

Associations Between Sleep Disorders, Sleep Duration, Quality of Sleep, and Hypertension: Results From the National Health and Nutrition Examination Survey, 2005 to 2008

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Sleep is a contributing factor to optimal health and vitality. However, to date, no national study has evaluated the simultaneous relationship between sleep disorders, quality, and duration with hypertension. Using data from National Health and Nutrition Examination Survey (NHANES) (2005 to 2008), hypertension was defined by current use of anti-hypertensive medication or systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg. Self-reported sleep disorders and duration were categorized from a single household interview question, and sleep quality was determined from several questions on sleeping habits. The prevalence of hypertension was 30.2% and 7.5%, and 33.0% and 52.1% reported having sleep disorders, short sleep, and poor sleep, respectively. After

adjustment for demographic characteristics and comorbidities, having sleep disorders only was not significantly associated with hypertension (odds ratio [OR], 1.65; 95% confidence interval [CI], 0.73–3.77). However, this association was modified by sleep duration: significant associations were observed among adults with concurrent sleep disorders and short sleep (OR, 2.30; 95% CI, 1.49–3.56) and with sleep disorders, short sleep, and poor sleep (OR, 1.84; 95% CI, 1.13–2.98). These findings indicate an association between a combination of sleep problems and hypertension, but prospective studies are needed to understand the complex interplay between them. *J Clin Hypertens (Greenwich)*. 2011;13:739–743. ©2011 Wiley Periodicals, Inc.

An estimated 1 in 3 adults in the United States has hypertension.¹ Although the major risk factors for hypertension, including family history, sedentary lifestyle, poor diet, cigarette smoking, sex, race, and age, have been widely established,¹ one unconventional and often overlooked risk factor is sleep. Sleep is essential for optimal health and vitality, but a 2008 study by the Centers for Disease Control and Prevention (CDC) found, based on self-reports, that 11% of adults in the United States got insufficient rest or sleep.² Given its importance, it is not surprising that researchers have found an association between poor quality of sleep and negative health behaviors and outcomes.^{3,4} For example, several studies have shown a link between short sleep and hypertension among adults, with this association differing by sex (higher among women) and age (no association among the elderly aged 58–98 years).^{5–9} Furthermore, similar associations with hypertension have been documented for specific sleep disorders (apnea, insomnia, restless leg syndrome)^{10–13} and for the quality of sleep.¹⁴

To date, findings of the studies performed have been somewhat limited because of variations in study populations and study designs, small samples, and a focus largely on one sleep abnormality at a time and its relation with hypertension. Thus, the present study was

designed to describe the distribution of demographic and health characteristics by hypertension status and to examine the simultaneous association of sleep disorders, the duration of sleep, and sleep quality on hypertension among US adults.

METHODS

The National Health and Nutrition Examination Survey (NHANES), a continuous series of cross-sectional surveys based on nationally representative samples of the US civilian noninstitutionalized population, uses a complex, stratified, multistage sampling design to recruit participants from clusters of households.¹⁵ In NHANES, participants undergo a detailed home interview, followed by a physical examination and laboratory evaluation at a local mobile examination center (MEC). The present study analyzed NHANES data from the 2005 to 2006 and 2007 to 2008 study cycles. Among 11,791 eligible adults 18 years and older, 390 were excluded because of pregnancy, 1061 were dropped because of missing data on blood pressure (BP), and 32 were pregnant and lacking a measurement of BP, yielding a final analytic sample of 10,308 men and women. Informed consent was obtained from all participants, and the protocol was approved by the institutional review board of the National Center for Health Statistics.

