Published in final edited form as:

J Am Geriatr Soc. 2014 August ; 62(8): 1476–1483. doi:10.1111/jgs.12954.

Weight Change, Body Composition and Risk of Mobility Disability and Mortality in Older Adults: A Population Based Cohort Study

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Abstract

Objectives—To examine associations between weight change, body composition, risk of mobility disability and mortality in older adults.

Design—Prospective, longitudinal, population-based cohort.

Setting—The Health ABC Study.

Participants—Women (n=1044) and men (n=931) aged 70-79.

Measurements—Weight, lean and fat mass from DXA measured annually over 5 years. Weight was defined as stable (n=664, referent group), loss (n=662), gain (n=321) or cycling (gain and

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Conflict of Interest Disclosures: All authors report no potential conflicts of interest

Author Contributions: Dr. Murphy and Dr. Patel had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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Critical revision of the manuscript: Cawthon, Harris, Koster, Houston.

Statistical analysis: Murphy, Patel.

Obtained funding: Harris, Newman, Kritchevsky.

loss, n=328) using change of 5% from year to year or from year 1 to 6. Mobility disability (two consecutive reports of difficulty walking one-quarter mile or climbing 10 steps) and mortality were determined for 8 years subsequent to the weight change period. Associations were analyzed with cox proportional hazards regression adjusted for covariates.

Results—During follow-up, 313 women and 375 men developed mobility disability, 322 women and 378 men were deceased. There was no risk of mobility disability or mortality with weight gain. Weight loss and weight cycling were associated with mobility disability in women: hazard ratio (HR)=1.88 (95% confidence interval (CI)=1.40-2.53), HR=1.59 (95% CI=1.11-2.29) and weight loss was associated in men: HR=1.30 (95% CI=1.01-1.69). Weight loss and weight cycling were associated with mortality risk in women: HR=1.47 (95% CI=1.07-2.01), HR=1.62 (95% CI=1.15-2.30) and in men: HR=1.41 (95% CI=1.09-1.83), HR=1.50 (95% CI=1.08-2.08). Adjustment for lean and fat mass and change in lean and fat mass from year 1 to 6 attenuated relationships between weight loss and mobility disability in men, and weight loss and mortality in men and women.

Conclusion—Weight cycling and weight loss predict impending mobility disability and mortality in old age, underscoring the prognostic importance of weight history.

Keywords

Aging; obesity; physical function; body composition; muscle loss

INTRODUCTION

Monitoring of weight history is important in geriatric care as changes in weight may reflect declining health. Several studies in older adults have reported associations between weight loss and weight cycling (gain and loss of weight) with increased mortality risk.¹⁻⁶ Although most studies have not addressed intention of weight change,¹⁻⁵ it is hypothesized that relationships between weight change and mortality are driven by unintentional or illness related weight change^{3,6} as weight loss trials have reported lower mortality with intentional weight loss.^{7,8} However, previous studies of weight patterns and mortality have rarely explored weight change intention or indices of illness as potential mechanisms.

Excess body weight is a well-defined risk factor for disability in old age.⁹⁻¹¹ Much less is known regarding weight change patterns and risk of developing mobility disability. Arnold et al. reported that weight loss, weight cycling but not weight gain were associated with increased risk of new onset of disability.³ Launer et al. reported that weight loss increased the risk of mobility disability in women but this relationship was not consistent across all age groups.¹⁰

It has been hypothesized but seldom studied, that relationships between weight change and mortality as well as mobility disability may reflect changes in body composition resulting from weight fluctuations. Previous studies have shown that weight cycling leads to greater central body fat,¹²⁻¹⁴ a risk factor for mortality. Weight cycling may also result in net loss of lean tissue as individuals do not completely regain lean tissue lost during periods of weight loss.^{15,16}

The purpose of this study was to examine associations between weight change patterns over a 5-year period and risk of mobility disability and mortality in older adults using data from the Health, Aging, and Body Composition (Health ABC) Study. The second objective was to examine whether the components of weight change; the amount of lean and fat mass differed across weight change patterns at the end of the 5-year period. We hypothesized a priori that weight cycling and weight loss would be associated with increased risk of mobility disability and mortality. We further hypothesized a priori that individuals with weight loss and weight cycling would have disproportionate loss of lean mass relative to fat mass which may help to explain the increased risk of mobility disability and mortality.

