Sleep Duration and Cardiovascular Disease: Results from the National Health Interview Survey

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Background: Previous studies have shown that both short and long sleep durations are related to increased likelihood of diabetes and hypertension. However, the relation between sleep duration and cardiovascular disease (CVD) is not clear. We examined the hypothesis that compared with sleep duration of 7 hours, shorter and longer sleep durations are independently related to CVD.

Methods: We conducted a cross-sectional study of 30,397 National Health Interview Survey 2005 participants ≥ 18 years of age (57.1% women). Sleep duration was categorized as ≤ 5 hours, 6 hours, 7 hours, 8 hours, and ≥ 9 hours. The main outcome of interest was the presence of any CVD (n = 2146), including myocardial infarction, angina, and stroke.

Results: We found both short and long sleep durations to be independently associated with CVD, independent of age, sex, race-ethnicity, smoking, alcohol intake, body mass index, physical activity, diabetes mellitus, hypertension, and depression. Compared with a sleep duration of 7 h (referent), the multivariate odds ratio (95% confidence interval) of CVD was 2.20 (1.78, 2.71), 1.33 (1.13, 1.57), 1.23 (1.06, 1.41), and 1.57 (1.31, 1.89) for sleep duration ≤ 5 h, 6 h, 8 h, and ≥ 9 h. This association persisted in subgroup analyses by gender, race-ethnicity, and body mass index categories. Also, similar associations were observed when we examined myocardial infarction and stroke separately.

Conclusion: Compared with sleep duration of 7 h, there was a positive association between both shorter and longer sleep durations and CVD in a representative sample of US adults. These results suggest that sleep duration may be an important marker of CVD.

Keywords: Sleep, sleep duration, cardiovascular disease, NHIS

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CARDIOVASCULAR DISEASE (CVD) IS THE LEADING CAUSE OF MORTALITY IN THE UNITED STATES AND ELSEWHERE.[1] RECENT STUDIES SUGGEST THAT sleep disorders adversely affect cardiovascular health.[2] In the National Health Interview Survey (NHIS) 2004-2007, more than one-third of the population in the US were reported to have an abnormal sleep duration, defined as either a short or long sleep duration.[3] Several studies have shown that compared to 7-8 hours of sleep, both shorter and longer sleep durations are associated with CVD risk factors such as diabetes,[4,5] hypertension,[6] and obesity.[7] However, previous studies[8-13] that examined the association between sleep duration and CVD showed inconsistent associations. This included studies that reported an association with CVD for short sleep duration only,[13] or long sleep duration only,[9,11,14] or both short and long sleep durations.[8,10,12] Three previous studies have examined the association between sleep duration and CVD in the US.[8,9,14] The Nurses' Health Study[8] and the Women's Health Initiative Observational Study[14] reported positive associations between sleep duration and coronary heart disease (CHD) in women. The First National Health and Nutrition Examination Survey (NHANES-1) Follow-up Study reported a positive association between sleep duration and stroke in a nationally representative cohort of 7,844 men and women; however no significant association was found between sleep duration and CHD.[9] Accumulating evidence have shown that depression is related to both sleep duration[15] and CVD risk.[16] However, most of the studies[8-10,13] that assessed the association between sleep duration and CVD have not adjusted for depression, potentially an important confounder in the association between sleep duration and CVD. In this context, we examined the association between sleep duration and CVD, including CHD and stroke in the NHIS 2005, a large, nationally representative sample of US adults after controlling for the effect of depression and other confounders.

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METHODS

The study sample is derived from the 2005 NHIS, a survey of the civilian, non institutionalized household population of the United States. The procedures involved in NHIS 2005 have been published in detail and are available online.[17] In brief, NHIS survey involves a complex, multistage probability sampling design that permits representative sampling of US households. Blacks and Hispanics are oversampled to provide stable estimates for these groups and the sample is weighted to account for the complex sampling design and for survey nonresponse. This study used the sample adult core component of the NHIS survey, administered by in-person interview to 31,428 persons, aged ≥ 18 years (response rate = 69%).[18] The questionnaire collected information on demographic factors, socioeconomic characteristics, lifestyle characteristics and health status.

