Journal of Gerontology: MEDICAL SCIENCES
Cite journal as: J Gerontol A Biol Sci Med Sci
2010 Vol. 65A, No. 1, 78–83
doi:10.1093/gerona/glp042

Advance Access published on April 14, 2009

Special Issue: Obesity in Older Persons

Weight Loss and Regain and Effects on Body Composition: The Health, Aging, and Body Composition Study

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Background. Older adults are less able to conserve lean mass relative to fat mass with weight change. A cycle of weight loss and regain in an older individual could accelerate sarcopenia. We examined whether older adults experiencing weight loss and regain would show a greater loss of lean mass during a weight-loss period than gain in lean mass during the weight-regain period, thus have overall a greater net loss of lean mass compared with those who maintained weight in the Health, Aging, and Body Composition Study.

Methods. We compared the body composition change in 147 older weight changers (54% women, 38% black) with the gender- and race-matched weight-stable individuals over the weight-cycling period. A weight cycle was defined as weight loss of 3% or more with regain of within ±3% of baseline weight for a period of 2 years.

Results. Both men and women showed significantly lower total body mass after the weight loss and regain. Proportionally, more lean mass was lost during the weight-loss period than was gained during the weight-regain period, especially in men. After weight regain, men showed only a slightly lower lean mass than the stable group, and this was not statistically significant, although the failure to fully regain total weight explained most of the deficit in lean mass after the weight cycle.

Conclusion. These data suggest that weight loss even with regain may contribute to a net loss of lean mass in older men but warrant further studies.

Key Words: Weight cycle—Body composition—Older adults.

WITH advancing age, human beings lose lean mass, but the rate of loss is influenced by body weight change (1). With weight change, relatively greater lean mass was lost in individuals with weight loss than was gained in other individuals who had a weight gain, particularly in older men (2). These findings suggested that if an individual older adult experiences a cycle of loss with subsequent regain, the resulting body composition might be expected to become more sarcopenic than if weight had been maintained.

There are contradictory theories about the deleterious metabolic, physiological, behavioral, and health consequences of weight cycling, including a change in body composition to a higher proportion of body fat (3–12). Studies of the changes in body composition in weight cycling in middle-aged obese dieters, however, show a strong tendency to return to starting body composition (12,13). Older adults who have been shown to be less effective in regulating weight may be less able to conserve lean mass with weight cycling than younger adults. However, little is known about the prevalence of weight cycling in older adults using objectively measured weight (not to mention the lack of generally agreed upon definition of weight cycling) and the composition of the weight change across the weight-cycling period among relatively healthy older adults.

The purpose of this study was to examine whether individuals who were observed to experience a single weight cycle (loss and then regain) would differ in body composition change compared with those who maintained weight, using data from the Health, Aging, and Body Composition (Health ABC) Study cohort. We examined whether (a) the body composition of the weight lost in the weight-loss period differed from that of the weight-gain period, (b) the overall body composition was different before and after the weight cycle, and (c) the final body composition after the weight cycle differed between weight cyclers and weight-stable persons. We hypothesized that older adults with a weight cycle might show an accelerated loss of lean mass.

Methods

Study Population

The Health ABC Study is a longitudinal investigation of the relationship between changes in body composition and functional decline. The Health ABC Study enrolled 3,075 community-dwelling black and white men and women aged 70–79 years. Participants were recruited from a random sample of white and all black Medicare-eligible residents in designated ZIP code areas in and around Pittsburgh, Pennsylvania, and Memphis, Tennessee. Individuals were eligible if they reported no difficulty walking one fourth of a mile, climbing up 10 steps, or performing basic activities of daily living; were free of life-threatening illness; planned to remain in the geographic area for at least 3 years; and were not enrolled in lifestyle intervention trials. The protocol was approved by the institutional review boards of the participating institutions, and all study participants gave informed consent.

Body Composition

Health ABC Study measured whole- and regional body composition annually by fan-beam dual-energy x-ray absorptiometry (DXA; QDR 4500A; Hologic Inc, Waltham, MA). The validity and reproducibility of the body composition data in the Health ABC Study have been reported previously (14–19). Quality assurance measures included use of a body composition phantom for cross-calibration and a phantom at each site for longitudinal monitoring.

Body Composition Change

This study used total mass, total body bone-free lean mass, total bone-free appendicular lean mass (sum of bone-free lean mass of legs and arms), and total body fat mass, measured by DXA between baseline and 4-year follow-up. Consecutive annual and overall changes across weight-cycling period (weight-loss period, weight-regain period, and total weight-cycling period) in each body composition compartment were calculated as both absolute and percent change. The composition of each body composition compartment of the baseline weight and of the weight change across the weight-cycling period was also calculated.

