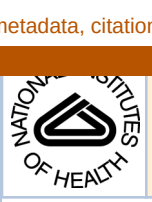



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# Differences in Cardiovascular Disease Risk Factors by Weight History: The Aerobics Center Longitudinal Study

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## Abstract

The objective of this study was to compare cardiovascular disease (CVD) risk factor levels in adults with a history of weight loss to levels in adults who did not lose weight, after both groups subsequently experienced an approximate 1-year interval of weight maintenance. Extant data from the Aerobics Center Longitudinal Study (ACLS) were used to identify 5,151 adults who were weight maintainers (maintained weight within ±3.0% over two consecutive periods of ~1 year) or weight-loss maintainers (lost >3.0–<5.0% or ≥5.0% of body weight in the first interval and maintained that loss in the second interval). Mixed models regression was used to accommodate repeated measures and adjust for gender, age, smoking, cardiorespiratory fitness, decade of clinic visit, interval length, and BMI at the time of risk factor measurement. Coefficients from the model were used to calculate the adjusted risk factor levels in the three groups. Differences in total cholesterol (−3.8 mg/dl, 95% confidence interval: −5.5, −2.0), low-density lipoprotein (LDL) cholesterol (−3.0 mg/dl, confidence interval: −4.8, −1.1), triglycerides (−6.1 mg/dl, confidence interval: −10.6, −1.7) and diastolic blood pressure (−0.8 mg/dl, confidence interval: −1.4, −0.3) indicated that levels were slightly more favorable in the ≥5.0% weight-loss maintenance group than weight maintenance group. Levels were similar for glucose, high-density lipoprotein (HDL) cholesterol and systolic blood pressure. This work indicates that, when adjusted for covariates including current BMI, adults with a history of weight loss may have CVD risk factors to levels as good, or perhaps even better than, those observed in adults who maintain their weight.

## INTRODUCTION

The health benefits of weight loss among overweight individuals are well-known (1), however, the effects of weight history are less well-studied. For example, little is known about the question: can an overweight adult expect that if they lose weight, they will obtain the risk factor profile of an individual (of the same weight) who was not previously



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overweight? Analogous information is known for smoking, another modifiable behavioral risk factor for cardiovascular disease (CVD). Evidence from longitudinal studies has shown that the risk of CVD decreases 50% 1 year after quitting smoking; and after 15 years, the relative risk of coronary heart disease mortality is similar for former and never smokers (2).

Our group has examined the impact of weight history using extant data from the Atherosclerosis Risk in Communities (ARIC) study (3,4). We found that normal weight adults who were overweight 3 years prior have similar glucose, high-density lipoprotein (HDL) cholesterol and triglyceride levels and more favorable total and low-density lipoprotein (LDL) cholesterol levels compared to normal weight adults with a history of weight maintenance (3). Adjusting for differences in BMI, we found that men who were previously heavier (3 years prior) had systolic and diastolic blood pressure levels lower than those of men who maintained their weight (4). In women, blood pressure levels were similar in the two groups. These findings suggested that, in regard to levels of classic CVD risk factors, formerly overweight adults who lose weight do not have increased risk as a result of being overweight in the past; in fact they may even have more favorable levels of some risk factors.

It is possible that these results (similar or more favorable CVD risk factors in those previously overweight) were driven by negative energy balance since individuals who have lost weight must have experienced negative energy balance and negative energy balance is known to be associated with improvements in CVD risk factors (1,5–7). Although the timing of weight loss and changes in energy balance were not measured within the 3-year interval studied, it seems reasonable to assume that the ARIC participants in the weight-loss group were more likely to have experienced negative energy balance in the year prior to assessment than the participants who maintained their weight. This issue could not be effectively studied using data from ARIC but could be examined using other data such as the Aerobics Center Longitudinal Study (ACLS). The objectives of the present study were to compare levels of glucose, lipids, and blood pressure in adults with a history of weight loss to levels in adults who did not lose weight, when both groups subsequently experienced an approximate 1-year interval of weight maintenance. We hypothesize that the more favorable risk factor levels observed in the group with a history of weight loss in our previous work will be extinguished or reversed when both groups experience a weight maintenance interval prior to measurement.

