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Original Contribution

Obesity and All-Cause Mortality Among Black Adults and White Adults

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In recent pooled analyses among whites and Asians, mortality was shown to rise markedly with increasing body mass index (BMI; weight (kg)/height (m)^2), but much less is known about this association among blacks. This study prospectively examined all-cause mortality in relation to BMI among 22,014 black males, 9,343 white males, 30,810 black females, and 14,447 white females, aged 40–79 years, from the Southern Community Cohort Study, an epidemiologic cohort of largely low-income participants in 12 southeastern US states. Participants enrolled in the cohort from 2002 to 2009 and were followed up to 8.9 years. Hazard ratios and 95% confidence intervals for mortality were obtained from sex- and race-stratified Cox proportional hazards models in association with BMI at cohort entry, adjusting for age, education, income, cigarette smoking, and alcohol consumption. Elevated BMI was associated with increased mortality among whites (hazard ratios for BMI >40 vs. 20–24.9 = 1.37 (95% confidence interval (CI): 1.02, 1.84) and 1.47 (95% CI: 1.15, 1.89) for white males and white females, respectively) but not significantly among blacks (hazard ratios = 1.13 (95% CI: 0.89, 1.43) and 0.87 (95% CI: 0.72, 1.04) for black males and black females, respectively). In this large cohort, obesity in mid-to-late adulthood among blacks was not associated with the same excess mortality risk seen among whites.

African Americans; body mass index; mortality

Abbreviations: BMI, body mass index; CI, confidence interval; HR, hazard ratio; ICD-10, *International Classification of Diseases*, Tenth Revision; SCCS, Southern Community Cohort Study.

The rise in obesity levels in the general population over the past 3 decades (1–3) is expected to result in enormous health burdens and health-care costs as obesity is linked to many adverse health outcomes, including diabetes, cardiovascular disease, cancer, and overall mortality (4–6). Recent pooled cohort analyses have reported a J-shaped relation between body mass index (BMI) and all-cause mortality with more than doubled mortality risks among extremely obese whites (6, 7) and parallel but less pronounced risks among East Asians (8). Some previous studies have found a weaker obesity-mortality association among African Americans (9–14), but few studies have examined this question in large populations of African Americans, and none have been concentrated in low-income populations or in the southeastern United States where the obesity epidemic is pronounced (15). Our objective therefore was to prospectively examine the association between BMI and all-cause mortality in the Southern Community Cohort Study (SCCS), a unique cohort with a large African-American population as well as a sizeable group of socioeconomically comparable whites.

MATERIALS AND METHODS

Study participants

The SCCS is a prospective cohort study assessing disparities in chronic diseases among adults in urban and rural areas in 12 southeastern US states (16–18). From 2002 to 2009, nearly 86,000 adults were enrolled in the cohort, most (86%) at one of 71 participating community health centers that provide basic health services mainly to low-income and uninsured persons (19). An additional 14% of the cohort enrolled from 2004 to 2006 by responding to a

mailed questionnaire sent to randomly selected residents of the same 12 states. SCCS participants were required to be 40–79 years of age, to speak English, and not to be under treatment for cancer in the 12 months preceding cohort enrollment. The enrollment protocol was designed so that overall approximately two-thirds of participants would be black. The SCCS was approved by institutional review boards at Vanderbilt University and Meharry Medical College, and all participants provided written, informed consent.

Data collection and BMI assessment

Participants completed a baseline survey (via in-person interview for community health center enrollees and a self-administered questionnaire for mail enrollees) at enrollment. This survey, available online (18), contained questions about demographic, medical, familial, lifestyle, and other participant characteristics. Race was self-reported. Current weight and height were self-reported in the baseline survey through September 2007 and, in addition, for 25% of the community health center participants, height and weight measured on the day of the baseline interview were abstracted from community health center medical records. Starting in October 2007, height and weight were measured for all community health center participants by trained interviewers using a SECA 703 digital scale (SECA Corp., Hanover, Maryland) and height rod, and waist and hip circumferences were measured using a standardized protocol with a tape measure over a single layer of clothing.

BMI was calculated as weight (kg)/height (m)^2 and categorized as <18.5, 18.5–19.9, 20–22.4, 22.5–24.9 (referent, selected for comparability to existing studies (6, 7, 14)), 25–27.4, 27.5–29.9, and obesity classes I (30.0–34.9), II (35.0–39.9), and III or extreme obesity (≥40). For most analyses, BMI categories were collapsed to <20, 20–24.9 (referent), 25–29.9, 30–34.9, 35–39.9, and ≥40 to compare with other existing reports.

Mortality ascertainment

Vital status was ascertained from the Social Security Administration through February 2011, while the National Death Index provided cause of death information through December 2009. Participants were followed starting 1 year after cohort entry to avoid including deaths where disease-related weight change near the time of enrollment might bias the results. For analyses of all-cause mortality, follow-up extended through February 25, 2011 (coincident with the most recent Social Security Administration linkage) or date of death. For those whose vital status was reported as unknown by the Social Security Administration in 2011, follow-up was censored at the last SCCS contact with the participant or December 31, 2009 (latest National Death Index linkage). Using cause of death information provided by the National Death Index, we examined cause-specific mortality with follow-up ending on December 31, 2009.

Statistical analyses

Cox proportional hazards models were used to estimate hazard ratios and accompanying 95% confidence intervals for all-cause mortality separately among black participants and white participants in relation to BMI at cohort entry. Age was used as the underlying time metric. Our a priori analysis plan called for examination of risk separately among blacks and whites, although likelihood ratio tests comparing models with and without race-BMI interaction terms showed significant interaction only for women ($P = 0.003$; $P = 0.11$ among men). Interactions between sex and BMI were significant in both race groups (likelihood ratio test $P = 0.02$ for blacks and $P = 0.04$ for whites). Covariates included in all models were source of enrollment (community health center/general population); education (<9 years, 9–11 years, high school, some college, and college or postgraduate); annual household income (<$15,000, $15,000–$24,999, $25,000–$49,999, and $50,000 or more); cigarette smoking status (never, former, current <1 pack/day, current/ ≥ 1 packs/day); and alcohol consumption (0, <1, ≥1 drinks/day). Cigarette smoking was also examined in finer categories with no appreciable differences in results. Total physical activity, health insurance status, and ever use of hormone replacement therapy (women only) were examined as potential confounders, but their inclusions made no material differences in the hazard ratios and therefore were not retained in the final models.