Consecutive annual total body weight change was also categorized into loss (≥3% of loss), stable (within ±3% change), and gain (≥3% of gain). This 3% cutoff point was used in previous studies (2,20), is within the reported coefficient of variation for DXA soft tissue mass, and is a recommended range to determine weight maintenance (21).

Weight Cycling/Fluctuation and Weight-Stable Group

For the purpose of this study, we defined weight cycling as weight loss of 3% or more of baseline weight for the first-year follow-up period and regain to within ±3% of baseline weight by the second-year follow-up. This definition allowed us to choose as homogeneous a weight-cycle group as possible. Of 2,654 participants who had both baseline and first-year follow-up DXA data, 489 and 381 participants had lost and gained 3% or more of baseline weight for the first-year follow-up period, respectively. The remaining participants maintained within ±3% of their baseline weight. Of 489 participants who had weight loss (53.3% women, 46.1% black), 147 participants (4.8% of the original Health ABC cohort; 51.0% women, 38.1% black) regained within ±3% of their baseline weight in the following year. The remainder of 489 participants mostly continued to lose weight (n = 263) or gained (n = 9) more than 3% of baseline weight, or did not have the second-year follow-up DXA data (n = 70).

To compare with the weight-change group, we used a conservative approach to randomly select the same number of gender- and race-matched weight-stable group who maintained overall and consecutive annual weight change within ±3% of their baseline weight by using all available weight data by the time when the analysis was conducted (n = 303, using 4-year data or five consecutive observations).

Thus, the final analytic sample for this study included the cycling group and a gender- and race-matched weight-stable group (n = 294).

Other Variables

This analysis included sociodemographic factors (age, race, gender) that are known to influence weight and weight change. Comorbidity was examined by summing the total of 11 conditions (i.e., cancer, coronary heart disease, congestive heart failure, high blood pressure, knee osteoarthritis, peripheral artery disease, diabetes, pulmonary disease, depression, osteoporosis, and ulcer), and assessed by self-report and validated with medication review at baseline. Hospitalization was defined as an overnight stay of more than 24 hours in an acute care hospital and was ascertained at 6-month intervals by interview at the annual clinic visit or in on 6-month phone call and was confirmed by review of medical records. We created a variable of having any interim hospitalization over the weight-change period and used it as an indicator of potential unintentional weight change.

Detailed information on causes of weight change over the weight-cycle period was not available; thus, we included relevant information available at baseline including impaired appetite (report of moderate/poor/very poor appetite in the past month (22)), weight-loss intention (report of trying to lose weight at the present time (23)), and following a special diet.

Statistical Analysis

Descriptive statistics were used to describe demographics and baseline body composition of the analytic sample by weight-change group. Because body composition pattern between men and women is significantly different, analyses were conducted separately as was done in our previous study (2). Differences in means and proportions of baseline characteristics by gender and weight-cycling group were tested using student's *t* tests and chi-square tests. Differences in means of change in body composition by gender across weight-cycling period (weight-loss period, weight-regain period, and total weight-cycling period) were tested using paired *t* tests. Analysis of covariance was used to determine the main effects of weight-cycling category on changes in total body bone-free lean mass and appendicular lean mass across weight-cycling period for a period of 2 years while controlling for potential confounders (including age, race, initial body composition, and total weight change) in men and women, separately. All analyses were done using SAS software (version 9.1; SAS Institute Inc, Cary, NC (24)).

Results

The baseline characteristics of the study sample are shown in Table 1. As expected, starting body composition differed by gender: Women had a substantially higher body fat, whereas men had higher lean and appendicular lean mass. Weight-loss intention did not differ by weight-change group or by gender. The weight-cycling group was more likely to report a greater number of chronic conditions, poorer appetite, and following special diets at baseline, and have any interim hospitalization during the weight-cycling period than stable group.