## METHODS AND PROCEDURES

### Study population

The ACLS is a prospective epidemiologic study of participants who received a preventive medical examination at the Cooper Clinic in Dallas, TX. The majority of the participants were well-educated non-Hispanic whites. The procedures used in the ACLS have been well-described (8,9). All participants gave informed consent to participate in the clinical examination and follow-up and for use of their examination data for research purposes. The study was approved by the institutional review board of Cooper Institute, and this analysis was approved by the institutional review board of University of North Carolina at Chapel Hill Public Health on research involving human subjects.

### Clinical examination

CVD risk factors examined include fasting glucose, total, LDL, and HDL-cholesterol, triglycerides and systolic and diastolic blood pressure. Participants were instructed to fast 12-h prior to clinic examination. Serum samples were analyzed for lipids and glucose by automated techniques. Total cholesterol and triglycerides were measured since 1970 and HDL-cholesterol was measured after 1978. LDL-cholesterol was calculated using the

Friedewald formula (10). LDL-cholesterol was not calculated if the participant's triglyceride levels were >400 mg/dl. All blood chemistries were performed in the Cooper Clinic laboratory, which meets quality control standards of the US Centers for Disease Control and Prevention Lipid Standardization Program. Blood pressure was measured with mercury manometers while the participant was sitting according to the American Heart Association protocol.

Height (cm) and body weight (kg) were measured according to standard procedures using a stadiometer and balance beam scale, respectively. BMI was calculated as weight in kilograms divided by height in meters squared. Percent weight change was calculated between consecutive clinic visits using the weight at the beginning of the interval as the denominator. Weight change was categorized as follows: ≥5.0 percent weight loss; >3.0–<5.0 percent weight loss; weight maintenance (within 3.0%); and >3.0% weight gain. Justification for defining weight maintenance as a change of in weight of 3.0% is detailed in a previous publication (11).

Age and gender were self-reported at each clinic visit. Based on participants responses to several questions on current and past smoking habits, we created four smoking status categories (never, former, current, and unknown). Since the clinic visits occurred over a long time period (30 years), we created a decade variable (1970s, 1980s, or 1990s) so that we could control for any period effects. Cardiorespiratory fitness was evaluated using a modified Balke maximal exercise test protocol performed on a treadmill (12).

### Study design

In order to take advantage of the multiple measurements (3–25 visits per subject), we identified all sets of three consecutive visits (time 1, 2 and 3) for each subject. We included the set of observations in a stacked data set if: (i) the interval length between time 1 and time 2 was between 2 and 24 months; (ii) the participant experienced weight loss (>3.0 percent of body weight) or weight maintenance (±3.0%) between time 1 and time 2; (iii) the interval length between time 2 and time 3 was between 6 and 24 months; and (iv) the participant maintained their body weight between time 2 and time 3. The analysis sample included 5,151 participants with 15,935 observations. Approximately 41% of the participants had only one observation, 20% had two observations, 11% had three observations, 23% had four to nine observations and 5% had ten to twenty-two observations.

### Statistical analyses

Repeated measures regression (PROC MIXED procedure with autoregressive order one in SAS, version 9.1 (SAS Institute, Cary, NC) was used to construct longitudinal models of weight history. The LSMEANS option was used with the PROC MIXED procedure to estimate the adjusted mean risk factor levels. Covariates included gender and age, BMI, smoking status, cardiorespiratory fitness, decade of clinic visit and interval length between examinations. The mean CVD risk factor levels were estimated based on the population prevalence or mean for each covariate except BMI, which was set at 25.0 $kg/m^2$.

## RESULTS

Demographic characteristics of participants with a history of weight-loss maintenance or weight maintenance are shown in **Table 1**. Participants with a history of weight maintenance were older, more likely to be males, had better cardiorespira-tory fitness at time 1 and time 2, and had fewer clinic visits during the 1970's compared to participants with a history of weight loss. Cigarette smoking tended to be similar between the weight history groups. By design, the mean BMI was higher at time 1 for the participants with a history of large and

small weight loss compared to the history of weight maintenance group, 26.2, 25.1, and 24.6 kg/m$^2$, respectively. At time 2 and time 3, the mean BMI was slightly lower among weight losers (24.2 and 24.3 kg/m$^2$) compared to weight maintainers (24.6 and 24.7 kg/m$^2$). In addition, weight maintainers had slightly smaller percent weight change during the weight maintenance phase (time 2 to time 3) compared to large and small weight losers, 0.2, 0.6 and 0.5%, respectively.

