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Sleep Duration, Snoring Habits, and Cardiovascular Disease Risk Factors in an Ethnically Diverse Population

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Abstract

Background—Lack of sleep has been associated with an increased risk for cardiovascular disease (CVD) and all-cause mortality, but the mechanisms are not fully understood. Prior research has often been conducted in select populations and has not consistently adjusted for confounders, especially psychosocial factors.

Objective—The aims of this study were to assess the association between sleep habits and established risk factors for CVD and to evaluate potential interactions by race and gender.

Methods—Participants were part of a CVD screening and educational outreach program in New York City. Free-living men older than 40 years and women older than 50 years ($n = 371$, mean age = 60 years, 57% women, 60% racial/ethnic minorities) were systematically assessed for CVD risk (including traditional, lifestyle, and psychosocial risk factors) and completed a standardized questionnaire regarding sleep habits (including sleep duration and snoring). Lipids were analyzed by validated finger-stick technology. Stress at work and at home was assessed using a validated screening tool from the INTERHEART study. Associations between participants' sleep habits and CVD risk factors/demographic factors were assessed using multivariable logistic regression.

Results—The proportion of participants who reported sleeping less than 6 hours per night on average was 28%, and 52% of participants reported snoring. Sleeping less than 6 hours per night was significantly ($P < .05$) associated with female gender, being single, increased stress at home, increased financial stress, and low-density lipoprotein cholesterol (LDL-C) level. Gender modified the association between sleep duration and LDL-C level ($P = .04$): Sleeping less than 6 hours per night was significantly associated with reduced LDL-C level among women and increased LDL-C level among men. Snoring was significantly associated with low high-density lipoprotein cholesterol (HDL-C) level (<40 mg/dL for men/ <50 mg/dL for women), being married, increased stress at work and at home, less than 30 minutes of exercise per day, less than 5 servings of fruits and vegetables per day, and being overweight/obese (body mass index ≥ 25 kg/m²). The association between snoring and low HDL-C level remained significant in logistic regression models adjusted for demographic confounders (odds ratio, 1.83; 95% confidence interval, 1.06–3.19) but not after adjustment for body mass index greater than 25 kg/m².

Conclusions—Sleeping less than 6 hours per night was associated with several traditional and psychosocial CVD risk factors, and snoring was associated with low HDL-C level, likely mediated

through overweight/obesity. These data may have significance for health care providers to identify individuals who may be at increased CVD risk based on sleep habits.

Keywords

cardiovascular disease; psychosocial; risk factors; sleep; snoring

Sleep duration has been associated with cardiovascular disease (CVD),¹⁻⁴ stroke,⁵ diabetes,^{6,7} hypertension,⁸ and all-cause mortality.⁹⁻¹² A recent meta-analysis documented that compared with 7 hours of sleep, shorter duration of sleep was associated with up to a 2-fold increased risk for CVD-related mortality.¹ For both men and women, lack of sleep has been associated with increased risk of cardiovascular events.^{3,4} Amagai et al³ showed that sleeping less than 6 hours per night, when compared with sleeping 7 to 7.9 hours per night, was associated with an increased CVD risk of 2.14 for men and 1.46 for women. A meta-analysis of prospective population studies documented that both short and long duration of sleep was significantly associated with all-cause mortality.⁹ While some studies have shown a U-shaped association between duration of sleep and mortality, the data are inconsistent.¹³ Understanding the relation between lack of sleep and adverse health effects is important because over the last 30 years, diminished sleep duration (<6 hours) has increased from 7.6% of the population in 1975 to 9.3% in 2006.¹⁴

Potential mechanisms for the relation between inadequate sleep and increased cardiovascular risk include up-regulation of appetite and decreased energy expenditure, leading to obesity and its metabolic consequences, and alterations in glucose metabolism.^{15,16} Recently, Donga et al¹⁷ showed that a single night of partial sleep deprivation can cause insulin resistance and suggested that there is a threshold effect for the minimum amount of sleep needed to maintain an individual's glucose tolerance set point. Increased cortisol levels and changes in circulating levels of leptin and ghrelin because of sleep deprivation may facilitate the development of obesity, an increasingly prevalent risk factor for the development of atherosclerosis.¹⁸ Dyslipidemia has been associated with obesity, but the relation with sleep habits has been inconsistent.¹⁹⁻²¹ Research has been limited by select populations, lack of standardized measures of lipids, inconsistent adjustment for cholesterol-lowering medications, and self-reports of sleep habits.

