Insomnia Symptom Frequency and Hypertension Risk: A Population-Based Study

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ABSTRACT

Objective: To determine whether increasing frequency of insomnia symptoms is associated with increasing hypertension risk.

Method: This was a large population-based multiyear cross-sectional study. Participants of the 2005–2008 National Health and Nutrition Examination Surveys responding to sleep quality questions were included (n = 12,643). Self-reported insomnia symptoms (ie, difficulty falling asleep, prolonged nocturnal awakening, or undesired early morning awakening, based on *DSM-IV-TR*, National Institutes of Health, and American Academy of Sleep Medicine criteria) over the past month with and without self-reported short sleep time (ie, < 6 hours) were categorized as 0, 1–4, 5–15, and 16–30 times in the past month. Outcomes included doctor-diagnosed self-reported hypertension made at any point in the past, self-reported current receipt of antihypertensive medications, and measured systolic and diastolic hypertension.

Results: While significant and increasing unadjusted odds of doctor-diagnosed hypertension and current antihypertensive medication receipt were found among individuals with increasing insomnia symptom frequency, these odds ratios (ORs) were for the most part rendered nonsignificant after controlling for covariates (eg, adjusted ORs and 95% confidence intervals [CIs] of current antihypertensive receipt for insomnia symptoms coupled with short sleep time: 1–4 times in the past month: 1.17, 0.78–1.76; 5–15 times in the past month: 1.60, 1.01–2.53; and 16–30 times in the past month: 1.41, 0.93–2.14). Even before controlling for covariates, there were generally no significant positive associations between objectively measured systolic and diastolic hypertension and insomnia symptoms regardless of symptom frequency (eg, unadjusted ORs and 95% CIs of measured systolic hypertension for insomnia symptoms coupled with short sleep time: 1–4 times in the past month: 0.88, 0.53–1.47; 5–15 times in the past month: 1.16, 0.77–1.77; and 16–30 times in the past month: 1.30, 0.95–1.78).

Conclusions: Insomnia symptoms, regardless of their frequency, are generally not significantly positively associated with hypertension. These results have important implications relating to screening and management of patients with insomnia symptoms.

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There is growing concern among patients and health care providers regarding the potential medical sequelae of insomnia,[1] especially on the cardiovascular system. If a causal link between insomnia and hypertension exists, this would have several important implications for patients and their medical care. First, screening for hypertension among individuals with insomnia would be required. However, insomnia symptoms are very common in the United States, affecting up to about one-third of the general American adult population,[2,3] and insomnia symptoms are often chronic in duration.[4,5] Second, patient fears regarding the potential cardiovascular sequelae of insomnia may aggravate their poor sleep quality symptoms, especially since depression and anxiety disorders are associated with insomnia.[6] Third, sedative medications, which are generally used to treat insomnia and whose use is on the rise,[7] have been found to be associated with increased morbidity and mortality.[8–11]

Although not consistently demonstrated,[12–14] hypothalamic-pituitary-adrenal axis and sympathetic nervous system activation in individuals with insomnia symptoms provides a biological basis on which hypertension could develop in insomnia. Adrenocorticotropic hormone (ACTH) and cortisol levels,[15] as well as catecholamines and their metabolite levels,[16] have been reported to be significantly higher in individuals with insomnia symptoms accompanied by reduced sleep efficiency on polysomnography. Population-level studies examining for associations between insomnia and hypertension have found mixed results though.[3,17–25] Differences in study designs, study populations, insomnia and hypertension definitions, and adjustment for confounders may explain the discrepancies in results among studies. One notable difference among previous studies is that the frequency of insomnia symptoms varied considerably, from any frequency[17] to "high" frequency,[24,25] and very few studies specifically quantified the frequency of insomnia symptoms examined.[3,20,26] If a causal link between insomnia and hypertension exists, it stands to reason that hypertension should be more often found among those with more frequent insomnia symptoms.

The US National Health and Nutrition Examination Surveys (NHANES), which include large nationally representative population samples and a broad range of sociodemographic and health data, provide a unique opportunity to explore the association between insomnia symptom frequency and hypertension. The purpose of this study was to determine if hypertension risk would increase with increasing frequency of insomnia symptoms.

METHOD

Study Design

A population-based multiyear cross-sectional design was used.