Glucose, lipid and blood pressure levels by weight history group are shown in **Table 2**. As expected, given the BMI differences at time 1, we found significant differences between participants with a history of large and small weight loss vs. a history of weight maintenance for all CVD risk factors at time 1 except glucose among small weight losers. Approximately 1 year later after weight loss or maintenance (time 2) and setting the mean BMI the same in both groups, the results varied depending on which metabolic risk factor was examined. Participants with a history of large weight loss had significantly more favorable glucose (−1.0 mg/dl), total cholesterol (−3.0 mg/dl), LDL-cholesterol (−3.0 mg/dl), and triglycerides (−7.4 mg/dl) than participants with a history of weight maintenance. In contrast, we found no significant difference at time 2 between the two groups for HDL-cholesterol and systolic and diastolic blood pressure. Compared to participants with a history of weight maintenance, participants with a history of small weight loss had similar levels for all CVD risk factors examined except HDL-cholesterol.

At the end of the second interval (time 3), during which all groups maintained their weight, glucose, HDL-cholesterol and systolic blood pressure levels were similar between the large weight losers and weight maintainers. In contrast, differences were statistically significant and more favorable among participants with a history of large weight loss (followed by weight maintenance) compared to participants with a history of weight maintenance (followed by a second maintenance phase) for total cholesterol (−3.8 mg/dl), LDL-cholesterol (−3.0 mg/ dl), triglycerides (−6.1 mg/dl), and diastolic blood pressure (−0.8 mm Hg). CVD risk factors remained similar between small weight loss maintainers and weight maintainers.

## DISCUSSION

We found that participants with a history of large weight loss (≥5.0%) followed by weight maintenance had a lower total cholesterol, LDL-cholesterol, triglycerides, and diastolic blood pressure levels compared to weight maintainers. For glucose, HDL-cholesterol and systolic blood pressure, levels were similar between the two groups, but point estimates all tended to be more favorable (lower for glucose and systolic blood pressure and higher for HDL-cholesterol) in the large weight-loss history group. Contrary to our study hypothesis, similar results were found before (time 2) and after (time 3) the weight maintenance interval for the CVD risk factors examined. In addition, these findings are consistent with our earlier studies that used data from the ARIC cohort and found similar or more favorable levels of cardiovascular risk factors among adults with a history of large weight loss compared to those who maintained their weight (3,4). This similarity in results from the ARIC and ACLS cohorts was found despite several differences in the study design, most notable of which was that all participants in the current study experienced a period of weight maintenance over an average interval of ~400 days prior to the end point measurement. The weight maintenance interval, added to the current study design, was hypothesized to extinguish or reverse the finding of similar or more favorable risk factor levels in adults with a large weight-loss history compared to adults with a history of weight maintenance. We did not find support for this hypothesis.

The studies differed in that triglycerides were the same in the ARIC cohort but more favorable in the ACLS cohort. In the study of the ARIC cohort, analyses were limited to adults who were normal weight at the end point; whereas, no weight status restriction was applied in the current study. When only participants who were normal weight at end point were included in the current analysis, results for all the risk factors were the same in the two studies.

It is plausible that adults with a history of large weight loss were more physically active than those who maintained weight. Our analyses controlled for cardiorespiratory fitness as a surrogate measure for physical activity. We also examined the interaction between fitness and weight history group, and it was not significant for any of the risk factors studied. In addition, (as shown in **Table 1**) the cardiorespiratory fitness levels in the two weight history groups were almost identical at time 2. Therefore, it is unlikely that differences in cardiorespiratory fitness levels or physical activity account for our results.

Although the specific research question addressed here has not been previously studied, there are several studies that are pertinent to our findings (10–14). French *et al.* used data from the Iowa Women's Health Study to compare diabetes prevalence among weight stable women and weight-loss maintainers (13). Weight stable was defined as ±5.0% weight change between age 18 and 30 and ±5.0% between age 30 and 50. Weight loss maintainers were defined as losing at least 10% between age 18 and 30 and maintaining (±5%) their weight between age 30 and 50. Among women who were not overweight at age 18, the prevalence of diabetes at age 62 was similar between weight-stable and weight-loss maintainers. In contrast, among women who were overweight at 18, the diabetes prevalence was higher among the weight stable compared to the weight-loss maintainers (10 vs. 2.5%).