Outcomes

The primary outcome of interest in the current study was any CVD, defined as a physician diagnosis of myocardial infarc-

Table 1—Baseline characteristics of the study participants, by usual sleep duration

Characteristics	≤ 5 h	6 h	7 h	8 h	≥ 9 h	P-value*
Unweighted sample size	2536	6369	9123	9688	2681	
Age, years	48.3 (17.0)	46.5 (16.5)	46.0 (16.6)	48.1 (18.3)	53.1 (21.6)	< 0.0001
Women, %	58.9	55.2	53.8	56.4	58.4	< 0.0001
Race-ethnicity, %						< 0.0001
Non-Hispanic whites	61.5	63.4	68.0	63.8	62.6	
Non-Hispanic blacks	17.7	15.6	10.8	12.6	16.8	
Hispanic-Americans	15.5	16.1	16.8	19.5	16.8	
Others	5.2	4.9	4.4	4.1	3.8	
Smoking, %						< 0.0001
Never smoker	47.3	54.2	60.7	59.1	51.3	
Current smoker	31.6	23.5	18.2	18.8	22.8	
Drinking, %						< 0.0001
Never drinker	22.2	20.9	22.9	27.8	29.4	
Current drinker	58.6	64.1	64.0	58.0	49.5	
Body mass index (kg/m^2)	30.7 (14.1)	30.1 (14.2)	29.1 (13.4)	29.5 (14.6)	29.4 (13.7)	< 0.0001
No weekly moderate physical activity, %	55.9	50.8	47.8	52.2	60.5	< 0.0001
Hypertension, %	37.2	28.7	23.9	27.4	37.0	< 0.0001
Diabetes, %	11.2	8.3	6.2	8.2	13.5	< 0.0001
Depression, %	0.4	0.0	0.1	0.1	0.2	< 0.0001

*The P value represents difference in characteristics by usual sleep duration based on the analysis of variance or chi square test as appropriate.

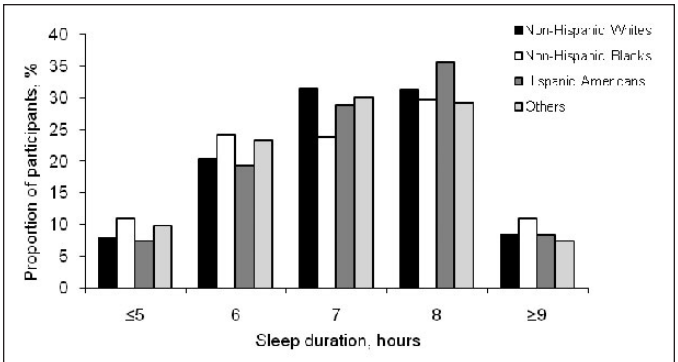

Figure 1—Proportion of participants by ethnic groups and by duration of sleep in hours.

tion, angina or stroke. This was ascertained by a "yes" response to any of the following questions: "Have you ever been told by a doctor or health professional that you have—"coronary heart disease" or "angina, also called angina pectoris" or "heart attack, also called myocardial infarction," or "stroke?" We also performed secondary analyses that examined myocardial infarction, angina and stroke separately.

Exposure Assessment

Sleep duration was assessed by asking participants the following question: "On average, how many hours of sleep do you get in a 24-hour period?" We categorized the response into 5 groups for the current analysis: ≤ 5 h, 6 h, 7 h, 8 h, and ≥ 9 h.

