# Seven-Year Trends in Body Weight and Associations with Lifestyle and Behavioral Characteristics in Black and White Young Adults: The CARDIA Study

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ABSTRACT

*Objectives.* This study estimated the amount of weight change in a biracial cohort of young adults and the separate components attributable to time-related and aging-related changes, as well as identified possible determinants of weight change.

*Methods.* In this population-based prospective study of 18- to 30-year-old African-American and White men and women, body weight and prevalence of overweight were measured from 1985/86 to 1992/93.

*Results.* Average weight increased over the 7 years, increases ranging from 5.2 kg (SE = 0.2, n = 811) in White women to 8.5 kg (SE = 0.3, n = 882) in African-American women. Significant time-related increases in weight, ranging from 2.0 kg (SE = 1.0) in White women to 4.8 kg (SE = 1.0, n = 711) in African-American men, accounted for 40% to 60% of the average total weight gain. Aging-related increases were also significant, ranging from 2.6 kg (SE = 0.8, n = 944) in White men to 5.0 kg (SE = 1.1) in African-American women. The prevalence of overweight increased progressively in each group. Decreased physical fitness was most strongly associated with weight gain in both sexes.

*Conclusions.* The observed dramatic time-related weight gains, most likely due to secular (period-related) trends, are a serious public health concern. (*Am J Public Health.* 1997; 87:635–642)

## *Introduction*

Excess body weight, a widely prevalent condition in the United States,[1,2] is associated with hypertension, diabetes, and hypercholesterolemia,[3] and is a risk factor in terms of coronary heart disease, some cancers, and total mortality.[4] Obesity is a better predictor of cardiovascular disease risk in younger than in older men, and it has greater effects on cardiovascular risk factors, such as diabetes mellitus and hypertension, in the young.[4] Modest weight gain, even within the desirable weight range, is associated with significantly increased risk of coronary heart disease and all-cause mortality in middle-aged women.[5–7]

Given these adverse health effects, as well as the difficulties involved in maintaining weight loss,[8] the primary prevention of obesity is a public health imperative.[9] However, epidemiologic studies have shown that the prevalence of obesity is increasing,[1] although other cardiovascular risk factors, such as cholesterol levels and smoking prevalence, are declining.[10,11] Unfortunately, there is little information to use in formulating effective obesity prevention strategies since there are few population-based prospective studies of the associations of lifestyle factors with trends in weight, particularly in ethnically diverse cohorts.[12–14]

We analyzed data on African-American and White young adults followed from 1985/86 to 1992/93 in order to determine weight changes related to aging (among individuals) and to time (secular or period-related trends). We also explored the associations of sociodemographic and lifestyle characteristics with 7-year weight change.

## *Methods*

The Coronary Artery Risk Development in Young Adults (CARDIA) study is a prospective epidemiologic study of the determinants and evolution of cardiovascular risk factors among young adults.[15,16] Young adults 18 to 30 years of age were recruited from four geographic locations by community-based sampling methods (Birmingham, Ala; Chicago, Ill; and Minneapolis, Minn) and through the membership of a large prepaid health care plan (Oakland, Calif). Examinations were performed on 5115 (51%) of the eligible persons contacted in 1985/86. The study population was approximately balanced according to age of the participants (45% were 18 to 24 years old, and 55% were 25 to 30 years old), sex (46% men, 54% women), ethnicity (52% African American, 48% White), and education (40% had 12 years of education or less, and 60% had more than 12 years of education). Participants were contacted every 6 months and reexamined at years 2 (1987/88), 5 (1990/91), and 7 (1992/1993).