Moore *et al.* found similar results using data from the Framingham study (14). The weight-loss maintenance group was defined as losing >8 pounds over 8 years, then maintaining (±8 pounds) weight over the next 8 years. The referent group (weight maintainers) was defined as maintaining weight (±8 pounds) over the first and second 8-year periods. In participants with a BMI ≥27.0 kg/m$^2$ at baseline, the authors found a 29% lower risk of developing diabetes among the weight-loss maintainers compared to the referent group (weight maintainers). The results from French *et al.* (13) and Moore *et al.* (14) were consistent with our findings for glucose. Different from our work, neither the French nor Moore study controlled for follow-up weight or BMI.

Dixon *et al.* compared obese adults who sustained weight loss for at least 3 years after laparoscopic adjustable gastric banding surgery to weight stable (BMI: 30–35 kg/m$^2$) controls (15). There was a small but significant difference in mean attained BMI in the weight-loss group (33.0 kg/m$^2$) compared to mean BMI for the controls (33.4 kg/m$^2$). However, no significant differences were found between the two groups for weight, waist and hip circumferences or waist-to-hip ratio. Subjects in the weight-loss group had more favorable glucose (4.81 vs. 5.01 mmol/l), triglyceride (1.25 vs. 1.58 mmol/l), and HDL (1.58 vs. 1.37 mmol/l) levels compared to obese weight stable controls. There was no difference in total cholesterol, LDL-cholesterol, or systolic and diastolic blood pressure, but all tended to be more favorable among the weight losers. The authors concluded that weight history (i.e., weight loss) had benefits that were independent of attained weight.

The Swedish Obesity Study has shown that marked weight loss induced by gastric surgery improved or completely resolved hypertension in approximately two-thirds of participants (16,17). However, 8-year results showed that the beneficial effects of surgically induced weight loss on blood pressure were not maintained after 3 years (18). It should be noted that,

on average, patients began steadily regaining weight after 1 year although weight losses remained substantial, even at the end of 8 years.

Wolf and Grundy completed a well-controlled study of 17 patients in a metabolic ward (19). Obese subjects underwent a 4–5 week period of weight maintenance, followed by caloric restriction until a weight within 10% of ideal body weight was obtained, followed finally by another 4–5 weeks of weight maintenance. Triglyceride levels dropped and HDL levels rose during the weight-loss phase, and changes were sustained during subsequent weight maintenance. In contrast, total cholesterol and LDL levels decreased early in the weight-loss phase, but began to rise near the end of the caloric restriction period, and in the final weight maintenance period were similar to preweight loss levels. Thus, both the Swedish Obesity studies (16,17) and the study by Wolf and Grundy (19) indicated that some of the benefits of weight loss may be transient. Different from our work, there was no comparison to a control at the same attained weight.

One limitation of our study is that the ACLS study cohort is predominately composed of well-educated white men, and therefore results may not be generalizable to other populations. It would have been preferable to randomize subjects to weight loss and weight maintenance over the 2-year study period. Since there was no randomization, this observational study is susceptible to bias. We used regression analysis to statistically adjust for differences in BMI at end point in this study, and this adjustment can be imperfect. However, when we restricted the analysis to only adults who were normal weight at end point we found similar results for all risk factors examined except triglycerides (data not shown).

In summary, the results of the current study show that adults with a history of higher weight can achieve equivalent or more favorable CVD risk factor profiles compared to those of adults with a history of weight maintenance, when BMI levels are the same. In addition, given the similar pattern of results after a weight maintenance phase it is not likely that the results were influenced greatly by negative energy balance. This work has important public health implications since it indicates that weight loss can restore CVD risk factors to levels as good, or perhaps even better, than those observed in adults of similar BMI who maintained their weight.

