ORIGINAL INVESTIGATION

Race, Education, and Weight Change in a Biracial Sample of Women at Midlife

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Background: Overall rates of obesity have increased dramatically in the United States, yet African American women remain disproportionately represented among the overweight and obese. The excess weight observed in African American women is primarily considered a result of low socioeconomic status, but recent cross-sectional findings suggest otherwise.

Methods: We examined the interactive effects of race and 3 levels of education (low [high school or less]; moderate [some college]; and high [college degree or more]) on body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) and changes in BMI over 4 years in 2019 middle-aged African American and white women from the Study of Women's Health Across the Nation (SWAN). Data were analyzed with mixed effects regression models.

Results: At baseline, we observed a significant race × education interaction (estimate, −3.7; 95% confidence interval, −5.3 to −2.1; $P<.001$) on BMI. Compared with whites, African Americans had higher BMIs, but only at the moderate (means, 32.1 and 29.2) and highest (means, 31.5 and 27.8) level of education. At the lowest level of education, African American and white women were similar in BMI (means, 31.1 [African American] and 31.2 [white]). Body mass index increased significantly for all women over follow-up (estimate, 0.22; 95% confidence interval, 0.17 to 0.26; $P<.001$), but increases did not differ by race, education, or race × education. Results were unchanged after adjustment for potential confounding variables.

Conclusions: For middle-aged women, racial disparities in BMI are largely patterned by education, with the greatest disparities observed at higher levels of education. The absence of significant longitudinal effects suggests that these race-education patterns are set in place and well established before midlife.

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Overall rates of obesity have increased dramatically in the United States, yet African American women remain disproportionately represented among the overweight and obese.[1,2] Age-adjusted prevalence rates indicate that approximately 50% of African American women are obese, compared with 30% of white women.[1] Although these differences have been well documented over the past 2 decades,[3,4] factors underlying black-white disparities in obesity remain poorly understood.

Several researchers have posited that racial disparities in the prevalence of obesity are primarily due to black-white differences in socioeconomic status (SES).[5] There is a well-established association between SES (measured as education or income) and obesity for white women,[6] and this is generally assumed to be true for African American women. However, evidence suggests that SES exerts differential effects on overweight and obesity for women of different racial groups. Cross-sectional data from the National Center for Health Statistics (1988-1994) revealed that 42% of poor white women were overweight compared with 30% of middle/high income white women.[7] Conversely, 53.3% of poor African American women were overweight compared with 52.4% of middle/high income African American women.[7] Thus, middle or high SES was "protective" against excess weight for white women but did not influence the prevalence of excess weight in African American women. Similar findings for both education and income have been observed in cross-sectional studies of adults,[8] adolescents,[9] and young girls.[10]

Longitudinal studies of race, SES, and weight rarely have adequate representation of African American women from middle to high socioeconomic back-

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grounds[11]; thus, these studies have been unable to effectively examine the *interactive* effects of race and SES on weight gain and the development of obesity over time. Consequently, it is difficult to determine whether observed cross-sectional black-white differences in the effects of SES on weight persist over time. One exception to this, a study by Burke and colleagues,[12] investigated the relationships among race, education, and weight gain in a sample of young women (aged 18-30 years). Main effects for both race and education on weight gain were noted, but there was no evidence of an interaction. However, this study did not control for important potential confounds such as smoking and childbearing—both believed to influence black-white differences in weight gain among young women.[13,14]

The present study is designed to examine the interactive effects of race and SES (measured by education) on weight and weight gain over a 4-year follow-up in a cohort of middle-aged African American and white women. A major strength of the study design is the approximately equal representation of African American and white women from low, middle, and high socioeconomic backgrounds.

METHODS

PARTICIPANTS

African American and white women from 4 sites of the Study of Women's Health Across the Nation (SWAN) (an ongoing longitudinal study of the natural history of the menopausal transition) provided data for the present analysis. Details of the SWAN study design are published elsewhere.[15] Briefly, SWAN includes 7 community sites, each recruited whites and 1 racial/ethnic minority group. The present analyses are limited to the 4 sites that targeted African American women (Boston, Mass; Chicago, Ill; Detroit, Mich; and Pittsburgh, Pa).