Models limited to participants who were nonsmokers with no major chronic disease (heart attack or coronary artery bypass surgery, stroke, or cancer excluding nonmelanoma skin cancer) at baseline were also examined to reduce the potential for reverse confounding due to smoking or underlying disease processes. Models further separating the nonsmokers into never smokers and former smokers showed little evidence of differences in hazard ratios, so only the combined group of nonsmokers is presented. To assess the proportionality assumptions of the Cox models, we compared hazard ratios for the first 5 versus subsequent years. To examine potential effect modification by socioeconomic status, we stratified models by education (less than high school and high school or more) and household income (<$15,000/year and $15,000 or more per year), and models with and without interaction terms between these factors and BMI were evaluated using the likelihood ratio test.

Cause-specific categories of mortality were examined (cardiovascular disease (*International Classification of Diseases*, Tenth Revision (ICD-10), codes I00–I99), cancer (ICD-10 codes C00–C97), and all other nonexternal causes that excluded cardiovascular disease, cancer, and all ICD-10 codes beginning with S, T, V, W, X, and Y) in race- and sex-stratified models with the same set of covariates as in the all-cause mortality models.

Although relatively few participants had measured waist and hip circumferences ($n = 8{,}319$) and follow-up was shorter (maximum = 3.4 years) due to the addition of these measurements in October 2007, in exploratory analyses we examined mortality according to sex-specific quartiles of waist circumference and waist/hip ratio in race-stratified

models with adjustment for sex and the other variables included in the BMI-mortality models as described above.

All analyses were conducted using SAS/STAT software, version 9.3, of the SAS System for Windows (SAS Institute, Inc., Cary, North Carolina).

RESULTS

A total of 85,759 individuals enrolled in the SCCS between March 2002 and September 2009. After excluding 5,017 participants (5.9%) who reported their race as other than only “white” or “black/African American,” 852 participants (1.1%) with missing height or weight values, and 3,276 participants with follow-up of less than 1 year, 76,614 participants remained for analysis. The mean age at enrollment was 51.8 years for blacks and 54.4 years for whites. Regardless of race or sex, the cohort members were generally of low income and educational status, and cigarette smoking was common, especially among men (Table 1).

Obesity (BMI >30) at entry was common in all 4 race and sex groups, with the highest prevalence (58%) in black women (Table 1). There was little difference in BMI between never smokers and former smokers and between light and heavy current smokers, but BMI was markedly lower among current compared with former/never smokers (data not shown).

During follow-up of up to 8.9 years (mean, 5.2 years), 5,427 deaths were identified. In all sex-race groups except white males, underweight individuals experienced significantly higher mortality than those who were of normal weight (Table 2; Figure 1). Among blacks, the hazard ratios for mortality were lower for those who were overweight or in obesity classes I and II compared with those of normal weight. In contrast, among whites, the lowest mortality risk occurred among those with BMI 25–29, and hazard ratios rose thereafter, reaching a 40%–50% excess among those in obesity class III.

Restricting the participants to nonsmokers not reporting cancer, heart disease, or stroke at baseline resulted in little change; hazard ratios for those with current BMI <20, 20–24.9 (referent), 25–29.9, 30–34.9, 35–39.9, and ≥40 were, respectively, 2.06 (95% confidence interval (CI): 1.53, 2.79), 1.0 (referent), 0.72 (95% CI: 0.61, 0.86), 0.66 (95% CI: 0.54, 0.80), 0.72 (95% CI: 0.58, 0.89), and 1.09 (95% CI: 0.89, 1.35) among blacks and 0.81 (95% CI: 0.35, 1.87), 1.0 (referent), 0.84 (95% CI: 0.62, 1.13), 0.85 (95% CI: 0.62, 1.17), 1.12 (95% CI: 0.79, 1.59), and 1.74 (95% CI: 1.25, 2.41) among whites.

Excess mortality associated with low BMI of <18.5 tended to be less pronounced in the ≥5-year follow-up period than in the period 1–4.9 years. Otherwise, few consistent or marked changes were apparent in the BMI-mortality patterns between the 2 time periods (Table 3).

The association between BMI and all-cause mortality differed very little for black males or black females when stratified by age at cohort entry (<55 vs. ≥55 years) (Table 3). Among whites, the hazard ratios for mortality associated with extreme obesity were somewhat higher in males and females aged ≥55 years versus <55 years (Table 3).

In analyses stratified by education or income, the hazard ratios associated with obesity tended to be lower among those with lower socioeconomic status in all sex-race groups (Table 4). Interaction terms between income and BMI, however, were significant only for black men ($P = 0.01$) and borderline for black women ($P = 0.06$), and interactions with education were significant only in black women ($P = 0.03$).

Cancer and then heart disease were the leading causes of death among both blacks and whites. Among other causes, human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS), diabetes, and cerebrovascular disease were the most common in blacks, and chronic lower respiratory diseases, diabetes, and liver disease were most common among whites. Increased body size was positively associated with death from cardiovascular disease in all sex-race groups, with higher hazard ratios among whites compared with blacks in the highest BMI categories (hazard ratios (HRs) for BMI >40 vs. 20–24.9 = 1.40, 2.10, 1.17, and 2.62 for black males, white males, black females, and white females, respectively) (Table 5). Cancer mortality was significantly elevated among white males but not black males with extreme obesity, while obesity was not associated with increased risk of cancer mortality in either black women or white women (Table 5).