METHODS

Study population

The Health ABC study is a prospective, longitudinal cohort study of community-dwelling, initially well-functioning, black and white men and women aged 70-79 years. Participants were recruited from a random sample of white Medicare beneficiaries and all black Medicare-eligible residents in the Memphis, TN, and Pittsburgh, PA areas. Participants were enrolled between April 1997 and June 1998. Eligibility criteria included: 1) no reported difficulty walking one quarter of a mile, climbing 10 steps without resting or performing activities of daily living, 2) no active treatment for cancer in the prior 3 years, 3) no plans to leave the study area for at least 3 years, and 4) no active participation in a lifestyle intervention trial. All participants signed informed consent forms approved by the institutional review boards of the clinic sites.

The main study cohort consisted of 3,075 participants. Of these, 113 were missing dual-energy X-ray absorptiometry (DXA) measurements at year 1, 360 (12%) were deceased before year 6, 453 did not have a clinic visit at year 6, and 174 were missing DXA at year 6. Therefore the analytic sample included 1,975 participants (1,044 women, 931 men, 37% black) with complete DXA measurements at year 1 and year 6. Excluded participants were more likely to be older, black, have lower education, report current smoking, have lower physical activity and lower Health ABC physical performance battery (H_SPPB) score ($P < 0.05$ for all). Excluded participants were more likely to have cancer (men only), diabetes (women only), hypertension, fracture, myocardial infarction and stroke ($P < 0.05$ for all).

Anthropometric measures

An overview of the study timeline is provided in Figure 1. Weight and body composition were measured annually between baseline and year 6. Weight was measured using a balance beam scale and height was measured using a stadiometer. Body mass index (BMI) was calculated in kg/m^2 . A 5% or greater change in weight from year to year or from year 1 to year 6 was used to define weight patterns as a change of at least 5%, is considered clinically significant¹⁷ and exceeds the coefficient of variation (CV) of DXA measurements in Health ABC.¹⁸ Weight was categorized as stable, loss, gain or cycling (gain and loss). Categories were mutually exclusive, for example a participant who gained and lost weight was classified as weight cycling and not as weight losing or gaining. We also examined the %

CV of weight from year 1 to year 6 in relation to mobility disability and mortality to test that potential associations were not an artifact of our definition of weight categories.

Participants were asked if they were intentionally trying to lose or gain weight during annual clinic visits. A high proportion (over 45%) of participants reported trying to lose or gain weight at one or more visit which may lead to misperception regarding intentionality of weight change. Indeed, a detailed analysis of individuals intending to lose weight suggests that intentional versus unintentional weight change cannot be accurately captured.¹⁹ As a result, we used data on hospitalization as an objectively measured index of illness-related, unintentional weight change. Participants were asked to report any hospitalizations that occurred during the study. If a hospitalization was reported, medical records were obtained and verified at each site by the Health ABC Diagnosis and Disease Ascertainment committee. We considered the frequency of hospitalization (overnight stay exceeding 24 hours) and total days in hospital during the 5-year weight change period.

Total mass and total body fat were measured from whole body DXA. DXA scans were performed annually using fan-beam technology (Hologic QDR4500A version 8.20a, Hologic, Waltham, MA). Total non-bone lean mass was determined from the difference between bone mineral content and total lean mass. Soft tissue results were corrected to account for underestimation of fat mass.²⁰ Detailed methods and validation data from DXA have been previously reported.^{18,21} Quality assurance measurements included the use of daily and cross-calibration phantoms at both study sites to ensure scanner reliability. Participant scan protocols were identical between sites and were employed for all participants.

Outcomes

Mobility disability was defined using accepted self-reported measures of physical function^{22,23} associated with physical performance²⁴: two consecutive reports of having any difficulty walking ¼ mile or climbing 10 steps. Reports must have involved the same function. Participants were asked about their function during annual clinic visits and telephone interviews every 6 months for 8 years following the weight change period. If participants reported difficulty at one visit but were deceased before the next 6 month contact mobility difficulty was presumed to persist until death, and the participant was classified with mobility disability. Since the outcome of interest was new onset of mobility disability following the weight change period, we excluded 692 participants (35% of analytic sample) that developed mobility disability during the weight change period, leaving 1,283 participants. Time to event or censorship was calculated from the date of year 6 contact to the date of the first report of difficulty or last completed contact. If participants missed a study visit, target dates for when the visit should have been completed were used to calculate time.

Mortality was determined from death certificates, hospital records and interview with next of kin through August 10, 2011. This represents 8 years of follow-up subsequent to the weight change period. Participants who were not deceased were censored at the date of last completed contact.

