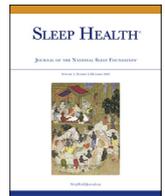


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## Age- and body weight-dependent association between sleep duration and hypertension in US adults: findings from the 2014–2017 National Health Interview Survey

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### ABSTRACT

**Objectives:** Previous studies have confirmed the relationship between sleep duration and hypertension. However, there are unanswered questions on how this relationship is affected by age and body mass index (BMI). This study examined the association between sleep duration and hypertension in US adults and evaluated interaction by age and BMI.

**Design:** Nationwide, population-based, cross-sectional survey.

**Setting:** National Health Interview Survey (NHIS), 2014 to 2017.

**Participants:** Adult participants aged 18 years or older (n = 130,139).

**Measurements:** Sleep duration, hypertension, age, and BMI status were assessed based on self-reported survey responses. Odds ratios (ORs) and 95% confidence intervals (CIs) for sleep duration-hypertension associations were estimated by logistic regression, adjusting for potential confounders.

**Results:** The proportion of participants who reported sleeping less than 7 hours (short sleepers) and more than 9 hours (long sleepers) per night was 32% and 4%, respectively. In adjusted analysis, short sleepers had higher odds of hypertension (OR: 1.54, 95% CI: 1.10–2.17). Although not statistically significant, long sleepers also had higher odds of hypertension (OR: 1.28, 95% CI: 0.80–2.05). In stratified analyses by age and BMI, the association between short sleep and hypertension was especially notable in adults aged 18–44 years (OR: 1.25, 95% CI: 1.16–1.35) and adults with normal weight (OR: 1.21, 95% CI: 1.11–1.33).

**Conclusions:** Short sleep is associated with increased odds of hypertension among American adults and this relationship is dependent on age and BMI.

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### Introduction

The American College of Cardiology/American Heart Association (ACC/AHA) defines hypertension in adults as elevated resting systolic blood pressure (SBP) greater than 130 mmHg and/or diastolic blood pressure (DBP) greater than 80 mmHg.<sup>1</sup> The current ACC/AHA guidelines on defining hypertension is a shift from the Joint National Committee (JNC 7) guidelines released in 2003 which defined

hypertension as SBP >140 and/or DBP >90 mmHg.<sup>2</sup> As a result of this new classification, the prevalence of hypertension in the US is expected to increase from 32 to 46%.<sup>1</sup> Although the etiology of hypertension is unclear, associated risk factors include age, gender, race, physical inactivity, obesity, sodium intake, alcohol, and genetic predisposition.<sup>1,3</sup> Hypertension has extensive health implications as it is a major risk factor for cardiovascular diseases and mortality, and it also places a substantial financial burden on patients and the nation.<sup>4</sup> Between 2005 and 2015, deaths attributed to hypertension in the US increased by 37.5% and by 2020, hypertension will be the most common risk factor for mortality and disability.<sup>5–7</sup> As a chronic medical condition, hypertension contributes significantly to incurred healthcare expenditures in the US, with total healthcare cost of cardiovascular diseases projected to reach 1.1 trillion dollars in 2035.<sup>5,6</sup>

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Despite increasing awareness of the importance of sleep, global sleep patterns show that adults in developed countries experience insufficient sleep.<sup>8</sup> Between 1985 and 2012, the proportion of American adults who reported sleeping  $\leq 6$  hours a day increased by about 7% (from 22.3% to 29.2%).<sup>9</sup> Findings from previous studies show that sleep deprivation is related to coronary heart disease, obesity, depression, and mortality.<sup>10,11,12,13</sup> In furtherance of its mission to improve the health and well-being of Americans, the National Sleep Foundation (NSF) recommends 7 to 9 hours of sleep per night for adults.<sup>14</sup> Also, according to the published guidelines, sleep durations of 6 hours and 10 to 11 hours may be appropriate for adults aged 18–64 years, while sleep durations of 5 to 6 hours and 9 hours may be appropriate for older adults ( $\geq 65$  years).<sup>14</sup>

Few studies have reported an association between sleep duration and hypertension.<sup>10,15,16</sup> Epidemiological evidence identified short sleep duration as a potential risk factor for hypertension in a longitudinal analysis of the first National Health and Nutrition Examination Survey (NHANES) by Gangswich et al.<sup>16</sup> In another study conducted using aggregated Behavioral Risk Factor Surveillance System (BRFSS) and National Health Interview Survey (NHIS) data, short and long sleep were associated with an increased risk of hypertension.<sup>10</sup> Considering that hypertension occurs more in the elderly and obese population, coupled with lack of sleep being an established risk factor for obesity, the association between sleep duration and hypertension may be modified by age and body mass index (BMI).<sup>17,18</sup> Gangswich et al. reported no association in older adults while data on this relationship among American adults across different BMI levels is limited.<sup>12</sup>

To this end, it is critical to identify individuals at highest risk for hypertension and understand the synergistic impact of sleep, age, and BMI on hypertension. In this analysis using data obtained from the NHIS, we evaluated the association between self-reported sleep duration and prevalence of hypertension among US adults and explored if age and BMI modify this association.