Assessment of Covariates

Age was included as a continuous variable. Diabetes was defined as a "yes" response to the question: "Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" Hypertension was defined as a self-reported hypertension or high blood pressure. We categorized the covariates using definitions similar to the NHIS questionnaire.[19-21] Cigarette smoking was classified into never smoker, former smoker, and current smoker based on the participant's choice of 3 possible responses to the question, "Have you smoked at least 100 cigarettes in your entire life?" Participants who answered "no" were classified as never smokers; those who answered "yes, but I quit smoking" were classified as former smokers; and those who answered "yes, and I currently smoke some days or every day" were classified as current someday smokers and current every day smokers.[20] Alcohol consumption was assessed based on the responses to the following questions: "In any one year, have you had at least 12 drinks of any type of alcoholic beverage?" "In your entire life, have you had at least 12 drinks of any type of alcoholic beverage?" "In the past year, how often did you drink any type of alcoholic beverage?" "In the past year, on those days that you drank alcoholic beverages, on the average, how many drinks did you have?" Respondents who had consumed < 12 drinks in their entire life were classified as never-drinkers, respondents who had consumed ≥ 12 drinks in any year or their entire life but not in the past year were classified as former drinkers, and respondents who had consumed ≥ 12 drinks in any year or their entire life and one or more drinks in the past year were considered current drinkers.[22] Current drinking was further categorized into light (≤ 3 drinks/week), moderate (4-7 drinks/week for women; 4-14 drinks/week for men), heavy (> 7 drinks/week for women; > 14 drinks/week for men), and unknown drinking status. Body mass index (BMI) was calculated with self-reported height and weight as weight in kilograms divided by height in meter squared. Overweight was defined as a BMI 25-29.9 kg/m^2 and obese as a BMI ≥ 30.[23] Moderate physical activity was defined as engaging in light or moderate leisure-time physical activity ≥ 10 min/week.[20] Depression was assessed from the question, "How long have you had depression, anxiety, or emotional problem?" with the response categorized into absent, chronic (≥ 3 months), and not chronic (< 3 months).[19] Education was categorized into less than high school graduate, high school graduate, and more than high school graduate.[20] Participants were considered to have access to healthcare if they answered negatively to the question "During the past 12 months, was there any time when needed medical care, but did not get because couldn't afford it" or if

they answered affirmatively to the question "Are you covered by health insurance or some other kind of health care plan?"[20]

Statistical Analysis

We compared the characteristics of the study participants by categories of sleep duration employing the chi square test or analysis of variance, as appropriate. We used multivariable logistic regression models to calculate the odds ratio (OR) and 95% confidence interval (CI) of any CVD (our primary outcome) associated with higher and lower categories of sleep duration relative to a reference category of 7 h. We chose sleep duration of 7 h as the reference category, as previous studies have shown this to be the optimal sleep duration.[24,25] We used 2 multivariable models. In the first model, we adjusted for age (years) and sex. In the second multivariable model, we additionally adjusted for race-ethnicity (non-Hispanic whites, non-Hispanic blacks, Hispanic-Americans, others), smoking (never, former, current someday, current everyday), alcohol consumption (never, former, current light, current moderate, current heavy), moderate physical activity (times/week), body mass index (kg/m^2), diabetes mellitus (absent, present), hypertension (absent, present), and depression (absent, chronic, not chronic). We also examined the association between sleep duration and our secondary outcomes, including myocardial infarction, angina, and stroke in separate analyses. To examine the consistency of the association between sleep duration and any CVD, we performed subgroup analysis stratified by potential confounders such as age, sex, race-ethnicity, and categories of BMI. We separately calculated the dose-response effect of short and long sleep duration by analyzing them as a continuous variable in the age-sex and multivariable-adjusted models and calculating the corresponding P-value for trend. We tested for interactions between sleep duration and age, gender, and ethnicity by including cross-product interaction terms in the corresponding multivariable logistic regression models. Statistical interaction was deemed significant if P-interaction was < 0.10. In a supplementary analysis, we evaluated the association between sleep duration and any CVD after excluding participants with diabetes mellitus, hypertension, or depression (n = 20,557 included). In a second supplementary analysis, we additionally adjusted for education and access to care in the multivariable model for any CVD. Sample weights that account for the unequal probabilities of selection, oversampling, and nonresponse were applied for all analyses using SUDAAN (version 8.0; Research Triangle Institute, Research Triangle Park, NC) and SAS (version 9.1.; SAS institute, Cary, NC) software; SEs were estimated using the Taylor series linearization method.