Covariates

The end of the 5-year weight change period (year 6) served as the study baseline since our analysis examined risk of mobility disability and mortality subsequent to the weight change period. Thus covariates were chosen a-priori based on year 6 variables. Sociodemographic variables were collected from in-person interviews and clinic based exams. Variables included age, race, study site and education (<high school, high school graduate or >high school). Lifestyle factors included smoking history, alcohol consumption, and physical activity. Smoking was defined as at least 100 cigarettes in a lifetime and characterized as never, former or current. Physical activity was assessed as walking and climbing stairs in the week prior to baseline as described previously.²⁵ Physical performance was assessed using the Health ABC short physical performance battery score (H_SPPB), which is a modification of the lower extremity performance tests used in the Established Populations for the Epidemiologic Studies of the Elderly.²⁴ Depressive symptoms, cancer, diabetes, hip fracture, hypertension, stroke, and myocardial infarction were determined through self-report, medications and clinical assessments at year 1 and aggregated with incident conditions determined over the 5-year weight change period.

Statistical analyses

Two-way interactions between sex and weight change over the 5-year period were found to be significant ($P < 0.0001$), thus analyses were stratified by sex. Interactions between race and weight change were not significant ($P = 0.13$). Descriptive statistics were performed using one-way analysis of variance with Bonferroni post-hoc comparison or chi-square tests. Year 6 weight, lean mass and fat mass were compared by weight change pattern with linear regression adjusted for age, race and study site. Cox proportional hazards models (reference category weight stable) were used to examine sequentially adjusted associations of weight change patterns, with mobility disability and mortality. The proportional hazards assumption was tested using Schoenfeld residuals and was met. Model 1 was adjusted for age, race, education and study site. Model 2 was adjusted for model 1 covariates plus smoking status, physical activity, medical conditions and H_SPPB score. H_SPPB score was excluded from models of mobility disability as it is correlated with physical function. To test for effects of unintentional weight change, Model 3 was adjusted for history of hospitalization and days in hospital. To account for overall weight as well as body composition, Model 4 was adjusted for year 6 lean and fat mass and % change in lean and fat mass from year 1 to year 6. Sensitivity analyses were conducted examining associations between quartiles of % CV of weight with mobility disability and mortality using sequentially adjusted models as in the analysis of weight change patterns. All analyses were performed with STATA version 12.1 (StataCorp, College Station, TX).

RESULTS

Characteristics of participants according to 5-year weight change patterns are shown in Table 1. Age differed by weight pattern: women and men with weight loss and weight cycling were older on average ($P = 0.04$, $P = 0.002$). Across weight patterns, weight cycling women and men were more likely to be black ($P = 0.005$, $P = 0.002$), current smokers ($P = 0.05$, $P = 0.002$) and have lower H_SPPB scores ($P < 0.001$, $P = 0.002$). Overweight BMI was

common in all groups and weight gainers had the highest mean BMI ($P<0.001$). History of hospitalization and days in hospital varied across weight patterns with the highest frequency and days in hospital among those with weight cycling.

The mean ($\pm$ SE) absolute weight change over the 5-year period in women was -0.26kg (± 0.21) for stable; -4.75kg (± 0.20) for loss; 4.59kg (0.28) for gain and -1.01kg (± 0.26) for cycling. In men the absolute weight change was -0.19kg (0.19) for stable; -5.13kg (± 0.20) for loss; 4.48kg (± 0.30) for gain and -1.06kg (± 0.31) for cycling. Body composition at the end of the 5-year period and change in body composition over the 5-year period are shown in Table 2. Weight cycling women did not weigh less than weight stable women but tended to have greater percent weight loss. There were no significant differences in weight between weight stable or weight cycling men. Compared to stable weight, women and men with weight cycling had similar lean and fat mass but the % CV of lean and fat mass was greater in weight cycling women and men than in weight stable.

Over a mean ($\pm$ SD) follow-up of 7.29 (± 2.02) years, 313 women (incidence rate 70.4/1000 person years) and 375 men (incidence rate 76.6/1000 person years) developed mobility disability. Associations between weight patterns and onset of mobility disability are shown in Table 3. Compared to weight stable, weight loss in women and men and weight cycling in women was associated with increased risk of mobility disability (Model 1). The addition of risk factors (Model 2) did not attenuate associations. Adjustment for hospitalization and days in hospital during the weight change period did not attenuate associations (Model 3). The addition of year 6 lean and fat mass and % change in lean and fat mass (Model 4) attenuated relationships for weight loss in men only, although only fat mass ($P=0.01$) and % change in lean mass ($P=0.04$) were independently associated with risk of mobility disability in the models. Relationships with mobility disability were similar for % CV of weight from year 1 to year 6 (Appendix Table 1, on-line).