Women were eligible for SWAN if they were between the ages of 42 and 52 years and self-identified as white or one of the targeted racial/ethnic minority groups (women who self-identified as "mixed" race/ethnicity were considered ineligible). Additional criteria included having an intact uterus and at least 1 ovary and reporting a menstrual period in the preceding 3 months. Women who were pregnant, were breastfeeding, or reported exogenous hormone use in the 3 months preceding the baseline examination were ineligible.

A total of 2322 (1103 African American and 1219 white) women were recruited from the 4 sites. Women were excluded from the present analyses if they experienced an extreme weight gain or loss of more than 23 kg (3 SDs from the mean; n=16), were pregnant or breastfeeding at any follow-up examination (n=13), reported having cancer other than skin cancer (n=48), had missing data on education (n=69) or body mass index (BMI) (n=13), or had missing covariate data (n=144). The final sample included 2019 (948 African American [47%] and 1071 white [53%]) women. Women missing education data did not differ from those with educational data on race or baseline BMI. Women excluded for other reasons did not differ from those included on race, education, or baseline BMI. Retention at the end of the fourth follow-up visit was 80%.

PROCEDURE

At the baseline examination (1996-1997) and annually thereafter, participants underwent a standard protocol that included self- and interviewer-administered questionnaires, height and weight measures, clinical tests, and a fasting blood and urine collection. Interviews were approximately 3 hours long and included detailed assessments of reproductive, demographic, psychosocial, and behavioral characteristics. Study procedures were approved by the Institutional Review Board at each site and all women provided informed consent.

MEASURES

Race/Ethnicity and Education

Race was self-reported as black/African American or non-Hispanic white (referent). Education was used as a marker of SES because it is fairly stable throughout adulthood, unlikely to be influenced by obesity-related morbidity, and less prone to missing or distorted values.[16] Education is a particularly valid indicator of SES for middle-aged/older women because it is available for women who are retired, recently widowed, or not employed outside of the home. Highest level of education was assessed at baseline and divided into 3 categories that represent meaningful differences in educational attainment in the United States: high school education or less, some college, and college degree or higher (referent).

Body Weight

Weight was measured to the nearest 0.01 kg using either a digital or balance beam scale, with women wearing light clothing without shoes (consistent over time within each site). Height was measured to the nearest 0.01 cm without shoes using a metric folding wooden ruler or a fixed stadiometer (consistent over time within sites). Body mass index was calculated as weight in kilograms divided by the square of height in meters.

Covariates

Covariates assessed at baseline included self-reported age, parity, age at menarche, smoking status, physical activity, caloric intake, fat intake, and chronic conditions. Total caloric intake and percentage of fat intake were assessed with the revised Block Food Frequency Questionnaire,[17] with 2 summary scores representing total and percentage of fat calories consumed per week. Physical activity was measured using an adapted version of the Kaiser Physical Activity Survey,[18] which assesses the frequency and intensity of activity in sports/exercise, household/caregiving, and daily activity/nonsports leisure time. Domain-specific activity indices were summed to create a measure of overall activity. Both the Kaiser Physical Activity Survey and the Block Food Frequency Questionnaire have shown adequate reliability and validity in samples of women from various racial/ethnic backgrounds.[18,19] Chronic conditions were represented by a dichotomous variable indicating the presence/absence of heart disease, diabetes, stroke, overactive/underactive thyroid, or the use of medications that might influence weight (eg, corticosteroids, antidepressants, and lipid-lowering drugs).

Menopausal status was assessed annually via self-reported bleeding and categorized as (1) premenopausal (menstrual period in the past 3 months with no irregularities in the past year); (2) early perimenopausal (menstrual period in the past 3 months with some irregularity over the previous year); (3) late perimenopausal (no menstrual period within the past 3 months, but some bleeding within the past year); (4) postmenopausal (no menstrual period within the past year); (5) surgical menopause (bilateral oophorectomy); and (6) undetermined (new use of hormone therapy prior to 1 year of amenorrhea). All women were premenopausal or early perimenopausal at baseline. Menopausal status was modeled as a time-dependent categorical covariate, with the premenopausal category as the referent.