RESULTS

The prevalence of any CVD, angina, myocardial infarction and stroke in the study population were 7.1%, 2.7%, 3.6% and 2.7%. Table 1 presents the characteristics of the study participants by sleep duration categories. Eight percent of the study population reported sleeping ≤ 5 h/day, 21% slept 6 h/day, 30% slept 7 h/day, 32% slept 8 h/day, and 9% slept ≥ 9 h/day. Compared to those who slept 7 h a day, those with both short (≤ 5 h) and long (≥ 9 h) durations of sleep were more likely to be older; women; non-Hispanic blacks; to smoke; to have higher BMI; higher prevalence of diabetes mellitus, hypertension, and depression; and less likely to be current drinkers and engage in moderate physical activity. As Figure 1 illustrates, non-Hispanic blacks were more likely to have extreme durations of sleep (≤ 5 and ≥ 9 h) than other ethnic groups. Non-Hispanic whites were more likely to have sleep duration of 7 h than other ethnic groups.

Table 2—Association between sleep duration and cardiovascular disease

Sleep duration (h)			Age, sex-adjusted	Multivariable-adjusted
Any cardiovascular disease (n = 2146)	No. at risk*	Cases*	OR (95% CI)†	OR (95% CI)‡
≤ 5 h	2536	304	2.75 (2.23-3.38)	2.20 (1.78-2.71)
6 h	6369	418	1.46 (1.24-1.72)	1.33 (1.13-1.57)
7 h	9123	434	1 (referent)	1 (referent)
8 h	9688	639	1.27 (1.10-1.46)	1.23 (1.06-1.41)
≥ 9 h	2681	351	1.89 (1.57-2.27)	1.57 (1.31-1.89)
Angina (n = 826)				
≤ 5 h	2536	151	3.23 (2.47-4.23)	2.59 (1.98-3.40)
6 h	6369	165	1.46 (1.15-1.85)	1.32 (1.04-1.67)
7 h	9123	169	1 (referent)	1 (referent)
8 h	9688	225	1.11 (0.89-1.39)	1.08 (0.86-1.36)
≥ 9 h	2681	116	1.36 (1.01-1.82)	1.13 (0.84-1.51)
Myocardial infarction (n = 1090)				
≤ 5 h	2536	142	2.11 (1.62-2.74)	1.70 (1.31-2.22)
6 h	6369	202	1.34 (1.07-1.69)	1.23 (0.97-1.54)
7 h	9123	235	1 (referent)	1 (referent)
8 h	9688	340	1.25 (1.03-1.52)	1.20 (0.99-1.46)
≥ 9 h	2681	171	1.57 (1.22-2.00)	1.30 (1.02-1.66)
Stroke (n = 823)				
≤ 5 h	2536	111	2.59 (1.94-3.46)	2.01 (1.50-2.70)
6 h	6369	149	1.35 (1.03-1.78)	1.21 (0.91-1.60)
7 h	9123	147	1 (referent)	1 (referent)
8 h	9688	238	1.39 (1.09-1.77)	1.33 (1.04-1.70)
≥ 9 h	2681	178	2.69 (2.06-3.52)	2.22 (1.69-2.91)

*Unweighted sample size; †OR (95% CI): odds ratio (95% confidence interval) from weighted analysis; ‡Adjusted for age (years), sex (men, women), race-ethnicity (non-Hispanic whites, non-Hispanic blacks, Hispanic-Americans, others), smoking (never smoker, former smoker, current someday smoker, current every day smoker), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker), moderate physical activity (times/week), body mass index (kg/m^2), diabetes mellitus (absent, present), hypertension (absent, present), depression (absent, chronic, not chronic). P-trend for both short and long sleep duration < 0.005 for any cardiovascular disease, myocardial infarction, and stroke in the age-sex adjusted model; < 0.005 for any cardiovascular disease and stroke in the multivariable model.