Clinical Points

- Insomnia symptoms, regardless of their frequency and the inclusion of short sleep time in the insomnia definition, do not appear to be significantly positively related to hypertension.
- Physicians should be discouraged from prescribing chronic sedative pharmacotherapy for insomnia symptoms from a possible cardio-protective perspective.

Data Sources

This study was conducted with data from the combined 2005–2006 and 2007–2008 National Health and Nutrition Examination Surveys (NHANES). NHANES is undertaken annually by the United States Centers for Disease Control and collects cross-sectional sociodemographic and health data on a nationally representative sample of the United States population. A description of the survey design and methodology appears elsewhere.[27] Information on sleep health in individuals aged 16 years and older was first collected by NHANES in the 2005–2006 cycle.

Identification of Insomnia Symptoms

Participants were asked regarding the frequency of difficulty falling asleep, of prolonged nocturnal awakening, and of undesired early morning awakening over the past month. These symptoms are contained in the insomnia definitions of the *DSM-IV-TR*,[28] National Institutes of Health Consensus Conference,[29] and the American Academy of Sleep Medicine.[30] Individuals were classified as having insomnia symptoms if they responded affirmatively to experiencing at least 1 complaint of difficulty falling asleep, prolonged nocturnal awakening, or undesired early morning awakening. For the purposes of this study, frequency of insomnia symptoms over the past month were categorized as 0, 1–4, 5–15, and 16–30 times in the past month. If a participant reported more than 1 type of insomnia symptom, participants' insomnia frequency status was based on the most frequent insomnia symptom. Although the presence and frequency of insomnia symptoms were established by self-report, physicians in the "real word" identify insomnia symptoms by patient report. Participants were also asked about the usual amount of sleep obtained in whole number hours on weeknights or work nights. Insomnia symptoms were also considered in conjunction with short sleep time (ie, less than 6 hours of sleep), because there is some evidence to indicate that hypertension may occur in the subset of patients with insomnia symptoms accompanied by short sleep duration.[22,23] A cutoff of less than 6 hours of sleep to denote short sleep time has been used in the literature.[22,23] Although sleep duration was based on self-report, physicians in the "real word" identify sleep duration by patient report. Moreover, patient-reported sleep duration agrees reasonably well with both actigraphic[31,32] and polysomnographic[21] measurements, among individuals both with and without insomnia,[21,31] with differences between subjective and objective sleep duration measures generally less than 1 hour.[21,31,32] Nonresponse to the insomnia questions was very low (0.3% of NHANES participants from both survey cycles). Nonresponse to the sleep duration question was also very low (0.2% of participants from the 2005–2006 NHANES and 0.1% of participants from the 2007–2008 NHANES).

Identification of Hypertension

Participants reported doctor-diagnosed hypertension made at any point in the past and current receipt of antihypertensive drugs. Individuals who responded "don't know" to self-reported health professional–diagnosed hypertension represented 0.3% and 0.1% of respective participants in the 2005–2006 and 2007–2008 NHANES. Less than 0.1% of individuals responded "don't know" to self-reported current receipt of antihypertensive drugs in the 2 NHANES cycles. Three blood pressure measurements were also taken consecutively at a single sitting, and the mean systolic and diastolic blood pressures were determined from these 3 readings. Systolic and diastolic blood pressures of > 140 mm Hg and > 90 mm Hg were considered abnormal, respectively. Three systolic and diastolic blood pressure measurements were not obtained on 39% and 31% of respective participants in the 2005–2006 and 2007–2008 NHANES.