Baseline waist and hip circumferences were available for 4,977 black participants and 3,342 white participants, 178 of whom died during follow-up. Waist circumference was strongly correlated with BMI at cohort entry (Pearson's correlation coefficient (r) = 0.82, $P < 0.001$), while the waist/hip ratio was less so ($r = 0.22$, $P < 0.001$) overall, with slightly higher correlations with BMI among whites ($r = 0.25$, $P < 0.001$ for the waist/hip ratio; $r = 0.84$, $P < 0.001$ for waist circumference) than among blacks ($r = 0.21$, $P < 0.001$ for the waist/hip ratio; $r = 0.81$, $P < 0.001$ for the waist circumference). Mortality hazard ratios were significantly increased among white participants for the highest versus lowest quartile of waist circumference (HR = 2.09, 95% CI: 1.01, 4.35) and nonsignificantly for the waist/hip ratio (HR = 1.29, 95% CI: 0.63, 2.63); among blacks, neither metric was associated with increased mortality (Table 6).

DISCUSSION

In this follow-up of a large, low-income population of black adults and white adults among whom obesity is common, the association between adult BMI and all-cause mortality differed by race. Being obese at cohort entry was not associated with elevated mortality among blacks; indeed, the lowest hazard ratios were observed among those with BMI of 30–34.9, and hazard ratios were near or even below 1.0 among those with extreme obesity. Among socioeconomically comparable whites, however, extreme obesity was associated with mortality increases up to 50% higher than among normal weight individuals.

Only a few cohort studies have had adequate samples of both blacks and whites to compare BMI–all-cause mortality patterns by race. This report includes one of the largest

Table 1. Characteristics of 76,614 Southern Community Cohort Study Participants by Sex and Race, 2002–2009

	Black Males (n = 22,014)		White Males (n = 9,343)		Black Females (n = 30,810)		White Females (n = 14,447)	
	No.	%	No.	%	No.	%	No.	%
Age, years								
40–49	11,179	51	3,407	37	14,599	47	5,486	38
50–59	7,526	34	3,222	34	10,474	34	5,176	36
≥60	3,309	15	2,714	29	5,737	19	3,785	26
Mean	51.3		54.7		52.2		54.2	
Median	49.8		53.9		50.6		53.1	
Education								
<9 years	1,913	9	777	8	2,192	7	1,060	7
9–11 years	5,422	25	1,261	14	6,954	23	2,388	17
High school	8,996	41	3,214	34	11,955	39	5,625	39
Some college	3,766	17	1,810	19	6,314	21	2,975	21
College or postgraduate	1,899	9	2,270	24	3,366	11	2,392	17
Income								
<$15,000	12,925	59	3,730	41	17,945	59	6,955	49
$15,000–$24,999	4,693	22	1,565	17	7,064	23	2,778	20
$25,000–$49,999	2,799	13	1,611	18	3,887	13	2,344	17
$50,000 or more	1,351	6	2,291	25	1,491	5	2,125	15
Source								
Community Health Center	20,040	91	6,183	66	28,086	91	11,570	80
General population	1,974	9	3,160	34	2,724	9	2,877	20
Smoking								
Never	4,863	22	2,389	26	14,578	48	5,573	39
Former	4,553	21	3,137	34	5,978	20	3,628	25
Current, <1 pack/day	8,983	41	1,200	13	7,684	25	2,268	16
Current, ≥1 packs/day	3,411	16	2,467	27	2,299	8	2,875	20
Major chronic disease at baseline[a]								
Yes	2,874	13	2,203	24	4,662	15	3,271	23
No	18,841	87	6,873	76	25,721	85	10,839	77
Alcohol consumption								
None	6,607	30	3,631	40	16,684	55	7,999	56
<1 drink/day	6,284	29	2,964	32	9,610	32	4,944	35
≥1 drinks/day	8,792	41	2,534	28	3,971	13	1,231	9
Body mass index at cohort entry[b]								
<18.5	278	1	82	1	311	1	254	2
18.5–19.9	661	3	189	2	542	2	411	3
20–22.4	2,863	13	834	9	1,586	5	1,365	9
22.5–24.9	4,135	19	1,521	16	2,649	9	1,862	13
25–27.4	4,388	20	2,004	22	3,928	13	2,040	14
27.5–29.9	3,349	15	1,538	16	3,932	13	1,791	12
30–34.9	3,972	18	1,939	21	7,697	25	3,143	22
35–39.9	1,563	7	766	8	5,095	16	1,815	12
≥40	851	4	507	5	5,160	17	1,866	13

[a] Participant reported prior heart attack or coronary artery bypass surgery, stroke, or cancer (excluding nonmelanoma skin cancer) at baseline.
[b] Body mass index: weight (kg)/height (m)^2.

Table 2. Hazard Ratios and 95% Confidence Intervals From Race- and Sex-stratified Cox Proportional Hazards Models Examining All-Cause Mortality in Relation to Body Mass Index at Cohort Entry, Omitting the First 12 Months of Follow-up, Southern Community Cohort Study, 2002–2009

Body Mass Index[a] by Sex at Cohort Entry	Blacks				Whites			
	No. of Deaths	Death Rate[b]	Hazard Ratio[c]	95% CI	No. of Deaths	Death Rate[b]	Hazard Ratio[c]	95% CI
Males								
<20	166	362.8	1.47	1.24, 1.74	32	285.6	0.96	0.67, 1.39
20–24.9	757	220.7	1.00	Referent	263	236.7	1.00	Referent
25–29.9	650	173.3	0.80	0.72, 0.90	245	139.6	0.72	0.60, 0.85
30–34.9	275	141.6	0.70	0.61, 0.81	137	145.3	0.75	0.60, 0.93
35–39.9	133	175.2	0.90	0.74, 1.08	85	228.6	1.12	0.87, 1.45
≥40	80	197.5	1.13	0.89, 1.43	60	265.1	1.37	1.02, 1.84
Females								
<20	93	238.4	1.71	1.35, 2.17	115	134.7	1.40	1.04, 1.89
20–24.9	267	134.0	1.00	Referent	58	176.0	1.00	Referent
25–29.9	410	103.6	0.80	0.69, 0.94	163	105.1	0.96	0.77, 1.18
30–34.9	325	81.5	0.66	0.56, 0.78	192	102.6	1.07	0.86, 1.34
35–39.9	227	85.2	0.72	0.60, 0.86	164	113.5	1.03	0.79, 1.34
≥40	246	91.6	0.87	0.72, 1.04	89	105.2	1.47	1.15, 1.89

Abbreviation: CI, confidence interval.

