The Association Between Habitual Sleep Duration and Hypertension Control in the United States (US) Adults With Hypertension

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Research Article

Keywords: Habitual Sleep Duration, Hypertension Control, Adults, Hypertension, United States (US)

Posted Date: September 27th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-909529/v1

Abstract

Although sleep duration has been identified as a significant factor in risk for hypertension, there is limited data on the relationship between sleep duration and hypertension control. This study examined the association between habitual sleep duration and hypertension control in United States of America (USA) adults with hypertension. A total of 5,163 adults from the National Health and Nutrition Examination Survey (2015 – 2018) were analyzed. Survey-weighted multivariable logistic regression models were fit to examine the association between habitual sleep duration (coded as <6, 6 - <7, 7 – 9 (reference), and >9 hours) and hypertension control (BP <130/80mmHg versus ≥130/80mmHg), adjusted for sociodemographic, sleep and health characteristics. In the fully adjusted model, habitual sleep duration of <6 hours/main sleep period was associated with reduced odds of hypertension control (OR = 0.66, 95% CI: 0.46 – 0.95, *P* = 0.027) when compared to 7 – 9 hours. No significant differences were noted in hypertension control between the reference group (7 - 9 hours) and the 6 - <7 or >9 hours groups. These findings suggest that measures to support adequate habitual sleep duration may help improve hypertension control in adults who habitually sleep for <6 hours/day.

Introduction

In the 2015–2018 period, 47.3% of US adults had hypertension, defined as systolic blood pressure (SBP) ≥ 130 mmHg or diastolic blood pressure (DBP) ≥ 80 mmHg, or current intake of BP-lowering medications[1]. Of those, only 20.6% had achieved hypertension control[1]. Hypertension is a major modifiable risk factor for heart disease and stroke[2]. In 2018, heart disease and stroke were among the top 5 causes of death in the United States of America (USA)[3]. Insufficient sleep is also a significant health issue, with over one-third of US adults sleeping < 7 hours per day[4]. The American Academy of Sleep Medicine and Sleep Research Society (AASM/SRS) recommends a minimum of 7 hours daily of sleep to support optimal function of body systems, including the systems involved in BP regulation[5].

The 2017 American College of Cardiology and American Heart Association (ACC/AHA) guidelines on non-pharmacological interventions for prevention and management of hypertension focus on well-known modifiable risk factors for hypertension such as obesity, unhealthy diet, and excessive alcohol intake[2,6,7]. However, several observational studies have also found a link between insufficient sleep and the risk of hypertension[8–14]. These findings are supported by experimental studies, which have demonstrated a link between sleep restriction and elevation of BP[15–18]. Other findings indicate that the strength of the relationship between short sleep and hypertension risk decreases with age[9,11,19], and is stronger in women than men[9,20].

The growing evidence showing that sleep duration is a significant predictor of hypertension risk points to the need to examine the potential role of sleep duration in managing and controlling hypertension. Little is known, however, about the relationship between habitual sleep duration and hypertension control. A few studies that have examined the relationship between sleep duration and BP outcomes in adults with

hypertension have yielded mixed results. One of the studies demonstrated a significant BP increase when sleep was restricted to < 5 hours a day[15]. The other, a cross-sectional study, found a positive correlation between self-reported long sleep duration (≥ 10 hours/day) and SBP[21].

Further research is needed to explore if any differences noted in BP across various sleep duration categories translate to differences in hypertension control. We addressed this gap in knowledge by examining the association between habitual sleep duration and hypertension control in adults with hypertension. We also examined whether the relationship between sleep duration and hypertension control was modified by age or gender.

Methods

Data Source and study population

This cross-sectional study used data from the 2015–2016 and 2017–2018 cycles of the National Health and Nutrition Examination Survey (NHANES). NHANES employs complex multistage sampling procedures to survey the civilian, noninstitutionalized USA population. The participants are interviewed at home, followed by physical examinations and further interviews at a mobile examination center (MEC)[22]. The NHANES protocol was approved by the National Center for Health Statistics Ethics Review Board[23]. Informed consents were obtained for all eligible subjects before they participated in the NHANES interviews and physical examinations. All methods were performed in accordance with relevant guidelines and regulations of the NHANES. We used de-identified and publicly available data that did not meet human subjects research criteria and thus was exempt from institutional review board oversight. The datasets used are available at https://wwwn.cdc.gov/nchs/nhanes/.