Covariates

Based on a review of the literature, variables that were identified as potential confounders, that is, associated with both the exposure (ie, insomnia)[33,34] and the outcome (ie, hypertension)[35,36] of interest, were controlled for in the analysis. These variables included sex, age, and race (collected on all participants); education level (not collected on 0.1% of participants from both survey cycles); total household income (not collected on ~ 4% of participants from both survey cycles); ever smoking (not collected on 31% and 17% of respective participants from the 2005–2006 and 2007–2008 survey cycles); alcohol consumption over the past year (not collected on ~ 8% of respective participants from both survey cycles); frequency of experiencing depressed mood and anhedonia over the previous 2 weeks (not collected on ~ 10% of respective participants from both survey cycles); ever doctor-diagnosed self-reported diabetes (not collected on 0.1% of respective participants from both survey cycles); ever doctor-diagnosed self-reported high cholesterol (not collected on ~ 4% of respective participants from both survey cycles); and items contained in the Berlin Questionnaire, including objectively measured height and weight from which body mass index (BMI) was calculated (not collected on < 1% of respective participants from both survey cycles); frequency of reported snoring and/or apneas (not collected on ~ 10% of respective participants from both survey cycles); frequency of reported daytime fatigue (not collected on ~ 0.2% of respective participants from both survey cycles); and frequency of daytime sleepiness (not collected on ~ 0.2% of respective participants from both survey cycles). The Berlin Questionnaire is a validated screening instrument for obstructive sleep apnea (for a respiratory distress index ≥ 5 events per hour, the sensitivity and specificity of the Berlin

Questionnaire are 86% and 77%, respectively).[37] Although symptoms of daytime fatigue and sleepiness are considered criteria for or consequences of insomnia, because the Berlin Questionnaire was used to estimate the presence or absence of obstructive sleep apnea, adjustment of analyses for these variables was unavoidable. Analyses were also adjusted for self-reported receipt of sleeping pills in the preceding month (not collected on ~0.2% of respective participants from both survey cycles). Sedative medications have been linked with increased mortality,[11] and therefore by extension, their receipt may also potentially influence the presence or absence of hypertension.

Statistical Analysis

Forced-entry multiple logistic regression was used to examine associations between frequencies of insomnia symptoms and self-reported and objective hypertension measures. Insomnia symptoms were considered both with and without short sleep time. Individuals with insomnia symptoms 0 in the past month were used as the reference group in all analyses. Unadjusted odds ratios were first calculated. A second regression model was run for each hypertension outcome including all the following covariates: sex, age, race, education level, total household income, ever smoking, alcohol consumption over the past year, depressed mood and anhedonia over the previous 2 weeks, doctor-diagnosed diabetes, doctor-diagnosed high cholesterol, BMI, frequency of reported snoring and/or apneas, frequency of reported daytime fatigue, and frequency of daytime sleepiness. Analyses of measured systolic and diastolic hypertension were stratified by current antihypertensive receipt, as receipt of these drugs may influence the identification of measured hypertension. All hypertension outcomes were also examined stratifying by current sedative medication receipt.

NHANES uses a complex sampling design, employing stratification and multistage clustering.[27] To account for the unequal probabilities of selecting respondents, all point estimates were appropriately weighted using the survey sample weights provided. Combined new sample weights were appropriately created given that 2 NHANES cycles were used. To account for the effects of stratification and clustering on variance estimates, Taylor linearization procedures were performed on all confidence intervals using stratum and cluster variables provided by NHANES. All analyses were performed on SAS version 9.1.3. Ethics approval was granted by the University of Toronto Office of Research Ethics (no. 27439).

RESULTS

In the combined 2005–2008 NHANES, 12,643 (99.7%) individuals responded to questions on insomnia symptoms and sleep duration and formed the final analytic sample. The prevalence of different frequencies of insomnia symptoms, including and not including short sleep time in the insomnia definition, are presented in Table 1. When short sleep time is not considered, 78.6% of participants experienced insomnia symptoms at least once in the preceding month and the prevalence decreased with increasing category of insomnia symptom frequency. When short sleep time is considered, only 11.4% of participants experienced insomnia symptoms at least once in the preceding month and the prevalence was roughly equally distributed across insomnia frequency categories. Descriptive profiles of individuals with and without insomnia symptoms (with and without including short sleep time in the insomnia definition) are presented in Table 2.

When sleep duration was not considered in the insomnia definition and before controlling for covariates, there were significant and increasing odds of doctor-diagnosed hypertension and current antihypertensive use across

Table 1. Prevalence of Different Frequencies of Insomnia Symptoms (N = 12,643)

Insomnia Symptom Frequency in Preceding Month	Without Including Short Sleep Time in Insomnia Definition, n (%)	Including Short Sleep Time (< 6 hours) in Insomnia Definition, n (%)
0	2,703 (21.4)	11,191 (88.5)
1–4	6,134 (48.5)	433 (3.4)
5–15	2,260 (17.9)	396 (3.1)
16–30	1,546 (12.2)	623 (4.9)