### Participants and methods

#### Data source

The NHIS, conducted since 1957 by the National Center for Health Statistics/Centers for Disease Control and Prevention (CDC) is a cross-sectional household health survey that is administered annually to about 87,500 individuals.<sup>19</sup> The survey collects information on a wide range of topics including demographics, health status, health-care access, and utilization. For this study, NHIS datasets from 2014 to 2017 were combined.

#### Study measures

Sleep duration was assessed with the question, “On average, how many hours of sleep do you get in a 24-hour period?” Respondents reported in 1-hour increment, and the variables ranged from 1 to 23 hours. Duration of sleep was categorized as  $< 7$  hours, 7–9 hours, and  $> 9$  hours. In comparison to those who slept the recommended 7–9 hours, participants were classified as short sleepers ( $< 7$  hours) or long sleepers ( $> 9$  hours). Hypertension was determined with the survey item, “Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?” Responses were recoded as “Yes” or “No.” Variables measured included age (18–44, 45–64, and  $\geq 65$  years), gender (male or female), race (Non-Hispanic Whites, Black/African-American, Hispanic/Latino, American Indian/Alaskan Native [AIAN]/Asian or other), employment status (employed or unemployed), smoking status (current, former, or never), and alcohol use (never, former, moderate, or heavy). BMI ( $\text{kg}/\text{m}^2$ ) was categorized based on the World Health Organization criteria as underweight ( $< 18.5$ ), normal (18.5–24.9), overweight (25–29.9), and obese ( $\geq 30$ ).<sup>20</sup> Insomnia is commonly

defined as sleep difficulty occurring at least three times per week.<sup>21</sup> Symptoms of insomnia were assessed with two survey items “# times having trouble falling asleep, past week” and “# times having trouble staying asleep, past week.” Participants were classified into three groups based on their responses: 0 as “none”, “1–2” and “3 or more” insomnia symptoms per week.

### Statistical analyses

Descriptive analysis was conducted on all study variables for the total sample and categorized by hypertension status. NHIS data were weighted using sample weights to produce nationally representative estimates and the Rao-Scott chi-square test was used to determine statistically significant differences ( $P < .05$ ) between groups. A logistic regression analysis (unadjusted and adjusted) was used to examine the association between sleep duration and hypertension. In the adjusted model, potential confounding variables controlled for included age, gender, race, BMI, employment, smoking, alcohol use, and insomnia symptoms. Crude and adjusted odds ratio (AOR) along with 95% confidence intervals (CI) were calculated from the regression model. To explore possible effect modification, interaction terms for *sleep  $\times$  age* and *sleep  $\times$  BMI* were tested. Separate analyses to assess the association between sleep duration and hypertension were conducted for different age and BMI categories. A  $P$  value  $< .05$  indicated statistical significance and all statistical analyses were performed in SAS 9.4 (SAS Inc., Cary, NC, USA).

Due to the additional sleep times suggested by the NSF as “appropriate” for some individuals, there was a need to assess the stability of the combined results. Therefore, sensitivity analysis was conducted by including additional sleep duration cut-offs ( $< 5$ , 5–6, 10–11, and  $> 11$  hours) and examining the impact of these sleep categories on the prevalence of hypertension.

### Results

**Table 1** summarizes characteristics of the total sample ( $n = 130,139$  adults) and by hypertension status. About 32% of the sample reported sleep of  $< 7$  hours, with 64% and 4% reporting sleep of 7–9 hours and  $> 9$  hours, respectively. Most participants were aged 18–44 years (46%), females (52%), Whites (65%), resided in the South (37%), employed (62%), non-smokers (63%), and moderate alcohol drinkers (61%). Half of the total sample (50%) reported having no insomnia symptoms in the past week. Hypertension showed significant association with all sociodemographic and other covariates in univariate analyses ( $P < .0001$ ).

#### Sleep duration and hypertension

Results of the logistic regression analysis evaluating the relationship between sleep duration and hypertension are shown in **Table 2**. Compared to adults with the recommended sleep duration of 7–9 hours, short and long sleepers had higher odds of hypertension (OR: 1.25, 95% CI: 1.21–1.29; OR: 1.99, 95% CI: 1.83–2.15, respectively). After adjusting for confounders, short sleepers had higher odds of hypertension (OR: 1.54, 95% CI: 1.10–2.17). No significant association was found between long sleep and hypertension (OR: 1.28, 95% CI: 0.80–2.05).