Figure 1 illustrates the criteria used for identifying the study sample. Of the 19,225 adults (≥ 18 years old) in the 2015–2018 NHANES[24], 5,712 participated in interviews and physical examinations and met at least one of the following criteria for hypertension: current use of BP-lowering medication (*n = 3,706)*, average SBP ≥ 130mmHg *(n = 3,744)*, or SBP ≥ 80mmHg *(n = 2,323)*[2]. We excluded participants who were pregnant or missing sleep duration or BP data. To minimize the potential for unmeasured confounding[25], we excluded those with severe disease, including congestive heart failure and severe (stage 4–5) chronic kidney disease (defined as a history of undergoing dialysis in the previous 12 months or a Chronic Kidney Disease Epidemiology Collaboration estimated glomerular filtration rate < 30 mL/min/1.73 m^2)[26, 27,28].

Key Measures

Habitual Sleep Duration. The NHANES calculated the amount of sleep usually obtained in a night or main sleep period during weekdays or workdays from two survey questions: “What time do you usually fall asleep on weekdays or workdays?” and “What time do you usually wake up on weekdays or workdays?”

We categorized habitual sleep duration into < 6, 6 – <7, 7–9, and > 9 hours/night or main sleep period[5,11,12].

Hypertension Control. A standardized protocol was used to obtain three BP readings taken one minute apart at the MEC[29]. Hypertension control was defined as average SBP < 130mmHg and DBP < 80mmHg[2].

Confounders. Sociodemographic, sleep, and health-related factors associated with sleep duration and hypertension control were identified as potential confounders[9,11,12,30–35]. The factors include gender (male, female), age (< 18–39, 40–59, 60–79, ≥ 80 years), nativity (US.-born, not US.-born), education level (less than high school, high school graduate, some college, college graduate), employment status (parttime < 35 hours, fulltime 35–44 hours, fulltime ≥ 45 hours, not working), health insurance (insured, uninsured), and annual household income (<$55,000, ≥$55,000). The $55,000 NHANES income category was used as a cut-point because it is close to the US median household income for the 2015 to 2017 period[36]. Race/ethnicity was self-reported and classified as non-Hispanic White, non-Hispanic Black, Hispanic, and Other.

History of sleep apnea symptoms was defined as a history of; (1) snoring ≥ 3 times/week; (2) snorting, gasping, or stopping breathing while sleeping ≥ 3 times/week; or (3) being excessively sleepy during the day ≥ 16 times/month despite sleeping for ≥ 7 hours per night[37,38]. Help-seeking for sleeping difficulty was defined as a history of ever telling a health care professional that one had trouble sleeping. Depressive symptoms were screened using the 9-item Patient Health Questionnaire (PHQ-9, range of 0–27) and categorized as minimal or none (0–4), mild (5–9), moderate to severe (≥ 10–14)[39].

The number of healthcare visits in the past 12 months (excluding home visits, phone consultations, overnight hospitalization, and emergency room visits) was grouped into none, 1–2, and > 2 visits. Body mass index (BMI) was analyzed as a continuous variable. Cardiovascular disease was defined as a history of being told by a health professional that one had coronary heart disease, angina, a heart attack, or stroke. Diabetes was defined based on either a history of being told by a health care professional that one has diabetes or having a blood glycohemoglobin level of 6.5% or higher[40]. Moderate chronic kidney disease was defined as an eGFR of 30 - <60 mL/min/1.73 m^2 [26].