Table 2 presents the age-sex and multivariable-adjusted associations between sleep duration and CVD. Compared with persons with sleep duration of 7 h, both shorter and longer sleep durations were positively associated with any CVD in both the age-sex adjusted and the multivariable-adjusted models. A similar pattern of association was observed for CVD components, including angina, MI, and stroke in the age-sex adjusted model. However, in the multivariable model, compared to the referent category (sleep duration 7 h), only shorter durations of sleep

Table 3—Association between sleep duration and any cardiovascular disease, by age group

	Age < 60 years (n = 22505)		Age ≥ 60 (n = 7892)	
Sleep duration (h)	No. at risk (cases)*	Multivariable OR (95% CI) †‡	No. at risk (cases)*	Multivariable OR (95% CI) †‡
≤ 5 h	1911 (147)	3.08 (2.26-4.20)	625 (157)	1.65 (1.28-2.13)
6 h	5000 (160)	1.77 (1.33-2.35)	1369 (258)	1.14 (0.93-1.40)
7 h	7154 (119)	1 (referent)	1969 (315)	1 (referent)
8 h	6914 (145)	1.38 (1.02-1.87)	2774 (494)	1.18 (1.00-1.39)
≥ 9 h	1526 (57)	1.81 (1.20-2.75)	1155 (294)	1.75 (1.44-2.14)

*Unweighted sample size; †OR (95% CI): odds ratio (95% confidence interval) from weighted analysis; ‡Adjusted for sex (men, women), race-ethnicity (non-Hispanic whites, non-Hispanic blacks, Hispanic-Americans, others), smoking (never smoker, former smoker, current someday smoker, current every day smoker), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker), moderate physical activity (times/week), body mass index (kg/m^2), diabetes mellitus (absent, present), hypertension (absent, present), depression (absent, chronic, not chronic); P-interaction between sleep duration and age = 1.0.

Table 4—Association between sleep duration and any cardiovascular disease, by gender

	Men (n = 13452)		Women (n = 16945)	
Sleep duration (h)	No. at risk (cases)*	Multivariable OR (95% CI) †‡	No. at risk (cases)*	Multivariable OR (95% CI) †‡
≤ 5 h	1042 (125)	1.88 (1.37-2.56)	1494 (179)	2.57 (1.94-3.39)
6 h	2854 (181)	1.14 (0.88-1.47)	3515 (237)	1.60 (1.26-2.02)
7 h	4218 (233)	1 (referent)	4905 (201)	1 (referent)
8 h	4223 (325)	1.23 (0.99-1.52)	5465 (314)	1.25 (1.01-1.54)
≥ 9 h	1115 (157)	1.43 (1.08-1.91)	1566 (194)	1.75 (1.34-2.27)

*Unweighted sample size; †OR (95% CI): odds ratio (95% confidence interval) from weighted analysis; ‡Adjusted for age (years), race-ethnicity (non-Hispanic whites, non-Hispanic blacks, Hispanic-Americans, others), smoking (never smoker, former smoker, current someday smoker, current every day smoker), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker), moderate physical activity (times/week), body mass index (kg/m^2), diabetes mellitus (absent, present), hypertension (absent, present), depression (absent, chronic, not chronic); P-interaction between sleep duration and gender = 0.9.

were associated with angina; both short and long durations of sleep (≤ 5 and ≥ 9 h) were associated with MI, with the magnitude of association relatively stronger for short sleep duration; and both short and long durations of sleep (≤ 5 and ≥ 9 h) were associated with stroke, with a similar magnitude of association.

In subgroup analysis, the associations between short and long durations of sleep with any CVD were consistently present across categories of age, sex, race-ethnicity, and BMI (Tables 3-6). As diabetes, hypertension, and depression are major confounders of the putative association between sleep duration and CVD, we repeated the analysis after excluding study subjects with diabetes, hypertension, or depression (Table 7). Overall, consistent with the main results in Table 2, the association with any CVD was found to be consistently present with both short and long durations of sleep. In another supplementary analysis, when we additionally adjusted for education and access to care in the multivariable model in Table 2, the results were similar. For example, compared with persons with sleep duration of 7 h, the multivariable OR (95% CI) were 2.13 (1.73-2.64), 1.31 (1.11-1.55), 1.21 (1.05-1.40), and 1.54 (1.28-1.85) among those with sleep duration ≤ 5 h, 6 h, 8 h, and ≥ 9 h. No significant interactions were detected between sleep duration and age (P-interaction = 1.00), gender (P-interaction = 0.90), and ethnicity (P = 0.43).