After a mean ($\pm$ SD) follow-up of 6.62 (± 1.99) years, 322 women (mortality rate 45/1000 person years) and 378 men (mortality rate 63/1000 person years) were deceased. Associations between weight patterns and mortality are shown in Table 4. Compared to stable weight, weight gain was not associated with mortality risk in any model. Compared to weight stable, weight loss and weight cycling were associated with increased mortality risk for women and men (Model 1). Adjustment for risk factors did not attenuate these associations (Model 2). Associations remained after adjustment for hospitalization and days in hospital during the weight change period (Model 3). The addition of year 6 lean and fat mass and % change in lean and fat mass (Model 4) attenuated relationships for weight loss in women and men, although only year 6 fat mass in women was independently associated with mortality risk in the model ($P=0.01$). Relationships with mortality were similar for % CV of weight from year 1 to year 6 (Appendix Table 2, on-line).

DISCUSSION

This study expands our understanding of associations between weight change and risk of mobility disability and mortality in older adults by exploring indices of illness and features of body composition as potential mechanisms. Overall, weight fluctuations were common

and only approximately one-third of participants had stable weight over the 5 year study period. Compared to stable weight, weight gain was not associated with increased risk of mobility disability or mortality. However, in line with our hypothesis, weight loss and weight cycling increased the risk of subsequent mobility disability and mortality independent of other risk factors. Notably, associations between weight cycling and mobility disability and mortality do not appear to be strongly related to body composition.

The relationships between weight change and increased risk of mobility disability and mortality observed here were likely related to unintentional weight change. Intentionality is difficult to truly capture from self-report¹⁹ and may be better examined in the context of clinical trials. Indeed, results from randomized controlled trials of weight loss in older adults support the notion of increased risk reflecting unintentional weight loss as even modest intentional weight loss has been shown to improve function^{26,27} and lower mortality risk.^{7,8}

Compared to stable weight, weight cycling and weight loss were associated with poorer physical function and more comorbid conditions at the end of the 5-year period. However, adjustment for these factors did not attenuate risk estimates for mobility disability and mortality. Hospitalization was explored as an indicator of involuntary weight loss and potential mediator of relationships between weight patterns, mobility disability and mortality. Participants with weight cycling and weight loss had the greatest prevalence of hospitalization and most number of days in hospital. However, periods of illness do not appear to fully explain associations between weight patterns, as adjustment for hospitalization and days of hospitalization did not attenuate associations between weight patterns, mobility disability or mortality.

Our results align with previous studies reporting increased mortality risk and mobility disability with weight loss and/or weight cycling.^{3-6,28} In contrast, some studies have reported no excess mortality risk for weight cycling.^{4,29-31} Discrepancies may be due in part to different age ranges between studies as the significance of weight change in old age is distinct from young and mid-age when individuals are more effective at regulating their weight.³² The definition of weight cycling also differs between studies, variably defined as loss and gain of 3 to 5% or change of 5kg, making cross study comparisons difficult.

Prior studies suggest and we hypothesized that weight cycling may have detrimental effects on health because it leads to a higher proportion of body fat or net loss of lean mass.^{15,16} However, this has seldom been explored and does not appear to be supported by our results. In our analysis weight cycling participants had the greatest % CV of lean and fat mass over the 5-year period but weight stable and weight cyclers had similar lean mass and fat mass at the end of the weight change period. It is possible that the 5-year weight change period in this analysis was not long enough to detect significant alterations in lean and fat mass with weight cycling. However, adjustment for lean mass, fat mass and % change in lean and fat mass did not significantly attenuate risk estimates for weight cycling, mobility disability and mortality, suggesting that associations are not driven by body composition. For weight loss, addition of body composition variables to risk models attenuated associations except for mobility disability in women, but within models lean mass, fat mass

and % change in lean and fat mass were not strongly associated to risk of mobility disability or mortality.

Strengths and limitations

Strengths of this study include the biracial cohort with measured rather than self-reported weight, serial measures of weight and DXA assessments of lean and fat tissue. Participants also had extensive health history including hospitalization and health status at the end of the 5 year characterization period to adjust for the influence of health conditions on weight patterns and mortality. The primary limitation concerns the generalizability to the general population of older adults as individuals in this study were selected to be well functioning at year 1 and we additionally selected participants who had body composition measures at year 1 and year 6, leading to a healthier population. There are also inherent limitations to examining weight change. Unhealthy participants who may be more likely to experience weight fluctuations are also more likely to be lost to follow-up or die during the weight change period. We selected a weight change period of 5 years to allow adequate time for weight cycling to occur, 12% of the population died during this time period. Nonetheless, even in our healthier population, weight fluctuations were common and predictive of mobility disability and mortality.