Table 2. Sociodemographic and Health Profile of Individuals With and Without Insomnia Symptoms

Characteristic	Individuals With Insomnia Symptoms 1–30 Times in Past Month Without Including Short Sleep Time in Insomnia Definition (n = 9,940)	Individuals With Insomnia Symptoms 1–30 Times in Past Month Including Short Sleep Time (< 6 hours) in Insomnia Definition (n = 1,452)	Individuals Without Insomnia Symptoms (n = 2,703)
Age, mean, y	45.0[a]	45.5[a]	43.0
Women, %	53.4[b]	51.3[b]	43.2
African American, %	10.6[b]	20.5[b]	15.5
With at least some college education, %	52.9[b]	44.5	47.1
With household income < $20,000, %	16.9[b]	25.7[b]	20.0
BMI (mean in kg/m^2)	28.2	29.7[a]	28.4
Ever life-time smoker, %	48.9[b]	56.8[b]	44.3
Ever drank alcohol past 12 months, %	80.6	74.1[b]	79.5
With depression symptoms more than half the days over the past 2 weeks, %	9.5[b]	18.3[b]	5.2
With diabetes, %	7.9[b]	11.5[b]	6.7
With high cholesterol, %	32.8[b]	33.5[b]	24.0

[a]Compared to no insomnia group, $P < .05$ by t test.
[b]Compared to no insomnia group, $P < .05$ by χ^2 test of proportions.

Table 3. Odds of Self-Reported Hypertension Measures Among Individuals With Different Frequencies of Insomnia Symptoms

Insomnia Symptom Frequency in Preceding Month	Without Including Short Sleep Time in Insomnia Definition		Including Short Sleep Time (< 6 hours) in Insomnia Definition	
	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)
Doctor-diagnosed hypertension				
0	1.00	1.00	1.00	1.00
1–4	1.34 (1.20–1.50)	1.23 (1.06–1.43)	1.54 (1.22–1.95)	1.31 (0.95–1.79)
5–15	1.48 (1.27–1.73)	1.15 (0.93–1.41)	1.94 (1.50–2.51)	1.44 (0.99–2.07)
16–30	1.99 (1.69–2.33)	1.49 (1.16–1.92)	2.52 (2.07–3.07)	1.87 (1.39–2.52)
Currently receiving antihypertensive drugs				
0	1.00	1.00	1.00	1.00
1–4	1.27 (1.10–1.46)	1.12 (0.93–1.35)	1.40 (1.06–1.86)	1.17 (0.78–1.76)
5–15	1.44 (1.22–1.70)	1.13 (0.91–1.40)	1.87 (1.41–2.49)	1.60 (1.01–2.53)
16–30	1.60 (1.35–1.88)	1.16 (0.85–1.57)	1.93 (1.56–2.39)	1.41 (0.93–2.14)

[a]Adjusted for sex, age, race, education, household income, smoking status, alcohol intake, depression symptoms, doctor-diagnosed diabetes, doctor-diagnosed high cholesterol, measured body mass index, self-reported snoring, self-reported snorting/gasping sounds and apneas, self-reported daytime fatigue, and self-reported daytime sleepiness.

increasing insomnia frequency categories (Table 3). After controlling for covariates, the odds of doctor-diagnosed hypertension were attenuated across all insomnia frequency categories and the 5–15-times-in-the-past-month frequency category was no longer statistically significant. The odds of current antihypertensive use also attenuated and became nonsignificant across all insomnia frequency categories. When sleep duration was considered in the insomnia definition and before controlling for covariates, there were significant and increasing odds of doctor-diagnosed hypertension and current antihypertensive use across increasing insomnia frequency categories. After controlling for covariates, the odds of doctor-diagnosed hypertension were attenuated across all insomnia frequency categories, and the 1–4- and 5–15-times-in-the-past-month frequency categories were no longer statistically significant. The odds of current antihypertensive use also attenuated, and the 1–4- and 16–30-times-in-the-past-month frequency categories were no longer statistically significant.