Overall retention rates for follow-up examinations were 91%, 86%, and 81%

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TABLE 1—Selected Characteristics at Baseline (1985/86) in Year 7 (1992/93) Attenders and Nonattenders: The CARDIA Study

| | African American | | | White | | |
|---|---|---|---|---|---|---|
| | Attenders | Nonattenders | P | Attenders | Nonattenders | P |
| **Men** | | | | | | |
| No. | 820 | 304 | ... | 1003 | 148 | ... |
| Age, y, mean (SD) | 24.4 (3.7) | 23.6 (3.7) | <.01 | 25.5 (3.3) | 25.0 (3.6) | .09 |
| Education, y, mean (SD) | 13.0 (1.9) | 12.6 (1.7) | <.01 | 14.7 (2.4) | 14.3 (2.9) | .11 |
| Weight, kg, mean (SD) | 77.3 (15.4) | 75.9 (14.0) | .16 | 77.0 (12.8) | 77.4 (13.6) | .7 |
| Smokers, % | 34 | 42 | .02 | 25 | 36 | <.01 |
| **Women** | | | | | | |
| No. | 1086 | 329 | ... | 997 | 200 | ... |
| Age, y, mean (SD) | 24.6 (3.8) | 23.9 (3.9) | <.01 | 25.6 (3.4) | 24.9 (3.4) | .02 |
| Education, y, mean (SD) | 13.2 (1.8) | 12.7 (1.7) | <.01 | 14.5 (2.3) | 14.3 (2.3) | .19 |
| Weight, kg, mean (SD) | 69.4 (18.4) | 68.6 (19.0) | .5 | 63.3 (12.7) | 61.8 (12.8) | .13 |
| Smokers, % | 31 | 36 | .08 | 27 | 36 | <.01 |

of surviving participants, respectively (approximately 1% died during follow-up). Ninety-five percent of the cohort attended at least one follow-up exam, and 74% of the participants were examined at all three. Whites, nonsmokers, better educated participants, and slightly older participants returned at year 7 at higher rates than did African Americans, smokers, those with less education, and younger participants (Table 1). The prevalence of overweight and the mean weight at baseline were not significantly different between year 7 attenders and nonattenders.

### *Data Collection*

Body weight was measured, with participants wearing light clothing, via a calibrated balance beam scale (to the nearest 0.2 kg); height (without shoes) was measured with a vertical ruler to the nearest 0.5 cm. Body mass index was computed as weight in kilograms divided by height in meters squared. Overweight was defined as a body mass index of 27.3 kg/m$^2$ or more in women or 27.8 kg/m$^2$ or more in men, the 85th percentile of nonpregnant, noninstitutionalized US residents 20 to 29 years of age in the second National Health and Nutrition Examination Survey (NHANES II).[17] Underweight was defined as a body mass index of less than 19.1 kg/m$^2$ in women or less than 20.7 kg/m$^2$ in men.[17] Analyses of weight change with body weight or body mass index as dependent variables produced similar results; only body weight models are reported.

Skinfold measurements were obtained as a surrogate measure of body fat via the same methods, training, and certification procedures at each examination. Duplicate measures of triceps, subscapular, and suprailiac skinfolds were obtained at standard sites on the participant's right side with Harpenden calipers (Quinton; Seattle, Wash); the maximum extension was 50 mm, which occurred in less than 1% of participants at baseline. The averages for each site were used to obtain the sum of skinfolds.[15]

Sociodemographic data were obtained by questionnaire. Years of education from the last follow-up exam were used in analyses. Women reported reproductive history (number and outcomes of all previous pregnancies) at baseline, as well as current breast-feeding and pregnancies between previous and current exams at follow-up. Women were classified in parity groups based on whether or not they had experienced a pregnancy of any length during follow-up. Women who were pregnant or breast-feeding at the time of a CARDIA exam were excluded from analyses at that particular exam (approximately 50 women at each examination); however, inclusion of these women did not significantly alter the findings.

Centrally trained and certified interviewers obtained a detailed, quantitative dietary history at baseline and year 7 to assess "usual" intake, referencing the previous month.[18–20] The methods used to train interviewers, conduct the dietary interviews, and perform quality control were the same in both examinations. Dietary data were processed with the University of Minnesota Nutrition Coordinating Center Tape 10 nutrient database at baseline[21] and Tape 20 at year 7. Food codes were the same at both examinations except in the cases in which the Nutrition Coordinating Center had archived a Tape 10 code as a result of manufacturing changes that led to meaningful differences in nutrient composition or added a new food product to the database. The same algorithms for the addition of specified amounts of fat during food preparation were used at baseline and year 7 to minimize artifactual changes in fat and calories. Since fat intake may be associated with obesity independent of total energy intake,[22] we included change in both energy-adjusted fat intake and total daily energy intake in models.

