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Nine-Year Changes in Cardiovascular Disease Risk Factors with Weight Maintenance in the Atherosclerosis Risk in Communities Cohort

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Abstract

Few studies have focused on the impact of weight maintenance on cardiovascular disease risk factors or addressed whether changes differ by baseline weight status and medication usage. The authors examined these issues using 9 years of follow-up data on 3,235 men and women from the Atherosclerosis Risk in Communities (ARIC) Study who were aged 45–64 years at baseline (1987–1989). In participants not using medications, glucose (3.0 mg/dl, 95% confidence interval (CI): 2.4, 3.5) and triglycerides (10.1 mg/dl, 95% CI: 8.3, 11.9) increased, while total cholesterol (−9.6 mg/dl, 95% CI: −10.6, −8.6), low density lipoprotein cholesterol (−9.9 mg/dl, 95% CI: −10.9, −9.0), and high density lipoprotein cholesterol (−1.7 mg/dl, 95% CI: −2.1, −1.3) decreased. Systolic blood pressure (7.9 mmHg, 95% CI: 7.3, 8.4) increased, but diastolic blood pressure (−1.1 mmHg, 95% CI: −1.4, −0.7) declined. Normal weight (body mass index: 18.5–<25.0 kg/m^2) participants had smaller increases in glucose compared with obese (body mass index: ≥30.0 kg/m^2) participants. In contrast, the authors found less favorable changes in total, low density lipoprotein, and high density lipoprotein cholesterol, triglycerides, and diastolic blood pressure among normal weight compared with obese participants who maintained their weight. These patterns were similar across weight status groups regardless of medication usage.

Keywords

blood pressure; cholesterol; HDL; cholesterol; LDL; glucose; obesity; triglycerides; weight gain; weight loss

Many types of weight loss programs have shown some success in reducing body weight in the short term but little success in maintaining weight loss in the long term. In recognition of the importance of weight maintenance, investigators are now developing and testing interventions designed specifically to promote weight maintenance (1–4). Weight maintenance is important, not just for individuals who have lost weight, but also for adults in general. On average, Americans gain weight throughout early and middle adulthood, and this trend may continue through the sixth or seventh decade (5–10).

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It is reasonable to hypothesize that maintenance of an obese weight might be associated with less favorable changes in risk factors than maintenance of a leaner weight. The presence of excessive amounts of subcutaneous and visceral adipose tissue could drive deleterious changes in risk. On the other hand, changes in risk factors with weight maintenance could be more favorable in obese individuals if their risk factors had reached a threshold level beyond which further increases over time were attenuated. Either way, the effects of weight maintenance could differ depending on baseline weight status. We know of only one study that has examined the influence of baseline weight on changes in risk factors among individuals who have maintained their weight (11). That study, conducted in young adults, did not examine changes with and without medications. Risk factor levels are less favorable in obese than in normal weight individuals, and obese adults are more likely to be taking medications designed to control or lower risk factors. This could complicate comparisons among weight status groups. In addition, types and usage of medications change over time, and responses to medications could be associated with body weight.

The primary objective of this study was to describe changes in cardiovascular disease risk factors in individuals who maintained their weight over a 9-year interval. We also examined whether changes in risk factors differed by baseline weight status (normal weight, overweight, or obese) in individuals who maintained their weight. We focused separately on individuals who did not use medications in order to estimate changes that were unaffected by pharmaceutical interventions and also compared patterns in risk factor changes with medications. The cardiovascular disease risk factors examined were fasting glucose; triglycerides; total, low density lipoprotein (LDL), and high density lipoprotein (HDL) cholesterol; and systolic and diastolic blood pressure.

MATERIALS AND METHODS

Study population

The Atherosclerosis Risk in Communities (ARIC) Study is a prospective investigation of the natural history and etiology of atherosclerosis and cardiovascular disease. Between 1987 and 1989, population-based samples of White and African-American adults, 45–64 years of age, were studied in four US communities: Forsyth County, North Carolina; Jackson, Mississippi; the northwestern suburbs of Minneapolis, Minnesota; and Washington County, Maryland. A total of 15,792 participants were included in the baseline data collection. A 9-year follow-up visit took place between 1996 and 1998 with two intermediate visits at approximately 3 and 6 years. The details of the study design have been described previously (12). This study was approved by the institutional review board at each field center, and this analysis was approved by the University of North Carolina at Chapel Hill School of Public Health institutional review board on research involving human subjects.

Measures and covariates

Study participants were instructed to fast for 12 hours prior to their clinic visit. At each clinic visit, blood samples were drawn and sent to the Central Clinical Chemistry Laboratory in Minneapolis, Minnesota, for glucose determination. Serum glucose was measured by the hexokinase/glucose-6-phosphate dehydrogense method. For lipid determinations, blood samples were sent to the Central Lipid Laboratory in Houston, Texas, which participated in the Centers for Disease Control and Prevention's Lipids Standardization Program. Plasma total cholesterol (13) and triglycerides (14) were determined by enzymatic methods. HDL cholesterol was measured after dextran-magnesium precipitation (15). The Friedewald method was used to calculate LDL cholesterol (16). LDL cholesterol was not calculated for participants with triglyceride levels of ≥400 mg/dl (4.52 mmol/liter). Systolic and diastolic blood pressure was measured three times after a 5-minute rest by use of a random zero

sphygmomanometer on the right arm of the seated participant. The average of the last two measures was used for the analysis.