When sleep duration was not considered in the insomnia definition and before controlling for covariates, individuals with insomnia symptoms 1–4 times in the preceding month were significantly less likely to have measured systolic hypertension, among all individuals and among those receiving and not receiving antihypertensive medications (Table 4). Otherwise, there were no significant associations between measured systolic and diastolic hypertension and insomnia symptom frequency. After controlling for covariates, many of the odds ratios for measured systolic and diastolic hypertension decreased. Nonsignificance generally persisted, with the exception that, among those not receiving antihypertensive therapy, the odds of systolic hypertension were now significantly decreased in the 5–15-times-in-the-past-month insomnia symptom frequency category. When sleep duration was considered in the insomnia definition and before controlling for covariates, individuals with insomnia symptoms 16–30 times in the preceding month who were not on antihypertensives had significantly higher odds of systolic hypertension. Otherwise, there were no significant associations between measured systolic and diastolic hypertension and insomnia symptom frequency. After controlling for covariates, the odds of systolic hypertension among those with insomnia symptoms 16–30 times in the past month and not receiving antihypertensives decreased and were no longer significant. Many of the other odds ratios for measured systolic and diastolic hypertension also decreased and nonsignificance persisted.

Among individuals not receiving sedative medication, there were significant and increasing unadjusted odds of doctor-diagnosed hypertension and current antihypertensive drug receipt across all insomnia frequency categories when short sleep time was not considered (Table 5). Even before adjusting for covariates, there were no significant associations between any of the insomnia frequency categories, without considering short sleep time, and measured systolic and diastolic hypertension. After adjusting for covariates, all odds ratios attenuated, doctor-diagnosed hypertension was no longer significantly increased in the 5–15-times-per-month insomnia symptoms category, and receipt of current antihypertensive drugs was no longer significantly elevated across any of the insomnia frequency categories. Nonsignificance persisted for the remainder of the associations. When short sleep time was considered in the insomnia definition, there were significant and increasing unadjusted odds of doctor-diagnosed hypertension and current antihypertensive drug receipt across all insomnia frequency categories, as well as significantly increased odds of systolic hypertension in the 16–30-times-per-month insomnia symptoms category. All other associations were nonsignificant. After adjusting for confounders, nearly all odds ratios decreased, the odds of current antihypertensive drug receipt were no longer significantly increased in any of the insomnia frequency categories, and systolic hypertension was no longer significantly elevated in the 16–30-times-per-month insomnia symptoms category. The statistical significance of all other associations remained unchanged.

Among individuals receiving sedative medication, there were no significant associations between any of the

Table 4. Odds of Objectively Measured Hypertension Among Individuals With Different Frequencies of Insomnia Symptoms Stratified by Current Antihypertensive Therapy Status

	Without Including Short Sleep Time in Insomnia Definition		Including Short Sleep Time (<6 hours) in Insomnia Definition	
Insomnia Symptom Frequency in Preceding Month	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)
Systolic blood pressure >140 mm Hg				
All individuals				
0	1.00	1.00	1.00	1.00
1–4	0.77 (0.63–0.94)	0.72 (0.54–0.97)	0.88 (0.53–1.47)	0.83 (0.41–1.67)
5–15	0.98 (0.74–1.29)	0.80 (0.56–1.14)	1.16 (0.77–1.77)	0.91 (0.49–1.69)
16–30	1.13 (0.87–1.45)	0.94 (0.64–1.39)	1.30 (0.95–1.78)	1.02 (0.60–1.73)
Individuals currently receiving antihypertensive drugs				
0	1.00	1.00	1.00	1.00
1–4	0.65 (0.46–0.90)	0.69 (0.43–1.11)	0.66 (0.37–1.17)	0.79 (0.40–1.59)
5–15	0.96 (0.70–1.31)	0.97 (0.60–1.58)	1.36 (0.80–2.33)	1.25 (0.53–2.93)
16–30	0.67 (0.42–1.06)	0.57 (0.30–1.08)	0.63 (0.38–1.05)	0.52 (0.24–1.13)
Individuals not currently receiving antihypertensive drugs				
0	1.00	1.00	1.00	1.00
1–4	0.70 (0.51–0.96)	0.68 (0.44–1.04)	0.99 (0.46–2.16)	0.91 (0.30–2.78)
5–15	0.79 (0.53–1.17)	0.61 (0.38–0.98)	0.51 (0.24–1.12)	0.46 (0.17–1.24)
16–30	1.38 (0.94–2.03)	1.38 (0.79–2.44)	1.62 (1.01–2.58)	1.40 (0.70–2.79)
Diastolic blood pressure >90 mm Hg				
All individuals				
0	1.00	1.00	1.00	1.00
1–4	0.71 (0.46–1.10)	0.71 (0.42–1.22)	1.18 (0.48–2.89)	1.00 (0.34–2.94)
5–15	0.98 (0.55–1.74)	0.93 (0.46–1.87)	1.06 (0.56–1.98)	0.79 (0.35–1.76)
16–30	1.04 (0.64–1.68)	0.98 (0.49–1.97)	0.82 (0.45–1.51)	0.55 (0.24–1.25)
Individuals currently receiving antihypertensive drugs				
0	1.00	1.00	1.00	1.00
1–4	0.63 (0.31–1.27)	0.71 (0.28–1.81)	1.64 (0.54–1.98)	1.58 (0.38–6.50)
5–15	0.99 (0.52–1.89)	0.97 (0.36–2.56)	0.81 (0.30–2.18)	0.57 (0.14–2.40)
16–30	0.99 (0.44–2.25)	0.92 (0.29–2.92)	0.70 (0.21–2.30)	0.41 (0.07–2.34)
Individuals not currently receiving antihypertensive drugs				
0	1.00	1.00	1.00	1.00
1–4	0.64 (0.34–1.22)	0.59 (0.30–1.18)	0.88 (0.23–3.30)	0.79 (0.17–3.75)
5–15	0.87 (0.42–1.83)	0.87 (0.41–1.82)	0.76 (0.24–2.45)	0.44 (0.11–1.76)
16–30	1.00 (0.46–2.18)	1.01 (0.31–3.27)	0.70 (0.24–2.03)	0.48 (0.16–1.44)