Total average daily alcohol intake (milliliters of ethanol) was estimated at each exam from the number of drinks of wine (1 drink = 17.0 mL), beer (1 drink = 16.7 mL), and hard liquor (1 drink = 19.1 mL) each participant reported usually consuming per week.[23] Cigarette smoking status was obtained by self-report[24] at each exam, and the following classifications were used: smoker, nonsmoker, started smoking, quit smoking, and off-and-on smoker. Physical activity was assessed by questionnaire at each exam, and a score was calculated by summing the intensity-weighted frequencies of 13 activities reported in the previous year.[25] Physical fitness was assessed at baseline and year 7 by calculating the total duration of exercise (in seconds) obtained from a symptom-limited, graded treadmill exercise test with a modified Balke protocol.[26]

### *Statistical Analysis*

We used *t* tests and tests of binomial proportions to examine baseline differ-

**TABLE 2—Selected Characteristics at Baseline (1985/86), by Race and Sex: The CARDIA Study**

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | African American | White | *P* | African American | White | *P* |
| No. | 1124 | 1151 | ... | 1415 | 1197 | ... |
| Age, y, mean (SD) | 24.1 (3.8) | 25.4 (3.4) | <.01 | 24.4 (3.9) | 25.4 (3.4) | <.01 |
| Education, y, mean (SD) | 12.9 (1.9) | 14.6 (2.5) | <.01 | 13.1 (1.8) | 14.6 (2.3) | <.01 |
| Weight, kg, mean (SD) | 77.0 (15.1) | 77.0 (12.9) | .89 | 69.1 (18.6) | 62.7 (12.5) | <.01 |
| Overweight,[a] % | 18 | 13 | <.01 | 32 | 12 | <.01 |
| Total energy, kcal, mean (SD) | 4033 (2422) | 3284 (1429) | <.01 | 2585 (1363) | 2134 (886) | <.01 |
| Energy from fat, % | 37.8 | 37.2 | .01 | 37.3 | 36.4 | <.01 |
| Alcohol, mL/d, mean (SD) | 17.7 (30.2) | 18.5 (24.7) | .46 | 5.1 (11.9) | 9.1 (15.6) | <.01 |
| Current smokers, % | 37 | 26 | <.01 | 31 | 27 | .02 |
| Never smokers, % | 54 | 58 | .04 | 60 | 53 | <.01 |
| Physical activity,[b] mean (SD) | 533 (342) | 510 (301) | .09 | 278 (227) | 400 (261) | <.01 |
| Physical fitness,[c] s, mean (SD) | 660 (159) | 722 (157) | <.01 | 425 (127) | 547 (147) | <.01 |

[a]Men: body mass index ≥27.8 kg/m$^2$; women: body mass index ≥27.3 kg/m$^2$.
[b]Assessed by self-report.
[c]Assessed by duration of symptom-limited graded exercise test.

**TABLE 3—Seven-Year Change in Average Body Weight and Percentage of Overweight, 1985/86 to 1992/93: The CARDIA Study**

| | Men | | Women | |
|---|---|---|---|---|
| | African American | White | African American | White |
| No. | 820 | 1003 | 1086 | 997 |
| Overweight,[a] % | | | | |
| Baseline | 18 | 13 | 32 | 13 |
| Year 2 | 23 | 17 | 38 | 17 |
| Year 5 | 33 | 23 | 47 | 21 |
| Year 7 | 37 | 26 | 50 | 24 |
| Weight, kg, mean (SD) | | | | |
| Baseline | 77.3 (15.4) | 77.0 (12.8) | 69.4 (18.5) | 63.3 (12.7) |
| Year 2 | 79.6 (16.1) | 78.8 (13.4) | 71.7 (19.6) | 64.8 (13.8) |
| Year 5 | 83.4 (18.0) | 81.2 (14.2) | 75.3 (20.7) | 66.7 (15.3) |
| Year 7 | 85.4 (18.5) | 82.9 (14.9) | 78.0 (21.4) | 68.5 (16.6) |
| 7-year total weight gain | 8.0 (8.0) | 5.9 (6.7) | 8.6 (9.8) | 5.2 (8.4) |