## Acknowledgments

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## Table 1

Demographic characteristics of analysis sample by weight history group, the Aerobic Clinic Longitudinal Study, 1970–2000

| | Weight history group | | |
|---|---|---|---|
| | **Large weight-loss maintainers[a] (≥5.0% → ±3.0%) (*n* = 1,010)** | **Small weight-loss maintainers[b] (±3–±5.0% → ±3.0%) (*n* = 1,276)** | **Weight maintainers[c] (±3.0% → ±3.0%) (*n* = 13,649)** |
| Gender (% male) | 89.9* | 91.5 | 92.1 |
| *Age (years, (s.d.))* | | | |
| At time 1 | 49.4 (10.0)* | 50.1 (10.1)* | 50.8 (9.7) |
| At time 2 | 50.5 (10.0)* | 51.2 (10.1)* | 51.9 (9.7) |
| At time 3 | 51.6 (10.0)* | 52.3 (10.1)* | 53.0 (9.7) |
| *BMI (kg/m$^2$, (s.d.))* | | | |
| At time 1 | 26.2 (2.9)* | 25.1 (2.9)* | 24.6 (2.8) |
| At time 2 | 24.2 (2.5)* | 24.2 (2.8)* | 24.6 (2.8) |
| At time 3 | 24.3 (2.6)* | 24.3 (2.8)* | 24.7 (2.8) |
| *Weight change (%, (s.d.))* | | | |
| Between time 1 and time 2 | –7.8 (3.1)* | –3.8 (0.6)* | 0.1 (1.5) |
| Between time 2 and time 3 | 0.6 (1.5)* | 0.5 (1.5)* | 0.2 (1.5) |
| *Smoking status (%)* | | | |
| At time 1 | | | |
| Current | 12.0 | 12.2* | 12.0 |
| Former | 53.9 | 51.2 | 53.6 |
| Never | 24.4 | 27.3 | 28.3 |
| Unknown | 9.8 | 9.3 | 6.1 |
| At time 2 | | | |
| Current | 12.2 | 12.0* | 11.5 |
| Former | 54.0 | 51.4 | 54.4 |
| Never | 24.1 | 27.3 | 28.1 |
| Unknown | 9.8 | 9.3 | 6.1 |
| At time 3 | | | |
| Current | 12.0 | 12.5 | 10.8 |
| Former | 54.4 | 50.9 | 55.2 |
| Never | 23.9 | 27.3 | 27.9 |
| Unknown | 9.8 | 9.3 | 6.1 |
| *Decade of clinic visit (%)* | | | |
| At time 1 | | | |
| 1970s | 36.2* | 32.8* | 25.6* |
| 1980s | 47.2 | 50.2 | 52.6 |
| 1990s | 16.5 | 16.9 | 21.8 |

| | Weight history group | | |
|---|---|---|---|
| | **Large weight-loss maintainers[a] (≥5.0% → ±3.0%) (*n* = 1,010)** | **Small weight-loss maintainers[b] (±3–±5.0% → ±3.0%) (*n* = 1,276)** | **Weight maintainers[c] (±3.0% → ±3.0%) (*n* = 13,649)** |
| At time 2 | | | |
| 1970s | 30.8* | 27.7 | 20.2 |
| 1980s | 47.7 | 51.3 | 52.9 |
| 1990s | 21.5 | 20.9 | 26.9 |
| At time 3 | | | |
| 1970s | 26.1* | 22.1* | 15.2 |
| 1980s | 48.2 | 52.6 | 52.3 |
| 1990s | 25.6 | 25.3 | 32.5 |
| *Cardiorespiratory fitness (min, (s.d.))* | | | |
| At time 1 | 16.5 (5.0)* | 18.2 (4.9)* | 19.5 (4.8) |
| At time 2 | 19.3 (4.9)* | 19.6 (4.8) | 19.7 (4.8) |
| At time 3 | 19.3 (5.0) | 19.5 (4.9) | 19.6 (4.8) |
| *Interval length (days, (s.d.))* | | | |
| Between time 1 and time 2 | 394.8 (103.1) | 400.7 (92.5) | 396.6 (83.1) |
| Between time 2 and time 3 | 398.4 (85.8) | 398.0 (81.8) | 402.0 (86.5) |

[a] Participants who lost ≥5.0% of their body weight between time 1 and time 2 and their interval length was between 2 and 24 months and maintained (±3.0%) their body weight for interval 2 (time 2 to time 3) and their interval 2 length was between 6 and 24 months.

[b] Participants who lost ±3.0–±5.0% of their body weight between time 1 and time 2 and their interval length was between 2 and 24 months and maintained (±3.0%) their body weight for interval 2 (time 2 to time 3) and their interval 2 length was between 6 and 24 months.

