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Unequal burden of sleep-related obesity among black and white Americans

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Abstract

Background—This study ascertained whether individuals of the black race/ethnicity are unequally burdened by sleep-related overweight/obesity.

Methods—Analysis was based on data obtained from Americans (ages, 18–85 years) in the National Health Interview Survey (1977–2009). Sleep duration was coded as either very short sleep (VSS) (< 5 hours), short sleep (SS) (5–6 hours), or long sleep (>8 hours), referenced to 7–8-hour sleepers. Overweight was defined as body mass index (BMI) ≥ 25.0 and < 29.9 kg/m² and obesity, BMI ≥ 30 kg/m², referenced to normal weight (BMI = 18.5–24.9 kg/m²).

Results—Multivariate-adjusted regression analyses indicated that, among whites, VSS was associated with a 10% increased likelihood of being overweight and 51% increased likelihood of being obese, relative to 7–8-hour sleepers. Short sleep was associated with a 13% increased likelihood of being overweight and 45% increased likelihood of being obese. Long sleep was associated with 21% increased likelihood of being obese. Among blacks, VSS was associated with a 76% increased likelihood of being overweight and 81% increased likelihood of being obese. Short sleep was associated with a 16% increased likelihood of being overweight and 32% increased likelihood of being obese. As for the white stratum, long sleep was associated with a 25% increased likelihood of being obese.

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Conclusion—Our investigation demonstrates strong linkages between inadequate sleep and overweight/ obesity among black and white Americans. Although it cannot be said that insufficient sleep causes overweight/obesity, individuals of the black race/ethnicity sleeping 5 hours may be unequally burdened by sleep-related overweight/obesity.

Keywords

Obesity; Inadequate sleep; Race/ethnicity

Introduction

The notion that inadequate sleep (short sleep [SS] or long sleep [LS]) is a sufficient cause for overweight/obesity has been the subject of much controversy.^{1–8} This controversy is spurred by mixed epidemiologic evidence, with cross-sectional and longitudinal studies showing independent associations of inadequate sleep with overweight/ obesity,^{9–17} whereas others seem to indicate no significant associations.^{11,18–21} Plausibly, differences in study design, sampling techniques, and definitional criteria for exposure and outcome variables are the reasons for observed discrepancies. The case for causal associations seems stronger when considering experimental sleep curtailment evidence.^{22–24,13,25,26} However, subgroup analyses potentially revealing important clues as to which populations may be at greatest risk could not be rigorously performed in such studies because of inherently small sample sizes.

Evidence from large-scale controlled trials delineating causal links of inadequate sleep to overweight/obesity is not yet available. Although awaiting such evidence, it is important to address the concern that varying racial/ethnic strata in the US population may be differentially affected. Individuals of the black, relative to the white race/ethnicity, may be at greater overweight/obesity risk burden²⁷ conferred by inadequate sleep.^{28,29} Addressing this concern is all the more important from a health equity standpoint, if indeed causality is demonstrated. Interventions aiming at reducing cardiovascular morbidity and mortality, which are significantly higher among blacks,^{30–32} would of necessity target both inadequate sleep and overweight/ obesity as modifiable risk factors.

The National Health Interview Survey (NHIS), a surveillance study of the health of the US population, provides a unique data set to ascertain the strength of linkages between inadequate sleep, defined as very short (<5 hours), short (5–6 hours), or long (>8 hours) sleep, and overweight/obesity. Specifically, we ascertained whether inadequate sleep places unequal burden on individuals of the black race/ethnicity, relative to their white counterparts, by examining its influence on body mass index (BMI), a widely used cardiometabolic risk marker. These stratified analyses are anchored by converging evidence that prevalence estimates of both inadequate sleep and overweight/obesity are alarmingly greater among blacks.

Materials and methods

The NHIS is an ongoing, cross-sectional, in-person household interview survey conducted annually by Centers for Disease Control and Prevention's National Center for Health

Statistics. The NHIS uses a multistage area probability design, sampling noninstitutionalized representatives of US civilian population. Probability samples of the adult population of all 50 states and the District of Columbia were obtained.³³

During face-to-face interviews, respondents provided socio-demographic data, health risks, and professionally diagnosed chronic conditions. Participants estimated habitual sleep duration (using full-hour increments) by responding to the following question: “On average, how many hours of sleep do you get in a 24-hour period?” Sleep duration was coded as either very SS (VSS) (< 5 hours), SS (5–6 hours), or LS (>8 hours), referenced to 7–8 hours as healthy sleep over a 24-hour period.³⁴ These cutoff points showed significant associations with health risks.^{35,36} Body mass index, obtained by computing the ratio of self-reported weight and height, was coded as overweight (BMI = 25–29.9 kg/m²) and obesity (> 30 kg/m²), referenced to normal weight (BMI = 18.5–24.9 kg/m²). Participants rated their mood within the last 30 days based on the K6 scaling system³⁷; a score > 13 indicated emotional distress. The K6 is a widely used scale that asks participants how often they experienced symptoms of psychological distress (eg, “so depressed that nothing could cheer you up”). Participants were asked how often they do light or moderate or vigorous physical activity. If participants reported either moderate activity or vigorous or both, they were classified as having engaged in physical activity (defined as > 150 minutes/wk of moderate physical activity or > 75 minutes/wk of vigorous activity).

Statistical analysis

Analyses were based on NHIS data obtained from 1977 to 2009. Because the NHIS data set includes data from different samples using a multistage area probability sampling design, all analyses used Centers for Disease Control and Prevention–provided weights. These weights represent a product of weights for corresponding units computed in each of the sampling stages.