Sleep disorders were identified by a response of “yes” to the household interview question “Have you ever been told that you have a sleep disorder?” Individuals that answered “yes” were asked to specify the type of sleep disorder (sleep apnea, insomnia, restless legs, and other). The duration of sleep was assessed by

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the reported number of hours and minutes usually slept on weekday or workday nights. Based on the national recommendations for sleep, a cutpoint of <7 hours was used to categorize individuals as sleep deprived (“short sleep” in this study). Participants were classified as having poor sleep (poor quality) if they answered “often” or “almost always” (together defined as 5–30 times a month) to any of the 6 items on sleeping habits as follows: (1) having trouble falling asleep; (2) waking up during the night and having trouble getting back to sleep; (3) waking up too early in the morning and being unable to get back to sleep; (4) feeling unrested during the day, no matter how many hours of sleep were obtained; (5) feeling excessively or overly sleepy during the day; and (6) not getting enough sleep. To assess the combined associations of sleep disorders, short sleep, and poor sleep, a composite sleep variable was created with 8 mutually exclusive categories: (1) sleep disorder, short sleep, and poor sleep; (2) sleep disorder and short sleep; (3) sleep disorder and poor sleep; (4) sleep disorder only; (5) short sleep and poor sleep; (6) short sleep only; (7) poor sleep only; and (8) none of the above.

Participants were defined as having hypertension if they met any of 3 criteria: mean systolic BP (SBP) ≥ 140 mm Hg, mean diastolic BP (DBP) ≥ 90 mm Hg, or currently taking prescription medication to lower high BP. The average of up to 3 brachial BP readings was obtained at the visit for the physical examination. According to the standard protocol for both NHANES cycles, trained physicians measured the BP using a cuff size appropriate for the participant.¹⁵ Additional variables of interest in this analysis were body mass index (BMI; weight in kilograms divided by height in meters squared), diabetes (participant had ever been told that she/he had diabetes), and current smoker (reported smoking cigarettes every day or some days).

Demographic information obtained from the interview included sex, age in years (18–39, 40–59, and 60 and older), and race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, other). The poverty-income ratio (PIR), which is the ratio of a family’s income to the federally defined poverty threshold for a family of the same size in the same calendar year, was used as a proxy for socioeconomic status. A cutpoint of 1.00 for the PIR was used to differentiate persons living below the federal poverty level (PIR <1.00) from those living at (1.00 \leq PIR \leq 3.00) or above the federal poverty level (PIR > 3.00).

To assess the stability of our estimates, relative standard errors (RSEs) were calculated. Any estimates with an RSE >0.30 were suppressed. Statistical hypotheses were tested using chi-square tests (with a significance level of $P=.05$), and logistic regression was employed to estimate the likelihood of hypertension in adults by individual and combined sleep problems. All statistical analyses were conducted using SAS-callable SUDAAN (Research Triangle Institute, Research Triangle Park,

NC) to account for the complex design of the NHANES sample.

RESULTS

Among the eligible 10,308 study participants, 3587 (30.2%) had hypertension, and the overall prevalence of sleep disorders, short sleep, and poor sleep was 7.5%, 33.0%, and 52.1%, respectively (Table I). Of those with sleep disorders, sleep apnea was the most common type of sleep disorder (4.4%), followed by insomnia (1.2%), restless leg syndrome (1.2%), and other or unknown sleep disorders (0.7%) (data not shown). In addition, 6.5% of those with a sleep disorder had concurrent short and poor sleep (data not shown).

Compared with normotensive adults, those with hypertension were more likely (P for all comparisons <.001) to be obese (46% vs 28%) but less likely to be current smokers (19% vs 24%) (Table I). In addition, hypertensive adults had a higher prevalence of sleep disorders (11% vs 6%; $P<.001$) and were more likely to sleep <7 hours (35% vs 32%; $P<.02$), but there was no difference in the prevalence of poor sleep ($P<.78$) (Table I).

Among hypertensive adults (data not shown), findings included the following: having a sleep disorder was significantly more common among middle-aged (15%, aged 40–59) than it was among young (10%) or older adults (9%) ($P=.01$). No significant difference in the presence of a sleep disorder was observed by sex ($P=.15$) or race/ethnicity ($P=.54$), but short sleep was significantly more common among older individuals (60 and older, 42.7%) and non-Hispanic whites (37.3%) than it was in their comparison groups. Finally, poor sleep was more common in women (58.6%) than men and in non-Hispanic whites (53.3%) than in the other groups.