Body weight was measured at all clinic visits in a scrub suit to the nearest pound (1 pound = 0.45 kg) by use of a beam balance scale. Height (without shoes) was measured to the nearest centimeter using a metal rule attached to a wall and a standard triangular headboard. Body mass index (weight (kg)/height $(m)^2$) was categorized as normal weight (18.5–<25.0 kg/m^2), overweight (25.0–<30.0 kg/m^2), or obese (≥30.0 kg/m^2).

Participants were classified as weight maintainers if they met one of the two following conditions: 1) 9-year follow-up weight was ±3.0 percent of baseline weight, or 2) baseline and follow-up weights were ±3.0 percent of the average weight calculated for each participant over all visits during the 9-year interval. A recent review recommended that weight maintenance be defined as ±3.0 percent (17). Among participants who attended the 9-year examination, 99 percent had a measured weight for at least three of the four visits, and 95 percent had weights at all four visits. Among the weight maintainers, 73.0 and 87.8 percent met the first and second definitions, respectively, and 60.8 percent met both definitions.

To measure weight fluctuation, we calculated the root mean squared error around the regression line of weight in relation to age for each subject, using all available measured weights. This indicated weight fluctuation independent of the overall trend in weight.

Age (date of birth), race/ethnicity, and gender were self-reported during the recruitment phase and confirmed during the clinic visit. Additional covariates assessed by interviewer-administered questionnaires at baseline included education level, physical activity, and diet. We categorized education as less than a high school education, high school graduate, or at least some college. Physical activity was assessed with the Baecke leisure time physical activity questionnaire (18) and categorized using tertiles. A 66-item, semi-quantitative food frequency questionnaire was used to assess diet (19). The specific aspects of diet examined included total energy, total dietary fat, saturated fat, dietary cholesterol, and dietary fiber and the percentage of calories from total dietary fat.

At each visit, participants self-reported their cigarette smoking status and alcoholic beverage consumption and were categorized as current, former, or never cigarette smokers and as current, former, seldom/rare, or never alcoholic beverage consumers. In addition, participants self-reported taking medications for high blood pressure or diabetes or high blood sugar in the past 2 weeks. They were asked to bring all medications taken during this period to the clinic examination, and the names of all medications were transcribed, coded, and then mapped to Medi-Span Therapeutic Classification codes and American Hospital Formulary Service Classification Compilation codes. The former codes for vitamin B_3 and antihyperlipidemic and bile sequestrants or the latter code for antilipemic agents was coded for lipid-lowering medications.

Samples for analyses

It is standard ARIC protocol to exclude African Americans from the Washington County, Maryland, or Minneapolis, Minnesota, centers (n = 55), as well as participants who classified their ethnicity as other than White or African American (n = 48), because they were too small in number to allow ethnic- and center-specific analyses. In addition, we excluded participants who met one of the following conditions: 1) died prior to visit 4 (n = 1,441); 2) did not attend the 9-year examination (n = 2,661); 3) had missing baseline (n = 20) or 9-year follow-up (n = 34) weight; 4) was underweight at baseline (n = 78); 5) had diabetes, stroke, cancer, or heart disease at baseline (n = 2,029); 6) had unknown prevalent

disease status at baseline (n = 443); 7) reported fasting less than 8 hours at baseline (n = 159) or follow-up (n = 209); 8) had missing any outcome variable at baseline (n = 184) or follow-up (n = 145); 9) had missing pertinent covariates (n = 101); or 10) did not meet weight maintenance criteria (n = 4,950). The final analysis data set included 1,147 normal weight, 1,333 overweight, and 755 obese White and African-American men and women.

Statistical analysis

Mean values, standard deviations, and percentages were used to describe weight maintainers overall and to compare across baseline weight status categories. All four race-gender groups were combined for these analyses, as we found no significant interactions of gender or race with weight change. Because not all four field sites included Whites and African-American participants, we created a race-center variable (five levels). Generalized linear models adjusted for age, education, and race-center were used to estimate and compare the mean level of each cardiovascular disease risk factor at baseline and follow-up.

A priori variables for inclusion in the multivariable linear regression models included race-center, gender, age, education level, and interval length. The final full models also included baseline smoking status, baseline alcoholic beverage consumption status, absolute weight change, weight fluctuation, and medication usage at baseline or follow-up (when applicable). We examined analyses that adjusted for self-reported physical activity, dietary cholesterol, total fat, saturated fat, dietary fiber, and energy intake at baseline and alcohol consumption and smoking status at follow-up. None of these adjustments changed our mean estimates by an amount as large as 3 percent of one standard deviation. The LSMEANS option was used with the PROC GENMOD procedure (SAS Institute, Inc., Cary, North Carolina) to estimate the adjusted mean 9-year change and 95 percent confidence interval for each outcome by baseline weight status group and to determine if there were significant differences ($p < 0.05$) in the magnitude and direction of the changes between groups. Similar analyses were conducted after stratifying weight maintainers by medication usage. For lipids and blood pressure, individuals on medication were also stratified into three mutually exclusive groups (follow-up only; baseline only; or baseline and follow-up). Data were analyzed using SAS, version 9.1, software (SAS Institute, Inc.).