STATISTICAL ANALYSIS

Analyses included data from the baseline examination through the fourth annual follow-up visit. *t* Tests and χ^2 analyses were conducted to examine differences in baseline sample characteristics by race and education. Mixed effects regression models (SAS PROC MIXED version 8.2; SAS Inc, Cary, NC) were used to model baseline BMI and change in BMI over follow-up. Body mass index was modeled as a linear function of time, allowing each woman to have her own starting level (intercept) and rate of change over time (slope).

The core model included the following 7 terms: time since baseline in years (aging), race, education, race × education, race × time, education × time, and race × education × time. The initial term for time represents the average annual increase in BMI for all women, while the terms for race, education, and race × education represent the cross-sectional associations of these variables with BMI when time=0 (baseline BMI). The race × time, education × time, and race × education × time terms represent the longitudinal associations of these variables with changes in BMI over the 4-year follow-up, essentially testing whether changes in BMI over time vary by race, education, or the race × education interaction. The core model was repeated with adjustments for baseline age, menopausal status, parity, age at menarche, chronic conditions, smoking status, physical activity, and total caloric and percentage of fat intake. Research suggests these variables are related to race, education, and BMI.[3,5,13,14,20] Because we anticipated a significant race × education interaction, we also ran models stratified by education. All models were adjusted for clinic site.

We chose to use BMI instead of body weight as our primary outcome because it incorporates both height and weight and has considerable clinical significance. Analyses of body weight (controlling for height) yielded similar results; only data for BMI are reported.

Table 1. Baseline Demographic and Behavioral Characteristics by Education and Race*

Educational Level	African Americans	Whites	*P* Value
High school or less (n = 464)	(n = 267)	(n = 197)	
Age, y	45.7 ± 2.9	46.1 (2.5)	.21
Parity	2.9 ± 1.6	2.4 (1.4)	<.001
Age at menarche, y	12.7 ± 2.1	12.4 (1.7)	.22
Physical activity	7.1 ± 1.7	7.7 (1.6)	<.001
Total caloric intake†	1972.2 ± 842.3	1816.2 (616.6)	.03
Percentage of fat intake†	35.3 ± 7.45	34.9 (8.31)	.62
Chronic condition, %	40.1	33.5	.17
Current smoker, %	31.0	34.2	.48
Some college (n = 748)	(n = 424)	(n = 324)	
Age, y	45.5 ± 2.6	45.6 (2.7)	.73
Parity	2.4 ± 1.4	2.2 (1.5)	.08
Age at menarche, y	12.4 ± 1.9	12.5 (1.6)	.49
Physical activity	7.4 ± 1.7	8.1 (1.83)	<.001
Total caloric intake†	1905.6 ± 774.8	1829 (669.7)	.16
Percentage of fat intake†	34.3 ± 6.92	33.4 (7.39)	.08
Chronic condition, %	39.4	29.0	<.001
Current smoker, %	27.2	25.9	.74
College or higher (n = 951)	(n = 339)	(n = 612)	.38
Age, y	45.9 ± 2.6	45.8 (2.7)	<.001
Parity	2.1 ± 1.4	1.6 (1.4)	.67
Age at menarche, y	12.4 ± 1.8	12.5 (1.4)	<.001
Physical activity	7.3 ± 1.7	8.3 (1.7)	.95
Total caloric intake†	1894.7 ± 840.3	1891.6 (613.7)	.45
Percentage of fat intake†	33.1 ± 7.48	32.7 (6.56)	.01
Chronic condition, %	36.6	28.4	<.001
Current smoker, %	19.1	12.0	.38

*Data are given as mean ± SD or prevalence percentage unless otherwise specified. Physical activity scores range from 3 to 14, with higher scores indicating more activity. *P* values represent racial differences within educational groups and are from χ^2 and *t* tests.