CONCLUSION

Weight fluctuations are common in old age. Although the optimal means to support weight maintenance in geriatric care is unclear, our results underscore the prognostic importance of weight history whereby weight loss and weight cycling may predict impending mobility disability and mortality in old age. Our results further suggest that monitoring weight should be specifically underscored for individuals who have experienced periods of illness requiring hospitalization, where weight instability is likely. Importantly, information on weight is often a routine part of geriatric care or could be included as a routine measurement and thus, our results may help inform the care of older adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding sources: National Institute on Aging (NIA) Contracts N01-AG-6-2101; N01-AG-6-2103, N01-AG-6-2106; NIA grant R01-AG028050, and NINR grant R01-NR-012459. This research was supported in part by the Intramural Research Program of the NIH, National Institute on Aging. RAM is supported by a Banting Postdoctoral Fellowship.

Sponsor's Role: This work was supported in part by the Intramural Research Program of the National Institute on Aging, National Institutes of Health

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FIGURE 1.
Overview of study time points and follow-up

Table 1
Baseline (year 6 Exam) participant characteristics according to 5-year weight pattern (year 1-year 6)

	Weight Stable	Weight Loss	Weight Gain	Weight Cycling	P value
<i>Women</i>					
N Participants (%)	308 (29.5)	356 (34.1)	179 (17.2)	201 (19.3)	
Age in years, Mean $\pm$ SD	78.1 $\pm$ 2.81	78.5 $\pm$ 2.86	77.9 $\pm$ 2.82	77.8 $\pm$ 2.69	0.04
Black race, n (%)	110 (35.7)	156 (43.8) ^a	69 (38.6)	102 (50.8) ^a	0.005
Education, n (%)					0.17
<High school graduate	52 (16.9)	79 (22.2)	41 (22.9)	51 (25.6) ^a	
High school graduate	116 (37.7)	137 (38.5)	58 (32.4)	74 (37.2)	
Postsecondary	140 (45.5)	140 (39.3)	80 (44.7)	74 (37.2)	
Pittsburgh site, n (%)	148 (48.1)	183 (51.4)	75 (41.9)	91 (45.3)	0.18
BMI in kg/m ² , Mean $\pm$ SD	27.8 $\pm$ 5.17	26.4 $\pm$ 5.04 ^a	29.1 $\pm$ 5.58 ^b	27.4 $\pm$ 5.94	<0.001
<25.0 kg/m ² , n (%)	95 (30.8)	158 (44.4)	46 (25.7)	75 (37.3)	
25.0-29.9 kg/m ² , n (%)	120 (39.0)	116 (32.6)	63 (35.2)	70 (34.8)	
30.0 kg/m ² , n (%)	93 (30.2)	82 (23.0)	70 (39.1)	56 (27.9)	
Current smoking, n (%)	12 (3.89)	28 (7.87) ^b	15 (8.38) ^b	24 (12.0) ^a	0.05
Physical activity in kcal/kg/wk, Mean $\pm$ SD	3.46 $\pm$ 5.34	3.34 $\pm$ 5.05	3.94 $\pm$ 6.41	2.81 $\pm$ 5.39	0.25
CES-D, Mean $\pm$ SD	7.16 $\pm$ 6.3	8.86 $\pm$ 7.57 ^a	9.08 $\pm$ 7.71 ^a	8.48 $\pm$ 7.44	0.008
Cancer, n (%)	69 (22.4)	83 (23.3)	42 (23.5)	50 (24.9)	0.94
Diabetes, n (%)	106 (34.4)	135 (37.9)	53 (29.6)	67 (33.3)	0.28
Hypertension, n (%)	151 (49.0)	183 (51.4)	91 (50.8)	108 (53.7)	0.78
Hip fracture, n (%)	3 (.97)	8 (2.25)	4 (2.23)	3 (1.49)	0.59
Myocardial infarction, n (%)	36 (11.7)	65 (18.3) ^a	23 (12.9)	34 (16.9) ^b	0.08
Stroke, n (%)	21 (6.81)	39 (11.0) ^b	22 (12.3) ^a	18 (8.96)	0.17
H_SPPB, Mean $\pm$ SD	9.39 $\pm$ 2.04	8.85 $\pm$ 2.39 ^a	9.49 $\pm$ 2.05	8.54 $\pm$ 2.59 ^a	<0.001
Hospitalized, n (%)	101 (32.8)	147 (41.3) ^a	73 (40.8) ^b	107 (53.2) ^a	0.001
N days in hospital, Mean $\pm$ SD	2.19 $\pm$ 5.87	4.41 $\pm$ 8.43 ^a	3.86 $\pm$ 8.24	5.56 $\pm$ 10.4 ^a	<0.001
<i>Men</i>					
N Participants (%)	356 (38.2)	306 (32.9)	142 (15.3)	127 (13.6)	