[a] Body mass index: weight (kg)/height (m)^2.

[b] Death rates per 10,000 person-years, directly standardized to the age distribution of the entire male or female study population.

[c] Age was used as a timescale in Cox proportional hazards models. All models were adjusted for education (5 categories: <9 years, 9–11 years, high school, some college, college degree or postgraduate); income (4 categories: <$15,000, $15,000–$24,999, $25,000–$49,999, $50,000 or more); source (community health center vs. general population); cigarette smoking (never, former, current/<1 pack/day, current/ ≥1 packs/day); and alcohol consumption (0, <1, ≥1 drinks/day).

populations of blacks (nearly 53,000) thus far studied; further, the nearly 24,000 whites of similar socioeconomic status in the SCCS provided a comparison group to examine patterns across race while minimizing socioeconomic-related confounding. In the American Cancer Society's Cancer Prevention Study II that included 12,000 blacks, nonsmokers with no history of disease were found to have a significantly increased mortality risk among whites with extreme obesity (HR = 2.58 for males and 2.00 for females), but the association was weaker and nonsignificant among black males (HR = 1.35) and females (HR = 1.21) (20). In the National Institutes of Health (NIH)-AARP cohort of adults aged 50–71 years, including 20,200 blacks, associations between BMI and mortality were also lower among blacks than whites (HRs for BMI >40 were 1.68 for black males, 1.82 for white males, 1.70 for black females, and 1.95 for white females) (9). In a combined analysis of the First National Health and Nutrition Examination Survey Epidemiologic Follow-up Study and the National Health Interview Survey populations (including 19,000 blacks), the BMI associated with the lowest mortality risk was 3.1 kg/m^2 higher among black men than white men and 1.5 kg/m^2 higher among black women than white women (10). Hence, the emerging pattern is generally consistent with our findings of a weaker association between mid-to-later-life BMI and all-cause mortality among blacks than whites. However, the Black Women's Health Study reported elevated mortality among 51,695 black women for all BMI categories of 25 or higher with the highest hazard ratio observed in extremely obese black women (HR = 2.19) (14), a finding more in line with results from recent pooled analyses of whites (6, 7) than other cohort studies with large black populations.

The reasons for differing adult BMI-mortality patterns between blacks and whites are unknown. Socioeconomic differences have been postulated (12, 13) but seem unlikely to account for elevated BMI as a risk factor only for whites in this study, because income and education distributions were fairly similar between black participants and white participants (and residual differences were adjusted in the analysis). Among both blacks and whites, however, we did observe that mortality risks associated with obesity tended to be lower among those with lower socioeconomic status, perhaps because other detriments to health are more prominent among low income populations. Similar differences by education were also observed among black women in the Black Women's Health Study, where excess mortality among the obese was limited to those with greater than 12 years of education (14). Other factors related to overall mortality that might differ by race could play a role in the