RESULTS

Among all ARIC participants with 9 years of follow-up data, 39.3 percent met our criteria for weight maintenance, whereas 39.5 percent of the participants who met our other inclusion criteria maintained their weight. Characteristics of the sample for analysis are shown in table 1. At baseline, 35 percent of weight maintainers were normal weight, 41 percent were overweight, and 23 percent were obese. This is similar to the baseline weight status distribution in the entire ARIC cohort: 32 percent, 39 percent, and 28 percent, respectively. Given that our definition of weight maintenance was based on a percentage change in weight, it was expected that the absolute amount of weight change would be smallest among normal weight participants, intermediate among overweight participants, and largest among obese participants. The differences were small, and however expressed, the mean changes were near zero. The mean weight fluctuation, as measured by the root mean squared error, was larger in heavier participants. Overall, the root mean squared error was correlated with baseline body mass index (r = 0.26), indicating that participants who were heavier at baseline had greater weight fluctuations. There were few changes in smoking status over the 9-year interval, although the percentage of former smokers tended to increase. Obese participants were less likely to consume alcohol and were less physically active. Total energy and total and saturated fat intake were significantly different by weight status, with overweight participants having the highest intake. The percentages of calories from fat and dietary cholesterol intake were slightly lower in normal weight participants

compared with overweight and obese participants. Overweight and obese participants were more likely than normal weight participants to be taking diabetes, lipid-lowering, and antihypertensive medications at follow-up.

Table 2 shows the age-, gender-, race-, and field site-adjusted means for the seven risk factors at baseline and at the 9-year follow-up. At baseline, the risk factor levels were most favorable in normal weight participants and least favorable in obese participants, with overweight participants intermediate. At follow-up, total and LDL cholesterol did not follow this trend, and the estimate was highest among overweight participants, although differences were not statistically significant.

The fully adjusted 9-year mean changes in glucose and lipids are shown in figure 1. When examining baseline body mass index (continuous), we found significant linear associations with 9-year change in glucose, systolic blood pressure, diastolic blood pressure, and triglycerides. We found a quadratic association between baseline body mass index and 9-year changes in total and LDL cholesterol. There was no significant association between baseline body mass index and 9-year changes in HDL cholesterol. In general, there were unfavorable changes over time in glucose, HDL cholesterol, and triglycerides but favorable changes in total and LDL cholesterol. When comparing body mass index categories (weight status), we found that normal weight maintainers had smaller increases in glucose (2.2 mg/dl) compared with overweight (3.8 mg/dl) and obese (8.6 mg/dl) weight maintainers. In contrast, for all lipid parameters measured, changes tended to be least favorable in normal weight participants and most favorable in obese participants.

Similar analyses are shown for systolic and diastolic blood pressure in figure 2. Over the study period, there were increases in systolic blood pressure but decreases in diastolic blood pressure. There were no significant differences in 9-year changes in systolic blood pressure by baseline weight status. However, normal weight maintainers had less favorable changes (−1.6 mmHg) in diastolic blood pressure compared with overweight (−2.5 mmHg) and obese (−3.4 mmHg) weight maintainers.

We examined the two-way interactions between medications and weight status for all the changes in risk factors. It was significant only for glucose ($p < 0.0001$) and appeared to be driven by the difference in the relative sizes of the changes in normal weight compared with overweight maintainers in the medication usage categories. Table 3 illustrates that medications had large effects on the 9-year changes in lipids and blood pressure in the expected directions. For glucose, being on a glucose-lowering medication was a marker for diabetes, and the participants who developed diabetes over the follow-up had larger increases in glucose levels, despite taking medications. Overall, in participants who did not take medications at baseline or follow-up and maintained their weight, fasting glucose, triglycerides, and systolic blood pressure increased. HDL cholesterol also became less favorable (declined). However, total cholesterol, LDL cholesterol, and diastolic blood pressure became more favorable over the 9-year period (declined). The direction of trends in changes in risk factors among weight status groups was generally the same regardless of medication usage. There were some exceptions in categories with small sample sizes. Overall, glucose, triglycerides, and systolic blood pressure increased among weight maintainers not on glucose, lipid-lowering, or antihypertensive medications, respectively. HDL cholesterol decreased among weight maintainers not on lipid-lowering medications. In contrast, total and LDL cholesterol improved significantly among weight maintainers not on lipid-lowering medications. The magnitude of the 9-year changes in glucose, lipids, and blood pressure was attenuated when examining weight maintainers not on medication and with normal levels for the respective risk factor. We found no significant differences between normal weight and obese subjects, with two exceptions. Obese nondiabetic weight

maintainers had more adverse changes in glucose than did normal weight nondiabetic weight maintainers. However, obese normotensive weight maintainers had more favorable changes in diastolic blood pressure than did normal weight normotensive weight maintainers.