[a]Men: body mass index ≥27.8 kg/m$^2$; women: body mass index ≥27.3 kg/m$^2$.

ences between participants who attended the year 7 exam (attenders) and those who did not (nonattenders) and between the ethnic groups within sex at baseline. Also, *t* tests were used to examine average baseline to year 7 changes in certain behavioral factors (e.g., treadmill duration). We calculated prevalence of overweight and average weight, as well as increases in body mass index for the 10th, 50th, and 90th percentiles, for the ethnicity–sex groups at each examination. As a means of accounting for within-subject correlation, linear mixed model regression (PROC MIXED on SAS version 6.08) was used to construct longitudinal models of 7-year weight change for each race–sex group separately; approximate F tests were used for inferences. Analyses were performed with all available data from eligible individuals in the cohort as well as with data from only those participants who attended all exams. Since results were similar, we present only data from the latter models.

The longitudinal analyses describe the overall weight change in the cohort and partition this change into separate aging- and time-related components. The aging-related component is due to behavioral and physiologic changes within individuals. The time-related component is due to population-wide changes in behaviors and other exposures among individuals independent of aging. The longitudinal model included parameters for mean weight at 25 years of age at each exam and the cross-sectional age vs weight slope at each exam (which estimates weight change per year of aging). The 7-year total change was estimated as the difference between weight estimated from the model for the mean ages of the cohort at year 7 and at baseline. Cross-sectional age and weight information was used to estimate age-related trends, since both aging- and time-related effects were present within individuals. Thus, the 7-year aging-related weight change was estimated as a weighted sum of the aging vs weight cross-sectional slopes, with the weights reflecting the time span associated with a particular exam (1, 5/2, 5/2, and 1 for years 0, 2, 5, and 7, respectively). The time-related change was estimated as the difference between total change and aging-related change.

To explore associations of demographic and behavioral factors with weight change, we constructed linear models for men and women separately using the year 7–baseline weight difference as the dependent variable. Independent variables were clinical center (as a control variable); ethnicity; baseline age and overweight status; baseline total energy, relative fat and alcohol intake; baseline physical activity and fitness; highest reported education (12 years or less vs more than 12 years); smoking status; change in parity (for women); change in total

