.97 to 1.71	1.40	1.12 to 1.74	1.02	0.76 to 1.37
Current	115 (53)	14	27 (73)	28		1.68	1.35 to 2.10	1.33	0.87 to 2.05	1.51	1.20 to 1.89	1.29	0.83 to 1.99
Alcohol intake													
Never	227 (42)	9	146 (68)	20	0.05	1.10	0.89 to 1.36	0.89	0.65 to 1.21	1.11	0.90 to 1.37	0.86	0.63 to 1.17
Former	213 (52)	12	119 (72)	22		1.46	1.19 to 1.81	1.10	0.80 to 1.49	1.30	1.05 to 1.60	1.03	0.75 to 1.40
Low	168 (39)	8	91 (67)	19		1.06	0.87 to 1.33	1.09	0.80 to 1.50	1.14	0.92 to 1.41	1.07	0.79 to 1.48
Moderate	185 (34)	7	78 (60)	15		1.00		1.00		1.00		1.00	
High	42 (42)	9	8 (42)	9		1.29	0.92 to 1.81	0.49	0.23 to 1.03	1.39	0.99 to 1.96	0.54	0.26 to 1.14
Total physical activity													
High	167 (31)	6	91 (56)	15	0.27	1.00		1.00		1.00		1.00	
Medium	420 (41)	9	220 (65)	18		1.43	1.19 to 1.71	1.18	0.92 to 1.51	1.29	1.07 to 1.54	1.20	0.93 to 1.55
Low	248 (53)	13	131 (75)	25		1.97	1.61 to 2.41	1.50	1.14 to 1.98	1.78	1.45 to 2.18	1.44	1.08 to 1.92
Healthy Eating Index													
Good	141 (43)	7	85 (67)	19	0.03	1.00		1.00		1.00		1.00	
Fair	617 (42)	9	329 (67)	19		1.29	1.06 to 1.54	0.94	0.73 to 1.21	1.27	1.05 to 1.54	1.05	0.81 to 1.36
Poor	77 (52)	12	28 (56)	15		1.52	1.13 to 2.03	0.86	0.55 to 1.34	1.57	1.17 to 2.10	0.85	0.54 to 1.35
Number of high-risk lifestyle factors													
0	392 (35)	7	229 (63)	17	0.08	1.00		1.00		1.00		1.00	
1	305 (46)	11	162 (68)	20		1.44	1.23 to 1.67	1.16	0.94 to 1.43	1.31	1.12 to 1.53	1.16	0.94 to 1.44
2 or more	138 (59)	16	51 (75)	25		1.99	1.63 to 2.44	1.49	1.08 to 2.05	1.98	1.61 to 2.43	1.15	0.82 to 1.62

HR, hazard ratio; CI, confidence interval.
* *p* value for interaction between lifestyle factors and obesity as tested in model 1.
† Model 1: Adjusted for age, gender, race, site, marital status, and educational level.
‡ Model 2: Adjusted for age, gender, race, site, marital status, educational level, baseline functional performance, heart disease, cerebrovascular disease, peripheral arterial disease, osteoarthritis, lung disease, diabetes mellitus, depression, and cognitive impairment.

Table 3. HR (95% CI) of early onset and late onset of mobility limitation according to lifestyle factors for non-obese and obese persons*

	Early onset of mobility limitation				Late onset of mobility limitation			
	Non-obese		Obese		Non-obese		Obese	
Lifestyle factors	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**
Smoking								
Never	1.00		1.00		1.00		1.00	
Former, stopped >15 years ago	1.16	0.93 to 1.46	0.94	0.69 to 1.27	1.15	0.90 to 1.47	0.82	0.55 to 1.23
Former, stopped ≤15 years ago	1.29	0.96 to 1.75	0.85	0.58 to 1.25	1.55	1.12 to 2.14	1.39	0.88 to 2.18
Current	1.30	0.95 to 1.77	1.45	0.82 to 1.56	1.58	1.13 to 2.22	1.30	0.65 to 2.60
Alcohol intake								
Never	1.31	0.98 to 1.75	0.89	0.59 to 1.35	0.90	0.66 to 1.23	0.77	0.48 to 1.25
Former	1.40	1.04 to 1.88	1.12	0.74 to 1.68	1.20	0.89 to 1.64	0.89	0.54 to 1.46
Low	1.16	0.85 to 1.59	1.13	0.75 to 1.71	1.15	0.85 to 1.55	0.97	0.59 to 1.59
Moderate	1.00		1.00		1.00		1.00	
High	1.31	0.80 to 2.14	0.75	0.31 to 1.79	1.40	0.87 to 2.26	0.28	0.07 to 1.19
Total physical activity								
High	1.00		1.00		1.00		1.00	
Medium	1.30	1.01 to 1.69	1.39	0.98 to 1.97	1.28	0.99 to 1.66	1.01	0.69 to 1.50
Low	1.90	1.44 to 2.53	1.61	1.09 to 2.37	1.64	1.22 to 2.21	1.30	0.84 to 2.03
Healthy Eating Index								
Good	1.00		1.00		1.00		1.00	
Fair	1.49	1.13 to 1.96	1.04	0.75 to 1.45	1.08	0.83 to 1.41	1.08	0.70 to 1.65
Poor	1.86	1.24 to 2.79	1.10	0.64 to 1.90	1.27	0.82 to 1.97	0.46	0.20 to 1.09
Number of high-risk lifestyle factors								
0	1.00		1.00		1.00		1.00	
1	1.38	1.12 to 1.70	1.15	0.87 to 1.51	1.27	1.01 to 1.59	1.12	0.79 to 1.59
2 or more	1.73	1.31 to 2.30	1.14	0.74 to 1.75	2.07	1.53 to 2.81	1.25	0.71 to 2.20