DISCUSSION

Although weight maintenance literally implies no change in body weight, in free-living individuals, weight varies over time, even when fat stores are relatively constant. In practice, researchers must define a range of weight change to be called weight maintenance. Recently, we reviewed studies that examined weight change and included a category identified as "weight maintenance" (17). We found that there was little consensus among investigators in the definition of weight maintenance. Many definitions have been used, including ±5.0 percent (20–25), ±2.5 kg (26–33), and ±5.0 kg (5, 34–38). We have recommended that weight maintenance be defined as ±3.0 percent (17). These bounds were chosen as adequately large to avoid differences due to measurement error and normal fluid balance.

Using the ±3.0 percent weight maintenance definition, we have shown that a substantial number, albeit a minority, of adults from four communities in the United States maintained their weight over a 9-year period. Their waist circumference increased by 3.3–4.4 cm during this period. This is consistent with the research by Forbes (39), showing that even with weight maintenance, adults lose about 1.5 kg of fat-free mass per decade. With 9 years of aging, glucose, triglycerides, and systolic blood pressure increased. Also, HDL cholesterol became less favorable. In contrast, total cholesterol, LDL cholesterol, and diastolic blood pressure all declined, even in participants who were not taking medications. The direction of change among those who were not taking medications was the same regardless of baseline weight status, and changes in risk factors were equally or more favorable in obese compared with normal weight individuals for all the risk factors studied, with the exception of fasting glucose. Trends among weight status groups were generally the same, regardless of whether subjects were taking medications to control their risk factor levels.

There have been systematic secular trends in cardiovascular disease risk factors over the last four decades. Gregg et al. (40) recently showed that, among lean adults (body mass index: <25 kg/m^2), the prevalence of hypercholesterolemia (≥240 mg/dl) declined by 11.9 percentage points (95 percent CI: 8.1, 15.7) between national surveys conducted in 1960–1962 and 1999–2000. The prevalence of high blood pressure (systolic blood pressure: ≥140 mmHg, or diastolic blood pressure: ≥90 mmHg) declined over the same period from 24.8 percent to 10.5 percent. In contrast, the prevalence of diabetes did not change significantly over time, with diagnosed diabetes tending to increase from 1.5 percent to 2.8 percent among lean individuals over the span of approximately four decades.

Comparisons of results from the cross-sectional National Health and Nutrition Examination Survey over time allow an assessment of secular trends, while in longitudinal studies, secular trends are superimposed upon the effects of aging. Nevertheless, it is informative to observe changes over time in the same individuals, and the ARIC Study and the Coronary Artery Risk Development in Young Adults (CARDIA) Study are two longitudinal studies that can provide insights into changes in risk factors in the United States over the past two decades. An analysis of 3-year changes between the first two examinations of the ARIC cohort showed that total cholesterol and the prevalence of hypercholesterolemia declined (41). Among participants who did not take cholesterol-lowering medications, the change was −4.3 mg/dl, despite increases in body mass index over the entire cohort that averaged 1.2 kg/m^2.

During this 9-year time frame, the usage of statins and other lipid-lowering medications changed considerably. In the present study, less than 2 percent of weight maintainers were on lipid-lowering medications at baseline. This increased to approximately 11.2 percent 9 years later. The differential usage of lipid-lowering medications could bias our findings. However, when we examined participants not on lipid-lowering medications with normal cholesterol levels (total cholesterol: <200 mg/dl), we found significant decreases in total and LDL cholesterol, thus suggesting that the improvements found in total and LDL cholesterol among weight maintainers were not due to pharmacotherapy treatment.

Another potential limitation of this study is that approximately one fourth of the ARIC participants died prior to or did not attend the 9-year clinic visit. However, we found similar mean changes in risk factors over 3 and 6 years when comparing the excluded individuals who maintained their weight with our analysis sample (data not shown).

Norman et al. (42) showed that, in CARDIA Study participants who lost weight (≤0 kg), LDL cholesterol declined over a 10-year period starting in 1985–1986. The mean weight change in this group ranged from −5.9 to −2.0 kg in different gender and ethnic groups. Our analysis of 15-year changes in the CARDIA Study data (11), using the same definition of weight maintenance used here, also showed that LDL cholesterol levels declined in participants who maintained their weight. Thus, the results shown here from the ARIC Study are consistent with evidence from the National Health and Nutrition Examination Survey (40), the CARDIA Study (11), and previous work in the ARIC Study (41) showing declines in LDL cholesterol over the past two decades.

Similar to our findings in the ARIC Study, CARDIA Study participants who maintained their weight had increases in triglyceride levels over the follow-up period (11, 42). The direction of the changes in glucose, HDL cholesterol, and blood pressure varied among the groups in the CARDIA Study, and these were not always consistent with the ARIC Study results. Changes in risk factors may have differed because the CARDIA Study cohort was younger (18–30 years at baseline) than the ARIC Study cohort (45–64 years at baseline), and the number of weight maintainers in the CARDIA Study (n = 488) was much smaller than the group from the ARIC Study reported on here (n = 3,235).