	Weight Stable	Weight Loss	Weight Gain	Weight Cycling	P value
Age in years, Mean $\pm$ SD	78.3 $\pm$ 2.87	78.8 $\pm$ 2.85	77.8 $\pm$ 2.64	78.8 $\pm$ 2.76	0.002
Black race, n (%)	90 (25.3)	100 (32.7) ^a	52 (36.6) ^a	54 (42.5) ^a	0.002
Education, n (%)					
<High school graduate	68 (19.2)	81 (26.5) ^b	38 (26.8) ^a	33 (26.0)	0.01
High school graduate	85 (23.9)	65 (21.2)	46 (32.4)	32 (25.2)	
Postsecondary	202 (56.9)	160 (52.3)	58 (40.9)	62 (48.8)	
Pittsburgh site, n (%)	168 (47.2)	155 (50.7)	68 (47.9)	68 (53.5)	0.60
BMI in kg/m ² , Mean $\pm$ SD	27.1 $\pm$ 3.73	26.0 $\pm$ 38.9 ^a	28.6 $\pm$ 3.69 ^a	27.3 $\pm$ 4.47	<0.001
<25.0 kg/m ² , n (%)	98 (27.5)	127 (41.5)	20 (14.1)	41 (32.5)	
25.0-29.9 kg/m ² , n (%)	189 (53.1)	135 (44.1)	74 (52.1)	55 (43.7)	
30.0 kg/m ² , n (%)	69 (19.4)	44 (14.4)	48 (33.8)	30 (23.8)	
Current smoking, n (%)	20 (5.62)	24 (7.84) ^b	19 (13.4) ^a	20 (15.8) ^a	0.002
Physical activity in kcal/kg/wk, Mean $\pm$ SD	5.79 $\pm$ 8.60	5.92 $\pm$ 9.00	3.98 $\pm$ 5.79	5.08 $\pm$ 7.22	0.09
CES-D score, Mean $\pm$ SD	6.06 $\pm$ 6.32	7.83 $\pm$ 7.18 ^a	7.00 $\pm$ 6.22	7.27 $\pm$ 6.40	0.007
Cancer, n (%)	115 (32.3)	94 (30.7)	43 (30.3)	44 (34.7)	0.84
Diabetes, n (%)	127 (35.7)	134 (43.8) ^a	52 (36.6)	51 (40.2)	0.17
Hypertension, n (%)	139 (39.0)	116 (37.9)	67 (47.2) ^b	55 (43.3)	0.24
Hip fracture, n (%)	2 (0.56)	6 (1.96)	1 (70)	0 (.00)	0.16
Myocardial infarction, n (%)	92 (25.8)	96 (31.4)	40 (28.2)	28 (22.1)	0.19
Stroke, n (%)	30 (8.43)	33 (10.8)	15 (10.6)	16 (12.6)	0.54
H_SPPB, Mean $\pm$ SD	9.91 $\pm$ 1.79	9.45 $\pm$ 2.13 ^a	9.81 $\pm$ 1.87	9.26 $\pm$ 2.19 ^a	0.002
Hospitalized, n (%)	150 (42.3)	169 (55.2) ^a	75 (52.8) ^a	83 (65.4) ^a	<0.001
N days in hospital, Mean $\pm$ SD	2.45 $\pm$ 4.47	5.52 $\pm$ 8.56 ^a	3.83 $\pm$ 7.72	8.04 $\pm$ 10.4 ^a	<0.001

Weight change of 5% from year to year or from year 1 to 6 was used to define weight as stable, loss, gain or cycling (gain and loss of 5%).