†A total of 121 participants were excluded from descriptive analyses of total caloric intake and percentage of fat intake because of invalid data on the Block Food Frequency Questionnaire.

RESULTS

PARTICIPANT CHARACTERISTICS

The mean±SD age of participants was 45.7±2.7 years. On average, participants were well educated, with over 75% of the sample reporting some postsecondary education. Education varied by race ($P<.001$), with the largest proportion of white women reporting a college degree or higher (n=612; 54%), while the largest proportion of African American women reported their highest educational degree as "some college" (n=424; 41.2%). On average, women were overweight (mean±SD BMI, 29.7±7.1), with 78.3% of African Americans and 60.7% of whites meeting criteria for overweight (BMI, 25.0-29.9) or obesity (BMI ≥30).

Within educational levels, African American and white women differed on baseline demographic and behavioral characteristics (unadjusted data presented in **Table 1**). There were consistent racial differences in physical activity at each level of education, with African American women exercising less than their white counterparts. Less consistent racial differences were observed in parity (for women with low and high levels of education), chronic conditions (in women with moderate and high levels of education), total caloric intake (in women with a low level of education), and prevalence of smoking (in women with a high level of education only).

EFFECTS OF RACE AND EDUCATION ON BMI

At baseline (time=0 in the random effects model), being African American and having a high school education or less were both associated with larger BMIs (both $P<.001$). There was also a significant race × education interaction (estimate, −3.7; 95% CI, −5.3 to −2.1; $P<.001$), illustrated in **Figure 1**. African American women at all educational levels were comparable in BMI to white women with a high school education or less (means, 31.1, 32.1, 31.5, and 31.2, respectively), while BMI was lower for white women at each higher level of baseline education (means, 29.2 and 27.8).

Body mass index increased for all women over the course of the study (0.22 per year; 95% CI, 0.17 to 0.26; $P<.001$). Terms for race × time ($P=.89$), education × time ($P=.08$), and race × education × time ($P=.45$) were nonsignificant, indicating that increases in BMI did not vary by race, education, or the race × education interaction (data not shown). In other words, the absolute level differences in BMI by race and education observed at baseline did not change over time. Findings were unchanged after adjusting for age, menopausal status, number of pregnancies, age at menarche, chronic conditions, smoking status, physical activity, and caloric intake variables.

Because of the strong inverse association between education and BMI for white women, racial disparities in BMI *widened* with increasing baseline educational attainment. To gauge the magnitude of this effect, we ran additional models stratified by education (**Table 2**). Racial differences in BMI were not observed among women with a high school education or less, but for women reporting their highest level of education as "some college," African American women had BMIs that were, on average, 1.89 greater than those for white women. Among college-educated women, African American women had BMIs that were, on average, 2.89 greater than that for their white counterparts. Because women of both races and all educational levels gained weight equally over time, these absolute level differences persisted over follow-up. The relationship between race and BMI over time is graphically illustrated for each level of education in **Figure 2**, using predicted scores from the adjusted analyses.

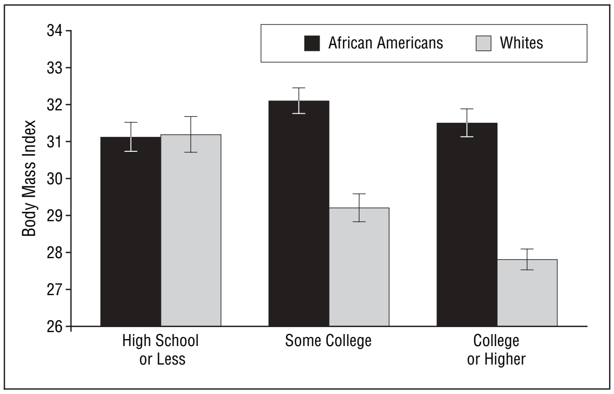

Figure 1. Baseline body mass index (calculated as weight in kilograms divided by the square of height in meters) by race and education. Error bars indicate SD.