In the ARIC Study cohort, obese adults who maintained their weight had long-term changes in risk factors that were the same or more favorable than changes in normal weight adults for lipid levels and blood pressure. This finding was not due to differences in the use of medications. Nevertheless, it is important to keep in mind that the absolute levels of cardiovascular disease risk factors were less favorable among obese compared with normal weight subjects. In the ARIC Study cohort, higher body mass index levels at baseline were associated with less favorable levels of glucose, LDL cholesterol, HDL cholesterol, triglycerides, and systolic and diastolic blood pressure. In addition, weight gain over a 9-year period was associated with unfavorable changes in all the same risk factors (data not shown). This is consistent with several other studies that have shown that cardiovascular risk factors improve with weight loss and become less favorable with excess weight gain (43–46).

We intentionally focused the current work on weight maintenance rather than weight change, because weight maintenance has not been as well studied. This is a special subpopulation and may limit the generalizability of the present study, because most Americans gain weight as they pass from early to late adulthood (5–10). For some individuals, weight maintenance may be a more attainable goal than weight loss, and careful examination of weight maintenance is merited. Although the public health message remains that obesity and excess weight gain should be avoided in order to reduce cardiovascular risk,

it is useful to know that changes in cardiovascular disease risk factors are not necessarily more favorable in normal weight compared with obese adults who maintain their weight.

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Abbreviations

ARIC	Atherosclerosis Risk in Communities
CARDIA	Coronary Artery Risk Development in Young Adults
HDL	high density lipoprotein
LDL	low density lipoprotein

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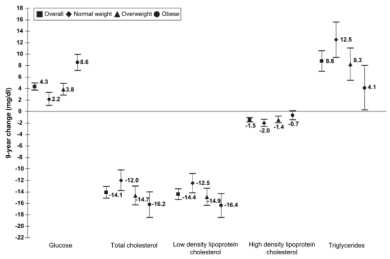

FIGURE 1.

Nine-year mean changes and 95% confidence intervals in glucose and lipids among adult weight maintainers by baseline weight status, the Atherosclerosis Risk in Communities Study, 1987–1998. Refer to the Materials and Methods section for the adjustment factors. For glucose, significant differences ($p < 0.05$) were observed between normal weight maintainers and overweight or obese weight maintainers and between overweight maintainers and obese maintainers. For total and low density lipoprotein cholesterol, significant differences were observed between normal weight maintainers and overweight or obese weight maintainers. For high density lipoprotein cholesterol and triglycerides, a significant difference was observed between normal weight maintainers and obese maintainers only.

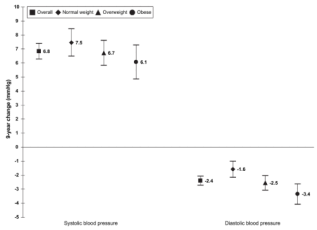

FIGURE 2.

Nine-year mean changes and 95% confidence intervals in systolic and diastolic blood pressure among adult weight maintainers by baseline weight status, the Atherosclerosis Risk in Communities Study, 1987–1998. Refer to the Materials and Methods section for the adjustment factors. For diastolic blood pressure, significant differences ($p < 0.05$) were observed between normal weight maintainers and overweight or obese weight maintainers.

TABLE 1

Demographic characteristics among weight maintainers by baseline weight status, the Atherosclerosis Risk in Communities Study, 1987–1998

	Overall (*n* = 3,235)	Baseline weight status		
		Normal weight (*n* = 1,147)	Overweight (*n* = 1,333)	Obese (*n* = 755)
Ethnicity (% White)	80.7	89.5	81.5*	66.1†
Gender (% male)	50.9	41.1	64.5*	42.0‡
Age at baseline (years, mean (SD§))	54.2 (5.6)	54.3 (5.6)	54.5 (5.6)	53.6 (5.6)†
Body mass index at baseline (kg/m^2, mean (SD))	27.2 (5.0)	22.7 (1.6)	27.2 (1.4)*	34.1 (4.4)†
9-year weight change (kg, mean (SD))	0.6 (2.0)	0.5 (1.6)	0.7 (1.9)*	0.7 (2.5)*
9-year weight change (%, mean (SD))	0.8 (2.5)	0.8 (2.5)	0.9 (2.4)	0.7 (2.6)
Weight fluctuation (RMSE,§ mean (SD))	4.2 (3.6)	3.2 (2.5)	4.2 (3.0)*	5.7 (5.1)†
Education level (%)				
Less than high school education	17.2	11.5	17.9*	25.0†
High school graduate	41.4	42.4	41.1	40.3
Some college or more	41.4	46.1	41.0	34.7
Cigarette smoking status at baseline (%)				
Current	46.9	48.6	41.8	53.3†
Former	35.8	30.5	41.6	33.5
Never	17.3	20.9	16.6	13.2
Cigarette smoking status at follow-up (%)				
Current	43.0	44.1	38.0	50.1†
Former	43.6	38.8	49.4	40.4
Never	13.4	17.1	12.6	9.4
Physical activity tertiles at baseline (%)				
Low	25.21	20.9	23.6	34.5†
Middle	42.8	42.7	41.8	44.6
High	32.1	36.4	34.6	20.9
Alcoholic beverage consumption status at baseline (%)				
Current	43.5	44.5	48.8*	32.6†
Former	14.4	12.1	14.6	17.6
Seldom/rare	18.6	21.3	16.7	18.2
Never	23.5	22.1	20.0	31.7
Alcoholic beverage consumption status at follow-up (%)				
Current	35.5	39.2	39.9	22.1†
Former	27.1	23.3	27.8	31.4
Seldom/rare	17.4	18.9	15.3	19.0
Never	20.0	18.6	17.0	27.5
Total energy intake at baseline (kcal, mean (SD))	1,654.9 (595.3)	1,590.0 (564.1)	1,713.7 (617.6)*	1,649.2 (591.7)†