Cigarette smoking was categorized as never smoker (never smoked at least 100 cigarettes in their lifetime), former smoker (smoked at least 100 cigarettes in their lifetime but not smoking currently), and current smoker. Physical activity was self-reported and included leisure, work, and transportation (commuting by walking or bicycling) activities. Moderate-intensity and transportation-related physical activities were assigned four metabolic equivalents of task (MET) scores/minute, and vigorous-intensity physical activity eight MET scores/minute[41]. Weekly physical activity levels were categorized as none (0 MET-minutes), low (< 600 MET-minutes), sufficient (600–1200 MET-minutes), and high (> 1200 MET-minutes)[42]. Alcohol intake was classified as none (never had at least 12 alcoholic drinks in a lifetime or any alcohol in the past year), moderate (not more than one drink for women and not more than two drinks for men in a day), and heavy (more than one or two drinks in a day for women and men, respectively)[43].

Statistical Analysis & Missing Data

Data distribution across various variables was analyzed for the total study sample and across habitual sleep duration categories. The percentage of observations with complete data for all covariates was 85%. The covariates with missing data (unweighted number and weighted percentage) included education level (*n = 6, 0.1%*), annual household income (*n = 413, 6.0%*), health insurance (*n = 10, 0.2%*), alcohol intake (*n = 333, 5.3%*), BMI (*n = 67, 1.0%*), depressive symptoms (*n = 357, 5.6%*), and healthcare visits in past year (*n = 10, 0.1%*). Missing data were imputed using multiple imputation with chained equations [44]. A total of 20 imputation datasets were generated, and the results pooled to generate estimates of the multiply impute model using STATA IC's multiple imputation (MI) estimate procedures [45].

The variables used in the imputation model included all the variables in the analysis model, the NHANES cluster, strata, and weights variables, and auxiliary variables significantly associated with missing data in some covariates (age and education level of the reference person, homeownership, number of rooms in house of residence, and household size).

We compared the observed data to the complete imputed data to check for differences in data distribution in the covariates with missing data. The distribution remained similar for depressive symptoms, BMI, healthcare visits in the past year, education level, health insurance, and alcohol intake. In the annual household income, the proportion of the < $55,000 group increased from 48.5–49.3% while the ≥ $55,000 group reduced from 51.5–50.7% after imputation (Appendix Table 1).

Models to analyze the association between habitual sleep duration and hypertension control were fit using the complete imputed data. Logistic regression models (unadjusted and adjusted) were fit to analyze the association between habitual sleep duration and hypertension control, with the crude and adjusted odds ratios for hypertension control and their corresponding 95% confidence intervals presented. Effect modification by age and gender was assessed separately by adding an interaction term (sleep duration × age or sleep duration × gender) to the adjusted logistic regression model. All data were analyzed using STATA 1C software (Version 15, StataCorp LLC, College Station, Texas, 2017). Survey commands were used to apply sample weights to account for the NHANES complex sampling design. The level of significance for all analyses was set at a p-value < 0.05.

Results

The current study included 5,163 study participants (see Fig. 1). Table 1 presents the descriptive characteristics of the participants by habitual sleep duration based on the 2015–2018 NHANES data. The average age of the adults with hypertension was 55.4 years, and 52.2% were male. Most participants (64.3%) were non-Hispanic White. More than half (53.2%) had some college education or higher level of education. Most of the participants had health insurance and had visited a health care facility for care at least once in the past year. The mean BMI was 31.2 kg/m^2, and 49.3% reported being highly physically active (> 1200 MET minutes/week) while 25.1% were physically inactive.

Over half (54.3%) had sleep apnea symptoms, and 36.2% had a history of telling a health care professional that they had trouble sleeping. The majority (66.0%) reported sleeping 7–9 hours in a night or main sleep period, while 23.7% slept < 7 hours. The proportion that had hypertension control (SBP < 130mmHg and DBP < 80mmHg) was 19.7% (Table 1).

In the unadjusted logistic regression model of hypertension control as a function of habitual sleep duration (Table 2), those with a sleep duration of < 6 hours were less likely to have hypertension control when compared to those whose sleep duration was 7–9 hours (OR = 0.65, 95% CI: 0.44–0.98, *P* = 0.041). No significant differences were noted in hypertension control between the sleep duration reference group (7–9 hours) and those whose sleep duration was 6 - <7 hours or > 9 hours. After adjusting for all covariates (sociodemographic characteristics and other sleep and health-related characteristics), the finding that those with a sleep duration of < 6 hours were less likely to have hypertension control than those with a sleep duration of 7–9 hours remained robust (OR = 0.66, 95% CI: 0.46–0.95, *P* = 0.027). In the fully adjusted model, no significant differences were noted in hypertension control between those with 6 - <7 hours of sleep (OR = 1.41, 95% CI: 0.93–2.13, *P* = 0.099) or > 9 hours of sleep (OR = 0.99, 95% CI: 0.69–1.42, *P* = 0.941) compared to the reference group (7–9 hours of sleep).