Because the study hypothesis focused on black and white respondents, data from other race/ethnic strata were excluded; we should also note that cells from other ethnic groups were too small to support the rigor of statistical analyses. All analyses took into account the complex sampling design of NHIS and were performed using SAS version 9.1.2 and SAS-callable SUDAAN version 9 (SAS Institute, Cary, NC).³⁸

Given the significant interactions observed between the main factors, stratified analyses were performed. The rationale for stratified analysis was further supported by varying year-to-year changes in the parameters of interest, comparing black and white respondents. Next, using aggregated data (1983–2009), we ascertained which factors (ie, sociodemographics, health risks, or medical conditions) were associated with inadequate sleep and overweight/obesity within each stratum using multivariate-adjusted multinomial logistic regressions. This yielded age- and sex-adjusted estimates of inadequate sleep and overweight/obesity (Tables 3 and 4).^{39,40} Predictors were chosen based on preliminary analyses demonstrating that these factors tended to change over time, with potential effects on sleep and overweight/obesity.¹⁹ A review of factors likely to influence sleep duration has been published.⁴¹

We also used a hierarchical multivariate-adjusted multinomial logistic regression for complex survey to obtain 8 separate adjusted models (Tables 5 and 6). Because data were not available for each year from 1977 to 2009, a lag-time factor (3-year interval) was created to determine potential time effects on associations between inadequate sleep and overweight/obesity with simultaneous adjustment for covariates with demonstrable correlations with both sleep and weight.

Results

Preliminary analysis based on aggregated NHIS data was conducted. They showed significant interactions between inadequate sleep and race/ethnicity on the presence of obesity. Black very short, short, or long sleepers were more likely to be overweight, relative to whites ([odds ratio {OR} = 1.76; 95% confidence interval {CI} = 1.27–2.44; $P < .001$], [OR = 1.39; 95% CI = 1.26–1.54; $P < .001$], and [OR = 1.25; 95% CI = 1.04–1.51; $P < .001$], respectively). Similarly, black very short, short, or long sleepers were more likely to be obese, relative to whites ([OR = 1.77; 95% CI = 1.29–2.44; $P < .001$], [OR = 1.60; 95% CI = 1.44–1.77; $P < .001$], and [OR = 1.63; 95% CI = 1.35–1.97; $P < .001$], respectively). Consistent with these findings, stratified analyses were conducted contrasting black and white participants (see below).

Characteristics of the sample are reported separately for white and black participants in Tables 1 and 2. These analyses indicated that prevalence estimates of the main exposure variable (eg, sleep duration over a 24-hour period) for these 2 strata varied considerably over time. Among whites, the prevalence of VSS increased from 1.5% in 1977 to 2.3% in 2009, and the prevalence of SS increased from 19.3% to 25.4%, whereas prevalence of LS decreased from 11.2% to 7.8%. Among blacks, the prevalence of VSS increased from 3.3% to 4.0%, and the prevalence of SS increased from 24.6% to 33.7%, whereas the prevalence of LS decreased from 16.1% to 9.4%. Analyses depicting associations of sociodemographics, health risks, and medical conditions with overweight/obesity and inadequate sleep are presented in Tables 3 and 4.

Hierarchical, multivariate-adjusted associations of inadequate sleep (VSS, SS, and LS) with overweight/obesity based on aggregated data are depicted in Tables 5 and 6. Among whites (Table 5), VSS and SS were associated with both overweight and obesity in all models. In the final adjusted model, VSS was associated with a 10% increased likelihood of being overweight and 51% increased likelihood of being obese, relative to 7–8-hour sleepers. Short sleep was associated with a 13% increased likelihood of being overweight and 45% increased likelihood of being obese. Long sleep was not significantly associated with being overweight in any of the models, but LS was associated with 21% increased likelihood of being obese in all models except for the final one.

Similarly, among blacks (Table 6), VSS and SS were associated with increased likelihood of being overweight and obese in all models. Specifically, VSS was associated with a 76% increased likelihood of being overweight and 81% increased likelihood of being obese. Short sleep was associated with a 16% increased likelihood of being overweight and 32% increased likelihood of being obese. Analogous to findings among whites, LS was not a

significant predictor of overweight, but it was associated with a 25% increased likelihood of being obese in all models except for the final one. In these stratified analyses, the final model adjusted for all factors in the previous models with the addition of the lag-time factor. That the final model was not significant suggests that the actual year of observation may have been in some fashion deterministic of whether associations between the exposure and outcome variables would be significant.

Discussion

Evidently, analysis of cross-sectional epidemiologic data, as herein performed, cannot rigorously address hypothesized causal links between inadequate sleep and overweight/obesity. The purpose of our analyses was to determine whether these two cardiometabolic risk markers were independently associated among blacks and whites using stratified regression modeling. Our investigation expands on the extant epidemiologic sleep literature demonstrating that linkages between inadequate sleep and overweight/obesity among individuals of the black race/ethnicity may indeed be stronger than those observed among their white counterparts.

The finding of a general increase in prevalence estimates for overweight/obesity in the US population is consistent with several published articles.^{10,42} The National Health and Nutrition Examination Survey (NHANES) data indicated that the prevalence of obesity has nearly tripled from 13% in 1960 to 34% in 2008.^{10,27} Of relevance to our investigation, analyses also revealed that estimates in 2008 were higher among blacks (44.1%), relative to whites (32.6%).²⁷ According to our analyses, prevalence estimates of obesity among whites increased from 9.1% in 1977 to 26.8% in 2009; among blacks, they increased from 16.9% to 36.7%.