HR, hazard ratio; CI, confidence interval.
* Adjusted for age, gender, race, site, marital status, educational level, baseline functional performance, heart disease, cerebrovascular disease, peripheral arterial disease, osteoarthritis, lung disease, diabetes mellitus, depression, and cognitive impairment.

more strongly associated with late onset of mobility limitation, while eating an unhealthy diet was only significantly related to early onset of mobility limitation. Having two or more high-risk lifestyle factors was a strong predictor of both early and late onset of mobility limitation in the non-obese. These results show the robustness of our findings. People with unhealthy lifestyle factors may develop mobility limitation early in the follow-up because they were sicker at baseline. Even though we carefully adjusted for baseline prevalence of diseases and functional status, the possibility of reversed causation could not be ruled out completely. Lifestyle factors were, however, related to both early and late onset of mobility limitation.

This study constitutes one of the few longitudinal studies specifically studying the effect of different lifestyle factors on the onset of functional problems in a large cohort of older adults. Our findings are consistent with two previous studies that showed that current smoking and low physical activity levels predict the loss of mobility in older adults with intact mobility at baseline (16,17). Both studies also showed that moderate alcohol protected against mobility loss. In our study, only former alcohol consumption was

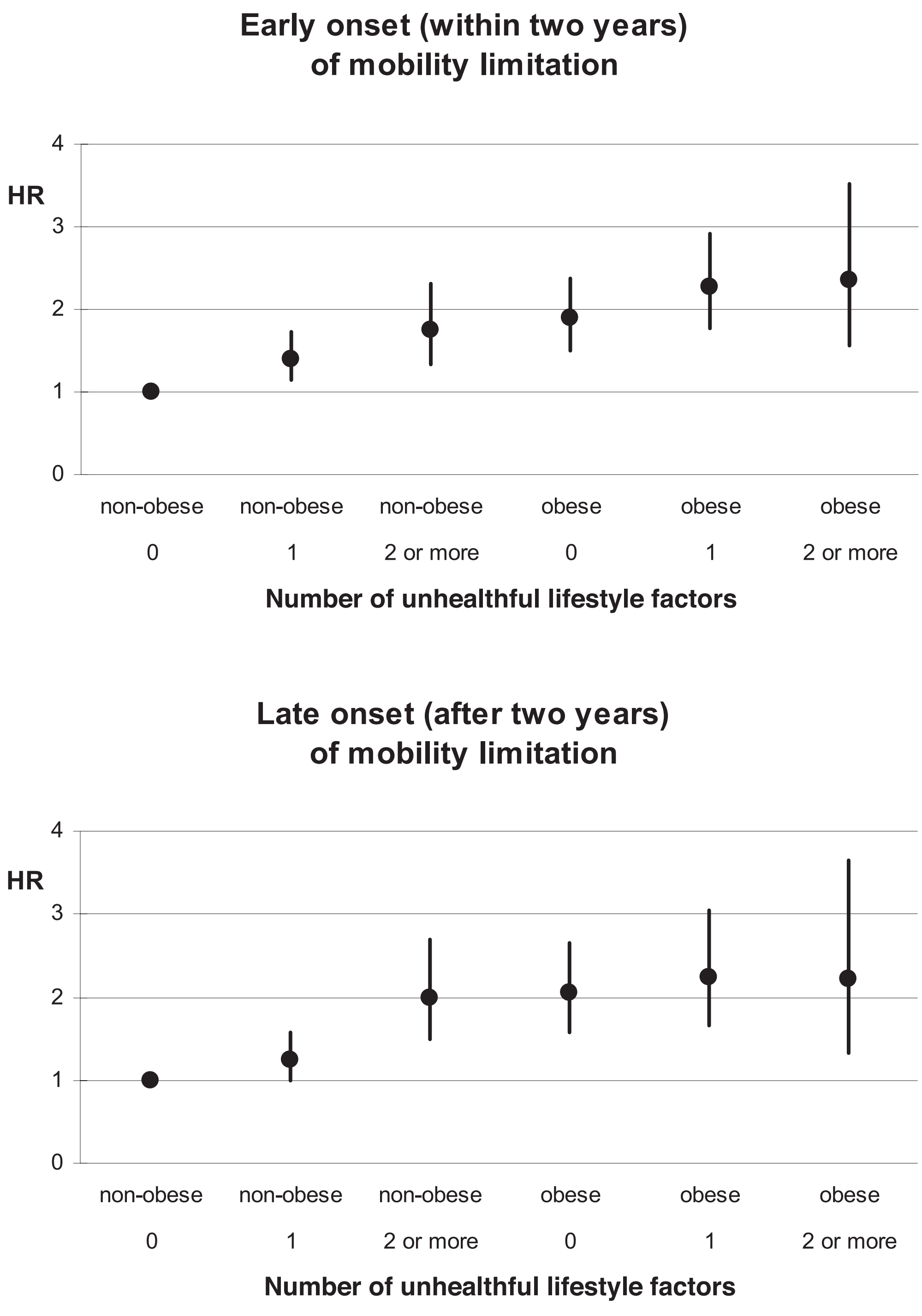

Figure 1: Adjusted HRs for incidence of mobility limitation according to the number of unhealthful lifestyle factors, which included current smoking or former smoking (stopped ≤15 years ago), high alcohol intake, low physical activity, and poor HEI and obesity, adjusted for age, gender, race, site, marital status, educational level, baseline functional performance, heart disease, cerebrovascular disease, peripheral arterial disease, osteoarthritis, lung disease, diabetes mellitus, depression, and cognitive impairment.

related to mobility limitation. These previous studies did not take into account diet. To date, there has been little published on the associations between diet and functional limitations (33–35), especially regarding the onset of functional limitations. We showed that, at least in the non-obese group, poor diet also was a predictor of incident mobility limitation. However, the effect of an unhealthy diet was not significantly associated with late onset of mobility limitation. So far, the effect of lifestyle factors on incident mobility limitation in both non-obese and obese older persons has not been studied extensively (36).

Lower physical activity levels were associated with increased risks of mobility limitation in both non-obese and obese older persons. The adverse effects of obesity persisted in both lower and higher physical activity categories. Obese persons with high physical activity levels had a lower risk of mobility limitation compared with obese persons with low physical activity levels. However, compared with their non-obese counterparts, obese persons with high physical activity levels had a higher risk of mobility limitation. Other studies have shown that active obese persons had lower morbidity and mortality than normal-weight individuals who are sedentary (20,22,37). Another study shows that overweight and obese women who are active had levels of physical function similar to that of normal-weight older women (21). In the present study, active obese older persons had approximately equal higher risk of mobility limitation as inactive non-obese older persons as compared with active non-obese persons (data not shown).