The mean absolute and proportional changes in body composition throughout the weight-change period by gender

Table 1. Baseline Characteristics of Study Sample by Weight-Cycling Group and Gender

	Weight-Cycle Group (*N* = 147)		Weight-Stable Group* (*N* = 147)	
Weight-Cycling Group Characteristics	Men (*N* = 72, 49.0%)	Women (*N* = 75, 51.0%)	Men (*N* = 72, 49.0%)	Women (*N* = 75, 51.0%)
Age, y (mean ± *SD*)	74.01 ± 2.60	72.97 ± 2.81†	73.78 ± 3.02	73.15 ± 2.83
Black, %‡	27.8	48.0†	27.8	48.0†
Education <12 y, %‡	29.2	26.7	22.2	17.3†
Smoking status, %‡		†		†
Current	5.6	4.2	2.8	5.3
Former	59.7	30.7	61.1	37.3
Never	34.7	65.3	36.1	57.3
Currently trying to lose weight, %	29.2	28.0	25.0	32.0
Reported impaired appetite, %§	11.1	18.7	4.2	4.0
Currently on special diet, %§	30.6	26.7	18.1	17.3
Baseline body composition and anthropometrics (mean ± *SD*)				
Total body weight, kg‡	83.14 ± 13.97	71.10 ± 12.36†	80.17 ± 11.65	70.44 ± 13.55†
Height, cm‡	173.10 ± 6.15	159.32 ± 6.35†	174.69 ± 6.49	159.36 ± 5.56†
Body mass index, kg/m^2‡	27.69 ± 4.00	28.09 ± 5.12	26.56 ± 3.26	27.69 ± 5.10
Lean mass, kg‡	55.42 ± 7.15	39.56 ± 5.19†	54.16 ± 6.30	39.08 ± 5.87†
Appendicular lean mass (ALM), kg‡	24.32 ± 3.86	16.58 ± 2.73†	23.72 ± 3.75	16.54 ± 3.31†
Total fat mass, kg‡	25.10 ± 7.90	29.69 ± 8.23†	23.34 ± 6.39	29.41 ± 8.52†
Lean mass/total body weight, %‡	67.19 ± 4.87	56.27 ± 5.36†	67.95 ± 4.34	56.05 ± 4.73†
ALM/total body weight, %‡	29.43 ± 2.99	23.49 ± 2.37†	29.80 ± 3.64	23.54 ± 2.11†
Fat mass/total body weight, %‡	29.62 ± 5.22	41.08 ± 5.66†	28.68 ± 4.66	41.13 ± 4.94†
Baseline comorbidity, %§		†		
0	25.0	22.7	26.4	26.7
1	31.9	29.3	36.1	38.7
2	12.5	32.0	26.4	25.3
≥3	30.6	16.0	11.1	9.3
Having any interim hospitalization (%)				
During the weight-cycle period	30.6	28.0	19.4	16.0

Notes: *Matched on race and gender to weight-cycle group.

† Significantly different by gender within each weight-cycling group at $p < .05$ (Student's *t* test for continuous variable and chi-square test for categorical variables).

‡ Significantly different by gender at $p < .05$ (Student's *t* test for continuous variable and chi-square test for categorical variables).

§ Significantly different by weight-cycling group at $p < .05$ (Student's *t* test for continuous variable and chi-square test for categorical variables).

Table 2. Absolute Changes in Body Composition in Each Weight-Cycling Period in Men and Women (mean ± *SD*)

	Weight-Cycle Group						Weight-Stable Group	
	Start	After Loss	Change After Loss	After Regain	Change After Regain	Final Net Change	Start	End
Men			*n* = 72				*n* = 72	
Total body weight, kg	83.14 ± 13.97	79.50 ± 13.27*	−3.64 ± 1.23	82.61 ± 13.69*,†	3.11 ± 1.45	−0.53 ± 1.28	80.17 ± 11.65	80.34 ± 11.70*
Lean mass, kg	55.42 ± 7.15	53.54 ± 6.80*	−1.89 ± 1.29	54.47 ± 7.00*,†	0.93 ± 1.36	−0.96 ± 1.39	54.16 ± 6.30	53.81 ± 6.24*
Total ALM, kg	24.32 ± 3.86	23.08 ± 4.07*	−1.24 ± 2.28	23.95 ± 3.79*,†	0.87 ± 2.38	−0.37 ± 0.74	23.72 ± 3.75	23.67 ± 3.66
Total fat mass, kg	25.10 ± 7.90	23.38 ± 7.50*	−1.73 ± 1.34	25.58 ± 7.85*,†	2.21 ± 1.59	0.48 ± 1.43	23.34 ± 6.39	23.90 ± 6.61*
Women			*n* = 75				*n* = 75	
Total body weight, kg	71.10 ± 12.36	67.75 ± 11.75*	−3.35 ± 1.30	70.36 ± 12.32*,†	2.60 ± 1.58	−0.75 ± 1.07	70.44 ± 13.55	70.59 ± 13.59
Lean mass, kg	39.56 ± 5.19	38.50 ± 4.79*	−1.06 ± 1.14	39.30 ± 5.08†	0.80 ± 1.39	−0.26 ± 1.32	39.08 ± 5.87	39.08 ± 6.10
Total ALM, kg	16.58 ± 2.73	16.09 ± 2.56*	−0.50 ± 0.68	16.55 ± 2.60†	0.47 ± 0.88	−0.03 ± 0.84	16.54 ± 3.31	16.58 ± 3.37
Total fat mass, kg	29.69 ± 8.23	27.41 ± 8.05*	−2.29 ± 1.58	29.23 ± 8.29*,†	1.82 ± 1.67	−0.46 ± 1.43	29.41 ± 8.52	29.59 ± 8.31