COMMENT

We observed significant racial differences in the effects of education on weight for middle-aged women. At all levels of education, African American women were equally heavy, while white women were thinner with increasing baseline educational attainment. These results are consistent with previous studies of young girls,[10] adolescents,[9] and adult women.[8] In this respect, African American women do not seem to benefit from educational attainment in the same way that white women do. In fact, black-white disparities in BMI widen with increasing levels of education. In our data, racial disparities in BMI were only observed in women with some postsecondary education or a college degree.

Table 2. Results From Education-Stratified Mixed-Effects Models Predicting Body Mass Index

	High School or Less		Some College		College or Higher	
Variable	**Estimate ± SE (95% CI)**	***P* Value**	**Estimate ± SE (95% CI)**	***P* Value**	**Estimate ± SE (95% CI)**	***P* Value**
Time (aging)	0.17 ± 0.06 (0.06 to 0.28)	<.001	0.27 ± 0.04 (0.19 to 0.35)	<.001	0.23 ± 0.03 (0.17 to 0.29)	<.001
Race						
African American	−1.11 ± 0.77 (−2.62 to 0.39)	.15	1.89 ± 0.52 (0.86 to 2.92)	<.001	2.89 ± 0.43 (2.02 to 3.74)	<.001
White	. . .		. . .		. . .	
Race × time						
African American	−0.00 ± 0.07 (−0.14 to 0.13)	.98	−0.05 ± 0.05 (−0.15 to 0.04)	.28	0.03 ± 0.05 (−0.06 to 0.12)	.48
White	. . .		. . .		. . .	
Baseline age	0.15 ± 0.13 (−0.11 to 0.41)	.25	0.10 ± 0.09 (−0.08 to 0.29)	.27	0.02 ± 0.07 (−0.12 to 0.16)	.80
Menopausal status						
Undetermined	0.35 ± 0.23 (−0.09 to 0.79)		0.08 ± 0.16 (−0.23 to 0.39)		0.00 ± 0.14 (−0.27 to 0.28)	
Surgical	0.03 ± 0.38 (−0.72 to 0.78)		0.54 ± 0.26 (0.03 to 1.05)		0.50 ± 0.29 (−0.09 to 1.10)	
Postmenopausal	0.19 ± 0.26 (0.32 to 0.72)	.62	0.13 ± 0.19 (−0.25 to 0.51)	.30	−0.14 ± 0.18 (−0.50 to 0.21)	.34
Late perimenopausal	0.16 ± 0.22 (−0.27 to 0.57)		−0.00 ± 0.16 (−0.32 to 0.31)		−0.18 ± 0.16 (−0.49 to 0.13)	
Early perimenopausal	0.22 ± 0.15 (−0.06 to 0.51)		0.12 ± 0.10 (−0.09 to 0.32)		−0.04 ± 0.09 (0.23 to 0.13)	
Premenopausal	. . .		. . .		. . .	
Parity	0.36 ± 0.23 (−0.08 to 0.81)	.11	0.03 ± 0.17 (−0.31 to 0.36)	.88	0.10 ± 0.15 (−0.18 to 0.39)	.52
Age at menarche	−0.67 ± 0.18 (−1.03 to −0.31)	<.001	−0.71 ± 0.15 (−0.99 to −0.42)	<.001	−0.58 ± 0.12 (−0.81 to −0.34)	<.001
Chronic health conditions*	2.53 ± 0.74 (1.07 to 3.99)	<.001	2.12 ± 0.54 (1.06 to 3.17)	<.001	2.76 ± 0.42 (1.94 to 3.57)	<.001
Smoking status						
Never	2.45 ± 0.84 (0.81 to 4.09)		2.14 ± 0.61 (0.94 to 3.33)		1.29 ± 0.58 (0.16 to 2.42)	
Past	2.85 ± 0.97 (0.95 to 4.75)	<.001	2.68 ± 0.69 (1.31 to 4.04)	<.001	1.72 ± 0.62 (0.49 to 2.93)	.02
Current	. . .		. . .		. . .	
Physical activity	−0.85 ± 0.22 (−1.28 to −0.42)	<.001	−0.88 ± 0.15 (−1.16 to −0.59)	<.001	−0.73 ± 0.12 (−0.97 to −0.49)	<.001
Total caloric intake†	0.00 ± 0.00 (−0.00 to 0.00)	.61	0.00 ± 0.00 (0.00 to 0.00)	.01	0.00 ± 0.00 (0.00 to 0.00)	.01
Percentage of fat intake†	0.01 ± 0.05 (−0.08 to 0.09)	.89	0.06 ± 0.04 (−0.01 to 0.13)	.09	0.12 ± 0.03 (0.39 to 3.15)	<.001