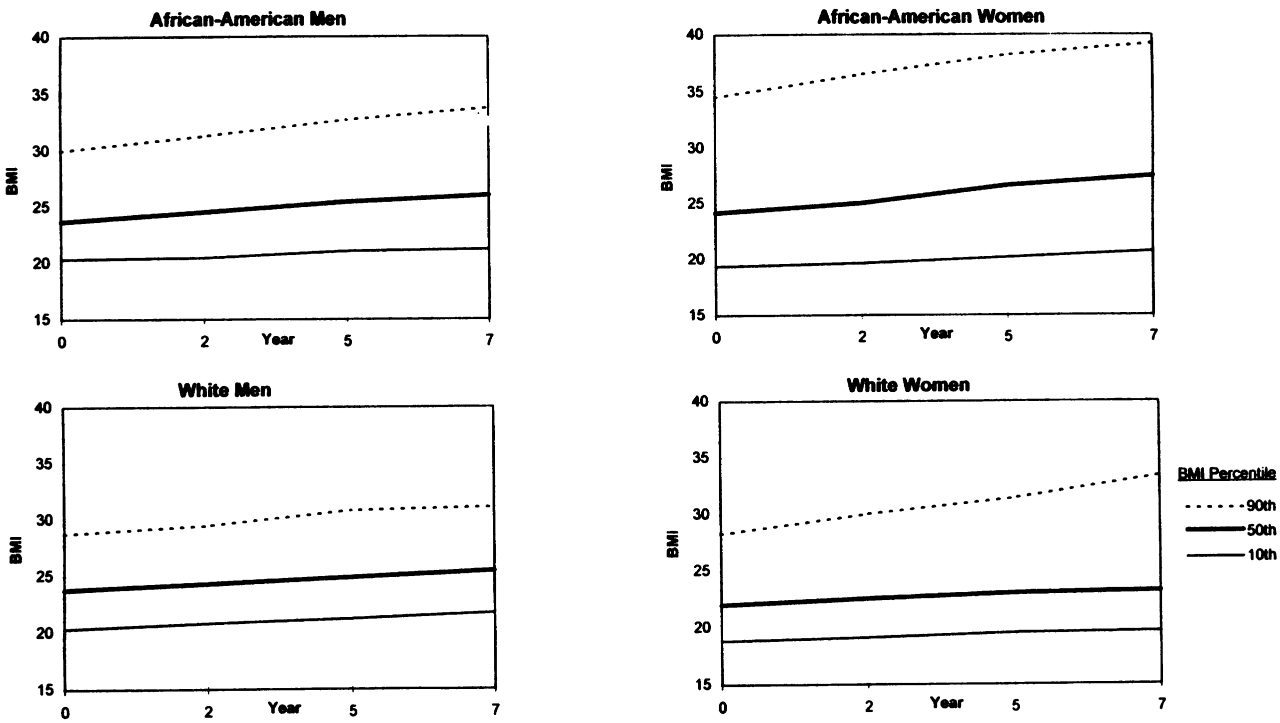


**FIGURE 1—Average 7-year increase in body mass index among those at the 10th, 50th, and 90th race- and sex-specific percentiles of body mass index at baseline in CARDIA, 1985/86 to 1992/93.**

energy, relative fat, and alcohol intake; and change in physical activity and fitness. Average change in energy-adjusted fat intake was calculated as follows:

$$\text{Average Change} = \frac{\text{Year 7 Fat Calories} - \text{Baseline Fat Calories}}{(\text{Baseline Total Energy} + \text{Year 7 Total Energy}) \div 2}$$

First-order interactions between categorical measures (e.g., ethnicity, overweight status) and continuous change measures (e.g., change in fitness) were included in the models as well.

We also generated models using weight and height as continuous variables and using the energy-adjusted fat intake from the residual method described by Willett.[27] These parameters did not appreciably improve the variance in weight change explained by the models and are not presented further. Reduced models were generated with a step-down procedure that sequentially eliminated, in a hierarchical sequence, factors that were not significantly associated with weight change at the $P \leq .05$ level.[28]

## Results

### Baseline Characteristics

There were significant differences in sociodemographic and behavioral characteristics between the ethnic groups at baseline (Table 2). Among both men and women, African Americans were younger, less educated, more often smokers, and more often overweight; reported greater total energy and marginally greater relative fat intake; and were less physically fit than Whites. African-American women weighed more and reported significantly less physical activity and alcohol intake than White women. The mean maximal treadmill performance of men and White women was comparable to that reported in other studies of men and women of similar age groups; the performance of African-American women in CARDIA was considerably lower.[26]

### Seven-Year Change in Body Weight and Body Fat

The percentage of participants who were overweight increased over 7 years in each race–sex group (Table 3). The increase was greatest among African-American women (from 32% at baseline to 51% at year 7) and smallest among White women (from 13% to 24%).

Each race–sex group experienced significant weight gains (Table 3). The average overall 7-year weight increase ranged from 5.2 kg in White women to 8.5 kg in African-American women (all $P$s $<$ .001). Moreover, there were significant time-related mean increases in each group: 4.8 kg (SE = 1.0, $P < .001$) in African-American men, 3.3 kg (SE = 0.8, $P < .001$) in White men, 3.4 kg (SE = 1.1, $P < .01$) in African-American women, and 2.0 kg (SE = 1.0, $P < .05$) in White women. Seven-year aging-related increases in body weight were also significant in each group: 3.3 kg (SE = 0.9, $P < .001$) in African-American men, 2.6 kg (SE = 0.8, $P < .01$) in White men, 5.0 kg (SE = 1.1, $P < .001$) in African-American women, and 3.2 kg (SE = 0.9, $P < .05$) in White women. Time-related change accounted for 40% to 60% of the average total weight gain in each group and accounted for a greater proportion than aging-related change in men.