Selective survival may have influenced the association between lifestyle factors and incident mobility limitation. The study population consists of a healthy group of persons in the eighth decade of life; persons with unhealthy lifestyle practices may have died at earlier ages or developed functional limitations and were, therefore, excluded from the study. Selective survival may have weakened the association between lifestyle factors and incident mobility limitation. The healthy survivor effect may have played an especially important role in the obese group. Obesity itself is associated also with decreased survival (38) and compared with non-obese persons, obese people are at higher risk of developing functional problems and, therefore, less likely to participate in this study. This may also explain why 55% of the study population had no unhealthy lifestyle factors.

A few additional limitations of the study must be considered. First, the non-obese group consists of underweight, normal-weight, and overweight people. The association between alcohol intake, physical activity, diet, and mobility limitation was similar for normal-weight and overweight persons. The association between smoking and incident mobility limitation was somewhat stronger in normal-weight persons compared with overweight persons. Furthermore, lifestyle practices may also partly reflect consequences of illness in sicker people with lower body weight. However, when we excluded underweight persons (BMI <18.5, $n = 30$), the association between lifestyle factors and incident mobility limitation remained similar. Second, no detailed information about a person's lifestyle earlier in life was available. For smoking and alcohol intake, we made a distinction between never and former. In the non-obese, former smokers and former alcohol drinkers had an increased risk of mobility limitation. These groups may consist of people who stopped smoking or drinking because of health problems and, therefore, had increased risk of mobility limitation. There is evidence that smoking and alcohol intake remain rather stable over time, whereas physical activity and dietary patterns show greater variability over time (39). Persons may have changed to a healthier lifestyle because of health problems. Stronger associations between lifestyle factors and incident mobility limitation may emerge if lifelong health behavior could be considered. Third, dietary information was only available at the second follow-up measurement and was not measured at baseline, like the other lifestyle factors. In additional analyses, we determined the effect of diet on mobility limitation when we excluded persons that already had become functionally impaired at the time of dietary interview; results were similar.

This study underscores the importance of a healthy lifestyle in old age. Especially in non-obese older persons, not smoking, high physical activity, and eating a healthy diet may protect against mobility loss. Even though it may be most beneficial to promote healthy behaviors earlier in life, changes toward a healthier lifestyle in old age have been shown to be effective (40–42) and may protect against functional disability. Compared with the non-obese, obese older adults are at higher risk of mobility limitation, independent of other lifestyle factors. This stresses the importance of preventing obesity to protect against mobility loss in older persons. For obese persons, losing weight may be more effective than other lifestyle modifications for reducing functional problems.

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