The purpose of this study was to assess the association between sleep habits, defined as sleep duration and snoring, and measured risk factors for CVD, including both traditional and psychosocial risk factors, in an ethnically diverse population of free-living individuals. An additional aim of the research was to evaluate the potential mechanisms related to sleep habits and cardiovascular risk as well as to assess any interaction by gender or race/ethnicity.

Methods

Design and Participants

This was a cross-sectional analysis of 371 adults who attended an outreach CVD screening and educational program between February 2008 and February 2009 targeted to community members, hospital employees, ambulatory outpatients, or visitors of New York Presbyterian Hospital/Columbia University Medical Center. Participants of this study were included if they had a history of CVD or diabetes or if they were men older than 40 years or women older than 50 years. Participants that gave informed consent were eligible for the study. Each participant received a free CVD risk factor screening after completion of a standardized questionnaire. Survey forms were available in both English and Spanish, and

bilingual research staff was available to aide in translation. This study was approved by the institutional review board of the Columbia University Medical Center.

Assessment of Sleeping Habits

Participants completed a standardized questionnaire that included demographic information, medical history, lifestyle habits, and psychosocial factors. Sleep status was determined by the following questions: “How many hours do you sleep per night?” “Do you wake up in the middle of the night?” “Do you work the night shift?” and “Do you snore?” Sleep duration was categorized as less than 6 versus greater than or equal to 6 hours per night. Other sleep habits were categorized as yes or no.

Assessment of CVD Risk

Standardized questionnaires were used to assess demographics and medical history. Standardized methods were used to measure body mass index (BMI) and waist circumference.²² Laboratory evaluation included measurement of fasting total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglyceride, and glucose levels using a validated finger-stick method with desktop analyzers.²³ Blood pressure was measured using Omron HEM-711 AC (Omron Corporation, Kyoto, Japan) automated blood pressure machines. Low HDL-C level was defined as less than 50mg/dL in women and less than 40 mg/dL in men, consistent with national guidelines.^{24,25} Metabolic syndrome was defined as having at least 3 of the following 5 risk factors for CVD: a waist circumference greater than 40 in for men or 35 in for women, triglyceride level greater than or equal to 150 mg/dL, HDL-C level less than 40 mg/dL for men or 50 mg/dL for women, a systolic blood pressure greater than or equal to 130 mm Hg or a diastolic blood pressure greater than or equal to 85 mm Hg, and a fasting glucose level greater than or equal to 100 mg/dL.²⁶

Psychological stress and financial stress were assessed using questions adapted from the INTERHEART study,²⁷ including questions about feeling irritable or anxious or having trouble sleeping. Participants were asked if they had felt stress at work in the past year, if they had felt stress at home in the past year, and to what level they felt financial stress. Stress at work and stress at home were categorized into (1) no stress, (2) some stress, (3) several instances of stress, and (4) permanent stress. Those who selected several instances of stress or permanent stress were classified as stressed. The level of financial stress was categorized into little/none, moderate, or severe stress. Moderate and severe stress levels were collapsed into 1 category (yes to financial stress). Depression was assessed using a validated series of questions adapted from the INTERHEART study.²⁷ If a participant answered yes to the question “During the past 12 months, was there a time when you felt sad, blue, or depressed for 2 weeks or more in a row?” a series of 7 additional questions were asked (eg, “Do you feel low on energy?”) to evaluate the degree of depression. The participant was classified as depressed if he or she answered positively to 5 or more of the 7 additional questions.