Although the average 7-year increase in body mass index was greatest in those who were the heaviest at baseline (ranging from 2.4 kg/m$^2$ in White men to 5.1 kg/m$^2$ in White women), even the leanest groups experienced mean increases (from 0.8 kg/m$^2$ in White women to 1.4 kg/m$^2$ in White men [Figure 1]). Furthermore, in each race–sex group, relative weight gain (5% or more from baseline) was much more common than either weight loss (5% or more) or weight maintenance, regardless of whether participants were overweight, underweight, or of normal weight at baseline (data not shown).

Increases in mean skinfold thicknesses were seen in all race–sex groups. Average 7-year increases in sum of skinfolds were 9.8 mm (40.3 mm [SE = 0.7] to 50.1 mm [SE = 0.8]) in African-American men and 5.8 mm (45.0 mm [SE = 0.6] to 50.8 mm [SE = 0.6]) in White men. For women, the increases were 9.9 mm (61.3 mm [SE = 0.8] to 71.3 mm [SE = 0.9]) in African Americans and 3.2 mm (52.5 mm [SE = 0.6] to 55.9 mm [SE = 0.7]) in Whites.

*Factors Associated with Weight Gain*

On average, all groups reported significant decreases in physical activity (Table 4). In addition, average total daily energy consumption increased in all of the groups except White men. However, Whites reported significantly less relative fat and alcohol intake at year 7 than at baseline. Overall treadmill duration decreased 10% over 7 years of follow-up, from 15% in African-American men to 7% in White women.[29]

Demographic and behavioral factors associated with 7-year total weight change were fairly consistent between men and women (Table 5). Change in physical fitness explained the greatest amount of the variance in weight change, all but 7% in both sexes. Each 60-second decline in exercise duration was associated with an average weight gain of 2.1 kg in women and 1.5 kg in men. Other factors significantly associated with greater weight gain in both sexes were ex-smoker status, younger baseline age, greater baseline relative fat intake, and lower baseline fitness. There was an interaction between overweight status at baseline and change in fitness among both men and women; weight gain associated with decreased fitness was greater among those who were overweight at baseline than among those who were of normal weight at baseline. Education, alcohol intake, total energy intake, and change in parity (in women) were not associated with weight change. There were no interactions of ethnicity with change in either fitness or dietary fat.

**TABLE 4—Seven-Year Change in Selected Characteristics by Race and Sex, 1985/86 to 1992/93: The CARDIA Study**

| | Men | | Women | |
|---|---|---|---|---|
| | African American | White | African American | White |
| No. | 820 | 1003 | 1086 | 997 |
| Physical activity score, mean (SD) | −80.1 (363.8)[a] | −95.8 (285.5)[a] | −58.6 (249.5)[a] | −96.6 (262.2)[a] |
| Total energy, kcal, mean (SD) | 260.1 (2494.9)[a] | −37.3 (1374.8) | 141.8 (1745.4)[a] | 115.6 (943.4)[a] |
| Energy from fat, % mean (SD) | 0.9 (8.0)[a] | −1.8 (7.7)[a] | 0.15 (8.5) | −3.2 (8.5)[a] |
| Alcohol, mL/d, mean (SD) | 1.9 (34.4) | −2.8 (27.8)[a] | 0.5 (12.6) | −2.2 (13.9)[a] |

[a]Test for statistical significance $\Delta \neq 0$ ($P \leq .05$).

**TABLE 5—Estimated 7-Year Weight Gain (kg) Associated with Demographic and Behavioral Factors in Young Adults: The CARDIA Study**