	Overall (*n* = 3,235)	Baseline weight status		
		Normal weight (*n* = 1,147)	Overweight (*n* = 1,333)	Obese (*n* = 755)
Total dietary fat at baseline (g, mean (SD))	61.2 (26.2)	57.9 (25.3)	64.2 (27.3)*	61.2 (25.0)†
Saturated fat at baseline (g, mean (SD))	22.5 (10.4)	21.2 (9.9)	23.6 (10.9)*	22.4 (9.9)†
Dietary cholesterol at baseline (mg, mean (SD))	244.9 (121.5)	228.0 (118.0)	254.7 (125.6)*	253.1 (116.7)*
Dietary fiber at baseline (g, mean (SD))	17.4 (7.9)	17.5 (7.9)	17.5 (7.8)	17.2 (8.1)
% of calories from total dietary fat at baseline (mean (SD))	33.1 (6.4)	32.4 (6.6)	33.5 (6.3)*	33.3 (6.1)*
Diabetes medications at follow-up (%)	2.7	0.6	1.7*	7.7†
Lipid-lowering medications (%)				
At baseline or follow-up	12.3	10.4	13.2*	13.7*
At baseline only	0.7	0.9	0.4	0.8
At follow-up only	10.5	8.4	11.8*	11.5*
At baseline and follow-up	1.0	1.1	0.9	1.2
Antihypertensive medications (%)				
At baseline or follow-up	32.4	20.8	32.0*	50.9†
At baseline only	1.6	1.2	1.4	2.5*
At follow-up only	13.6	10.6	13.4*	18.8†
At baseline and follow-up	17.2	9.0	17.3*	29.5†

*Significantly different ($p < 0.05$) from normal weight maintainers.

†Significantly different ($p < 0.05$) from normal weight and overweight weight maintainers.

‡Significantly different ($p < 0.05$) from overweight weight maintainers only.

§SD, standard deviation; RMSE, root mean squared error.

TABLE 2

Age-, gender-, race-, and field site-adjusted means for seven physiologic risk factors of cardiovascular disease at baseline and 9-year follow-up among weight maintainers by baseline weight status, the Atherosclerosis Risk in Communities Study, 1987–1998

			Baseline weight status					
	Overall (*n* = 3,235)		Normal weight (*n* = 1,147)		Overweight (*n* = 1,333)		Obese (*n* = 755)	
	Mean	95% confidence interval	Mean	95% confidence interval	Mean	95% confidence interval	Mean	95% confidence interval
Fasting glucose (mg/dl)								
Baseline	99.0	98.8, 99.4	96.6	96.1, 97.1	99.10*	98.7, 99.6	102.6†	102.0, 103.3
9-year follow-up	103.4	102.6, 104.2	97.8	96.5, 99.0	102.5*	101.4, 103.7	113.5†	111.9, 115.1
Total cholesterol (mg/dl)								
Baseline	214.3	213.0, 215.6	210.2	207.9, 212.4	216.8*	214.7, 218.9	216.0*	213.2, 218.8
9-year follow-up	200.2	199.0, 201.4	199.2	197.2, 201.2	201.8	200.0, 203.7	198.8	196.3, 201.3
LDL‡ cholesterol (mg/dl)								
Baseline	138.1	136.7, 139.4	132.4	130.2, 134.6	140.7*	138.7, 142.7	142.2*	139.5, 144.9
9-year follow-up	123.7	122.6, 124.8	120.9	119.0, 122.8	125.5*	123.8, 127.3	124.8*	122.5, 127.2
HDL‡ cholesterol (mg/dl)								
Baseline	52.1	51.6, 52.6	57.4	56.6, 58.3	51.2*	50.4, 51.9	45.8†	44.8, 46.8
9-year follow-up	50.7	50.2, 51.2	55.5	54.7, 56.4	49.7*	48.9, 50.4	45.1†	44.0, 46.1
Triglycerides (mg/dl)								
Baseline	120.2	118.2, 122.2	101.6	98.3, 104.9	124.8*	121.7, 127.8	140.4†	136.3, 144.5
9-year follow-up	129.0	126.9, 131.1	114.0	110.4, 117.5	133.2*	129.9, 136.5	144.4†	140.0, 148.9
Systolic blood pressure (mmHg)								
Baseline	119.2	118.7, 119.8	115.6	114.7, 116.6	119.5*	118.6, 120.3	124.2†	123.0, 125.3
9-year follow-up	126.0	125.5, 126.7	123.7	122.6, 124.7	126.2*	125.3, 127.2	129.3†	128.0, 130.6
Diastolic blood pressure (mmHg)								
Baseline	73.3	73.0, 73.6	71.4	70.9, 72.0	73.4*	72.9, 73.9	75.9†	75.3, 76.6
9-year follow-up	70.9	70.6, 71.2	70.3	69.8, 70.9	70.8	70.3, 71.3	71.8†	71.2, 72.5

*Significantly different ($p < 0.05$) from normal weight maintainers.