Statistical Analysis

All data were double entered into a Microsoft Access database and imported into SPSS version 18.0. Associations between categorical variables were evaluated using logistic regression and described using odds ratios (ORs) and 95% confidence intervals (CIs). The independent association between sleep habits and CVD risk factors was evaluated in multivariate logistic regression models adjusted for the following demographic factors: age, gender, ethnicity, and marital status. Multivariate models were then adjusted by addition of potential confounders and mediators. Interactions between sleep habits and gender and also by race/ethnicity were evaluated in both stratified analyses and by including an interaction

term in logistic regression models. All analyses were conducted using SPSS 18.0 and statistical significance was set at $P < .05$.

Post hoc power calculations indicate that we had greater than 80% power to detect a difference in proportions of 8 percentage points or greater for both sleep and snoring outcomes.

Results

The characteristics of the 371 participants are listed in Table 1. Most of the participants were nonwhite and women and had health insurance. The mean (SD) age was 59 (9) years. The mean (SD) amount of sleep per night was 6.1 (1.6) hours, with 28% of the participants sleeping less than 6 hours per night. Approximately two-thirds of the participants reported that they regularly woke up in the middle of the night, 52% reported snoring, and 8% worked night shifts. The mean (SD) BMI was 28.7 (5.7) kg/m², and the mean (SD) total cholesterol level was 193.5 (43.9) mg/dL. Nearly half of the participants reported being treated with antihypertensive medications, about 20% had diabetes (15% of the women and 44% of the men), and 38% of the women and 38% of the men were on lipid-lowering medications. The proportion of women with low HDL-C level was 29%, and 40% of the men had low HDL-C level.

Hours of Sleep

The univariate relations between sleep duration and CVD risk factors are illustrated in Table 2. Sleeping less than 6 hours versus greater than or equal to 6 hours was significantly associated with having an LDL-C level of 100 mg/dL or lower ($P = .04$); however, this did not remain significant after adjustment for use of lipid-lowering medications. There was an interaction ($P = .04$) between gender and sleep duration for LDL-C. Women were significantly less likely to have elevated LDL-C levels when sleeping less than 6 versus greater than or equal to 6 hours per night (OR, 0.40; 95% CI, 0.22–0.73; $P = .003$). Men were more likely to have elevated LDL-C levels with sleeping less than 6 versus greater than or equal to 6 hours per night (OR, 1.24; 95% CI, 0.52–2.95). There was no significant interaction noted for race/ethnicity. Shorter sleep duration also was associated with being female ($P < .001$), being single ($P = .03$), stress at home ($P = .04$), and financial stress ($P < .001$).

Snoring

Table 3 lists the univariate relations between snoring and CVD risk factors. Participants who reported snoring had increased risk for low HDL-C level (OR, 1.87; 95% CI, 1.09–3.23; $P = .02$). Snoring was also associated with overweight or obesity (OR, 1.96; 95% CI, 1.14–3.36; $P = .01$), being married (OR, 0.60; 95% CI, 0.37–0.98; $P = .04$), stress at home ($P = .03$), or stress at work ($P = .048$).

As illustrated in Table 4, in a logistic regression model adjusted for demographics, snoring remained a significant predictor of low HDL-C level (OR, 1.83; 95% CI, 1.06–3.19). The addition of BMI to the model resulted in snoring no longer being significantly related to HDL-C level; however, there was still a trend toward an increased risk. Addition of potential lifestyle mediators, including stress, exercise, and diet, did not alter the association between snoring and low HDL-C level. There was no significant interaction for gender or race/ethnicity between snoring and low HDL-C level.

Discussion

There are 3 main findings from these analyses: (1) Several traditional and psychosocial risk factors for CVD were significantly associated with sleeping less than 6 hours per night and snoring; (2) gender modified the association between sleep and LDL-C level, with less sleep associated with reduced LDL-C levels in women but increased levels in men; the relation was confounded by the use of lipid-lowering medications; and (3) snoring was significantly associated with low HDL-C levels in both men and women and was largely explained by increased BMI. These findings may have important implications for potential modulation of CVD risk, although it should be noted that no data are available to demonstrate that improvement in sleep habits is associated with the prevention of obesity or CVD.²⁸ Demographic factors associated with short sleep duration were female gender and being single; however being married was associated with snoring, possibly reflecting that individuals who are not married may not be aware of snoring. Potentially modifiable risk factors in our study that were significantly associated with inadequate sleep and/or snoring were stress, reduced exercise, low intake of fruits and vegetables, overweight/obesity, and suboptimal lipoproteins.