Prevalence estimates of insufficient sleep (<7 hours) from 1977 to 2009 among blacks have been consistently greater than those of their white counterparts. These are consistent with previous reports that insufficient sleep was more prevalent among blacks (OR = 1.97CI?).^{29,43} Similarly, the observation that LS prevalence was consistently greater among blacks is in line with published data. Analysis of the 1997 NHANES data indicated that a greater proportion of blacks (11%), compared with whites (8%), slept longer than 8 hours.⁴⁴ These findings suggest that black inadequate sleepers (VSS, SS, or LS) may be at greater risk for experiencing deleterious sleep-related physiological and hormonal effects,^{22,13,25,26} which may predispose them to adverse cardiometabolic outcomes.

The stratified analytic approach was justified by results of our interactional analysis, showing that associations between sleep duration and weight depended on race/ethnicity. The final multivariate-adjusted model suggested that, within the white stratum, an excess of 10% of respondents reporting VSS and 13% of those reporting SS were overweight, relative to healthy white sleepers. Likewise, an excess of 51% of respondents reporting VSS and 45% of those reporting SS were obese. Within the black stratum, associations were stronger; 76% of respondents reporting VSS and 16% of those reporting SS were overweight, relative to healthy black sleepers. Similarly, an excess of 81% of respondents reporting VSS and 32% of those reporting SS were obese. These results suggest that both blacks and whites

experiencing VSS or SS are more likely to be overweight or obese. However, consistent with our hypothesis, the magnitude of these associations among blacks seems stronger, constituting a greater public health concern, given their disproportionately greater burden of cardiovascular morbidity and mortality.^{30–32}

Results are consistent with multiple epidemiologic data evidencing linkages between insufficient sleep and overweight/obesity.^{9,13–17} Compared with healthy adult sleepers, a recent meta-analysis showed that the pooled OR for obesity conferred by insufficient sleep was 55%.³ Unfortunately, because investigators did not perform stratified analyses, excess risk that is attributable to a specific racial/ethnic group could not be determined. Converging data suggest that race/ethnicity should be considered in epidemiologic analysis linking inadequate sleep to overweight/obesity. Although it cannot be said that insufficient sleep causes overweight or obesity, it is apparent that individuals of the black race/ethnicity sleeping ≤ 5 hours may be unequally burdened by sleep-related overweight/obesity. This may be driven by greater opportunity for fat intake,⁴⁵ greater caloric intake,²⁵ suboptimal food choices,⁴⁶ and dysregulated leptin and ghrelin levels¹³ associated with insufficient sleep.

Despite the fact that we adjusted 17 covariates, odds of overweight/obesity associated with VSS or SS remained significant for both strata. Medical factors seem to have similarly influenced measures of inadequate sleep and overweight/obesity among blacks and whites, whereas demographic and health risk factors varied in the manner in which they affected these measures. It is yet uncertain what specific factors mediated greater odds of overweight/obesity conferred by VSS or SS among blacks. Conceivably, they might reflect greater prevalence of sleep apnea among blacks.^{47,48} Working on rotating or night-shift schedules, which is more prevalent among blacks, is also a common cause of insufficient sleep.⁴⁹ Unfortunately, because the NHIS database does not include these data, influences of these factors could not be ascertained.

As these epidemiologic data evidence, sleep duration may be a key factor in understanding excess overweight/obesity associated with insufficient sleep among blacks. Whether insufficient sleep is a function of lifestyle choices or sleep fragmentation, blacks may be at increased risk for developing diabetes and cardiovascular disease due to excess weight and insufficient sleep. Data from the Nurses' Health Study suggests that curtailed sleep duration may lead to the development or exacerbation of diabetes.⁵⁰ Although the mechanism linking insufficient sleep to overweight/obesity is not fully delineated, targeting sleep might be a novel and effective method of preventing and treating overweight/obesity.

Another important finding is that race/ethnicity also interacted with LS. Compared with healthy sleepers, black and white long sleepers were 25% and 21%, respectively, more likely to be obese. Adjusting for depressed moods and economic status, two factors commonly linked to sleeping long hours, did not affect the racial/ethnic difference in greater odds of obesity conferred by LS, which is consistent with published data.⁴ According to a 6-year follow-up study, individuals sleeping 9–10 hours were 21% more likely to become obese, relative to healthy sleepers.¹⁵ We surmise that blacks and whites sleeping >8 hours may be at increased risk for being obese, although to a lesser extent than those sleeping ≤ 6

hours. It is noteworthy that sleep-obesity associations in the aforementioned study were not substantially affected by adjustment for food intake, physical activity, or medical confounders, challenging the notion that LS is simply an epiphenomenon of comorbidity.¹⁹ Indeed, actigraphic findings suggest that some self-reported long sleepers in effect sleep longer than those reportedly sleeping 7–8 hours.⁵¹ It is, therefore, of interest to ascertain how much of the excess time in bed is due to medical or psychiatric comorbidity, sleep disorders, sleep habits, or mere physiological sleep needs. In addition, excess time in bed may be a manifestation of napping, which is related to adverse health outcomes. Indeed, a recent study showed that napping is associated with risk of type 2 diabetes among Chinese older adults.⁵²

We observed that linkages between LS and obesity were no longer significant after additional adjustment for lag time. The lag-time variable adjusted for variations in yearly intervals of NHIS data acquisition. This suggests that associations between LS and obesity might not be equally strong for all the years of observation. This is consistent with preliminary data showing that assessment in 1985 was associated with increased likelihood of reporting LS, whereas assessment in 2006–2007 was associated with decreased likelihood. This may in part explain why some analyses examining associations between inadequate sleep and overweight/obesity may fail to show consistent associations.