^a Significantly different from weight stable, P<0.05;

^b trend towards different from weight stable, P<0.10 from Bonferroni multiple comparison and chi-square pairwise comparison. Abbreviations: BMI, body mass index, CES-D, center for epidemiologic studies depression, H_SPPB, Health ABC short physical performance battery score

Table 2

Body composition changes between Year(Y) 1 and Y6 according to 5-Y weight patterns

	Weight Stable	Weight Loss	Weight Gain	Weight Cycling	P-value
<i>Women</i>					
<i>Weight</i>					
Y6 in kg, Mean $\pm$ SE	70.0 $\pm$ 0.81	66.1 $\pm$ 0.75 ^a	73.6 $\pm$ 1.06 ^a	69.2 $\pm$ 1.00	<0.001
Y1-Y6 % change, Mean $\pm$ SE	-0.28 $\pm$ 0.29	-6.58 $\pm$ 0.27 ^a	6.62 $\pm$ 0.38 ^a	-1.35 $\pm$ 0.35 ^b	<0.001
% CV (Y1 thru Y6), Mean $\pm$ SE	1.63 $\pm$ 0.10	3.70 $\pm$ 0.09 ^a	3.36 $\pm$ 0.12 ^a	4.44 $\pm$ 0.12 ^a	<0.001
<i>Lean mass</i>					
Y6 in kg, Mean $\pm$ SE	38.8 $\pm$ 0.34	38.3 $\pm$ 0.36	39.3 $\pm$ 0.52	39.0 $\pm$ 0.41	0.45
Y1-Y6 % change, Mean $\pm$ SE	-1.48 $\pm$ 0.18	-1.29 $\pm$ 0.19	-1.08 $\pm$ 0.28	-1.46 $\pm$ 0.22	0.55
% CV (Y1 thru Y6), Mean $\pm$ SE	2.11 $\pm$ 0.06	2.41 $\pm$ 0.07 ^a	3.14 $\pm$ 0.09 ^a	3.16 $\pm$ 0.08 ^a	<0.001
<i>Fat mass</i>					
Y6 in kg, Mean $\pm$ SE	29.0 $\pm$ 0.51	27.6 $\pm$ 0.54 ^b	29.9 $\pm$ 0.78	28.4 $\pm$ 0.63	0.17
Y1-Y6 % change, Mean $\pm$ SE	-0.87 $\pm$ 0.35	-2.36 $\pm$ 0.37 ^a	0.53 $\pm$ 0.54 ^a	-0.62 $\pm$ 0.43	<0.001
% CV (Y1 thru Y6), Mean $\pm$ SE	3.79 $\pm$ 0.19	5.42 $\pm$ 0.20 ^a	8.58 $\pm$ 0.29 ^a	8.28 $\pm$ 0.23 ^a	<0.001
<i>Men</i>					
<i>Weight</i>					
Y6 in kg, Mean $\pm$ SE	81.1 $\pm$ 0.69	77.8 $\pm$ 0.74 ^a	83.9 $\pm$ 1.09	80.8 $\pm$ 1.15	<0.001
Y1-Y6 % change, Mean $\pm$ SE	-0.22 $\pm$ 0.22	-6.16 $\pm$ 0.24 ^a	5.67 $\pm$ 0.35 ^a	-1.26 $\pm$ 0.37	<0.001
% CV (Y1 thru Y6), Mean $\pm$ SE	1.5 $\pm$ 0.07	3.5 $\pm$ 0.07 ^a	3.1 $\pm$ 0.10 ^a	4.4 $\pm$ 0.11 ^a	<0.001
<i>Lean mass</i>					
Y6 in kg, Mean $\pm$ SE	53.1 $\pm$ 0.36	53.2 $\pm$ 0.46	52.6 $\pm$ 0.67	53.0 $\pm$ 0.60	0.92
Y1-Y6 % change, Mean $\pm$ SE	-2.50 $\pm$ 0.14	-2.64 $\pm$ 0.18	-3.16 $\pm$ 0.26 ^a	-2.93 $\pm$ 0.24	0.09
% CV (Y1 thru Y6), Mean $\pm$ SE	1.95 $\pm$ 0.05	2.41 $\pm$ 0.07 ^a	2.99 $\pm$ 1.00 ^a	3.42 $\pm$ 0.09 ^a	<0.001
<i>Fat mass</i>					
Y6 in kg, Mean $\pm$ SE	24.7 $\pm$ 0.39	24.6 $\pm$ 0.49	25.0 $\pm$ 0.72	25.1 $\pm$ 0.64	0.94
Y1-Y6 % change, Mean $\pm$ SE	1.42 $\pm$ 0.41	0.94 $\pm$ 0.51	5.60 $\pm$ 0.75 ^a	2.51 $\pm$ 0.67	<0.001
% CV (Y1 thru Y6), Mean $\pm$ SE	4.42 $\pm$ 0.18	6.52 $\pm$ 0.22 ^a	8.92 $\pm$ 0.32 ^a	9.51 $\pm$ 0.29 ^a	<0.001

Means of lean mass and fat mass adjusted for change in weight from year 1-year 6, P value from Wald statistic to test for an overall effect of categorical weight patterns

^a Significantly different from weight stable, $P < 0.05$;

^b trend towards different from weight stable, $P < 0.10$ from Bonferroni multiple comparison. Abbreviation: % CV, coefficient of variation.