These results are consistent with those of a previous analysis that found that there was an increased risk for CVD for both men and women who slept less than 6 hours per day when compared with those who sleep 7 to 7.9 hours per day, after controlling for similar demographic and potential confounders.³ Another study found that the odds of sleeping less than 6 hours per night was lower for women and married persons.¹⁴ The Nurse's Health Study found a modest relationship between coronary events and sleeping 6 hours or less compared with 8 hours (OR, 1.18; 95% CI, 0.98–1.42).⁴ In a Japanese population, less than 6 hours of sleep was associated with a significant 2-fold increase in CVD events in men and a nonsignificant trend in women.³ Our data are consistent with those of the National Health Interview Survey that showed that sleep duration was a significant predictor of CVD independent of age, gender, and race/ethnicity.¹ Lack of sleep has been linked to several CVD traditional and psychosocial risk factors, as observed in our study. Previous research has shown that sleep deprivation results in decreased glucose tolerance and elevated blood pressure.¹ We observed a nonsignificant trend between less sleep and increased glucose level; however because of the large number of patients with diabetes in our population and the lack of information on diabetes medications, we may not have had enough power to determine significant associations in these parameters.

Other researchers have also shown that gender may modify the relation between sleep and CVD risk. Gangwisch et al⁸ documented that decreased sleep was significantly associated with hypercholesterolemia in female adolescents but not in male adolescents in a longitudinal study of adolescents. Similar to our study, adjustment of several lifestyle factors did not markedly attenuate the relationship between sleep habits and lipid levels. Our results are also consistent with those of Williams et al,²⁰ who documented that short sleep was associated with decreased HDL-C levels among nonhypertensive women and snoring was inversely associated with HDL-C level, but the study did not include men, and therefore, gender modification could not be evaluated. Snoring may be an indicator of CVD risk, as it may be a symptom of sleep apnea, which has been related to CVD risk.²⁹ Kaneita et al²¹ showed that sleeping less than 5 hours per night was significantly related to low HDL-C levels and increased triglyceride levels in a Japanese population. A possible explanation for the impact of decreased sleep on lipid levels is that it leads to decreased leptin and increased ghrelin levels, which may result in increased appetite and body weight. Stress, which was also linked to reduced sleep in our study, might lead to increased catecholamine-induced lipolysis, leading to an increase in free fatty acids and dyslipidemia.¹⁹ Interestingly, Cappuccio et al³⁰ documented that sleep deprivation had detrimental cardiovascular effects

in women but not in men. Published reports rarely evaluate a potential differential impact of sleep in men and women based on hormone therapy, which deserves further attention.

Strengths of our study include the large participation of women and minorities and the standardized methods and gender-specific definitions of dyslipidemia. There are also important limitations to our study that should be considered in the interpretation of results. The cross-sectional design does not allow for determination of cause and effect; however, many of our results were consistent with those of longitudinal studies that included CVD biomarkers. We had very few participants who slept more than 9 hours per night ($n = 2$), and we were not able to evaluate a U-shaped association between sleep duration and CVD risk. Similar to most epidemiologic studies, our assessment of sleep habits was based on self-report, and we may have misclassified participants; however, this would not be expected to be differential misclassification, and therefore, the results are likely biased toward the null. Moreover, research that has compared self-reports to direct measures of sleep has shown consistent results.³¹

Conclusions

In conclusion, sleep habits are associated with several traditional and psychosocial risk factors for CVD. The data suggest that clinicians and CVD researchers might consider the addition of simple questions related to sleep habits as part of a routine evaluation to identify individuals at risk. The finding that the association between sleep and LDL-C level is modified by gender deserves further evaluation and suggests that it may be important to consider the influence of hormones on sleep and lipids. Snoring was a significant predictor of low HDL-C level regardless of gender or ethnicity and was likely mediated by obesity. Even small changes in HDL-C level have been shown to have a significant impact on CVD risk, underscoring the potential importance of sleep on CVD risk.³² Future research is needed to determine if improvement in sleep habits results in beneficial clinical outcomes.