It is not entirely clear why black long sleepers were characterized by relatively greater odds of obesity. Conceivably, the mechanisms underlying associations of LS with obesity differ between blacks and whites. Plausibly, blacks reporting long hours of sleep spend less time engaged in social activities promoting healthy life choices. Recent evidence suggests that individuals spending more time in bed are characterized by reduced daily energy expenditure.⁵³ Another likely explanation is that medical comorbidity associated with obesity might predispose susceptible blacks to spending more time in bed.⁵¹ Oversleeping among whites might reflect presence of other factors promoting LS such as depression.^{54,55}

Conclusions

Future studies should investigate the mediators of excess odds of overweight/obesity associated with inadequate sleep. Our analyses adjusted effects of 17 important covariates.^{19,43} Yet, associations have remained significant, particularly among blacks, who seem unequally burdened by sleep-obesity linkages. They should also examine the accuracy of self-reported sleep duration, which may be biased by poor recall, social desirability, forward telescoping, or improperly constructed sleep questions that may not reflect respondents' sociocultural experience.^{56–58} Appraisal research suggests that recall bias may influence the accuracy of self-reported data among blacks.^{59,60} Another important study limitation is that medical data (ie, BMI) were based on subjective reports. It is of interest to examine whether inadequate sleep obtained from actigraphy would also predict increased risk of overweight/obesity, be it derived from BMI or from waist circumference or skinfold thickness measurements, as some studies have indicated that BMI may not be an adequate measure of cardiometabolic risk.⁶¹ Other measures including waist circumference may be more appropriate for risk assessment in minority populations.⁶²

Notwithstanding study limitations, results suggest that individuals experiencing inadequate sleep habitually might be at greater risk for overweight/obesity, although risk seems greater for blacks. Obesity-risk reduction interventions should incorporate evidence-based therapies to improve sleep. Moreover, they should be informed by evidence suggesting that increased prevalence of insufficient sleep might have negative health and societal effects, although extending sleep time might not necessarily confer positive health benefits. Furthermore, reductions in LS might benefit individuals experiencing insomnia.

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Table 1

Characteristics of white participants in the NHIS study (1977–2009).

Characteristics	1977	1983	1985	1990	2004	2005	2006	2007	2008	2009
n	16,429	8576	23,756	29,028	19,357	19,510	14,089	13,720	12,814	16,281
Sex, female (%)	54.2	55.8	51.3	51.2	49.9	49.9	49.5	49.3	49.5	49.8
Age, y (mean $\pm$ SD)	42 $\pm$ 15	40 $\pm$ 15	40 $\pm$ 17	41 $\pm$ 17	42 $\pm$ 17	42 $\pm$ 17	42 $\pm$ 17	43 $\pm$ 18	43 $\pm$ 18	43 $\pm$ 19
Education, HS (%)	73.0	78.6	81.2	83.5	88.1	88.3	87.7	88.7	88.5	88.8
Marital status										
Married	74.5	69.6	69.5	69.6	62.1	61.8	60.9	59.9	59.3	57.9
Widowed, divorced, & separated	12.3	13.0	11.7	12.6	15.2	15.3	15.7	15.5	16.1	16.4
Single	13.2	17.4	18.8	17.8	22.7	22.9	23.4	24.6	24.6	25.7
Total family income, \$35K (%)	–	23.7	32.0	48.3	66.6	67.8	67.9	71.5	72.9	72.5
Poverty status, below (%)	–	6.6	8.8	7.3	9.1	9.0	10.2	9.5	10.3	10.8
Ever smoked, yes (%)	58.8	56.3	56.5	52.5	44.2	44.3	44.0	43.7	44.2	44.6
Alcohol consumption										
Never drinkers	–	–	–	13.0	19.6	19.0	19.6	18.3	16.3	15.3
Former drinkers	–	–	–	9.0	13.2	12.8	12.9	13.1	12.4	13.1
Current drinkers	–	–	–	78.0	67.2	68.2	67.5	68.6	71.2	71.5
BMI (mean $\pm$ SD)	24.3 $\pm$ 4.3	24.4 $\pm$ 4.5	24.6 $\pm$ 5.1	25.0 $\pm$ 5.1	26.6 $\pm$ 5.6	26.8 $\pm$ 5.7	27.1 $\pm$ 6.4	27.0 $\pm$ 6.3	27.3 $\pm$ 6.4	27.3 $\pm$ 6.8
Obesity	9.1	10.3	10.8	12.9	22.9	23.9	25.7	25.5	26.8	26.8
Physical activity, yes (%)	–	–	–	–	10.9	11.4	11.2	11.3	11.5	12.5
Emotional stress, yes (%)	–	–	–	–	3.3	3.0	3.1	2.7	3.6	3.5
Comorbid conditions:										
Diabetes	–	3.4	–	–	5.9	6.5	6.6	6.2	7.1	7.9
Hypertension	–	20.7	21.4	19.9	20.3	20.4	22.3	22.0	23.9	23.4
Cancer	–	3.2	–	–	5.5	6.1	5.8	6.1	6.6	6.8
Coronary heart disease	–	1.8	–	–	2.7	3.1	2.9	2.9	2.7	3.2
Heart attack (MI)	–	–	–	–	2.2	2.4	2.3	2.1	2.5	2.3
Stroke	–	0.9	1.2	1.2	1.5	1.2	1.4	1.5	1.8	1.6
Kidney disease	–	–	–	–	1.2	1.2	1.1	1.0	1.2	1.4
Sleep measures:										