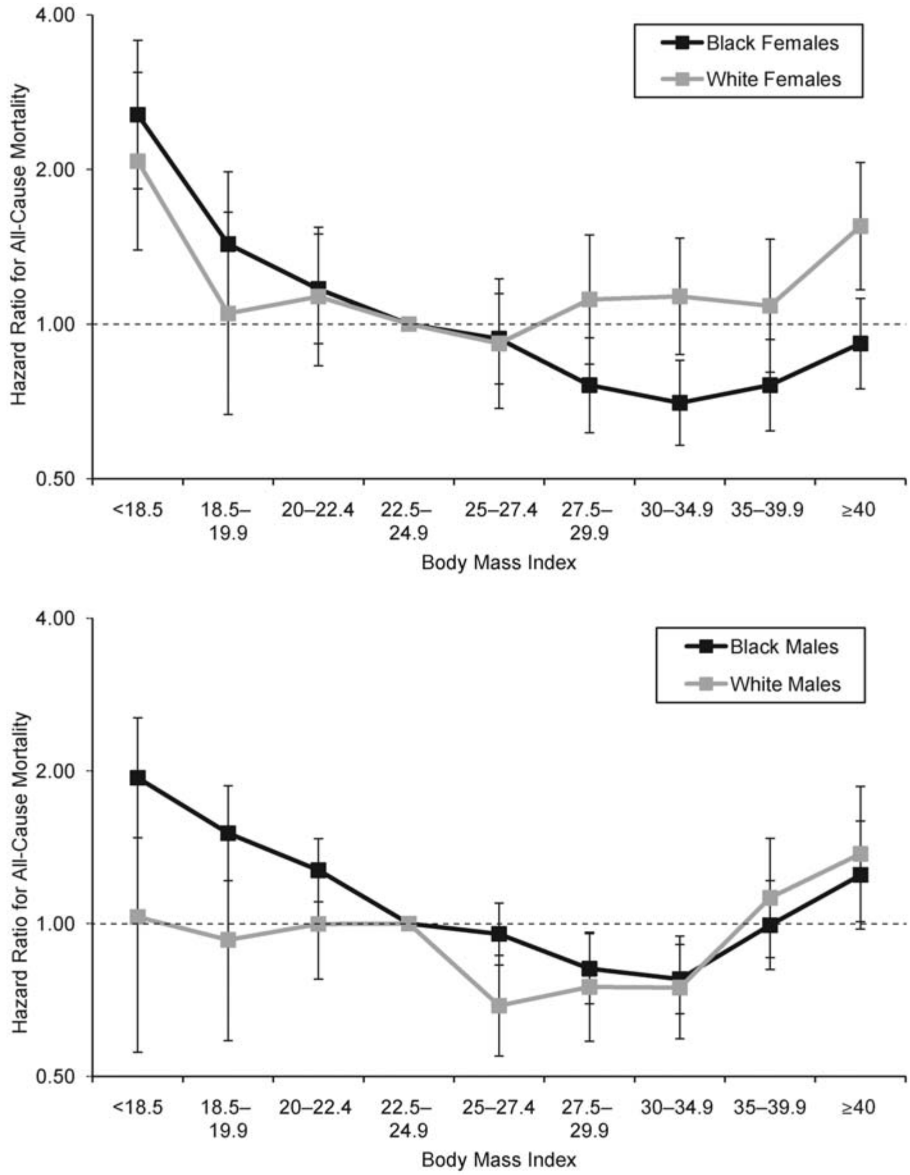

Figure 1. Hazard ratios for all-cause mortality by categories of body mass index at cohort entry for black adults and white adults by sex (females, top; males, bottom), Southern Community Cohort Study, 2002–2009. Cox proportional hazards models were adjusted for education, income, study enrollment source (community health center vs. general population), cigarette smoking, and alcohol consumption.

black-white difference in the BMI-mortality relation. We examined the effect of cigarette smoking by adjusting for smoking in the analyses and by restricting analyses to nonsmokers, but in both, the differential BMI mortality patterns between blacks and whites persisted.

In cause-specific mortality analyses, the most pronounced differences between blacks and whites were seen for cardiovascular disease mortality, where more than 2-fold increases were seen in whites in obesity classes II and III, while only slight and nonsignificant increases were observed in blacks of similarly elevated BMI. The stronger association between BMI and cardiovascular disease (compared with cancer or other combined causes of death) has been observed in previous large studies of primarily white individuals (6, 7, 20), as well black women (14). The difference seems likely to be due to stronger correlations between obesity and factors directly associated with increased risk of cardiovascular disease (more so than for cancer or other nonexternal causes) including dyslipidemia, hypertension, and insulin resistance (21). We have previously reported that the prevalence of diabetes, a strong cardiovascular disease risk factor, rose markedly with increasing BMI (22). In ongoing analyses, we have also observed a higher prevalence of atrial fibrillation, another

Table 3. Hazard Ratios and 95% Confidence Intervals From Race- and Sex-stratified Cox Proportional Hazards Models Examining All-Cause Mortality in Relation to Body Mass Index at Cohort Entry, Omitting the First 12 Months of Follow-up, Stratified by Follow-up Time (1–4.9 and ≥5 Years) and by Age at Cohort Entry, Southern Community Cohort Study, 2002–2009

Body Mass Index[a] by Follow-up Time and Age at Cohort Entry	Black Males			White Males			Black Females			White Females		
	No. of Deaths	Hazard Ratio[b]	95% CI	No. of Deaths	Hazard Ratio[b]	95% CI	No. of Deaths	Hazard Ratio[b]	95% CI	No. of Deaths	Hazard Ratio[b]	95% CI
Follow-up: 1–4.9 years												
<20	120	1.43	1.17, 1.74	26	0.99	0.65, 1.49	70	1.78	1.35, 2.35	44	1.48	1.04, 2.10
20–24.9	554	1.00	Referent	202	1.00	Referent	188	1.00	Referent	112	1.00	Referent
25–29.9	446	0.76	0.67, 0.86	199	0.74	0.60, 0.90	273	0.77	0.64, 0.93	135	0.97	0.76, 1.25
30–34.9	203	0.71	0.60, 0.84	94	0.65	0.50, 0.83	218	0.65	0.53, 0.79	133	1.24	0.96, 1.60
35–39.9	90	0.84	0.67, 1.05	65	1.10	0.83, 1.47	142	0.66	0.53, 0.82	65	1.09	0.80, 1.49
≥40	60	1.13	0.86, 1.49	48	1.36	0.98, 1.89	157	0.79	0.64, 0.99	87	1.58	1.18, 2.11
Follow-up: ≥5 years												
<20	46	1.56	1.13, 2.15	6	0.85	0.37, 2.00	23	1.50	0.94, 2.39	14	1.32	0.72, 2.40
20–24.9	203	1.00	Referent	61	1.00	Referent	79	1.00	Referent	51	1.00	Referent
25–29.9	204	0.93	0.76, 1.14	46	0.63	0.43, 0.94	137	0.87	0.66, 1.15	57	0.91	0.62, 1.33
30–34.9	72	0.67	0.50, 0.88	43	1.13	0.75, 1.71	107	0.68	0.51, 0.92	31	0.67	0.42, 1.05
35–39.9	43	1.05	0.75, 1.48	20	1.13	0.66, 1.92	85	0.84	0.62, 1.15	24	0.86	0.52, 1.42
≥40	20	1.10	0.69, 1.76	12	1.39	0.73, 2.68	89	1.01	0.74, 1.38	28	1.23	0.76, 1.99
Age at cohort entry: <55 years												
<20	90	1.44	1.14, 1.81	14	0.64	0.37, 1.11	56	1.68	1.23, 2.29	23	1.17	0.73, 1.88
20–24.9	455	1.00	Referent	142	1.00	Referent	142	1.00	Referent	74	1.00	Referent
25–29.9	336	0.80	0.70, 0.93	101	0.61	0.47, 0.80	207	0.89	0.72, 1.11	73	0.92	0.66, 1.28
30–34.9	136	0.71	0.58, 0.86	54	0.60	0.41, 0.79	143	0.64	0.51, 0.81	79	1.18	0.85, 1.63
35–39.9	60	0.81	0.62, 1.07	38	0.94	0.65, 1.37	102	0.67	0.52, 0.88	35	0.84	0.55, 1.26
≥40	51	1.19	0.88, 1.61	31	0.98	0.65, 1.48	147	0.91	0.72, 1.16	55	1.35	0.94, 1.94
Age at cohort entry: ≥55 years												
<20	76	1.46	1.13, 1.88	18	1.43	0.86, 2.40	37	1.79	1.23, 2.60	35	1.65	1.10, 2.45
20–24.9	302	1.00	Referent	121	1.00	Referent	125	1.00	Referent	89	1.00	Referent
25–29.9	314	0.80	0.68, 0.94	144	0.84	0.65, 1.07	203	0.70	0.56, 0.88	119	1.00	0.75, 1.32
30–34.9	139	0.68	0.55, 0.84	83	0.94	0.70, 1.26	182	0.68	0.54, 0.86	85	1.03	0.76, 1.40
35–39.9	73	0.98	0.75, 1.28	47	1.39	0.98, 1.98	125	0.74	0.57, 0.95	54	1.24	0.87, 1.76
≥40	29	0.97	0.65, 1.45	29	1.77	1.13, 2.75	99	0.77	0.58, 1.01	60	1.69	1.19, 2.39