In other findings from the adjusted model, those aged 40–79 years had higher odds of hypertension control than the 18–39 age group. Those with a history of cardiovascular disease, moderate chronic kidney disease, or diabetes mellitus had higher odds of hypertension control. Other factors positively associated with higher odds of hypertension control included BMI, current smoking (compared to no smoking), having a history of seeking help for sleeping difficulties, visiting a healthcare facility for care at least once in the past year, and having a household income ≥ $55,000 (compared to < $55,000) (Table 2).

In the fully adjusted logistic model with the interaction term, habitual sleep duration × age, no significant interactions were noted between habitual sleep duration and age on the odds of hypertension control. A separate fully adjusted model with the interaction term habitual sleep duration × gender also yielded no significant interactions.

In sensitivity analyses, the multivariable logistic regression model results from the complete imputed data (*n = 5,163*) were compared to those from the observed data, *n = 4,384*) to note any differences. The findings on odds for hypertension control in those with a habitual sleep duration of < 6 hours when using complete imputed data (OR = 0.66, 95% CI: 0.46–0.95) were comparable to the observed data results (OR = 0.65, 95% CI: 0.44–0.98). In both models, no significant differences were noted in hypertension control between the reference group (7–9 hours) and the 6-<7 hours or > 9 hours group (Appendix Table 2).

Discussion

In this nationally representative study of US adults with hypertension, we find a negative association between short sleep duration and hypertension control. This finding builds upon evidence from previous studies showing short sleep duration to be a significant risk factor for hypertension[8–13]. Importantly, the

association was robust, with no age or gender differences in magnitude or significance in the relationship between sleep duration and hypertension control.

Our findings of an association between short sleep duration and hypertension control at < 6 hours of sleep but not 6-<7 hours support prior findings that noted a stronger association between short sleep and hypertension at lower hours of sleep. In a cross-sectional study that used 7–8 hours/night as the normal sleep duration, self-reported sleep duration of 5–6 hours was associated with 22% increased risk for hypertension, and the risk substantially increased by twofold in those with a sleep duration of <5 hours/night[46]. These findings are consistent with another study, which reported a 86%, 56%, and 27% increase in the risk of hypertension in adults whose sleep duration was ≤4, 5, and 6 hours, respectively, compared to 7 hours of sleep[9]. A dose-response relationship has been demonstrated in a meta-analysis of longitudinal studies, which reported a 0.32% reduction in risk for hypertension with each hour increase in sleep duration. The meta-analysis findings also showed that a sleep duration of ≤5 hours was associated with a higher risk for hypertension than a sleep duration of 6 hours ($p < 0.05$) compared to 7 hours of sleep[8]. These findings, taken together, point to a higher risk of poor BP outcomes in adults habitually sleeping for less than 6 hours a day.

There are several ways through which inadequate sleep may negatively impact BP and hypertension control. Sleeping for less than the recommended hours can cause alterations in physiological functions, leading to many adverse effects, including an increase in BP. Examples of these alterations include increased sympathetic nervous system (SNS) activity, reduced insulin sensitivity, endothelial dysfunction, and hormonal alterations that increase the risk for obesity[47–51]. For instance, experimental studies in adults with normal BP and those with hypertension have shown that restricting sleep to less than 5 hours/day leads to a significant increase in SNS activity and elevation in BP[15–18]. Insufficient sleep is thought to lead to a sustained elevation in SNS activity throughout the time one remains awake during the night and throughout the next day following sleep loss[49]. Inadequate sleep can also interfere with specific neurocognitive functions and impair attention to health-related cues such as being physically active and eating healthy food[52]. All these factors can contribute to difficulty achieving hypertension control among individuals with hypertension.