† Significantly different ($p < 0.05$) from normal weight and overweight weight maintainers.

‡ LDL, low density lipoprotein; HDL, high density lipoprotein.

TABLE 3

Nine-year mean changes in physiologic risk factors for cardiovascular disease among adult weight maintainers by medication usage and baseline weight status, the Atherosclerosis Risk in Communities Study, 1987–1998

	Overall			Baseline weight status								
				Normal weight			Overweight			Obese		
	No.	Mean	95% confidence interval	No.	Mean	95% confidence interval	No.	Mean	95% confidence interval	No.	Mean	95% confidence interval
Fasting glucose (mg/dl)												
On medication*	88	51.6	40.2, 63.0	7	49.2	1.1, 97.3	23	41.3	15.5, 67.0	58	56.0	40.8, 71.2
No medication*	3,147	3.0	2.4, 3.5	1,140	0.9	−0.1, 1.8	1,310	3.0†	2.1, 3.8	697	6.7‡	5.5, 8.8
Nondiabetic§	2,969	0.6	0.4, 0.9	1,117	0.0	−0.5, 0.5	1,241	0.8	0.4, 1.3	611	1.5†	0.7, 2.2
Total cholesterol (mg/dl)												
On medication¶	397	−46.0	−49.8, −42.1	119	−45.8	−53.3, −38.4	176	−45.3	−51.2, −39.4	102	−47.4	−55.4, −39.4
Baseline only#	22	−1.0	−9.6, 7.7	10	−21.2	−34.2, −8.2	6	130.0†	117.2, 152.8	6	1.7	−18.9, 22.4
Follow-up only#	341	−49.8	−53.6, −45.9	96	−51.9	−59.8, −44.1	158	−47.9	−53.7, −42.1	87	−50.7	−58.8, −42.7
Baseline and follow-up#	34	−37.2	−46.5, −27.8	13	−31.2	−53.8, −8.5	12	−31.0	−51.2, −10.8	9	−54.1	−82.8, −25.5
No medication¶	2,838	−9.6	−10.6, −8.6	1,028	−7.3	−9.0, −5.5	1,157	−10.5†	−12.2, −8.9	653	−11.7†	−13.9, −9.4
Normal lipids**	927	−4.3	−5.5, −3.1	366	−4.7	−6.7, −2.6	349	−4.6	−6.6, −2.6	212	−3.5	−6.2, −0.8
LDL†† cholesterol (mg/dl)												
On medication¶	397	−46.3	−49.9, −42.7	119	−46.2	−53.2, −39.1	176	−45.9	−51.5, −40.3	102	−47.1	−54.6, −39.6
Baseline only#	22	−2.0	−9.8, 5.7	10	−21.1	−31.2, −11.1	6	34.9†	17.3, 52.5	6	−7.1‡	−23.1, 8.8
Follow-up only#	341	−50.0	−53.6, −46.3	96	−52.0	−59.4, −44.6	158	−48.7	−54.2, −43.3	87	−50.0	−57.6, −42.4
Baseline and follow-up#	34	−38.0	−46.6, −29.4	13	−36.7	−57.6, −15.8	12	−29.2	−47.9, −10.5	9	−51.7	−78.2, −25.2
No medication¶	2,838	−9.9	−10.9, −9.0	1,028	−7.8	−9.4, −6.1	1,157	−10.7†	−12.2, −9.2	653	−12.0†	−14.1, −9.9
Normal lipids**	927	−5.0	−6.2, −3.8	366	−5.3	−7.4, −3.3	349	−5.1	−7.1, −3.0	212	−4.4	−7.1, −1.7
HDL†† cholesterol (mg/dl)												
On medication¶	397	0.4	−0.5, 1.3	119	0.3	−1.5, 2.1	176	0.1	−1.3, 1.5	102	1.0	−0.8, 2.9
Baseline only#	22	−3.6	−5.5, −1.7	10	−6.5	−9.7, −3.2	6	−2.5	−8.2, 3.3	6	7.1†	−5.2, 5.3
Follow-up only#	341	0.6	−0.3, 1.6	96	1.3	−0.7, 3.3	158	0.2	−1.35, 1.67	87	0.8	−1.2, 2.8