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Characteristics	1977	1983	1985	1990	2004	2005	2006	2007	2008	2009
Hours of sleep (mean $\pm$ SD)	7.4 $\pm$ 1.2	7.3 $\pm$ 1.2	7.4 $\pm$ 1.4	7.3 $\pm$ 1.4	7.1 $\pm$ 1.4	7.1 $\pm$ 1.5	7.1 $\pm$ 1.3	7.1 $\pm$ 1.4	7.1 $\pm$ 1.5	7.1 $\pm$ 1.7
Categories of sleep quantity										
VSS	1.5	1.7	1.1	1.4	2.0	2.1	2.1	1.8	2.3	2.3
SS	19.3	20.1	20.2	22.3	26.0	26.0	26.2	24.7	25.6	25.4
Normal sleep	68.0	69.0	68.7	68.2	64.9	64.9	64.9	66.9	64.9	64.5
LS	11.2	9.1	10.0	8.1	7.0	7.0	6.8	6.6	7.2	7.8

Abbreviation: HS, high school; MI, myocardial infarction.

Note that several health factors were not collected before 2004.

Table 2

Characteristics of black participants in the NHIS study (1977–2009).

Characteristics	1977	1983	1985	1990	2004	2005	2006	2007	2008	2009
n	1703	942 ^a	4270	4922	3501	3496	3285	2977	2727	3738
Sex, female (%)	59.1	59.5	55.3	54.8	54.2	53.1	53.6	53.2	54.5	54.5
Age, y (mean ± SD)	40 ± 15	38 ± 15	38 ± 19	38 ± 18	40 ± 17	40 ± 17	40 ± 18	40 ± 17	40 ± 18	41 ± 16
Education, HS (%)	55.2	64.9	67.0	72.3	84.5	85.2	86.2	86.4	87.3	86.9
Marital status										
Married	50.3	47.0	46.7	45.9	38.9	37.7	37.9	37.4	35.3	36.0
Widowed, divorced & separated	29.3	21.8	20.6	21.5	22.4	22.0	21.2	22.2	20.6	21.0
Single	20.4	31.2	32.7	32.6	38.7	40.3	40.9	40.4	44.1	43.0
Family income, 35K (%)	–	10.3	13.5	25.4	45.9	47.2	45.3	52.3	54.9	53.0
Poverty status, below (%)	–	22.8	27.9	23.5	18.5	20.4	21.6	23.1	19.9	23.0
Ever smoked, yes (%)	57.2	50.5	52.1	43.5	32.8	34.7	34.3	33.3	34.9	35.2
Alcohol consumption										
Never drinkers	–	–	–	25.4	36.2	36.4	34.1	31.9	28.9	27.1
Former drinkers	–	–	–	9.3	13.2	13.0	13.8	14.5	14.9	15.1
Current drinkers	–	–	–	65.4	50.6	50.6	52.2	53.6	56.2	57.8
BMI (mean ± SD)	25.8 ± 5.4	25.6 ± 5.2	25.6 ± 6.2	26.5 ± 6.4	28.0 ± 6.3	27.8 ± 6.3	28.3 ± 7.2	28.4 ± 7.1	28.4 ± 7.3	28.7 ± 8.2
Obesity	16.9	17.6	16.1	21.3	31.9	31.3	32.9	34.4	35.9	36.7
Physical activity, yes (%)	–	–	–	–	11.5	11.5	10.9	11.9	13.6	13.7
Emotional stress, yes (%)	–	–	–	–	3.6	3.2	3.7	2.6	3.6	4.0
Comorbid conditions:										
Diabetes	–	5.8	–	–	8.3	8.7	9.7	9.5	9.4	10.7
Hypertension	–	31.2	28.1	28.0	27.8	27.5	28.9	29.9	30.6	30.9
Cancer	–	0.3	–	–	2.7	2.4	2.8	2.9	2.6	3.2
Coronary heart disease	–	1.4	–	–	2.2	2.5	2.5	2.6	2.3	2.9
Heart attack (MI)	–	–	–	–	1.4	1.6	2.1	1.6	2.3	2.5
Stroke	–	1.1	1.3	1.8	2.1	2.0	2.7	2.4	2.5	2.4
Kidney disease	–	–	–	–	1.8	1.9	1.5	2.6	1.6	1.6
Sleep measures:										

Characteristics	1977	1983	1985	1990	2004	2005	2006	2007	2008	2009
Hours of sleep (mean $\pm$ SD)	7.4 $\pm$ 1.6	7.2 $\pm$ 1.6	7.5 $\pm$ 2.3	7.4 $\pm$ 2.4	7.1 $\pm$ 2.3	7.1 $\pm$ 1.7	7.0 $\pm$ 1.8	7.1 $\pm$ 1.8	7.1 $\pm$ 2.1	7.0 $\pm$ 2.3
Categories of sleep quantity										
VSS	3.3	4.4	2.4	2.4	3.3	3.1	3.7	3.6	3.8	4.0
SS	24.6	27.8	25.8	27.4	31.7	31.7	32.6	30.9	33.2	33.7
Normal sleep	56.0	55.9	54.6	56.2	55.5	55.7	55.4	56.5	53.9	52.9
LS	16.1	11.9	17.2	14.0	9.4	9.4	8.3	9.0	9.1	9.4

Note: Note that several health factors were not collected before 2004.

^aThe total sample is 1934, but only 942 were usable in analysis due to weighting factors.