Notes: ALM: appendicular lean mass.
*Significantly different from baseline at $p<.05$ (paired *t* test).
†Significantly different from after loss at $p<.05$ (paired *t* test).

are shown in Tables 2 and 3, respectively. Both men and women lost proportionally more lean mass during the weight-loss period than was regained in the weight-regain period (at $p <.0001$ for both men and women). The percent change in fat mass was relatively greater than the percent change in lean mass during both weight-loss and weight-regain periods, particularly in women. In the weight-stable group, men showed a small loss of lean mass and gained total body weight and fat mass.

Although weight cyclers were within ±3% of their initial weight, the final weight was not completely back to their baseline weight. Both men and women showed significantly lower total body weight than that at baseline. Men showed significantly lower mean absolute lean mass and proportion of lean mass relative to total mass compared with their stable counterparts, whereas women showed significantly lower mean absolute fat mass and proportion of fat mass relative to total mass when compared with women in the stable group.

Changes in lean mass were further examined using gender-specific linear regression models predicting the loss of lean mass across the weight-cycling period between the weight-cycle group and the weight-stable group while adjusting for the magnitude of the total weight change, the starting body composition, age, and race during the weight-loss and weight-regain period (Table 4). For each kilogram of weight lost during the weight-loss period, there was an average of 0.42 kg of lean mass lost in men and 0.06 kg of lean mass lost in women. For each kilogram of weight gained during the weight-gain period, there was an average of 0.37 kg of lean mass gained in men and 0.32 kg of lean mass gain in women. However, only the magnitude of the total weight change during the weight-cycle period was significantly related with the loss or gain in lean mass over the weight-cycle period but the weight-cycle group did not show statistically significantly different composition of the lean mass lost or regained in either men or women. Black

Table 3. Mean ± *SD* Percentage Changes in Body Composition Across the Weight-Cycling Period—Lean and Fat Mass Composition at Baseline, and Composition of Weight Change During the Weight-Loss and Weight-Regain Period

%	Baseline Body Composition	Lean and Fat Mass Change*	
		Loss Period	Regain Period
Men			
Lean mass	67.19 ± 4.87	52.40 ± 33.21†	28.16 ± 74.91†,‡
Fat mass	29.62 ± 5.22	46.70 ± 66.54†	72.99 ± 76.68†
Women			
Lean mass	56.27 ± 5.36	33.38 ± 34.06†	28.07 ± 77.51†,‡
Fat mass	41.08 ± 5.66	66.54 ± 33.80†	73.27 ± 80.49†

Notes: *Adjusted for age, race, and baseline body composition.
†Significantly different from baseline composition at $p < .05$ (paired *t* test).
‡Significantly different from weight-loss period composition at $p < .05$ (paired *t* test).

Table 4. Adjusted Total Lean Mass Change per Total Weight Change (kg) Over the Weight-Cycling Period in Models Stratified by Weight-Cycling Period and Gender*

β Coefficients (*SEM*)	Lean Change Adjusted for Age, Race, and Baseline Body Composition		
	Loss Period	Regain Period	Cycling Period
Men			
Total weight change (kg)	0.42 (0.13)†	0.37 (0.11)†	0.45 (0.12)†
Baseline age (y)	−0.13 (0.06)†	0.14 (0.06)†	0.01 (0.06)
Black	0.09 (0.31)	−0.19 (0.33)	−0.11 (0.34)
Baseline lean mass (kg)	−0.05 (0.02)	0.02 (0.02)	−0.02 (0.02)
Intercept	11.8 (4.57)†	−11.7 (5.07)	−0.17 (5.13)
R^2	.2839	.2029	.2106
Women			
Total weight change (kg)	−0.06 (0.11)†	0.32 (0.11)	0.32 (0.14)†
Baseline age (y)	−0.03 (0.04)	0.003 (0.06)	−0.05 (0.05)
Black	0.18 (0.25)	−0.43 (0.32)	−0.22 (0.31)
Baseline lean mass (kg)	−0.10 (0.03)	−0.004 (0.03)	−0.06 (0.03)
Intercept	4.72 (3.53)†	0.02 (4.49)	5.91 (4.30)
R^2	.2121	.1581	.1330