Abbreviations: CI, confidence interval; ellipses, referent.
*Referent is no chronic health condition.
†A total of 121 women had invalid data on the Block Food Frequency Questionnaire. Results were similar when these participants were excluded from the analyses.

Interestingly, although all women gained weight over the 4-year follow up, racial differences in BMI at each level of education were stable over time. This was surprising because studies of weight gain in adolescent girls and young women consistently report larger increases in weight for African American compared with white women.[3,4,20] However, because women typically gain the most weight during their reproductive years,[4] it is possible that the observed race-education patterns are set in place by midlife. Thus, the black-white disparities observed in our study at baseline may largely reflect racial differences in weight gain prior to the perimenopause. This would suggest that African American women are not inherently more vulnerable to weight gain but may be more vulnerable during "critical periods" such as puberty or pregnancy and less vulnerable during the menopausal transition. Additional research in this area is warranted.

The fact that racial disparities in BMI persisted for educated women after controlling for parity, diet, and exercise is intriguing because most researchers attribute black-white differences in weight to poor health behaviors among African American women.[21] While there were significant racial differences in parity and physical activity, these differences did not explain black-white disparities in BMI at higher levels of education. Even after adjusting for potential confounds, African American women at the highest level of education had a BMI that was nearly 3.0 greater (approximately 17 lb [7.7kg]) than that for their white counterparts.

Why isn't educational attainment "protective" against excess weight for African American women? Some speculate that racial disparities in obesity are partially determined by innate biological or genetic differences. Several studies have found a lower resting metabolic rate in African American compared with white women,[22,23] and it is hypothesized that this lowered metabolism may explain the higher rates of obesity in African American women. However, these studies have been cross-sectional in nature, and it is unclear how resting metabolic rate relates to actual increases in weight or the prevalence of obesity. Further, although genetic factors contribute to obesity, the largest contributions are believed to be environmental, or a result of gene-environment interactions.[24] Thus, racial disparities in overweight and obesity are presumably a result of environmental rather than genetic differences.

Research suggests there is less stigma associated with being overweight or obese for African American compared with white women. When shown photographs of same-race thin, average, and overweight women, African American women rated African American women of all sizes similarly on intelligence, job success, relationship success, and happiness. Conversely, white women rated larger white women *lower* on all 4 domains, indicating a distinct bias against overweight white women.[25] Compared with white women, African American women report less of a "drive for thinness" and tend to prefer "curvaceous," normal weight vs thin body ideals.[26] Although it is unclear whether these factors are associated with weight gain or the prevalence of obesity in educated African American women, there is some speculation that the "culture of weight management" is less developed in African American compared with white women.[27]