	Overall			Baseline weight status								
				Normal weight			Overweight			Obese		
	No.	Mean	95% confidence interval	No.	Mean	95% confidence interval	No.	Mean	95% confidence interval	No.	Mean	95% confidence interval
Baseline and follow-up[#]	34	0.7	−1.4, 2.7	13	2.3	−2.3, 6.9	12	−2.6	−6.7, 1.6	9	2.6	−3.2, 8.4
No medication[¶]	2,838	−1.7	−2.1, −1.3	1,028	−2.3	−3.0, −1.6	1,157	−1.6	−2.3, −1.0	653	−0.9[†]	−1.8, −0.1
Normal lipids[**]	927	−0.9	−1.5, −0.2	366	−1.4	−2.4, −0.3	349	−0.9	−2.0, 0.1	212	0.2	−1.2, 1.6
Triglycerides (mg/dl)												
On medication[¶]	397	−0.5	−7.3, 6.2	119	5.1	−12.9, 13.2	176	2.6	−7.7, 12.9	102	−6.8	−20.7, 7.1
Baseline only[#]	22	23.3	17.5, 29.1	10	32.1	27.8, 36.4	6	−12.0[†]	−19.6, −4.4	6	44.0[‡]	37.2, 50.9
Follow-up only[#]	341	−2.2	−9.4, 4.9	96	−6.2	−20.7, 8.3	158	3.2	−7.5, 13.8	87	−7.6	−22.5, 7.3
Baseline and follow-up[#]	34	0.9	−18.1, 20.0	13	16.4	−28.2, 61.0	12	3.8	−36.0, 43.6	9	−25.2	−81.6, 31.3
No medication[¶]	2,838	10.1	8.3, 11.9	1,028	14.0	10.9, 17.1	1,157	8.9[†]	6.1, 11.8	653	6.0[†]	2.1, 9.9
Normal lipids[**]	927	7.7	4.9, 10.5	366	40.5	5.8, 15.1	349	7.2	2.6, 11.9	212	3.7	−2.6, 9.9
Systolic blood pressure (mmHg)												
On medication[‡‡]	1,048	4.9	3.4, 6.4	238	6.8	4.1, 9.5	426	4.4	2.5, 6.4	384	3.6	1.5, 5.7
Baseline only[#]	51	16.4	12.2, 20.0	14	22.1	14.1, 30.1	18	12.7	5.7, 19.8	19	15.6	8.3, 23.1
Follow-up only[#]	440	−0.5	−2.3, 1.2	121	3.1	−0.5, 6.6	177	−1.3	−4.1, 1.6	142	−2.7[†]	−6.0, 0.6
Baseline and follow-up[#]	557	7.0	4.4, 9.5	103	8.4	4.3, 12.6	231	8.4	5.7, 11.1	223	6.7	3.9, 9.6
No medication[‡‡]	2,187	7.9	7.3, 8.4	909	8.1	7.2, 9.0	907	7.8	6.9, 8.7	371	7.3	5.9, 8.8
Normotensive[§§]	1,817	5.8	5.3, 6.3	794	6.1	5.3, 6.9	739	5.7	4.9, 6.6	284	5.3	4.0, 6.6
Diastolic blood pressure (mmHg)												
On medication[‡‡]	1,048	−5.1	−6.0, −4.2	238	−3.4	−4.9, −1.9	426	−5.5[†]	−6.6, −4.4	384	−5.7[†]	−6.9, −4.5
Baseline only[#]	51	1.3	−0.7, 3.2	14	4.2	−0.2, 8.5	18	−0.4	−4.2, 3.5	19	0.6	−3.4, 4.7
Follow-up only[#]	440	−7.6	−8.7, −6.5	121	−4.9	−7.1, −2.8	177	−8.3[†]	−10.1, −6.5	142	−9.1[†]	11.1, −7.1
Baseline and follow-up[#]	557	−3.1	−4.5, −1.8	103	−2.9	−5.1, −0.7	231	−3.8	−5.2, −2.4	223	−4.0	−5.5, −2.5
No medication[‡‡]	2,187	−1.1	−1.4, −0.7	909	−0.5	−1.1, 0.0	907	−1.2	−1.7, −0.6	371	−2.3[‡]	−3.1, −1.4
Normotensive[§§]	1,817	−1.2	−1.6, −0.9	794	−0.7	−1.3, −0.2	739	−1.3	−1.9, −0.8	284	−2.3	−3.2, −1.3

[*] Diabetes medications at follow-up only.

[†] Significantly different ($p < 0.05$) from normal weight maintainers.

[‡] Significantly different ($p < 0.05$) from normal weight and overweight weight maintainers.

[§] Weight maintainers who were not on diabetes medications at follow-up and glucose of <126 mg/dl at follow-up.

[¶] Lipid-lowering medications.

[#] Mutually exclusive usage categories among weight maintainers who were on medication.

[**] Weight maintainers who were not on lipid-lowering medications at baseline or follow-up and total cholesterol of <200 mg/dl at baseline and follow-up.

[††] LDL, low density lipoprotein; HDL, high density lipoprotein.

[‡‡] Antihypertensive medications.

[§§] Weight maintainers who were not on antihypertensive medication at baseline or follow-up and systolic blood pressure of <140 mmHg and diastolic blood pressure of <90 mmHg at baseline and follow-up.