[c] Participants who maintained (±3.0%) their body weight between time 1 and time 2 and their interval length was between 2 and 24 months and maintained (±3.0%) their body weight for interval 2 (time 2 to time 3) and their interval 2 length was between 6 and 24 months.

* Significantly different ($P < 0.05$) than weight maintainers.

**Table 2**

Adjusted mean levels for glucose, lipids and blood pressure at time 1, 2 and 3 by weight history group, the Aerobic Clinic Longitudinal study, 1970–2000

| | Weight history groups | | | | | | Difference between weight maintainers and[d] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Large weight-loss maintainers[a] (≥ 5.0% → ± 3.0%) | | Small weight-loss maintainers[b] (±3 to ±5.0% → ± 3.0%) | | Weight maintainers[c] (± 3.0% → ± 3.0%) | | Large weight-loss maintainers | | Small weight-loss maintainers | |
| | Mean | (95% CI) | Mean | (95% CI) | Mean | (95% CI) | Mean | (95% CI) | Mean | (95% CI) |
| *Glucose (mg/dl)* | | | | | | | | | | |
| Time 1 | 100.9 | (100.0, 101.8) | 99.5 | (95.7, 100.3) | 98.9 | (98.6, 99.2) | 2.1* | (1.1, 3.0) | 0.6 | (–0.2, 1.5) |
| Time 2 | 97.9 | (97.0, 98.8) | 98.8 | (98.0, 99.6) | 98.9 | (98.6, 99.2) | –1.0* | (–1.9, –0.1) | –0.1 | (–0.9, 0.7) |
| Time 3 | 98.7 | (97.5, 99.6) | 99.2 | (98.3, 100.0) | 99.2 | (98.9, 99.5) | –0.5 | (–1.5, 0.4) | –0.0 | (–0.9, 0.8) |
| *Total cholesterol (mg/dl)* | | | | | | | | | | |
| Time 1 | 223.0 | (221.1, 224.9) | 215.0 | (213.4, 216.6) | 209.5 | (208.6, 210.4) | 13.5* | (11.7, 15.3) | 5.5* | (3.9, 7.1) |
| Time 2 | 204.8 | (203.0, 206.6) | 206.5 | (204.9, 208.1) | 208.7 | (207.0, 208.7) | –3.0* | (–4.8, –1.3) | –1.3 | (–2.8, 0.2) |
| Time 3 | 203.6 | (201.8, 205.4) | 206.7 | (205.1, 208.3) | 207.3 | (206.5, 208.2) | –3.8* | (–5.5, –2.0) | –0.6 | (–2.1, 0.9) |
| *LDL-cholesterol (mg/dl)* | | | | | | | | | | |
| Time 1 | 148.6 | (146.5, 150.7) | 142.3 | (140.5, 144.1) | 137.2 | (136.3, 138.2) | 11.3* | (9.3, 13.4) | 5.0* | (3.3, 6.8) |
| Time 2 | 133.1 | (131.1, 135.0) | 134.9 | (133.2, 136.5) | 136.1 | (135.2, 136.9) | –3.0* | (–4.9, –1.1) | –1.2 | (–2.8, 0.4) |
| Time 3 | 132.2 | (130.4, 134.1) | 134.9 | (133.3, 136.4) | 135.2 | (134.4, 136.0) | –3.0* | (–4.8, –1.1) | –0.3 | (–1.9, 1.2) |
| *HDL-cholesterol (mg/dl)* | | | | | | | | | | |
| Time 1 | 52.7 | (51.9, 53.7) | 54.5 | (53.6, 55.3) | 55.7 | (55.1, 56.4) | –2.9* | (–3.6, –2.3) | –1.3* | (–1.8, –0.7) |
| Time 2 | 48.8 | (48.1, 49.5) | 48.5 | (47.9, 49.1) | 49.1 | (48.7, 49.4) | –0.3 | (–0.9, 0.4) | –0.6* | (–1.1, –0.1) |
| Time 3 | 49.4 | (48.7, 50.0) | 49.3 | (48.8, 49.9) | 49.5 | (49.2, 49.8) | –0.1 | (–0.8, 0.5) | –0.2 | (–0.7, 0.3) |
| *Triglycerides (mg/dl)* | | | | | | | | | | |
| Time 1 | 144.5 | (140.2, 148.8) | 132.2 | (128.4, 136.1) | 116.2 | (114.3, 118.1) | 28.3* | (24.0, 32.7) | 16.1* | (12.3, 19.8) |
| Time 2 | 107.9 | (103.9, 111.9) | 113.2 | (109.6, 116.7) | 115.1 | (113.4, 116.8) | –7.2* | (–11.2, –3.2) | –1.9 | (–5.5, 1.6) |
| Time 3 | 108.9 | (104.5, 113.3) | 115.4 | (111.5, 119.3) | 115.0 | (113.2, 116.9) | –6.1* | (–10.6, –1.7) | 0.4 | (–3.6, 4.3) |
| *Systolic blood pressure (mm Hg)* | | | | | | | | | | |