[a]Adjusted for sex, age, race, education, household income, smoking status, alcohol intake, depression symptoms, doctor-diagnosed diabetes, doctor-diagnosed high cholesterol, measured body mass index, self-reported snoring, self-reported snorting/gasping sounds and apneas, self-reported daytime fatigue, and self-reported daytime sleepiness.

4 hypertension variables and insomnia symptom frequency without short sleep considered even before controlling for covariates. After controlling for covariates, there were significantly increased odds of diastolic hypertension in the 16–30-times-per-month insomnia symptoms category. Nonsignificance persisted for the remainder of the associations. When short sleep time was considered in the insomnia definition, there were no significant associations between any of the 4 hypertension variables and insomnia symptom frequency before and after covariate adjustment.

DISCUSSION

There were generally no significant positive associations between objectively measured hypertension and insomnia symptoms, regardless of insomnia symptom frequency and the consideration of short sleep time in the insomnia definition, even before covariate adjustment. Associations between objectively measured hypertension and insomnia symptom frequency remained nonsignificant even after stratifying by current antihypertensive medication receipt and receipt of sedative pharmacotherapy. While significant and increasing unadjusted odds of self-reported measures of hypertension were found across individuals with increasing insomnia symptom frequency, both with and without short sleep time, these odds ratios were for the most part rendered nonsignificant after controlling for relevant covariates. The results of this study are mainly negative for a relationship between insomnia symptoms and hypertension.

This study was based on data from a large, recent, multiyear, nationally representative sample of the United States population. This was the first study to examine for hypertension among individuals with insomnia symptoms across a spectrum of symptom frequency. There were excellent response rates to the sleep and hypertension questions and measurements. Both self-reported and objective measures of hypertension were examined, and a broad range of covariates were controlled for in the analysis.

Table 5. Odds of Subjective and Objective Hypertension Measures Among Individuals With Different Frequencies of Insomnia Symptoms Stratified by Current Sedative Use