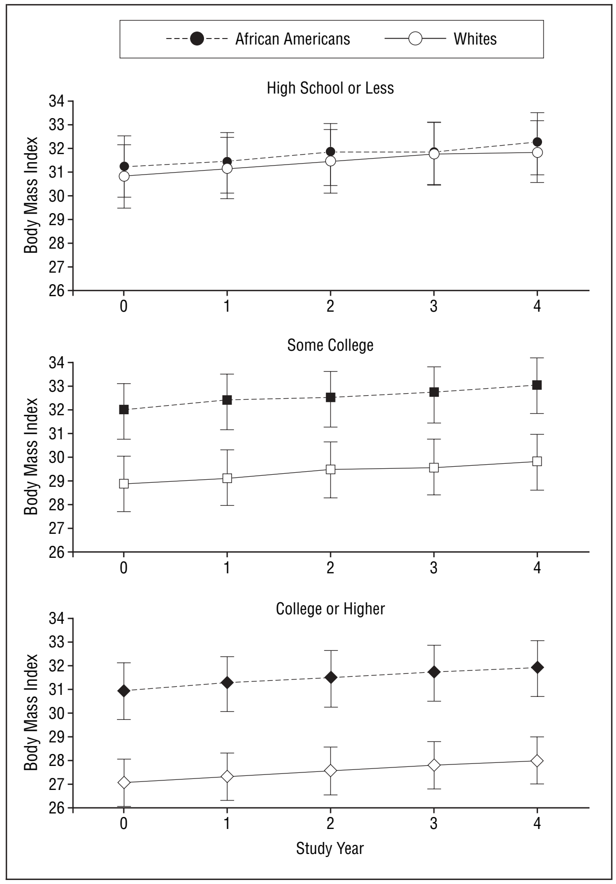

Figure 2. Racial disparities in body mass index (calculated as weight in kilograms divided by the square of height in meters) over time by educational level. Error bars indicate SD. Graphs present predicted scores from adjusted analyses.

Life stressors may also play a role. It is possible that greater educational attainment is protective against excess weight for white women because it decreases their exposure to negative life experiences, while African American women may be equally exposed to psychosocial stressors at all levels of education. At similar levels of SES, African Americans report a greater number of negative life events[28,29] and perceive these events as more stressful compared with their white counterparts. Additional research suggests that African American women may be particularly vulnerable to the effects of discrimination on health and that these effects are partially mediated by excess weight or BMI.[29] To date, however, we are aware of no studies that have examined the effects of race and psychosocial stressors on weight gain or the prevalence of obesity in women.

This study has limitations. First, although widely used, BMI is a crude measure of overall adiposity because it includes both fat and fat-free mass. Second, we used educational attainment as our sole indicator of SES. Although education is a strong indicator of individual SES and has been consistently associated with cardiovascular risk factors and mortality,[30] it may have less predictive utility for African American women, given the sigincreased black-white disparity in educated women should be thoroughly examined.

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nificant black-white differences in economic returns for a given level of education.[31] However, because a number of studies have found similar interactive associations among race, income, and weight,[7,9,10] it is unlikely that our findings would differ with the addition of economic indicators of SES. Finally, our study was limited to African American and white women from the Midwest and Northeast and may not generalize to women in other regions.

To our knowledge, this study is the first to prospectively examine the interactive effects of race and education on BMI over time in a middle-aged sample of African-American and white women. The lack of an observable benefit on BMI for educated African American women is particularly alarming given their disproportionately high rates of obesity and obesity-related illnesses.[32] Because race-education patterns appear to be well established by midlife, prevention efforts aimed at reducing the prevalence of obesity in African American women should begin in adolescence or early adulthood. To design effective prevention programs, longitudinal research on the complex interplay of race, SES, and weight and weight gain for women of all ages is needed. In particular, behavioral, biological, and psychosocial contributors to the

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Correction

Error in Editor's Note. In the Editor's Note that appeared with the article "The Effects of Cyclooxygenase-2 [COX-2] Inhibitors and Nonsteroidal Anti-inflammatory Therapy on 24-Hour Blood Pressure in Patients With Hypertension, Osteoarthritis, and Type 2 Diabetes Mellitus" (2005;165:161-168), the word "former" was used instead of the word "latter." The corrected sentence reads as follows: "The 4 articles on COX-2 inhibitors in this issue of the ARCHIVES demonstrate continued reason for concern about adverse cardiovascular effects of both rofecoxib and celecoxib (though less so for the latter) as well as serious concern about the apparent overuse of these drugs in the prescription marketplace."