The prevalence of hypertension differed by individual and combined sleep problems. Hypertension among adults with sleep disorders, short sleep, and poor sleep was 44.7%, 31.7%, and 30.3%, respectively (Table II). Among combined sleep problems, the prevalence of hypertension was the highest among adults with sleep disorders and short sleep (61.5%), followed by those with only sleep disorders (55.8%), and sleep disorders, short sleep, and poor sleep (49.7%) (Table II).

When taking into account individual associations, adults with sleep disorders were 1.36 (95% confidence interval [CI], 1.05–1.77) times more likely to have hypertension as adults with no sleep-related issues after adjustment for sex, age, race, poverty status, BMI, diabetes, and smoking. No significant association was observed among adults with short sleep or poor sleep (Table II). On the other hand, after adjustment for sex, age, race, poverty status, BMI, diabetes, and smoking, adults with sleep disorders were only 1.65 (95% CI, 0.77–3.77) times more likely to have hypertension as adults with no sleep-related problems. No

TABLE I. Percent Distribution of Demographic and Health Characteristics Among US Adults by Hypertension Status According to National Health and Nutrition Examination Survey, 2005 to 2008

	Total (N=10,308)	Normotensive (n=6721)	Hypertensive (n=3587)	P Value ^a
	Percent (SE)	Percent (SE)	Percent (SE)	
Sex				
Male	49.1 (0.40)	49.6 (0.58)	48.1 (0.78)	.17
Female	50.9 (0.40)	50.4 (0.58)	51.9 (0.78)	
Age, y				
18–39	38.9 (1.00)	51.6 (1.08)	9.6 (0.92)	<.001
40–59	38.3 (0.81)	37.5 (0.87)	40.3 (1.53)	
60+	22.7 (1.08)	10.9 (0.71)	50.1 (1.90)	
Race				
Non-Hispanic white	71.0 (2.30)	69.6 (2.19)	74.1 (2.53)	<.001
Non-Hispanic black	11.2 (1.36)	9.9 (1.17)	14.2 (1.94)	
Mexican American	8.1 (0.93)	9.7 (1.02)	4.6 (0.79)	
Other	9.7 (1.02)	10.8 (1.14)	7.2 (0.91)	
Insurance status				
Insured	80.7 (1.05)	77.2 (1.20)	88.8 (0.84)	<.001
Uninsured	19.3 (1.05)	22.8 (1.20)	11.2 (0.84)	
Education				
12th grade or less	18.9 (1.07)	17.1 (1.07)	22.8 (1.41)	<.001
High school graduate	25.2 (0.83)	23.9 (0.86)	28.0 (1.29)	
Some college or more	55.9 (1.63)	59.0 (1.59)	49.2 (2.16)	
Poverty level^b				
<1.00	12.5 (0.72)	13.3 (0.80)	10.6 (0.82)	<.001
1.00–3.00	36.1 (1.37)	34.1 (1.32)	41.0 (1.60)	
>3.00	51.3 (1.75)	52.6 (1.75)	48.4 (1.95)	
Body mass index				
Normal (<25)	33.2 (0.94)	38.5 (1.06)	21.4 (0.83)	<.001
Overweight (25–30)	33.4 (0.59)	33.6 (0.69)	33.0 (1.18)	
Obese (>30)	33.4 (0.65)	27.8 (1.03)	45.6 (1.04)	
Diabetes	7.9 (0.35)	3.8 (0.28)	17.5 (0.96)	<.001
Current smoker	22.7 (0.88)	24.4 (1.07)	18.8 (1.01)	<.001
Sleep disorder(s)				
Yes	7.5 (0.35)	6.0 (0.30)	11.2 (0.84)	<.001
No	92.5 (0.35)	94.0 (0.30)	88.8 (0.84)	
Sleep duration				
Short (<7 hours)	33.0 (0.87)	32.3 (0.88)	34.7 (1.20)	.02
Normal (≥7 hours)	67.0 (0.87)	67.7 (0.88)	65.3 (1.20)	
Sleep quality				
Poor	52.1 (0.67)	52.0 (0.80)	52.4 (1.16)	.78
Normal/fair	47.9 (0.67)	48.0 (0.80)	47.6 (1.16)	
Combination of sleep problems^c				
Sleep disorder, short sleep, and poor sleep	1.4 (0.15)	1.0 (0.16)	2.2 (0.33)	<.001
Sleep disorder and short sleep	0.7 (0.10)	0.4 (0.06)	1.4 (0.25)	
Sleep disorder and poor sleep	4.5 (0.25)	3.9 (0.06)	5.7 (0.48)	
Sleep disorder only	1.0 (0.12)	0.6 (0.30)	1.9 (0.34)	
Short sleep and poor sleep	11.9 (0.56)	11.9 (0.66)	11.9 (0.67)	
Short sleep only	19.1 (0.46)	19.0 (0.48)	19.2 (0.80)	
Poor sleep only	34.3 (0.64)	35.2 (0.72)	32.5 (1.09)	
None of the above	27.2 (0.60)	28.0 (0.70)	25.2 (1.04)	