Table 3

Age-sex-adjusted associations of demographics, health risks, and comorbid conditions with overweight/obesity and inadequate sleep among whites (1983–2009).

Characteristics	Overweight		Obesity		VSS		SS		LS	
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Education (reference: high school)	1.15 (1.10–1.20) ^b	1.33 (1.27–1.39) ^b	2.04 (1.83–2.28) ^b	1.06 (1.01–1.10) ^b	1.89 (1.79–2.01) ^b					
Marital status (reference: married)										
Widowed	0.91 (0.85–0.96) ^b	0.94 (0.87–1.02)	2.31 (1.92–2.77) ^b	1.43 (1.32–1.53) ^b	1.51 (1.35–1.69) ^b					
Divorced	0.90 (0.87–0.95) ^b	1.00 (0.95–1.05)	2.72 (2.41–3.07) ^b	1.58 (1.51–1.65) ^b	1.19 (1.11–1.28) ^b					
Separated	1.01 (0.93–1.11)	1.28 (1.15–1.41) ^b	3.90 (3.20–4.76) ^b	1.64 (1.50–1.78) ^b	1.29 (1.11–1.49) ^b					
Single	0.75 (0.72–0.78) ^b	0.82 (0.78–0.86) ^b	1.35 (1.17–1.56) ^b	0.96 (0.92–1.00)	1.68 (1.59–1.79) ^b					
Total family income (reference: 35K)	0.87 (0.84–0.89) ^b	0.89 (0.85–0.92) ^b	2.08 (1.89–2.30) ^b	1.06 (1.03–1.09) ^b	1.79 (1.69–1.88) ^b					
Poverty status (reference: above)	1.04 (0.98–1.09)	1.33 (1.25–1.48) ^b	2.95 (2.60–3.34) ^b	1.20 (1.14–1.26) ^b	1.94 (1.80–2.08) ^b					
Smoking status (reference: never smokers)	0.99 (0.98–0.99) ^b	0.99 (0.99–0.99) ^b	1.06 (1.05–1.07) ^b	1.03 (1.03–1.03) ^b	1.04 (1.03–1.04) ^b					
Alcohol consumption (reference: never)										
Former	1.03 (0.96–1.10) ^b	1.24 (1.16–1.33) ^b	2.12 (1.74–2.57) ^b	1.59 (1.49–1.69) ^b	1.37 (1.24–1.51) ^b					
Current	0.90 (0.86–0.94) ^b	0.78 (0.74–0.82) ^b	1.00 (0.87–1.15)	1.30 (1.24–1.36) ^b	0.80 (0.75–0.86) ^b					
Physical activity (reference: yes) ^a	0.84 (0.72–0.97) ^b	1.34 (1.16–1.35) ^b	4.35 (3.48–5.44) ^b	1.52 (1.33–1.75) ^b	3.12 (2.61–3.75) ^b					
Emotional distress (reference: no) ^a	1.09 (0.97–1.23)	1.95 (1.75–2.17) ^b	9.73 (7.18–13.17) ^b	2.46 (1.98–3.07) ^b	3.17 (2.34–4.25) ^b					
Self-report comorbid conditions:										
Cancer	0.88 (0.81–0.95) ^b	0.95 (0.88–1.03)	1.69 (1.42–2.02) ^b	1.13 (1.05–1.21) ^b	1.50 (1.34–1.68) ^b					
Diabetes	1.96 (1.78–2.16) ^b	5.23 (4.79–5.73) ^b	2.22 (1.88–2.63) ^b	1.23 (1.15–1.32) ^b	1.97 (1.77–2.18) ^b					
Hypertension	1.69 (1.63–1.76) ^b	3.60 (3.46–3.76) ^b	2.11 (1.90–2.36) ^b	1.28 (1.23–1.32) ^b	1.50 (1.42–1.59) ^b					
Kidney disease	0.98 (0.83–1.17)	1.53 (1.29–1.82) ^b	3.27 (2.40–4.47) ^b	0.58 (0.49–0.67) ^b	1.81 (1.47–2.24) ^b					
Heart Attack (MI)	1.21 (1.05–1.40) ^b	1.93 (1.68–2.23) ^b	3.05 (2.40–3.88) ^b	1.26 (1.12–1.42) ^b	2.58 (2.19–3.04) ^b					
Coronary heart disease	1.32 (1.17–1.49) ^b	1.94 (1.71–2.19) ^b	2.34 (1.88–2.91) ^b	1.16 (1.05–1.29) ^b	2.24 (1.93–2.61) ^b					
Stroke	1.08 (0.95–1.23)	1.50 (1.32–1.72) ^b	4.47 (3.56–5.63) ^b	1.47 (1.31–1.66) ^b	3.26 (2.81–3.78) ^b					

^aData available for 2004–2009.

Denotes significance at the 5% level (ie, OR is either significantly <1 or >1); data from 1977 were excluded because many of the medical comorbidities were not available; inadequate sleep was defined as VSS (5 hours/night), SS (5–6 hours/night), or LS (>8 hours/night), referenced to 7–8-hour/night sleepers.

Age-sex-adjusted associations of demographics, health risks, and comorbid conditions with overweight/obesity and inadequate sleep among blacks (1983–2009).