Notes: *Analysis of covariance was used to determine the main effects of weight-cycling category on changes in total body bone-free lean mass across weight-cycling period for a period of 2 years while controlling for age, race, baseline lean mass, and total weight change in men and women, separately.
†Statistical significance at $p < .05$.

race, age, and baseline body composition were also not statistically significantly related to changes in lean mass during the weight-cycling period, nor was interim hospitalization or weight-loss intention (data not shown). The results were consistent for appendicular lean mass.

Discussion

To our knowledge, this is the first study to identify natural history and body composition change that are associated with a single weight cycle in relatively healthy community-dwelling older men and women. As hypothesized, this study demonstrates that the composition of weight change within older individuals was different between weight-loss and weight-regain period. Although overall changes were greater in fat mass than lean in both men and women, proportionally more lean mass relative to total body mass was lost during weight-loss period than was gained during weight-regain period, especially in men. After the single weight-change cycle, only men showed a trend of slightly lower absolute and proportional lean mass than the stable group. These data confirm previous findings that there is a failure to conserve lean mass with weight loss in old age (1,2,13).

It is important to note that both men and women did not completely recover the weight lost even after an apparent weight cycle. The failure to fully regain the total weight after the weight cycle explained a large part of the deficit in lean mass after the weight cycle than any other factors including experiencing a weight cycle, baseline body composition, interim hospitalization, race, and age. Our data and those of others (13,25,26) document that older adults who experienced weight fluctuation were more likely to report or to experience poor health status than their counterparts who maintained weight. Thus, along with the asymmetry in body composition–change pattern between weight loss and regain, older adults who are prone to losing weight or failing to regain the weight may be at a greater risk for excessive loss of lean mass.

Similar to the findings from our earlier report (2) and others (13), men are more likely to have unfavorable relative changes in lean mass than women over a single weight cycle, which was not explained by the men's greater initial lean mass or by their worse health status. Men are known to experience age-related weight loss earlier and greater than are women (27,28), but it is unclear why it happens. There may be other aspects of poorer health in men that we did not take into account for in our analyses including the declining concentrations of sex steroid hormones.

Strengths of this study include the selection of weight cyclers in the large sample of community-dwelling older men and women and annual quantification of body composition by using DXA with careful calibration. However, this study has limitations. First, generalization of these findings to the older population is limited because the study participants were well functioning and relatively healthy at baseline. Our participants may have had a better ability to maintain a stable body weight or energy balance than did the persons who were excluded. Indeed, many of older weight cyclers were able to return to close to their original body composition over time if they regain close to the weight lost. Second, the findings of this study focusing on a single weight cycle for a period of 2 years may not be generalized to other types of weight cycling with different frequency of weight cycle, duration of each weight cycle, magnitude of weight change in each cycle, and intentionality of weight loss. Third, the number of our elderly participants with a 2-year weight cycle was too small to sort out whether the results vary by reasons for the weight cycle. Unintentional weight loss is often associated with the presence of either severe disease or unrecognized health problems (29,30) and is more likely to continue than intentional weight loss or gain (26). Unintentional weight gain was reported to be mainly due to changes in exercise and eating habits in the subsample of the Health ABC Study (26). Due to limited information, however, we were unable to examine how different causes and circumstances of weight loss or regain in our weight cyclers could influence body composition. An improved understanding on the natural history of weight fluctuation and patterns of weight change in population-based studies, such as the Health ABC Study, will provide insights to better define weight cycling and to understand further its health risks in older adults.

Our data suggest that weight cycling may contribute to a net loss of lean mass especially in older men. However, many of these older individuals demonstrated an ability to regain weight and lean mass to values very close to starting body composition. Our findings warrant further studies to better understand and develop strategies to maintain weight and lean mass for continued health, independence, and successful aging in older adults.

Funding

Supported by National Institute on Aging contracts N01-AG-6-2101, N01-AG-6-2103, and N01-AG-6-2106. This research was supported in part by the Intramural Research Program of the National Institutes of Health, National Institute on Aging.

Acknowledgment

The abstract of this article was presented at the Experimental Biology meeting, May 1, 2007.

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Received November 19, 2008
Accepted February 18, 2009
Decision Editor: Luigi Ferrucci, MD, PhD