Abbreviation: SE, standard error. ^aChi-square *P* value comparing the distribution between hypertensive and normotensive adults. ^bThe ratio of a family's income to the federally defined poverty threshold for a family of the same size in the same calendar year. ^cMutually exclusive sleep problem categories.

significant association was observed among adults with only short sleep or poor sleep (Table II). Adults with all 3 sleep-related problems (sleep disorders, short sleep, and poor sleep) were 1.84 (95% CI, 1.13–2.98)

times as likely to have hypertension as adults with none of these issues. Among adults with 2 sleep problems, only those with both sleep disorders and short sleep were significantly more likely to have

TABLE II. Percent and Odds Ratios of Hypertension Among US Adults With Individual and Combinations of Sleep Problems According to National Health and Nutrition Examination Survey, 2005 to 2008

	Total Sample, No.	Percent of Hypertension (SE)	Unadjusted OR (95% CI)	Adjusted OR ^a (95% CI)
Sleep disorders				
Yes	760	44.9 (1.95)	2.00 (1.64–2.43)	1.36 (1.05–1.77)
No	9533	29.0 (0.81)	1.00	1.00
Sleep duration				
Short (<7 hours)	3525	31.7 (1.20)	1.11 (1.02–1.22)	1.03 (0.91–1.18)
Normal (≥7 hours)	6783	29.4 (0.65)	1.00	1.00
Sleep quality				
Poor	5072	30.3 (0.95)	1.02 (0.91–1.14)	1.03 (0.87–1.21)
Normal/fair	5236	30.0 (0.94)	1.00	1.00
Combination of sleep problems^b				
Sleep disorders, short sleep, and poor sleep	142	49.7 (5.40)	2.54 (1.63–3.93)	1.84 (1.13–2.98)
Sleep disorders and short sleep	69	61.5 (4.38)	4.10 (2.85–5.92)	2.30 (1.49–3.56)
Sleep disorders and poor sleep	448	38.3 (2.68)	1.59 (1.18–2.14)	1.12 (0.77–1.63)
Sleep disorders only	101	55.8 (6.58)	3.23 (1.88–5.56)	1.65 (0.73–3.77)
Short sleep and poor sleep	1148	30.2 (1.73)	1.10 (0.93–1.32)	1.03 (0.81–1.29)
Short sleep only	2161	30.3 (1.31)	1.11 (0.97–1.28)	1.01 (0.86–1.17)
Poor sleep only	3323	28.5 (1.00)	1.02 (0.88–1.20)	1.03 (0.84–1.25)
None of the above	2901	28.1 (1.12)	1.00	1.00
Total	10,308	30.2 (0.74)	–	–

Abbreviations: CI, confidence interval; OR, odds ratio; SE, standard error. ^aComparing the likelihood of hypertension among adults with both individual and combined sleep problems vs those without, adjusted for sex, age, race, poverty status, body mass index, diabetes, and smoking.
^bMutually exclusive sleep problem categories.

hypertension (OR, 2.30; 95% CI, 1.49–3.56) than the reference group.