Abbreviation: CI, confidence interval.

[a] Body mass index: weight (kg)/height $(m)^2$.

[b] Age was used as a timescale. All models were adjusted for education (5 categories: <9 years, 9–11 years, high school, some college, college or postgraduate); income (4 categories: <$15,000, $15,000–$24,999, $25,000–$49,999, $50,000 or more); source (community health center vs. general population); cigarette smoking (never, former, current/<1 pack/day, current/≥1 packs/day); and alcohol consumption (0, <1, ≥1 drinks/day).

Table 4. Hazard Ratios and 95% Confidence Intervals From Race- and Sex-stratified Cox Proportional Hazards Models Examining All-Cause Mortality in Relation to Body Mass Index at Cohort Entry, Omitting the First 12 Months of Follow-up, Stratified by Measures of Socioeconomic Status (Education and Income), Southern Community Cohort Study, 2002–2009

Body Mass Index[a] by Socioeconomic Status at Cohort Entry	Black Males			White Males			Black Females			White Females		
	No. of Deaths	Hazard Ratio[b]	95% CI	No. of Deaths	Hazard Ratio[b]	95% CI	No. of Deaths	Hazard Ratio[b]	95% CI	No. of Deaths	Hazard Ratio[b]	95% CI
Household income: <$15,000/year												
<20	144	1.54	1.28, 1.84	23	0.93	0.60, 1.44	79	1.62	1.25, 2.10	45	1.39	0.98, 1.97
20–24.9	595	1.00	Referent	166	1.00	Referent	216	1.00	Referent	116	1.00	Referent
25–29.9	484	0.84	0.74, 0.94	136	0.74	0.59, 0.93	303	0.75	0.63, 0.89	134	0.91	0.71, 1.17
30–34.9	164	0.59	0.50, 0.71	85	0.84	0.64, 1.11	219	0.57	0.47, 0.69	115	1.01	0.77, 1.31
35–39.9	88	0.86	0.68, 1.08	48	1.00	0.72, 1.39	166	0.66	0.54, 0.81	66	0.99	0.73, 1.35
≥40	51	0.97	0.73, 1.30	38	1.26	0.87, 1.83	177	0.75	0.61, 0.92	81	1.29	0.96, 1.73
Household income: ≥$15,000/year												
<20	22	1.17	0.75, 1.83	9	1.20	0.60, 2.39	14	1.94	1.07, 3.52	13	1.76	0.95, 3.27
20–24.9	162	1.00	Referent	97	1.00	Referent	51	1.00	Referent	47	1.00	Referent
25–29.9	166	0.73	0.59, 0.91	109	0.69	0.52, 0.91	107	1.03	0.73, 1.44	58	1.11	0.75, 1.63
30–34.9	111	0.93	0.73, 1.20	52	0.63	0.45, 0.89	106	1.04	0.74, 1.45	49	1.33	0.88, 2.00
35–39.9	45	1.01	0.72, 1.43	37	1.38	0.93, 2.04	61	0.95	0.65, 1.39	23	1.25	0.75, 2.09
≥40	29	1.53	1.02, 2.30	22	1.68	1.04, 2.71	69	1.34	0.92, 1.93	34	2.19	1.38, 3.48
$P_{interaction}$		0.01			0.25			0.06			0.75	
Education: <12 years												
<20	72	1.34	1.04, 1.73	11	0.90	0.48, 1.69	37	1.30	0.90, 1.87	23	1.80	1.10, 2.95
20–24.9	339	1.00	Referent	79	1.00	Referent	136	1.00	Referent	56	1.00	Referent
25–29.9	278	0.75	0.64, 0.88	70	0.76	0.55, 1.05	184	0.69	0.55, 0.86	74	1.00	0.71, 1.42
30–34.9	121	0.62	0.50, 0.77	49	0.86	0.59, 1.24	131	0.51	0.40, 0.65	58	1.02	0.70, 1.48
35–39.9	63	0.88	0.66, 1.16	29	1.10	0.71, 1.70	104	0.61	0.47, 0.80	27	0.82	0.51, 1.32
≥40	30	0.91	0.62, 1.34	13	0.90	0.49, 1.64	100	0.63	0.49, 0.83	34	1.23	0.79, 1.91
Education: ≥12 years												
<20	94	1.61	1.28, 2.01	21	1.00	0.63, 1.57	56	2.13	1.55, 2.92	35	1.21	0.82, 1.77
20–24.9	418	1.00	Referent	184	1.00	Referent	131	1.00	Referent	107	1.00	Referent
25–29.9	372	0.86	0.74, 0.99	175	0.71	0.58, 0.88	226	0.91	0.73, 1.13	118	0.92	0.71, 1.20
30–34.9	154	0.78	0.64, 0.94	88	0.71	0.55, 0.93	194	0.83	0.66, 1.03	106	1.09	0.83, 1.43
35–39.9	70	0.92	0.71, 1.19	56	1.15	0.85, 1.58	123	0.82	0.64, 1.06	62	1.09	0.79, 1.50
≥40	50	1.33	0.98, 1.79	47	1.64	1.17, 2.30	146	1.11	0.87, 1.42	81	1.59	1.18, 2.15
$P_{interaction}$		0.55			0.39			0.03			0.24	

Abbreviation: CI, confidence interval.
[a] Body mass index: weight (kg)/height (m)^2.
[b] Age was used as a timescale. All models were adjusted for education (5 categories: <9 years, 9–11 years, high school, some college, college or postgraduate); income (4 categories: <$15,000, $15,000–$24,999, $25,000–$49,999, $50,000 or more); source (community health center vs. general population); cigarette smoking (never, former, current/ <1 pack/day, current/ ≥1 packs/day); and alcohol consumption (0, <1, ≥1 drinks/day). Interactions between body mass index and household income, as well as between body mass index and education, were evaluated by using the likelihood ratio test in race- and sex-stratified models.