Table 4

Characteristics	Overweight		Obesity		VSS		SS		LS	
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Education (reference: high school)	0.80 (0.73–0.87) ^b	0.92 (0.83–1.01)	1.22 (1.01–1.47) ^b	0.82 (0.75–0.89) ^b	2.12 (1.90–2.36) ^b					
Marital status (reference: married)										
Widowed	0.65 (0.54–0.78) ^b	0.72 (0.60–0.87) ^b	1.12 (0.77–1.63) ^b	1.01 (0.86–1.19)	1.43 (1.16–1.77) ^b					
Divorced	0.85 (0.76–0.94) ^b	0.92 (0.82–1.03)	1.61 (1.25–2.06) ^b	1.10 (1.00–1.21) ^b	0.89 (0.76–1.04)					
Separated	0.78 (0.67–0.91) ^b	0.82 (0.71–0.96) ^b	1.54 (1.14–2.09) ^b	1.02 (0.89–1.16)	1.32 (1.10–1.60) ^b					
Single	0.75 (0.69–0.82) ^b	0.86 (0.78–0.94) ^b	1.15 (0.91–1.45) ^b	0.88 (0.81–0.96) ^b	1.19 (1.06–1.34) ^b					
Family income (reference: < 35K)	0.76 (0.70–0.82) ^b	0.82 (0.75–0.89) ^b	1.52 (1.25–1.85) ^b	0.81 (0.75–0.87) ^b	1.77 (1.56–1.99) ^b					
Poverty status (reference: above)	0.81 (0.74–0.89) ^b	1.00 (0.91–1.10)	1.95 (1.61–2.36) ^b	0.96 (0.88–1.04)	1.94 (1.73–2.17) ^b					
Smoking status (reference: never smokers)	0.98 (0.97–0.99) ^b	1.27 (1.19–1.35) ^b	1.04 (1.02–1.06) ^b	1.02 (1.01–1.02) ^b	1.05 (1.04–1.06) ^b					
Alcohol consumption (reference: never)										
Former	1.18 (1.03–1.35) ^b	1.39 (1.21–1.59) ^b	1.67 (1.26–2.20) ^b	1.51 (1.34–1.70) ^b	1.29 (1.08–1.54) ^b					
Current	1.16 (1.06–1.28) ^b	1.20 (1.09–1.31) ^b	1.52 (1.22–1.89) ^b	1.58 (1.45–1.72) ^b	1.02 (0.90–1.16)					
Physical activity (reference: yes) ^a	1.01 (0.73–1.41)	1.36 (1.00–1.84)	2.51 (1.62–3.90) ^b	1.02 (0.78–1.35)	2.90 (2.07–4.05) ^b					
Emotional distress (reference: no) ^a	0.79 (0.61–1.02)	1.22 (0.96–1.55)	13.95 (11.89–16.37) ^b	2.70 (2.44–2.99) ^b	4.08 (3.53–4.71) ^b					
Self-report comorbid conditions:										
Cancer	1.08 (0.82–1.42)	1.17 (0.90–1.53)	1.27 (0.82–1.94) ^b	1.24 (1.00–1.53) ^b	1.36 (0.99–1.88)					
Diabetes	1.43 (1.20–1.71) ^b	2.94 (2.49–3.50) ^b	1.50 (1.04–2.15) ^b	1.13 (0.99–1.29) ^b	1.46 (1.21–1.76) ^b					
Hypertension	1.46 (1.34–1.60) ^b	2.91 (2.66–3.18) ^b	1.69 (1.39–2.05) ^b	1.09 (1.01–1.18) ^b	1.32 (1.18–1.49) ^b					
Kidney disease	0.98 (0.70–1.36)	1.18 (0.85–1.63)	2.27 (1.38–3.74) ^b	0.86 (0.65–1.13)	1.49 (0.96–2.31) ^b					
Heart attack (MI)	0.81 (0.58–1.14)	1.35 (0.99–1.82) ^b	1.71 (1.05–2.79) ^b	1.08 (0.83–1.39)	2.23 (1.56–3.18) ^b					
Coronary heart disease	1.06 (0.77–1.45)	1.60 (1.20–2.13) ^b	1.83 (1.15–2.92) ^b	1.09 (0.87–1.37)	1.61 (1.34–2.37) ^b					
Stroke	0.75 (0.58–0.98)	0.99 (0.77–1.28)	2.35 (1.57–3.51) ^b	0.86 (0.69–1.08)	1.78 (1.34–2.37) ^b					

^aData available for 2004–2009.

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Denotes significance at the 5% level (ie, OR is either significantly <1 or >1); data from 1977 were excluded because many of the medical comorbidities were not available; inadequate sleep was defined as VSS (5 hours/night), SS (5–6 hours/night), or LS (>8 hours/night), referenced to 7–8-hour/night sleepers.

Table 5

Hierarchical multinomial-adjusted associations of overweight/obesity with very short, short, and LS (1983–2009—whites).