Table 3Association of 5-year weight patterns year 1-year 6 with new onset mobility disability^a

	No. at risk	No of events	Rate per 1,000 person-years	Model 1 ^b HR (95% CI)	Model 2 ^c HR (95% CI)	Model 3 ^d HR (95% CI)	Model 4 ^e HR (95% CI)
<i>Women</i>							
Weight stable	194	90	59.2	1.00	1.00	1.00	1.00
Weight loss	198	117	81.5	1.67 (1.27-2.21)	1.82 (1.36-2.44)	1.88 (1.40-2.53)	1.67 (1.19-2.34)
Weight gain	108	53	63.7	1.33 (0.95-1.87)	1.24 (0.86-1.77)	1.23 (0.85-1.76)	1.33 (0.89-2.00)
Weight cycling	93	53	80.3	1.49 (1.06-2.11)	1.60 (1.13-2.27)	1.59 (1.11-2.29)	1.55 (1.07-2.23)
<i>Men</i>							
Weight stable	284	139	66.0	1.00	1.00	1.00	1.00
Weight loss	225	137	87.3	1.39 (1.09-1.76)	1.33 (1.03-1.72)	1.30 (1.01-1.69)	1.09 (0.81-1.47)
Weight gain	99	55	78.6	1.27 (0.93-1.74)	1.19 (0.86-1.64)	1.15 (0.83-1.60)	1.37 (0.95-1.97)
Weight cycling	82	44	84.6	1.35 (0.96-1.90)	1.18 (0.83-1.68)	1.15 (0.80-1.66)	1.15 (0.80-1.65)

^aThe number of participants varies from analysis of mortality due to exclusion of 692 participants who developed mobility disability during the weight change period

Abbreviations: CI, confidence interval, HR, hazard ratio

^bModel 1 adjusted for age, race, education, and study site^cModel 2 adjusted for Model 1 covariates, BMI, smoking status, physical activity, depressive symptoms, cancer, diabetes, hip fracture, hypertension, myocardial infarction and stroke^dModel 3 adjusted for Model 2 covariates, incidence of hospitalization and days of hospitalization^eModel 4 adjusted for Model 3 covariates, year 6 lean mass, year 6 fat mass, % change lean mass (year 1 thru year 6), % change fat mass (year 1 thru year 6)

Table 4

Association of 5-year weight patterns (year 1-year 6) with mortality

	No. at risk	No of events	Rate per 1,000 person-years	Model 1 ^a		Model 2 ^b		Model 3 ^c		Model 4 ^d	
				HR	(95% CI)	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Women											
Weight stable	308	66	30.0		1.00		1.00		1.00		1.00
Weight loss	356	130	55.7		1.86 (1.38-2.51)		1.52 (1.11-2.07)		1.47 (1.07-2.01)		1.30 (0.92-1.83)
Weight gain	179	46	36.2		1.23 (0.84-1.80)		1.23 (0.83-1.82)		1.21 (0.81-1.79)		1.37 (0.90-2.08)
Weight cycling	201	78	61.8		2.10 (1.51-2.94)		1.69 (1.20-2.39)		1.62 (1.15-2.30)		1.61 (1.14-2.28)
Men											
Weight stable	356	113	46.2		1.00		1.00		1.00		1.00
Weight loss	306	142	74.8		1.55 (1.21-1.99)		1.51 (1.14-1.91)		1.41 (1.09-1.83)		1.24 (0.92-1.67)
Weight gain	142	56	59.9		1.27 (0.92-1.75)		1.27 (0.86-1.68)		1.16 (0.83-1.62)		1.31 (0.91-1.89)
Weight cycling	127	67	93.1		2.02 (1.49-2.74)		2.00 (1.47-2.72)		1.50 (1.08-2.08)		1.45 (1.04-2.03)

Abbreviations: CI, confidence interval, HR, hazard ratio

^aModel 1 adjusted for age, race, education, and study site

^bModel 2 adjusted for Model 1 covariates. BMI, smoking status, physical activity, depressive symptoms, cancer, diabetes, hip fracture, hypertension, myocardial infarction, stroke and the Health ABC short physical performance battery score

^cModel 3 adjusted for Model 2 covariates, incidence of hospitalization and days of hospitalization

^dModel 4 adjusted for Model 3 covariates, year 6 lean mass, % change lean mass (year 1 thru year 6), % change fat mass (year 1 thru year 6)