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References

1. Sabanayagam C, Shanka A. Sleep duration and cardiovascular disease: results from the National Health Survey. *Sleep*. 2010; 33:1037–1042. [PubMed: 20815184]
2. Ikehara S, Iso H, Date C, et al. Association of sleep duration with mortality from cardiovascular disease and other causes for Japanese men and women: the JACC study. *Sleep*. 2009; 32:295–301. [PubMed: 19294949]
3. Amagai Y, Ishikawa S, Gotoh T, Kayaba K, Nakamura Y, Kajii E. Sleep duration and incidence of cardiovascular events in a Japanese population: the Jichi Medical School cohort study. *J Epidemiol*. 2010; 20:106–110. [PubMed: 20009370]
4. Ayas NT, White DP, Manson JE, et al. A prospective study of sleep duration and coronary heart disease in women. *Arch Inter Med*. 2003; 163:205–209.
5. Qureshi, Al; Giles, WH.; Croft, JB.; Bliwise, DL. Habitual sleep patterns and risk for stroke and coronary heart disease: a 10-year follow-up from NHANES I. *Neurology*. 1997; 48:904–911. [PubMed: 9109875]
6. Spiegel K, Knutson K, Leproult R, Tasali E, Van Cauter E. Sleep loss: a novel risk factor for insulin resistance and type 2 diabetes. *J Appl Physiol*. 2005; 99(5):2008–2019. [PubMed: 16227462]
7. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Quantity and quality of sleep and incidence of type 2 diabetes: a systematic review and meta-analysis. *Diabetes Care*. 2010; 33:414–420. [PubMed: 19910503]