DISCUSSION

In this study, compared to sleep duration of 7 hours, we found that both short and long durations of sleep (≤ 5 and ≥ 9 h) were positively associated with CVD in a large, nationally representative sample of US adults. This association was independent of age, sex, race-ethnicity, smoking, alcohol consumption, moderate physical activity, BMI, diabetes, hypertension, and depression. This association was consistently present in analysis stratified by age, sex, race-ethnicity, and BMI, as well as in the subgroup of apparently healthy study subjects, defined as those without diabetes, hypertension, or depression. Compared to sleep duration of 7 h, short sleep duration was associated with angina, whereas both short and long durations of sleep were associated with MI and stroke.

In the current study, sleep duration < 7 hours was associated with a dose-dependent increase in CVD. Likewise, sleep duration > 7 hours was also associated with a dose-dependent increase in CVD. This association between both short and long durations of sleep and CVD was consistently present in both men and women. This is consistent with previous reports from other countries examining the association between sleep duration and CVD mortality.[10,12] It is also consistent with a report from the US-based Nurses' Health Study, where both short and long durations of sleep were associated with MI and coronary heart disease in a large cohort of female nurses[8]; our study extends the association to men also. Shorter duration of sleep (< 7.5 h) was associated with incident CVD in Japanese hypertensive patients compared to sleep duration > 7.5 hours.[13] Sleep duration of 7-8 hours is generally accepted as total sleep requirement for adults.[26] However, in the current study, we found that compared to 7 hours, sleep duration of 8 hours was also associated with CVD. Consistent with our findings, Chen et al in a recent study involving postmenopausal women reported that sleep duration of 8 hours was associated with increased risk of stroke compared to those with a sleep duration of 7 hours.[14] Other mortality studies have also shown that sleep duration > 7.5 hours was associated with increased mortality.[25,27] The mechanism underlying this association is not clear. Future research studies are required to confirm if there is a true higher risk of CVD associated with 8 h of sleep. In the current study, in subgroup analysis by CVD components, both short and long durations of sleep were associated with MI and stroke; whereas only short duration of sleep showed an association with angina. In the Augsburg Survey in Germany, Meisinger et al. reported a modest association between short sleep duration and MI in women only.[28] Long duration of sleep was not associated with MI in both men and women. Although there was a gender spe-

cific association between short duration and MI, the authors could not demonstrate any significant interaction by sex. In NHANES-1 Follow-up Study, only long duration of sleep was associated with stroke.[9] The absence of association of stroke with short duration could be due to inadequate power for subgroup analysis. In the Women's Health Initiative Observational Study, longer duration of sleep was associated with stroke in a sample of postmenopausal women; short duration of sleep was associated with stroke in those without prevalent CVD.[14]

The mechanisms underlying the association of short duration of sleep with CVD may include sleep related disturbances in endocrine and metabolic functions.[29,30] Sleep deprivation results in impaired glucose tolerance, reduced insulin sensitivity, increased sympathetic activity, and elevated blood pressure, all leading to increased risk for atherosclerosis.[31] Animal studies show similar endocrine, metabolic, and inflammatory effects in sleep deprived rats.[32] Long duration of sleep could be related to an underlying sleep disordered breathing[24] or poor sleep quality.[11] Both short and long duration of sleep were shown to be associated with CVD risk factors such as diabetes,[4] hypertension,[6] lipids,[33] obesity,[34] and inflammation.[35] Based on our findings, a corollary observation is that the previously reported association between sleep duration and mortality may be partly mediated by the association between sleep duration and CVD.[12,36]

The major strengths of the present include its population-based design, large sample size, and information on potential confounders. Our study has several limitations. First, the cross-sectional nature of the study limits making causal inferences in the association between sleep

Table 5—Association between sleep duration and any cardiovascular disease, by race-ethnicity