Sleep measures	OR (95% CI)		OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Overweight	Obesity	Overweight	Obesity	Overweight	Obesity	Overweight	Obesity
Characteristics	Model 1 ^a		Model 2 ^b		Model 3 ^c			
Reference (7–8 h)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
VSS	1.18 (1.05–1.33) [†]	1.97 (1.75–2.23) [†]	1.20 (1.06–1.36) [†]	1.87 (1.64–2.13) [†]	1.21 (1.05–1.39) [†]	1.87 (1.63–2.15) [†]		
SS	1.16 (1.12–1.20) [†]	1.52 (1.46–1.58) [†]	1.17 (1.13–1.22) [†]	1.53 (1.47–1.60) [†]	1.18 (1.13–1.23) [†]	1.53 (1.46–1.61) [†]		
LS	1.00 (0.95–1.06)	1.24 (1.16–1.32) [†]	1.02 (0.95–1.09)	1.21 (1.13–1.30) [†]	1.02 (0.95–1.11)	1.21 (1.12–1.31) [†]		
Characteristics	Model 4 ^d		Model 5 ^e		Model 6 ^f			
Reference (7–8 h)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
VSS	1.16 (1.01–1.33) [†]	1.65 (1.43–1.90) [†]	1.21 (1.04–1.41) [†]	1.80 (1.54–2.10) [†]	1.20 (1.05–1.38) [†]	1.86 (1.62–2.19) [†]		
SS	1.16 (1.11–1.21) [†]	1.49 (1.42–1.56) [†]	1.15 (1.09–1.20) [†]	1.51 (1.43–1.59) [†]	1.18 (1.13–1.23) [†]	1.53 (1.46–1.61) [†]		
LS	1.00 (0.93–1.08)	1.13 (1.04–1.23) [†]	1.00 (0.92–1.09)	1.17 (1.07–1.28) [†]	1.02 (0.95–1.11)	1.21 (1.11–1.31) [†]		
Characteristics	Model 7 ^g		Model 8 ^h					
Sleep measures	Overweight	Obesity	Overweight	Obesity	Overweight	Obesity	Overweight	Obesity
Reference (7–8 h)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
VSS	1.23 (1.06–1.44) [†]	1.88 (1.62–2.19) [†]	1.10 (0.96–1.29) [†]	1.51 (1.29–1.76) [†]				
SS	1.15 (1.10–1.21) [†]	1.52 (1.44–1.60) [†]	1.13 (1.08–1.19) [†]	1.45 (1.38–1.53) [†]				
LS	1.01 (0.92–1.10)	1.21 (1.11–1.33) [†]	0.96 (0.88–1.05)	1.08 (0.98–1.18)				

[†] $P < .05$.

^aModel 1: age-sex-adjusted independent associations of inadequate sleep (short and long) with obesity.

^bModel 2: model 1 plus demographic factors.

^cModel 3: model 2 plus smoking and alcohol consumption.

^dModel 4: model 3 plus hypertension.

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^eModel 5: model 3 plus diabetes.

^fModel 6: model 3 plus and coronary heart disease/myocardial infarction.

^gModel 7: model 3 plus stroke.

^hModel 8: Parsimonious model (covariates adjusted in the model included age, sex, education, smoking status, alcohol consumption, history of diabetes, history of hypertension, history of stroke, and time of data collection).

Table 6

Hierarchical multinomial-adjusted associations of overweight/obesity with very short, short, and LS (1983–2009—blacks).

Sleep measures	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
	Overweight	Obesity	Overweight	Obesity	Obesity
Characteristics	Model 1 ^a		Model 2 ^b		Model 3 ^c
Reference (7–8 h)	1.00	1.00	1.00	1.00	1.00
VSS	1.35 (1.09–1.67) [†]	1.66 (1.33–2.07) [†]	1.58 (1.26–1.98) [†]	1.76 (1.39–2.22) [†]	1.62 (1.26–2.08) [†]
SS	1.16 (1.06–1.25) [†]	1.32 (1.21–1.44) [†]	1.17 (1.06–1.28) [†]	1.32 (1.20–1.45) [†]	1.19 (1.07–1.31) [†]
LS	0.91 (0.81–1.03)	1.15 (1.01–1.30) [†]	0.99 (0.87–1.13)	1.12 (0.97–1.28)	1.05 (0.90–1.22)
Characteristics	Model 4 ^d		Model 5 ^e		Model 6 ^f
Reference (7–8 h)	1.00	1.00	1.00	1.00	1.00
VSS	1.58 (1.23–2.04) [†]	1.68 (1.31–2.16) [†]	1.84 (1.40–2.43) [†]	1.94 (1.47–2.55) [†]	1.63 (1.27–2.10) [†]
SS	1.18 (1.07–1.31) [†]	1.33 (1.20–1.48) [†]	1.19 (1.06–1.33) [†]	1.33 (1.19–1.49) [†]	1.19 (1.07–1.31) [†]
LS	1.03 (0.88–1.20)	1.17 (0.99–1.37)	1.09 (0.91–1.30)	1.23 (1.03–1.46) [†]	1.05 (0.90–1.23)
Characteristics	Model 7 ^g		Model 8 ^h		
Sleep measures	Overweight	Obesity	Overweight	Obesity	
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	
Reference (7–8 h)	1.00	1.00	1.00	1.00	
VSS	1.84 (1.39–2.42) [†]	1.98 (1.50–2.60) [†]	1.76 (1.34–2.32) [†]	1.81 (1.38–2.37) [†]	
SS	1.19 (1.07–1.33) [†]	1.35 (1.20–1.50) [†]	1.16 (1.04–1.29) [†]	1.32 (1.18–1.47) [†]	
LS	1.09 (0.91–1.30)	1.25 (1.05–1.48) [†]	1.03 (0.86–1.22)	1.18 (0.99–1.41)	

[†] $P < .05$.

^aModel 1: age-sex-adjusted independent associations of inadequate sleep (short and long) with obesity.

^bModel 2: model 1 plus demographic factors.

^cModel 3: model 2 plus smoking and alcohol consumption.

^dModel 4: model 3 plus hypertension.

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^eModel 5: model 3 plus diabetes.

^fModel 6: model 3 plus coronary heart disease/myocardial infarction.

^gModel 7: model 3 plus stroke.

^hModel 8: Parsimonious model (covariates adjusted in the model included age, sex, education, marital status, smoking status, alcohol consumption, history of diabetes, history of hypertension, history of stroke, and time of data collection).