8. Gangwisch JE, Heymsfield SB, Boden-Albala B, et al. Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. *Hypertension*. 2006; 47:833–839. [PubMed: 16585410]
9. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. *Sleep*. 2010; 33:585–592. [PubMed: 20469800]
10. Gallicchio L, Kalesan B. Sleep duration and mortality: a systematic review and meta-analysis. *J Sleep Res*. 2009; 18:148–158. [PubMed: 19645960]
11. Ferrie JE, Shipley MJ, Cappuccio FP, et al. A prospective study of change in sleep duration: associations with mortality in the Whitehall II cohort. *Sleep*. 2007; 30:1659–1666. [PubMed: 18246975]
12. Patel SR, Ayas NT, Malhotra MR, et al. A prospective study of sleep duration and mortality risk in women. *Sleep*. 2004; 27:440–444. [PubMed: 15164896]
13. Eguchi K, Pickering TG, Schwartz JE, et al. Short sleep duration as an independent predictor of cardiovascular events in Japanese patients with hypertension. *Arch Intern Med*. 2008; 168:2225–2231. [PubMed: 19001199]
14. Knutson KL, Cauter EV, Rathouz JP, DeLeire TD, Lauderdale DS. Trends in the prevalence of short sleepers in the USA: 1975–2006. *Sleep*. 2010; 33:37–45. [PubMed: 20120619]
15. Knutson KL, Spiegel K, Penev P, Van Cauter E. The metabolic consequences of sleep deprivation. *Sleep*. 2007; 11:163–178.
16. Gangwisch JE. Epidemiological evidence for the links between sleep, circadian rhythms and metabolism. *Obes Rev*. 2009; 10:37–45. [PubMed: 19849800]
17. Donga E, Van Dijk M, Van Dijk G, et al. A single night of partial sleep deprivation induces insulin resistance in multiple metabolic pathways in healthy subjects. *J Clin Endocrinol Metab*. 2010; 10:1–6.
18. Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. *PLoS Med*. 2004; 1:e62. [PubMed: 15602591]
19. Gangwisch JE, Malaspina D, Babiss LA, et al. Short sleep duration as a risk factor for hypercholesterolemia: analysis of the National Longitudinal Study of Adolescent Health. *Sleep*. 2010; 33:956–961. [PubMed: 20614855]
20. Williams CJ, Hu FB, Patel SR, Mantzoros CS. Sleep duration and snoring in relation to biomarkers of cardiovascular disease risk among women with type 2 diabetes. *Diabetes Care*. 2007; 30:1233–1240. [PubMed: 17322482]
21. Kaneita Y, Uchiyama M, Yoshike N, Ohida T. Associations of usual sleep duration with serum lipid and lipoprotein levels. *Sleep*. 2008; 31:645–652. [PubMed: 18517035]
22. National Institutes of Health. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults—the evidence report. *Obes Res*. 1998; 6(suppl 2):51S–209S. [PubMed: 9813653]
23. Parikh P, Mochari H, Mosca L. Clinical utility of a finger-stick technology to identify individuals with abnormal lipids and high sensitivity C-reactive protein (hsCRP) levels. *Am J Health Promot*. 2009; 23(4):279–282. [PubMed: 19288850]
24. Mosca L, Banka CL, Benjamin EJ, et al. 2007 update: American Heart Association evidence-based guidelines for cardiovascular disease prevention in women. *Circulation*. 2007; 115(11):1481–1501. [PubMed: 17309915]
25. Grundy SM, Cleeman JI, Merz CN, et al. National Heart, Lung, and Blood Institute; American College of Cardiology Foundation; American Heart Association. Implications of recent clinical trials for the National Cholesterol Education Program Adult Treatment Panel III guidelines. *Circulation*. 2004; 110:227–239. [PubMed: 15249516]
26. Grundy S, Brewer B, James C, et al. Definition of metabolic syndrome: report of the National Heart, Lung, and Blood Institute/American Heart Association Conference on scientific issues related to the definition. *Circulation*. 2004; 109:433–438. [PubMed: 14744958]
27. Rosengren A, Hawken S, Ounpuu S, et al. INTERHEART Investigators. Association of psychosocial risk factors with risk of acute myocardial infarction in 11119 cases and 13648

- controls from 52 countries (the INTERHEART study): case-control study. *Lancet*. 2004; 364(9438):953–962. [PubMed: 15364186]
28. Marshall NS, Glozier N, Grunstein RR. Is sleep duration related to obesity? A critical review of the epidemiological evidence. *Sleep Med Rev*. 2008; 12:289–298. [PubMed: 18485764]
29. Meek D, Chakravorty I. Obstructive sleep apnea increases risk of CVD. *Practitioner*. 2009; 253:17–20. [PubMed: 20043505]
30. Cappuccio FP, Stranges S, Kandala NB, et al. Gender-specific associations of short sleep duration with prevalent and incident hypertension: the Whitehall II study. *Hypertension*. 2007; 50:693–700. [PubMed: 17785629]
31. Signal TL, Gale J, Gander PH, et al. Sleep measurement in flight crew: comparing actigraphic and subjective estimates to polysomnography. *Aviat Space Environ Med*. 2005; 76:1058–1063. [PubMed: 16313142]
32. Gordon DJ, Probstfield JL, Garrison RJ, et al. High-density lipoprotein cholesterol and cardiovascular disease. Four prospective American studies. *Circulation*. 1989; 79:8–15. [PubMed: 2642759]

What's New and Important

- Sleeping less than 6 hours per night was associated with several traditional and psychosocial risk factors for cardiovascular disease (CVD). Snoring was a significant predictor of low high-density lipoprotein cholesterol level regardless of gender or ethnicity and was likely mediated by obesity.
- The association between sleep and low-density lipoprotein cholesterol level was modified by gender, and this finding deserves further evaluation; it may be important to consider the influence of hormones on sleep and lipids.
- These data suggest that clinicians and CVD researchers might consider the addition of simple questions related to sleep habits as part of a routine evaluation to identify individuals at risk.