	Non-Hispanic Whites (n = 19658)		Hispanic Blacks (n = 4105)		Other race-ethnicities (n = 6634)	
Sleep duration (h)	No. at risk (cases)*	Multivariable OR (95% CI)†‡	No. at risk (cases)*	Multivariable OR (95% CI)†‡	No. at risk (cases)*	Multivariable OR (95% CI)†‡
≤ 5 h	1559 (196)	2.07 (1.60-2.66)	450 (54)	2.61 (1.56-4.31)	527 (54)	2.42 (1.53-3.84)
6 h	4037 (296)	1.33 (1.10-1.61)	992 (67)	1.64 (1.13-2.38)	1340 (55)	1.04 (0.68-1.61)
7 h	6203 (331)	1 (referent)	987 (48)	1 (referent)	1933 (55)	1 (referent)
8 h	6181 (490)	1.22 (1.03-1.45)	1225 (81)	1.33 (0.93-1.91)	2282 (68)	1.24 (0.82-1.88)
≥ 9 h	1678 (277)	1.67 (1.35-2.07)	451 (43)	1.43 (0.92-2.21)	552 (31)	1.21 (0.62-2.01)

*Unweighted sample size; †OR (95% CI): odds ratio (95% confidence interval) from weighted analysis; ‡Adjusted for age (years), sex (men, women), smoking (never smoker, former smoker, current someday smoker, current every day smoker), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker), moderate physical activity (times/week), body mass index (kg/m^2), diabetes mellitus (absent, present), hypertension (absent, present), depression (absent, chronic, not chronic); P-interaction between sleep duration and race-ethnicity = 0.43.

Table 6—Association between sleep duration and any cardiovascular disease, by body mass index (BMI)

	Normal BMI (< 25 kg/m^2) (n = 11542)		Overweight/ obese BMI (≥ 25 kg/m^2) (n = 18855)	
Sleep duration (h)	No. at risk (cases)*	Multivariable OR (95% CI)†‡	No. at risk (cases)*	Multivariable OR (95% CI)†‡
≤ 5 h	791 (79)	2.04 (1.38-3.01)	1745 (225)	2.26 (1.78-2.87)
6 h	2273 (125)	1.31 (0.99-1.73)	4096 (293)	1.33 (1.09-1.63)
7 h	3584 (137)	1 (referent)	5539 (297)	1 (referent)
8 h	3865 (205)	1.21 (0.95-1.55)	5823 (434)	1.24 (1.04-1.47)
≥ 9 h	1029 (115)	1.54 (1.09-2.17)	1652 (236)	1.60 (1.26-2.02)

*Unweighted sample size; †OR (95% CI): odds ratio (95% confidence interval) from weighted analysis; ‡Adjusted for age (years), sex (men, women), race-ethnicity (non-Hispanic whites, non-Hispanic blacks, Hispanic-Americans, others), smoking (never smoker, former smoker, current someday smoker, current every day smoker), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker), moderate physical activity (times/week), diabetes mellitus (absent, present), hypertension (absent, present), depression (absent, chronic, not chronic)

Table 7—Association between sleep duration and any cardiovascular disease among subjects without diabetes mellitus or hypertension or depression

	Any cardiovascular disease among subjects without diabetes mellitus or hypertension or depression (n = 20557)	
Sleep duration (h)	No. at risk (cases)*	Multivariable OR (95% CI)†‡
≤ 5 h	1419 (57)	2.26 (1.52-3.38)
6 h	4271 (106)	1.47 (1.09-1.98)
7 h	6678 (118)	1 (referent)
8 h	6674 (177)	1.32 (0.99-1.75)
≥ 9 h	1515 (87)	2.04 (1.39-3.00)

*Unweighted sample size; †OR (95% CI): odds ratio (95% confidence interval) from weighted analysis; ‡Adjusted for age (years), sex (men, women), race-ethnicity (non-Hispanic whites, non-Hispanic blacks, Hispanic-Americans, others), smoking (never smoker, former smoker, current someday smoker, current every day smoker), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker), moderate physical activity (times/week), body mass index (kg/m^2)

duration and CVD. Second, sleep duration was self-reported by participants with potential non-differential misclassification of the exposure biasing the reported association towards null. However, studies have shown that self-reported sleep duration correlates well with actigraphic assessment of sleep.

In conclusion, our study shows that both short and long durations of sleep are associated with CVD in a nationally representative sample of US adults. If supported by future prospective studies, our study findings may have important clinical implications in evaluation of sleep function in patients with CVD and initiation of public health initiatives focusing on improving sleep to reduce the burden of CVD.

DISCLOSURE STATEMENT

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