The 2017 ACC/AHA guidelines outline pharmacological and non-pharmacological interventions for hypertension management to improve overall health status and reduce cardiovascular disease risk[2]. The main non-pharmacological interventions recommended are based on findings from clinical trials. These interventions include weight control, physical activity, a healthy diet, increased dietary potassium, reduced dietary sodium, and reduced alcohol intake for those who consume alcohol[2]. These interventions are focused on well-known modifiable risk factors for hypertension such as obesity, unhealthy diet, and excessive alcohol intake[2,6,7], Based on the findings from our study and others[8–13,15,16,18], habitual sleep duration may play a crucial role in the prevention, management, and control of hypertension. Consequently, it should be one of the recommended basic lifestyle interventions for BP control in future iterations of the hypertension guidelines.

There are a few limitations related to this study. We cannot infer a causal link between habitual sleep duration and hypertension control because of the cross-sectional nature of the NHANES data. There may be response bias because data for several variables, including habitual sleep duration, other sleep characteristics, some chronic health conditions, and health behaviors, were self-reported. Although the measurement of BP was done by specially trained health professionals that followed a standardized protocol, the BP readings used to calculate the average BP were all obtained in a single visit to the mobile examination center. Using BP readings obtained only in a single visit can lead to misclassification of hypertension status or hypertension control status because of the difficulty of identifying whitecoat and masked hypertension cases in a single office visit[53].

Despite the limitations noted, the information generated on the relationship between sleep duration and hypertension control provides important insight on the potential role of habitual sleep duration in supporting hypertension management. Future longitudinal studies are recommended to examine how habitual sleep predicts BP changes and hypertension control in adults with hypertension. These findings also have implications in clinical practice. Working with patients who have hypertension to help them get enough sleep, as part of the other recommended lifestyle interventions, can positively impact their BP management.

Declarations

Availability of data and materials

The datasets analyzed during the current study are available in the Centers for Disease Control and Prevention (CDC) NHANES repository, https://wwwn.cdc.gov/nchs/nhanes/.

Authors' contributions

E.G.O. designed the study, downloaded, and analyzed the data, and drafted the manuscript. S.L.C., J.F.B., C.D., J.T.B., and J.E.G. provided expert guidance during the designing of the study and the analysis of data and critically reviewed and edited the manuscript. All authors read and approved the final manuscript.

Funding

This project was partially supported by Gordon and Betty Moore Foundation grant number 4294.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1
Characteristics of NHANES sample of US adults with hypertension, by habitual sleep duration

		Habitual sleep duration			
Characteristic	**Overall** N **(%)**	**< 6**	**6 - <7**	**7–9**	**> 9**
	5163	n **= 516**	n **= 808**	n **= 3214**	n **= 625**
Male sex, %	2662 (52.2)	56.6	61.6	51.5	39.4
Age, mean (SE)	5163 (55.4)	53.3 (0.8)	52.8 (0.7)	55.7 (0.5)	59.1 (0.9)
Race/Ethnicity, %					
Non-Hispanic White	1719 (64.3)	53.6	57.7	67.2	64.2
Non-Hispanic Black	1334 (13.0)	22.8	17.4	10.5	14.3
Hispanic	1268 (13.0)	13.6	14.6	12.4	13.5
Other race/ethnicity	842 (9.7)	10.0	10.3	9.8	8.0
US-born, %	3580 (83.0)	83.2	79.8	83.3	85.2
Education Level, %					
College graduate	1146 (27.6)	16.8	27.9	30.3	18.9
Some college	1587 (33.2)	36.4	36.2	33.5	23.5
High school graduate	1237 (25.9)	32.4	22.6	24.5	34.5
Less than high school	1187 (13.4)	14.5	13.3	11.7	23.2
Annual household income < $55,000, %	2966 (48.5)	61.5	40.2	46.1	65.4
Employment Status, %					
Fulltime 35–44 hours/week	1144 (24.7)	18.1	27.7	26.9	11.4
Fulltime ≥ 45 hours/week	794 (19.4)	29.7	29.6	18.1	4.4
Parttime < 35 hours/week	630 (12.3)	9.6	10.7	13.4	9.5