TABLE 1

Characteristics of the Participants (n = 371)

Characteristic	n	%
Age 60 y	183	49
Female	213	57
Race/ethnicity		
White	147	40
Hispanic	116	31
Black	55	15
Asian	43	12
Other	10	2
Married/living with partner	217	58
No health insurance	42	11
Sleep <6 h/night	105	28
Work night shift	30	8
Snore = yes	193	52
Total cholesterol 200 mg/dL	149	40
HDL cholesterol <40 mg/dL if male or <50 mg/dL if female	123	33
LDL cholesterol 100 mg/dL	201	54
Blood pressure 120/80 mm Hg	197	53
Waist circumference >40 in if male or >35 in if female	180	49
Glucose 100 mg/dL	177	48
BMI 25 kg/m ²	264	71
Triglycerides 50 mg/dL	157	42
Metabolic syndrome	122	33
Depressed (score 5)	63	17
Stressed at work	133	17
Stressed at home	108	29
Severe financial stress	51	14
Exercise <90 min/wk	240	65
Have <5 servings of fruit and vegetables per day	300	81
Watch >2 h of television	148	40
Eat fast-food 2 times/wk	46	12
Eat out 2 times/wk	157	42
Taking lipid-lowering therapy	140	38
Taking antihypertensive therapy	177	48
History of coronary heart disease	21	6
History of diabetes mellitus	69	19

Abbreviations: BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

TABLE 2

Univariate Associations Between Sleep Duration and Cardiovascular Disease (CVD) Risk Factors

CVD Risk Factors	Comparisons	Sleep (<6 vs 6 h/night)		
		Odds Ratio	95% CI	P
Age	60 vs <60 y	1.01	0.64–1.59	.962
Gender	Male vs female	0.41	0.25–0.66	<.001 ^a
Race/ethnicity	Asian, black, Hispanic, other vs white	1.09	0.69–1.74	.705
Marital status	Single vs married	1.67	1.06–2.63	.028 ^a
Total cholesterol, mg/dL	200 vs <200	0.90	0.57–1.44	.667
HDL-C, mg/dL	Male <40 or female <50 vs male 40 or female 50	0.97	0.60–1.58	.908
LDL-C, mg/dL	100 vs <100	0.61	0.38–0.98	.040 ^a
Blood pressure, mm Hg	Systolic 120 and diastolic 80 vs systolic <120 and diastolic <80	0.84	0.48–1.47	.535
Waist circumference, in	Male >40 or female >35 vs male 40 or female 35	1.50	0.95–2.38	.083
Glucose, mg/dL	100 vs <100	1.57	0.99–2.48	.053
BMI, kg/m ²	25 vs <25	1.43	0.84–2.44	.189
Triglycerides, mg/dL	150 vs <150	0.79	0.50–1.26	.326
Metabolic syndrome	Y vs N	1.10	0.69–1.76	.678
Depression	Y vs N	1.88	0.87–4.03	.105
Stress at work	Y vs N	1.34	0.79–2.29	.279
Stress at home	Y vs N	1.66	1.02–2.71	.040 ^a
Financial stress	Y vs N	3.30	1.80–6.06	<.001 ^a
Exercise	<30 vs 30 min/d	1.57	0.97–2.52	.063
Fruits and vegetables	<5 vs 5 servings per day	0.93	0.52–1.64	.791
Television	2 vs <2 h	1.40	0.89–2.21	.150
Eating fast-food	2 vs <2 times a week	1.65	0.86–3.15	.129
Eating outside the home	2 vs <2 times a week	1.01	0.64–1.60	.967

Abbreviations: BMI, body mass index; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; N, no; Y, yes.

^a*P* < .05.