Insomnia Symptom Frequency in Preceding Month	Without Including Short Sleep Time in Insomnia Definition		Including Short Sleep Time (<6 hours) in Insomnia Definition	
	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)
No sedative use in the past month				
Doctor-diagnosed hypertension				
0	1.00	1.00	1.00	1.00
1–4	1.30 (1.16–1.46)	1.26 (1.07–1.48)	1.59 (1.23–2.06)	1.42 (1.03–1.97)
5–15	1.42 (1.19–1.69)	1.23 (0.96–1.58)	2.07 (1.47–2.90)	1.82 (1.07–3.10)
16–30	1.91 (1.57–2.34)	1.63 (1.25–2.13)	2.52 (1.93–3.30)	1.92 (1.31–2.82)
Current antihypertensive use				
0	1.00	1.00	1.00	1.00
1–4	1.26 (1.08–1.46)	1.17 (0.95–1.43)	1.52 (1.15–2.00)	1.37 (0.92–2.05)
5–15	1.33 (1.10–1.60)	1.17 (0.90–1.51)	1.83 (1.28–2.62)	1.91 (0.97–3.77)
16–30	1.49 (1.20–1.85)	1.19 (0.87–1.62)	1.78 (1.36–2.34)	1.36 (0.84–2.19)
Systolic hypertension >140 mm Hg				
0	1.00	1.00	1.00	1.00
1–4	0.80 (0.65–1.98)	0.74 (0.54–1.00)	0.98 (0.58–1.64)	0.99 (0.47–2.07)
5–15	0.94 (0.62–1.41)	0.77 (0.44–1.35)	1.22 (0.67–2.20)	1.14 (0.50–2.64)
16–30	1.12 (0.85–1.46)	1.06 (0.68–1.66)	1.59 (1.16–2.19)	1.42 (0.83–2.41)
Diastolic hypertension >90 mm Hg				
0	1.00	1.00	1.00	1.00
1–4	0.68 (0.44–1.03)	0.59 (0.35–0.99)	1.23 (0.48–3.12)	1.11 (0.35–3.52)
5–15	0.74 (0.37–1.48)	0.58 (0.23–1.45)	0.95 (0.45–2.00)	0.42 (0.13–1.37)
16–30	0.75 (0.44–1.28)	0.65 (0.30–1.44)	1.00 (0.52–1.92)	0.79 (0.31–1.99)
Sedative use at least once in past month				
Doctor-diagnosed hypertension				
0	1.00	1.00	1.00	1.00
1–4	1.00 (0.57–1.76)	0.88 (0.48–1.63)	0.86 (0.40–1.88)	0.67 (0.21–2.13)
5–15	0.96 (0.55–1.69)	0.70 (0.37–1.36)	0.94 (0.53–1.84)	0.65 (0.29–1.44)
16–30	1.19 (0.73–1.79)	0.92 (0.49–1.76)	1.42 (0.80–2.52)	1.24 (0.52–2.93)
Current antihypertensive use				
0	1.00	1.00	1.00	1.00
1–4	0.77 (0.41–1.47)	0.63 (0.31–1.30)	0.53 (0.19–1.48)	0.35 (0.09–1.31)
5–15	0.86 (0.46–1.62)	0.66 (0.31–1.40)	1.00 (0.49–2.03)	0.78 (0.34–1.64)
16–30	0.85 (0.48–1.51)	0.66 (0.31–1.40)	1.02 (0.54–1.94)	0.83 (0.34–2.18)
Systolic hypertension >140 mm Hg				
0	1.00	1.00	1.00	1.00
1–4	0.46 (0.21–1.02)	0.39 (0.16–0.77)	0.28 (0.06–1.44)	0.28 (0.05–1.65)
5–15	0.68 (0.29–1.60)	0.49 (0.19–1.24)	0.67 (0.34–1.32)	0.39 (0.15–1.00)
16–30	0.70 (0.27–1.81)	0.45 (0.16–1.25)	0.59 (0.16–2.13)	0.26 (0.06–1.23)
Diastolic hypertension >90 mm Hg				
0	1.00	1.00	1.00	1.00
1–4	3.53 (0.41–30.53)	2.91 (0.33–25.94)	2.41 (0.14–40.17)	2.83 (0.10–77.65)
5–15	6.88 (0.90–52.80)	8.54 (0.98–74.78)	5.67 (0.94–34.12)	5.40 (0.55–53.43)
16–30	6.73 (0.81–55.67)	9.96 (1.01–98.16)	2.52 (0.27–23.26)	1.57 (0.14–17.85)

[a]Adjusted for sex, age, race, education, household income, smoking status, alcohol intake, depression symptoms, doctor-diagnosed diabetes, doctor-diagnosed high cholesterol, measured body mass index, self-reported snoring, self-reported snorting/gasping and apneas, self-reported daytime fatigue, and self-reported daytime sleepiness (and current antihypertensive receipt for systolic and diastolic hypertension outcomes only).