| | Weight history groups | | | | | | Difference between weight maintainers and[d] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Large weight-loss maintainers[a] (≥ 5.0% → ± 3.0%) | | Small weight-loss maintainers[b] (±3 to ±5.0% → ± 3.0%) | | Weight maintainers[c] (± 3.0% → ± 3.0%) | | Large weight-loss maintainers | | Small weight-loss maintainers | |
| | Mean | (95% CI) | Mean | (95% CI) | Mean | (95% CI) | Mean | (95% CI) | Mean | (95% CI) |
| Time 1 | 123.9 | (123.2, 124.6) | 122.1 | (121.5, 122.8) | 120.6 | (120.3, 121.0) | 3.2* | (2.5, 4.0) | 1.5* | (0.8, 2.1) |
| Time 2 | 120.3 | (119.6, 121.0) | 120.2 | (119.5, 120.8) | 120.5 | (120.2, 120.8) | –0.2 | (–0.9, 0.5) | –0.4 | (–1.0, 0.3) |
| Time 3 | 120.4 | (119.6, 121.1) | 120.8 | (120.1, 121.4) | 120.9 | (120.6, 121.2) | –0.5 | (–1.3, 0.2) | –0.1 | (–0.7, 0.6) |
| *Diastolic blood pressure (mm Hg)* | | | | | | | | | | |
| Time 1 | 81.7 | (81.2, 82.2) | 80.6 | (80.2, 81.1) | 79.6 | (79.4, 79.8) | 2.1* | (1.6, 2.6) | 1.0* | (0.5, 1.4) |
| Time 2 | 79.1 | (78.6, 79.6) | 79.3 | (78.9, 79.8) | 79.6 | (79.4, 79.8) | –0.5 | (–1.0, 0.0) | –0.2 | (–0.7, 0.2) |
| Time 3 | 78.9 | (78.4, 79.4) | 79.3 | (78.9, 79.8) | 79.7 | (79.5, 79.9) | –0.8* | (–1.4, –0.3) | –0.4 | (–0.8, 0.1) |

Time 1 models were adjusted for gender and age, smoking status and decade of clinic visit at time 1. Time 2 models were adjusted for gender and age, body mass index, smoking status, cardiorespiratory fitness and decade of clinic visit at time 2, and interval length between time 1 and time 2. Time 3 models were adjusted for gender and age, body mass index, smoking status, cardiorespiratory fitness and decade of clinic visit at time 3, and interval length between time 2 and time 3.

CI, confidence interval; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

[a] Participants who lost ≥5.0% of their body weight between time 1 and time 2 at time 2 and their interval length was between 2 and 24 months and maintained (±3.0%) their body weight for interval 2 (time 2 to time 3) and their interval 2 length was between 6 and 24 months.

[b] Participants who lost >3.0–<5.0% of their body weight between time 1 and time 2 and their interval length was between 2 and 24 months and maintained (±3.0%) their body weight for interval 2 (time 2 to time 3) and their interval 2 length was between 6 and 24 months.

[c] Participants who maintained (±3.0%) their body weight between time 1 and time 2 and their interval length was between 2 and 24 months and maintained (±3.0%) their body weight for interval 2 (time 2 to time 3) and their interval 2 length was between 6 and 24 months.

[d] A positive mean difference equals the mean for weight losers minus mean for weight maintainers.

* Significantly different ($P < 0.05$) than weight maintainers.

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