TABLE 3

Univariate Associations Between Snoring and Cardiovascular Disease (CVD) Risk Factors

CVD Risk Factors	Comparisons	Snoring (Y vs N)		
		Odds Ratio	95% CI	P
Age	60 vs <60 y	1.00	0.62–1.61	.995
Gender	Male vs female	1.46	0.89–2.37	.128
Race/ethnicity	Asian, black, Hispanic, other vs white	1.21	0.74–1.97	.441
Marital status	Single vs married	0.60	0.37–0.98	.039 ^a
Total cholesterol, mg/dL	200 vs <200	1.26	0.77–2.06	.349
HDL-C, mg/dL	Male <40 or female <50 vs male 40 or female 50	1.87	1.09–3.23	.023 ^a
LDL-C, mg/dL	100 vs <100	0.99	0.59–1.66	.975
Blood pressure, mm Hg	Systolic 120 or diastolic 80 vs systolic <120 and diastolic <80	1.08	0.59–1.98	.813
Waist circumference, in	Male >40 or female >35 vs male 40 or female 35	1.27	0.78	.060
Glucose, mg/dL	100 vs <100	1.32	0.82–2.15	.257
BMI, kg/m ²	25 vs <25	1.96	1.14–3.36	.014 ^a
Triglycerides, mg/dL	150 vs <150	1.39	0.85–2.28	.195
Metabolic syndrome	Y vs N	1.48	0.90–2.44	.121
Depression	Y vs N	1.19	0.47–3.00	.717
Stress at work	Y vs N	1.78	1.00–3.16	.048 ^a
Stress at home	Y vs N	1.86	1.06–3.28	.030 ^a
Financial stress	Y vs N	2.14	0.94–4.87	.065
Exercise	<30 vs 30 min/d	2.47	1.51–4.02	<.001 ^a
Fruits and vegetables	<5 vs 5 servings per day	1.79	1.01–3.17	.046 ^a
Television	2 vs <2 h	1.02	0.63–1.66	.937
Eating fast-food	2 vs <2 times a week	0.95	0.46–1.97	.896
Eating outside the home	2 vs <2 times a week	1.31	0.81–2.14	.276

Abbreviations: BMI, body mass index; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; N, no; Y, yes.

^a $P < .05$.

TABLE 4

Multivariable Logistic Regression Model: Predictors of High-Density Lipoprotein (HDL) Cholesterol (Low Vs Normal)

CVD Risk Factors	Comparisons	Base Model (Adjusted for Primary Predictor and Age)	Expanded Model (Adjusted for Age, Gender, Race/Ethnicity, Marital Status)	Extended Expanded Model (Expanded Model Adjusted for BMI)	Full Model (Adjusted for Expanded Model and Potential Confounders)
Snoring	Y vs N	1.87 (1.09–3.23) ^a	1.83 (1.06–3.19) ^a	1.74 (0.99–3.07)	1.77 (0.92–3.42)
Age	60 vs <60 y	1.08 (0.66–1.78)	1.16 (0.70–1.93)	1.18 (0.70–1.97)	1.00 (0.55–1.83)
Gender	Male vs female	–	1.62 (0.96–2.74)	1.54 (0.90–2.63)	1.61 (0.89–2.90)
Race/ethnicity	Asian, black, Hispanic, other vs white	–	1.35 (0.79–2.29)	1.37 (0.80–2.35)	1.32 (0.71–2.45)
Marital status	Single vs married	–	1.33 (0.78–2.27)	1.41 (0.82–2.43)	1.41 (0.77–2.59)
BMI, kg/m ²	25 vs <25	–	–	2.02 (1.06–3.85) ^a	1.50 (0.75–3.00)
Stress at work	Y vs N	–	–	–	1.16 (0.59–2.28)
Stress at home	Y vs N	–	–	–	0.81 (0.39–1.69)
Exercise	<30 vs ≥30 min/d	–	–	–	1.11 (0.60–2.07)
Fruits and vegetables	<5 vs ≥5 servings per day	–	–	–	1.01 (0.48–2.12)

Abbreviations: BMI, body mass index; CI, confidence interval; CVD, cardiovascular disease; N, no; OR, odds ratio; Y, yes.

^a $P < .05$.

Data are presented as OR (95% CI).