| Factor | Women's Parameter Estimate (95% CI) | Men's Parameter Estimate (95% CI) |
|---|---|---|
| Estimated weight gain of reference group[a] | 3.6 (2.7, 4.6) | 6.3 (5.1, 7.4) |
| Smoking status (vs nonsmokers)[b] | | |
| Started | −2.6 (−4.6, −0.6) | −3.3 (−4.8, −1.7) |
| Quit | 2.9 (1.4, 4.6) | 2.2 (0.7, 3.6) |
| Current | −1.8 (−2.7, −0.8) | −1.8 (−2.6, −1.0) |
| Baseline factors[b] | | |
| Age | −0.16 (−0.27, −0.06) | −0.33 (−0.43, −0.24) |
| Calories from fat, % | 0.10 (0.03, 0.16) | 0.08 (0.03, 0.14) |
| Exercise duration | −0.02 (−0.022, −0.017) | −0.01 (−0.027, −0.0074) |
| African American (vs White) | ... | 0.7 (0.008, 1.435) |
| 7-year change from baseline measurement[b] | | |
| In calories from fat, % | 0.02 (0.001, 0.05) | ... |
| In exercise duration | −0.035 (−0.04, −0.03) | −0.024 (−0.03, −0.018) |
| 7-year change, overweight at baseline[c] | | |
| In calories from fat, % | 0.047 (0.0005, 0.09) | ... |
| In exercise duration | −0.022 (−0.03, −0.016) | −0.011 (−0.017, −0.005) |

*Note.* Percentage variances in weight gain explained were 26 for women and 21 for men. CI = confidence interval.
[a]Estimated from the regression coefficients of a linear model with race, smoking status, baseline weight status, baseline age, baseline and 7-year change in percentage of calories from fat, and baseline and 7-year change in exercise duration as explanatory factors.
[b]Positive values indicate greater weight gain, and negative values indicate lower weight gain, than reference comparison group. Regression coefficients from a linear model are provided.
[c]Interactions comparing those overweight at baseline with those of normal weight (reference).

## *Discussion*

We have reported substantial overall increases in body weight in healthy young adults, ranging from 0.7 kg per year in White women to 1.2 kg per year in African-American women. The average aging-related weight increase ranged from 0.4 kg per year in White men to 0.7 kg per year in African-American women. Of particular concern are the time-related increases in body weight, ranging from 0.3 kg per year in White women to 0.7 kg per year in African-American men, representing approximately 40% to 60% of the total weight change. These time-related trends are similar to those observed in cross-sectional analyses comparing CARDIA participants 25 to 30 years of age at year 7 with those of the same age at baseline (the increases ranged from 0.5 kg per year in African-American women to 0.8 kg per year in African-American men).[30]

Furthermore, our analyses indicate a strong association between weight gain and decreased physical fitness over 7 years, although factors associated with weight gain explained only 21% of the variance in weight gain among men and 26% among women. Other factors not measured in CARDIA appear to be associated with weight gain in the cohort.

The weight gains reported here probably represent a greater increase in fat mass than in lean body mass. First, there was little change in height but consistent increases in skinfold thicknesses. Second, analyses involving body mass index were consistent with analyses of weight. Body mass index is highly correlated with densitometric measures of total fat mass and is a good predictor of blood pressure and glucose.[31] The validity of the body mass index as a measure of fatness among sex and ethnic groups is unlikely to change differentially over 7 years. Since mean treadmill duration decreased 10% over 7 years,[29] it is unlikely that weight change is due to substantially increased lean body mass. Finally, the steady increases in the prevalence of overweight are consistent with increases in body fat.

### *Potential Limitations*

Methodologic issues, such as measurement drift and differential loss to follow-up, could affect our interpretation of time-related change. Because our study maintained and calibrated equipment over time, methodologic errors in measuring body weight longitudinally were unlikely. Although only 74% of participants returned for all examinations, attendance at follow-up did not differ based on overweight status at baseline. Furthermore, 95% of the cohort returned for follow-up at least once, and analyses using all available follow-up data did not differ from the results reported here. Finally, the significantly greater dropout rate among current smokers at baseline may have led to overestimation of the average weight gain. Nevertheless, since even smokers experienced average weight gains, bias due to differential dropout would have been unlikely to negate the overall trends of increasing body weight in the cohort.