DISCUSSION

To our knowledge, this is the first national study to examine the joint associations of sleep disorders, short sleep, and poor sleep on the prevalence of hypertension among adults in the United States. We found no relationship between having a sleep disorder and hypertension if short sleep and/or poor sleep was not also present. Among people with both a sleep disorder and short sleep, however, we found that the likelihood of hypertension was slightly more than twice that for people with no sleep problems at all. This relationship may, in part, be the result of biologic mechanisms, suggesting that sleep deprivation may alter cortisol stress hormones and the sympathetic nervous system, resulting in elevated BP.^{16,17} On the other hand, our findings may reflect the growing trends in obesity and diabetes, as evidence indicates a high and increasing prevalence of hypertension and sleep-related problems among those with these conditions.^{14,16,18}

The lack of association between having a sleep disorder (considered individually) and hypertension in our study is inconsistent with findings from several previous studies.^{10–13,17,18} This may be explained by the fact that a large number of adults, in general, are likely to experience and report an occasional short sleep or poor sleep as compared with having a sleep disorder, which often requires a physician diagnosis based on the presence of a number of characteristic

symptoms. Further, the fact that we examined all types of sleep disorders, collectively, rather than individually, may have diluted the magnitude of this association. While evidence indicates that sleep apnea, the most common sleep disorder identified in our study, independently influences the development of hypertension by a factor of three,^{9,10,16} findings from recent studies have shown that insomnia and restless leg syndrome are strongly (up to 5 times) associated with hypertension.^{12,13}

Although our results demonstrate that sleep problems are common, they are a potentially treatable risk factor for cardiovascular morbidity. However, a recent poll found that only 32% of adults have ever discussed their problems regarding sleep with their health care professional.¹⁹ In 1994, US consumers spent an estimated \$8.4 million on sleep clinics and \$285 million on benzodiazepines as sleep aids,²⁰ demonstrating a common problem that lowers quality of life. The fact that only 54% of 116 US medical schools offer training in sleep physiology, and only 38% offer as much as 1 to 4 hours of lecture on this topic, further indicates that sleep-related problems may be overlooked in primary care.²⁰ Hence, it would be useful for health care professionals to be educated on how to adequately diagnose and manage both sleep disorders and disturbances among adults. Moreover, findings from a recent study showing that low efficiency of sleep is highly associated with both prehypertension and hypertension in adolescents suggests that screening needs to start early in life.²¹

LIMITATIONS

The present study has several limitations. First, because of the cross-sectional design we could not determine a causal relationship or rule out bidirectional relationships between sleep and hypertension. In addition, it is likely that BP measurements were subject to the white-coat effect. Given that white-coat hypertension may affect up to 20% of all diagnosed cases of hypertension,²² the observed associations between sleep disorders and hypertension may be underestimated in this study. Further, sleep disorders, duration of sleep, and sleep quality were elicited from self-reported questions and thus they may have been subject to recall bias. We note that a validity study that compared self-reported and actigraph-measured duration of sleep found only a moderate correlation (0.47), and there was systematic overreporting by an average of 34 minutes for each additional hour slept.²³ Thus, there is a potential for misclassification and underdiagnosis of the duration of sleep in our study.

CONCLUSIONS

As sleep habits may be a marker for health status and quality of life, prospective studies are needed to better understand the complex interplay between sleep and hypertension. While some intervention studies to improve the duration and quality of sleep have been effective in reducing both daytime and nighttime BPs,⁹ additional studies that examine the effect of the length and severity of any type of sleep-related problems on hypertension may be of added value.

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