Table 5. Hazard Ratios and 95% Confidence Intervals From Race- and Sex-stratified Cox Proportional Hazards Models Examining Cause-specific Mortality in Relation to Body Mass Index at Cohort Entry, Omitting the First 12 Months of Follow-up, Southern Community Cohort Study, 2002–2009

Body Mass Index[a] at Cohort Entry	Black Males			White Males			Black Females			White Females		
	No. of Deaths	Hazard Ratio[b]	95% CI	No. of Deaths	Hazard Ratio[b]	95% CI	No. of Deaths	Hazard Ratio[b]	95% CI	No. of Deaths	Hazard Ratio[b]	95% CI
Cardiovascular deaths (ICD-10 I00–I99)												
<20	29	1.04	0.70, 1.54	5	0.94	0.37, 2.39	17	1.77	1.02, 3.10	10	2.09	0.97, 4.51
20–24.9	186	1.00	Referent	44	1.00	Referent	47	1.00	Referent	19	1.00	Referent
25–29.9	164	0.79	0.64, 0.98	61	1.05	0.71, 1.55	93	1.01	0.71, 1.44	40	1.65	0.95, 2.86
30–34.9	91	0.88	0.68, 1.14	19	0.59	0.34, 1.02	85	0.98	0.68, 1.41	25	1.34	0.73, 2.45
35–39.9	44	1.10	0.78, 1.55	30	2.17	1.33, 3.52	75	1.33	0.91, 1.92	24	2.27	1.23, 4.19
≥40	26	1.40	0.92, 2.14	16	2.10	1.15, 3.83	58	1.17	0.78, 1.73	25	2.62	1.41, 4.87
Cancer deaths (ICD-10 C00–C97)												
<20	35	1.32	0.91, 1.90	5	1.23	0.48, 3.16	19	1.50	0.89, 2.52	15	1.65	0.89, 3.05
20–24.9	169	1.00	Referent	36	1.00	Referent	59	1.00	Referent	34	1.00	Referent
25–29.9	131	0.76	0.60, 0.96	50	1.03	0.66, 1.59	90	0.81	0.58, 1.13	48	1.22	0.78, 1.90
30–34.9	49	0.62	0.45, 0.86	20	0.82	0.47, 1.43	74	0.71	0.50, 1.01	32	1.14	0.70, 1.87
35–39.9	17	0.59	0.36, 0.99	9	0.95	0.45, 2.01	34	0.51	0.33, 0.79	11	0.74	0.37, 1.47
≥40	9	0.71	0.36, 1.40	10	2.20	1.06, 4.57	49	0.85	0.57, 1.25	11	0.86	0.43, 1.72
All other nonexternal causes[c]												
<20	63	1.94	1.46, 2.57	12	1.20	0.65, 2.21	30	1.83	1.20, 2.78	23	2.00	1.20, 3.32
20–24.9	224	1.00	Referent	75	1.00	Referent	79	1.00	Referent	45	1.00	Referent
25–29.9	169	0.72	0.59, 0.88	47	0.51	0.35, 0.74	107	0.72	0.54, 0.97	42	0.72	0.47, 1.10
30–34.9	56	0.50	0.37, 0.67	32	0.63	0.41, 0.97	86	0.60	0.44, 0.82	47	1.02	0.68, 1.55
35–39.9	33	0.77	0.53, 1.12	17	0.81	0.47, 1.39	45	0.47	0.33, 0.69	20	0.76	0.44, 1.29
≥40	24	1.11	0.72, 1.71	21	1.64	0.98, 2.74	71	0.81	0.58, 1.13	41	1.66	1.07, 2.59

Abbreviations: CI, confidence interval; ICD-10, *International Classification of Diseases*, Tenth Revision.

[a] Body mass index: weight (kg)/height (m)^2.

[b] Age was used as a timescale. All models were adjusted for education (5 categories: <9 years, 9–11 years, high school, some college, college or postgraduate); income (4 categories: <$15,000, $15,000–$24,999, $25,000–$49,999, $50,000 or more); source (community health center vs. general population); cigarette smoking (never, former, current/ <1 pack/day, current/ ≥1 packs/day); and alcohol consumption (0, <1, ≥1 drinks/day).

[c] "All other nonexternal causes" excludes deaths due to cardiovascular disease, cancer, and external cause (ICD-10 codes beginning with S, T, V, W, X, and Y).

Table 6. Hazard Ratios and 95% Confidence Intervals From Race-stratified Cox Proportional Hazards Models Examining All-Cause Mortality in Relation to Quartiles of Waist Circumference and Waist/Hip Ratio, Southern Community Cohort Study, 2002–2009

	Blacks (*n* = 4,977)			Whites (*n* = 3,342)		
	No. of Deaths	Hazard Ratio[a]	95% CI	No. of Deaths	Hazard Ratio[a]	95% CI
Waist/hip ratio[b]						
Quartile 1	22	1.00	Referent	12	1.00	Referent
Quartile 2	21	0.89	0.49, 1.64	18	1.18	0.56, 2.48
Quartile 3	34	1.32	0.76, 2.30	21	1.21	0.58, 2.50
Quartile 4	22	0.97	0.53, 1.79	25	1.29	0.63, 2.63
Waist circumference[c]						
Quartile 1	28	1.00	Referent	11	1.00	Referent
Quartile 2	28	0.94	0.55, 1.60	22	1.66	0.79, 3.48
Quartile 3	23	0.69	0.39, 1.22	15	1.03	0.47, 2.28
Quartile 4	20	0.67	0.37, 1.22	28	2.09	1.01, 4.35

Abbreviation: CI, confidence interval.