These results are consistent with multiple previous studies that used different population-level databases and found no relationship between insomnia and hypertension.[3,17–20] However, this study's results are not in keeping with the work of Vgontzas and colleagues using the Penn State Cohort.[22,23] Using both cross-sectional and prospective study designs, Vgontzas and colleagues have reported a significant 3- to 5-fold increase in hypertension among individuals with chronic insomnia (defined as insomnia symptoms with at least 1-year duration) combined with polysomnographically determined sleep duration of less than 6 hours.[22,23] There are important methodological differences between the current study and the work of Vgontzas and colleagues. This study was based on considerably larger, nationally representative data. Vgontzas and colleagues used only a self-reported measure of hypertension when they prospectively examined hypertension risk among individuals with insomnia,[23] whereas the current study also considered objective measures of hypertension. Vgontzas and colleagues examined chronic insomnia (ie, insomnia symptoms lasting at least 1 year), but without specifying symptom frequency, while the current study examined insomnia symptoms of only month duration, but with quantification of symptom frequency. Although the current study did not collect information on

duration of insomnia symptoms, insomnia symptoms tend to be chronic for the majority of affected individuals. Two studies, each involving a few thousand Americans with insomnia symptoms at baseline, reported that over half continued to experience insomnia symptoms at follow-up 3–7.5 years later.[4,5] Vgontzas and colleagues also included the reporting of "unrefreshing sleep" in their definition of insomnia, while the current study did not. Some have argued that "unrefreshing sleep" should be considered as a distinct entity from insomnia.[38,39] Finally, Vgontzas and colleagues used only a single night of polysomnography to establish participants' sleep duration. In contrast, the current study attempted to capture participants' usual sleep duration on weeknights and work nights at home. It is questionable how reflective a single night of sleep in a sleep laboratory is of an individual's usual sleep at home. Even if a true relationship between insomnia symptoms coupled with short sleep time and hypertension existed, individuals with insomnia and short sleep time represent a relatively small proportion of the total insomnia population (about 15% based on data in Table 1).

There are several limitations. First, the current study was based on cross-sectional and not longitudinal data. It could be argued that no association was found between insomnia symptoms and hypertension because hypertension may develop over time as a result of chronic insomnia and our observation window was too short to detect this. Nonetheless, many individuals with insomnia symptoms in the current study probably had insomnia long-standing, well before the time of hypertension identification, since the majority of insomnia is chronic in nature.[4,5] Second, misclassification of individuals with and without insomnia symptoms, and individuals with and without short sleep time, may have occurred as a result of recall and social desirability biases associated with self-reporting and potentially contributed to negative results. However, the presence of insomnia symptoms and short sleep time are established by physicians in the "real word" by patient self-report. Third, although odds of doctor-diagnosed hypertension, receipt of antihypertensive therapy, and measured systolic hypertension were generally nonsignificant among individuals with insomnia symptoms after adjusting for covariates, odds ratios were often still greater than 1.00, and it is possible that if sample sizes were increased that these results may have reached statistical significance. Increasing sample size numbers in the NHANES databases was not possible since data collection is determined and undertaken by the United States Centers for Disease Control. However, NHANES presently has the largest sample of individuals available with data on insomnia symptoms and hypertension. Fourth, it may be argued that associations between insomnia symptoms and doctor-diagnosed hypertension and receipt of antihypertensive drugs were generally rendered nonsignificant after adjusting for such covariates as daytime fatigue and sleepiness, which are considered criteria for or consequences of insomnia. However, possible collinearity would not explain the results involving measured systolic and diastolic hypertension, which were generally nonsignificant even in unadjusted analyses.

In conclusion, the results of this large, US nationally representative population-based study were mainly negative for a relationship between insomnia symptoms (regardless of their frequency and the inclusion of short sleep time in the insomnia definition) and hypertension. The lack of a frequency-response relationship between insomnia symptoms and hypertension suggests that there is very likely no causal link between the two. These results have important implications related to screening and management of patients with insomnia symptoms. Based on these results, physicians should be discouraged from prescribing chronic sedative pharmacotherapy, which is associated with increased morbidity and mortality,[8–11] for insomnia from a possible cardio-protective perspective.

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