		Habitual sleep duration			
Not working	2595 (43.6)	42.6	32.0	41.6	74.7
Has health insurance, %	4496 (89.5)	81.6	87.9	90.9	88.9
Healthcare visits in past year, %					
0	703 (12.7)	14.1	16.2	12.4	8.7
1–2	2320 (45.5)	47.0	47.4	46.2	37.0
> 2	2130 (41.8)	38.9	36.5	41.4	54.4
Symptoms of sleep apnea, %	2773 (54.3)	61.9	59.5	52.2	54.3
Ever sought help for sleeping difficulty, %	1603 (36.2)	49.9	33.2	34.7	38.4
Depressive symptoms, %					
Minimal or none	3600 (75.4)	61.5	79.5	78.4	61.9
Mild	790 (16.1)	23.4	12.4	15.0	22.8
Moderate to severe	416 (8.5)	15.2	8.1	6.6	15.3
BMI, mean (SE)	31.2 (0.2)	31.6 (0.4)	31.9 (0.3)	31.1 (0.2)	30.6 (0.4)
Cardiovascular disease, %	606 (10.5)	11.8	8.6	10.0	15.3
Diabetes mellitus, %	1303 (20.3)	17.9	22.1	19.1	27.7
Moderate chronic kidney disease, %	524 (9.1)	7.5	7.5	8.6	16.1
Cigarette smoking, %					
Never smoker	2853 (53.5)	44.9	55.1	54.8	50.2
Current smoker	928 (17.3)	28.6	19.1	14.6	22.4
Former smoker	1382 (29.2)	26.5	25.8	30.7	27.4
Alcohol intake, %					
None	1758 (28.5)	34.5	26.2	26.9	37.0

		Habitual sleep duration			
Moderate	1688 (38.8)	27.5	40.1	40.4	35.9
Heavy	1384 (32.7)	37.9	33.7	32.7	27.2
Physical activity level (MET minutes/week), %					
None	1542 (25.1)	27.0	25.0	23.1	36.6
Low (< 600)	737 (13.7)	11.8	9.0	15.2	12.5
Sufficient (600 to 1200)	592 (11.9)	10.4	10.3	12.5	11.5
High (> 1200)	2292 (49.3)	50.8	55.7	49.2	39.5
Hypertension control, %					
Controlled	954 (19.7)	13.7	22.8	19.5	21.4

** Note: Data are expressed as an unweighted number of participants and weighted percentages and means.*

† *Abbreviations: SE, standard error; BMI, body mass index; MET, metabolic equivalent of task*

Table 2
Weighted odds ratios for hypertension control in NHANES sample of US adults with hypertension

	Unadjusted model		Adjusted model *	
	Crude OR (95% CI)	P	AOR (95% CI)	P
Sleep duration				
7–9	1 (Ref)		1 (Ref)	
< 6	0.65 (0.44–0.98)	0.041	0.66 (0.46–0.95)	0.027
6 - <7	1.22 (0.81–1.82)	0.329	1.41 (0.93–2.13)	0.099
> 9	1.12 (0.81–1.55)	0.479	0.99 (0.69–1.42)	0.941
Age				
18–39	1 (Ref)		1 (Ref)	
40–59	4.05 (2.43–6.75)	< 0.001	2.97 (1.81–4.87)	< 0.001
60–79	7.63 (4.73–12.3)	< 0.001	4.29 (2.67–6.85)	< 0.001
80 and older	3.03 (1.69–5.46)	0.001	1.46 (0.80–2.66)	0.207
Female (vs male)	1.38 (1.12–1.71)	0.004	1.14 (0.88–1.47)	0.308
Race/Ethnicity				
Non-Hispanic White	1 (Ref)		1 (Ref)	
Non-Hispanic Black	0.78 (0.61–0.99)	0.038	0.94 (0.75–1.19)	0.604
Hispanic	0.60 (0.43–0.84)	0.004	1.15 (0.77–1.73)	0.472
Other race/ethnicity	1.04 (0.77–1.40)	0.793	1.42 (0.97–2.08)	0.069
Not US-born (vs. US-born)	0.63 (0.50–0.80)	< 0.001	0.74 (0.47–1.16)	0.183
Education Level, % (SE)				
College graduate	1 (Ref)		1 (Ref)	