[a] Age was used as a timescale. All models were adjusted for sex; education (5 categories: <9 years, 9–11 years, high school, some college, college or postgraduate); income (4 categories: <\$15,000, \$15,000–\$24,999, \$25,000–\$49,999, \$50,000 or more); cigarette smoking (never, former, current/ <1 pack/day, current/ ≥1 packs/day); and alcohol consumption (0, <1, ≥1 drinks/day).

[b] For waist/hip ratio, the quartile cutpoints for males were 0.89, 0.94, and 0.99, whereas for females, the cutpoints were 0.84, 0.90, and 0.95.

[c] For waist circumference, the quartile cutpoints for males were 89, 99, and 111, whereas for females, the cutpoints were 92, 103, and 116.

cardiovascular disease risk factor, among SCCS participants with high BMI (Loren Lipworth, Vanderbilt University, personal communication, 2011). Notably, for both our analyses of diabetes and atrial fibrillation within the SCCS, the association with obesity was stronger among whites than blacks, which may help to explain the larger racial difference seen for cardiovascular disease mortality than for cancer or other causes.

For all cancers, the differential pattern by race in the BMI-mortality association was evident only among males, but this finding should be viewed as preliminary given the relatively small number of cancers among whites. The major cause of cancer death among SCCS participants was lung cancer, which tends to be inversely associated with obesity (4). Thus, the influence of lung cancer on total cancer mortality likely dampened the association with obesity and accentuated the difference between the cardiovascular disease-BMI and cancer-BMI associations. Further, the absence of a strong association between cancer mortality and BMI tends to minimize the possibility for a racial difference, further accentuating the strong racial difference in cardiovascular disease mortality.

The different patterns by race for the BMI-overall mortality associations, as well as the more pronounced racial difference for cardiovascular disease mortality, may indicate that equivalency of BMI does not mean equivalency of the specific body composition parameters most associated with mortality. Although BMI is highly correlated with overall body fat, the distribution of fat is not well captured by BMI (23). As blacks have been shown to have less mean visceral fat than whites at the same level of BMI (24) and because visceral fat is more strongly associated with metabolic disorders and cardiovascular disease than subcutaneous fat (23), measures of adiposity such as waist circumference or waist/hip ratio may be better predictors of health outcomes than BMI, especially when examining populations with diverse racial backgrounds (25–27). In the SCCS, despite having measured data on waist circumference and waist/hip ratio for only a small subset of the cohort with limited follow-up, we observed that waist circumference was significantly associated with all-cause mortality only among whites, similar to the associations we observed with BMI, whereas trends in hazard ratios associated with waist circumference among blacks were flat. Thus, while BMI may be a less sensitive indicator of the body size characteristics (i.e., abdominal obesity) predictive of increased mortality among blacks, further study is needed to help identify factors underlying the racial differences in mortality patterns observed here and in other studies, as well as to clarify whether excess weight is actually less detrimental to health in blacks.

Future research would also benefit from the assessment of differences between blacks and whites in genetic variants thought to be associated with obesity and potential mortality. Within the SCCS, we recently reported that mean serum levels of adiponectin, an adipose tissue-derived protein that plays a critical role in several physiologic pathways related to disease risk (28), decreased monotonically with increasing BMI among white but not black women (29). Furthermore, we found that single nucleotide polymorphisms in adiponectin-related genes were associated with the serum levels only among whites (30). These preliminary findings suggest that genetically determined biologic attributes may be contributing to the differing patterns between obesity and overall mortality, but additional study is needed to clarify the roles of allelic variation and the potential mechanisms involved.

Limitations of this study first include the use of self-reported height and weight for a large proportion of participants. While height tends to be overreported and weight

underreported (31), data from the 1999 to 2004 National Health and Nutrition Examination Survey show that, despite errors in self-report, BMI categories based on self-reported values still generally demonstrate good agreement with BMI categories from measured values (32). Furthermore, in the SCCS, BMI values calculated from self-reported height and weight were highly correlated with values calculated from abstracted community health center medical records overall ($n = 14{,}000$; Pearson's correlation > 0.95) and within strata of race, income, and education, indicating that the self-reported values are generally of high quality. An additional limitation is the difficulty in controlling for existing disease, particularly with the relatively short follow-up currently available in the SCCS. It is likely that the higher mortality observed in underweight participants at least partially reflects preexisting disease processes. We attempted to address this issue by excluding the first 12 months of follow-up, but as the cohort is followed for longer periods, we anticipate that the high risks associated with lower weight will begin to dissipate, a trend that has already been seen in follow-up greater than 5 years after cohort entry.

This study also has several notable strengths. First, although the SCCS population is not reflective of the socioeconomic or racial distributions in the general US population because of the recruitment strategy through community health centers and the resulting overrepresentation of low-income individuals, it is a unique cohort in which to study health effects in blacks compared with whites because of both the large number of blacks and the comparability of socioeconomic status between the racial groups. The SCCS data add an important new dimension to the existing body of literature that for the most part has examined associations between obesity and mortality in middle or upper income cohorts, while the SCCS by contrast is composed of largely low-income individuals among whom obesity is more prevalent. Second, because of the large size of this cohort and the extensive data on smoking collected during the baseline questionnaire, we were able to carefully control for smoking, an important confounder of the mortality-obesity relation.

In summary, we found that racial differences in BMI-mortality associations exist between African Americans and whites of similarly low socioeconomic levels. These findings should stimulate additional research to untangle and identify the complex mechanisms underlying the observed racial differences and help in tailoring strategies to combat the adverse health effects of obesity in all population groups.

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