Participation of only 51% of those contacted at baseline could limit the generalizability of our findings. However, these time-related and aging-related trends are similar to those reported in other studies. In the Minnesota Heart Survey, the average body mass indexes of 25- to 34-year-olds increased 0.6 kg/m$^2$ in men and 1.5 kg/m$^2$ in women from 1980 through 1982 to 1985 through 1987.[10] Secular increases of approximately 0.3 kg per year in men and 0.5 kg per year in women during the 1980s in the Minnesota Heart Health Program[32] were similar to those reported here. There were secular increases in weight among women 18 to 34 years of age, especially African-American women, in the National Health Examination Surveys conducted from 1960 to 1980.[33] Data from NHANES III (1988 through 1991), however, show increases in obesity prevalence and secular trends for increased weight in all groups, especially African-American men.[1] Finally, other populations have experienced increases in prevalence of obesity.[34–38] Thus, we interpret time-related change in CARDIA as a secular trend of increased body weight.

### *Determinants of Weight Trends*

Potential determinants of weight trends in CARDIA include environmental–lifestyle factors and gene–environment interactions. Genetic factors per se are not plausible explanations for the dramatic increase in obesity prevalence in the United States during the short period of the 1980s.

Lifestyle factors are much more likely to explain these trends. In CARDIA, the factors most strongly associated with 7-year weight change were change in physical fitness and baseline fitness level. Other factors strongly associated with weight gain were age in men and the interaction of physical fitness and baseline overweight status in women. Ethnicity was independently associated with weight change in men; the lack of an independent association in women was probably due to confounding by differences in baseline overweight prevalence. Current smoking and smoking initiation were associated with less weight gain; however, all smoking groups experienced average weight gains. The lack of association with parity change is consistent with our observation that 5-year aging-related weight gain was similar in all but the group that experienced a first pregnancy.[39]

Surveys conducted in the 1980s showed that the majority of Australians were exercising less over time and that there were greater time-related than aging-related increases in body mass index.[35] These increases were similar across smoking, education, and employment strata. Steady increases in body mass index observed in the Minnesota Heart Studies were accompanied by a plateau in leisure time physical activity and stability of dietary caloric intake, suggesting decreases in other forms of physical activity.[40]

Secular decreases in relative fat intake, but not in total energy, have been reported in the United States.[41,42] Findings of decreased fat intake and unchanged total energy intake do not exclude dietary factors as contributors to body weight trends, particularly if these patterns are combined with decreased energy expenditure. Energy intake is measured crudely, and relatively small long-term changes in net energy balance may affect body weight.[27] Furthermore, it is very difficult to disentangle the independent contributions to risk of total energy and energy-adjusted macronutrient intakes.[43] In CARDIA, average daily energy intake among African Americans and White men was significantly higher in 25- to 30-year-olds at year 7 than in those of the same age at baseline,[44] consistent with the observed trends in weight. Thus, dietary factors cannot be excluded as contributors to these trends.

Physical activity is important in weight maintenance.[45] Unfortunately, it is complex and difficult to measure behavior.[46] The benchmark measure, maximal oxygen uptake during graded exercise testing, is estimated well from peak exercise intensity (as performed in CARDIA); however, participant motivation may affect results. The strong associations between treadmill-derived physical fitness and weight change and the lack of significant associations with self-reported physical activity were not due to collinearity and are consistent with the relative precision and validity of these measures. This finding does not indicate that physical activity, per se, is an insignificant determinant of body weight. On the other hand, our findings may indicate that preventing weight gain requires habitual exercise of sufficient duration and/or intensity to maintain a certain level of physical fitness.

*Implications for Prevention*

Although we cannot be certain of a cause–effect relationship, the strong association between decreased physical fitness and weight gain is plausible and indicates an important potential area for intervention. Maintaining a physically active lifestyle may help blunt aging-related increases in body weight[13,47]; however, physical activity and age are inversely associated.[48] Thus, increasing the prevalence of fitness and of a physically active lifestyle may limit the increasing prevalence of obesity. Unfortunately, the prevalence of this lifestyle decreased during the 1980s in the United States,[29,49,50] and thus research is needed to determine effective strategies to reverse this trend.

In conclusion, we found significant weight increases over 7 years in healthy young adults that were strongly associated with declines in physical fitness. There were significant time- and aging-related weight increases and increases in prevalence of overweight. The time-related trends were consistent with secular trends in other populations. The public health impact of these findings is great given the increased risk of morbidity and mortality attributable to overweight. □

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