Some college	1.09 (0.79–1.49)	0.589	1.15 (0.82–1.62)	0.604
High school graduate	1.01 (0.75–1.35)	0.968	1.07 (0.78–1.45)	0.667
Less than high school	0.72 (0.50–1.02)	0.065	0.83 (0.54–1.27)	0.378
Annual household income				
< $55,000	1 (Ref)		1 (Ref)	
≥ $55,000	1.24 (0.93–1.64)	0.133	1.42 (1.02–1.97)	0.037
Employment Status, % (SE)				
Fulltime 35–44 hours/week	1 (Ref)		1 (Ref)	
Fulltime ≥ 45 hours/week	0.94 (0.63–1.41)	0.749	1.01 (0.65–1.54)	0.982
Parttime < 35 hours/week	1.06 (0.66–1.71)	0.809	0.93 (0.59–1.49)	0.765
Not working	1.79 (1.23–2.62)	0.004	1.17 (0.82–1.67)	0.364
No health insurance (vs has health insurance)	0.34 (0.24–0.50)	< 0.001	0.72 (0.46–1.03)	0.148
Healthcare visits in the past year				
0	1 (Ref)		1 (Ref)	
1–2	13.85 (6.68–28.70)	< 0.001	8.87 (4.14–19.0)	< 0.001
> 2	22.04 (10.53–46.14)	< 0.001	10.77 (4.89–23.70)	< 0.001
Ever sought help for sleeping difficulty (vs no)	1.73 (1.43–2.09)	< 0.001	1.26 (1.02–1.54)	0.032
Sleep apnea symptoms (vs none)	0.99 (0.83–1.19)	0.934	0.94 (0.78–1.13)	0.492
Cardiovascular (vs no cardiovascular disease)	2.51 (1.82–3.45)	< 0.001	1.69 (1.22–2.34)	0.002
Diabetes (vs no diabetes)	2.19 (1.60–2.99)	< 0.001	1.48 (1.07–2.04)	0.020
Moderate chronic kidney disease (vs no moderate chronic kidney disease)	2.40 (1.58–3.66)	< 0.001	1.83 (1.16–2.89)	0.011
Depressive symptoms				

Minimal or none	1 (Ref)		1 (Ref)	
Mild	1.24 (0.87–1.76)	0.227	1.11 (0.78–1.56)	0.558
Moderate to severe	1.47 (0.95–2.28)	0.080	1.19 (0.72–1.96)	0.488
BMI (kg/m^2)	1.02 (1.01–1.03)	0.005	1.02 (1.003–1.03)	0.020
Alcohol intake				
None	1 (Ref)		1 (Ref)	
Moderate	1.05 (0.78–1.40)	0.753	1.17 (0.86–1.59)	0.300
Heavy	0.68 (0.48–0.98)	0.037	0.87 (0.59–1.27)	0.448
Cigarette smoking				
Never smoker	1 (Ref)		1 (Ref)	
Current smoker	1.18 (0.85–1.63)	0.318	1.61 (1.16–2.24)	0.007
Former smoker	1.38 (1.03–1.84)	0.032	1.16 (0.85–1.58)	0.331
Physical activity level (MET minutes/week)				
None	1 (Ref)		1 (Ref)	
Low (< 600)	1.20 (0.87–1.65)	0.266	1.31 (0.95–1.81)	0.095
Sufficient (600 to 1200)	0.82 (0.51–1.30)	0.373	0.84 (0.55–1.28)	0.398
High (> 1200)	0.70 (0.49–1.00)	0.047	0.88 (0.63–1.23)	0.435

** Adjusted for all covariates in the table*

†Abbreviations: NHANES, National Health and Nutrition Examination Survey; SE, standard error; AOR, adjusted odds ratio; BMI, body mass index; MET, metabolic equivalent of task

Figures

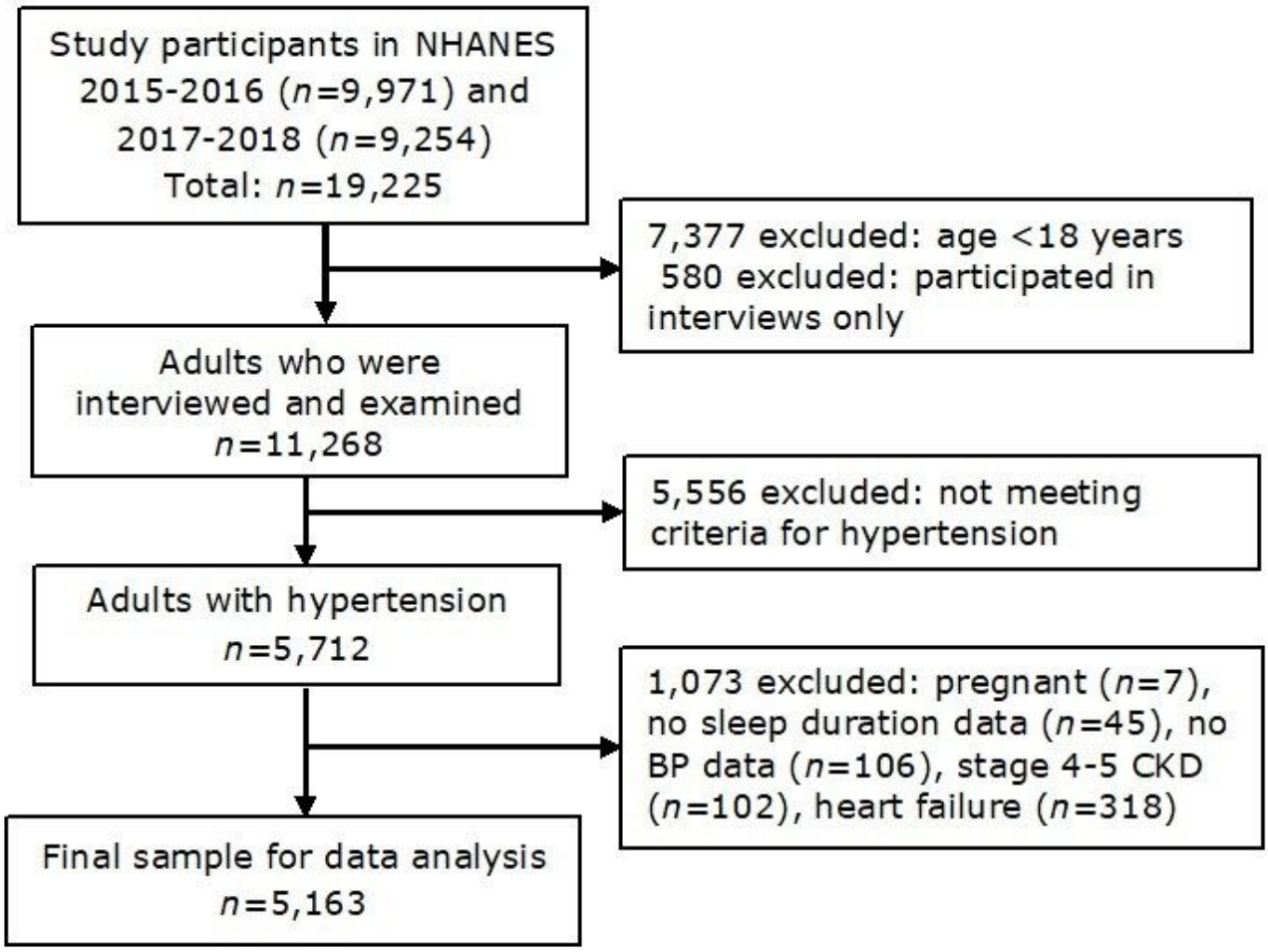

Figure 1

Flowchart for the inclusion and exclusion criteria for the study sample *Abbreviations: NHANES, National Health and Nutrition Examination Survey; CKD, chronic kidney disease.

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