#### Stratification by age

The strength of the association between sleep duration and hypertension depended on age with a significant *sleep  $\times$  age* interaction ( $P < .0001$ ). Thus, we explored this association stratified by age as shown in **Table 3**. Among short sleepers, adults aged 18–44 years had higher adjusted odds of hypertension (OR: 1.25, 95% CI:

**Table 1**  
 Characteristics of participants from the National Health Interview Survey (NHIS), stratified by hypertension status, 2014–2017

	Category	Total sample (n = 130,139)	Stratified by hypertension		P
			Yes	No	
Sleep Duration (hours)	<7	32%	11%	21%	<.0001
	7–9	64%	19%	46%	
	>9	4%	2%	2%	
Age (years)	18–44	46%	6%	41%	<.0001
	45–64	34%	13%	21%	
	≥65	19%	12%	7%	
Gender	Female	52%	16%	36%	<.0001
	Male	48%	16%	33%	
Race/Ethnicity	Non-Hispanic White	65%	21%	44%	<.0001
	Black/African-American	12%	5%	7%	
	Hispanic/Latino	16%	4%	12%	
	AIAN/Asian	6%	2%	5%	
	Other	2%	0%	1%	
Employment	Employed	62%	14%	48%	<.0001
	Not Employed	38%	17%	21%	
Smoking	Never	63%	17%	46%	<.0001
	Former	22%	10%	13%	
	Current	15%	5%	11%	
Alcohol	Never	20%	6%	14%	<.0001
	Former	14%	6%	7%	
	Moderate	61%	17%	44%	
BMI (kg/m <sup>2</sup> )	Underweight	2%	0%	2%	<.0001
	Normal	33%	6%	27%	
	Overweight	33%	10%	23%	
Insomnia symptoms (per week)	Obese	33%	14%	18%	<.0001
	None	50%	13%	37%	
	1–2	18%	5%	12%	
	≥3	32%	12%	20%	

Percentages may not add up to 100% due to rounding. Abbreviations: AIAN, American Indian/Alaskan Native; BMI, body mass index.

1.16–1.35) than older adults aged ≥65 years (OR: 1.09, 95% CI: 1.01–1.17). In middle-aged adults aged 45–64 years, this association was not statistically significant. Among long sleepers, older adults aged ≥65 years had higher adjusted odds of hypertension (OR: 1.45, 95% CI: 1.28–1.65) than middle-aged adults aged 45–64 years (OR: 1.24, 95% CI: 1.05–1.46). In adults aged 18–44 years, this association was not statistically significant.

**Stratification by BMI**

The strength of the relationship between sleep duration and hypertension also depended on BMI with a significant *sleep* × *BMI* interaction (*P* = .0031). Thus, we assessed this relationship stratified by BMI as shown in Table 4. Among short sleepers, adults with normal weight had higher adjusted odds of hypertension (OR: 1.21, 95% CI: 1.11–1.33) than obese adults (OR: 1.16, 95% CI: 1.09–1.24). The relationship was not statistically significant in underweight and

**Table 2**  
 Self-reported sleep duration and prevalence of hypertension

Sleep duration (hours) (n = 130,139)	Model 1†		Model 2‡	
	OR (95% CI)	p-value	AOR (95% CI)	P
7–9	1.00 (reference)		1.00 (reference)	
<7	1.25 (1.21–1.29)	<.0001	1.54 (1.10–2.17)	.0121
>9	1.99 (1.83–2.15)	<.0001	1.28 (0.80–2.05)	.3046

†Model 1: crude odds ratio (OR), confidence interval (CI); ‡Model 2: adjusted odds ratio (AOR). CI (confidence interval); adjusted for age, gender, race, BMI, employment status, smoking status, alcohol use, and insomnia symptoms.

**Table 3**  
 Stratified analysis of sleep duration and hypertension

Age categories (years)	AOR (95% CI)	P
18–44 (n = 53,023)		
7–9 h	1.00 (reference)	
<7 h	1.25 (1.16–1.35)	<.0001
>9 h	1.21 (0.94–1.55)	.1371
45–64 (n = 43,858)		
7–9 h	1.00 (reference)	
<7 h	1.06 (1.00–1.13)	.0513
>9 h	1.24 (1.05–1.46)	.0133
≥65 (n = 33,258)		
7–9 h	1.00 (reference)	
<7 h	1.09 (1.01–1.17)	.0273
>9 h	1.45 (1.28–1.65)	<.0001

Abbreviation: h, hours; adjusted odds ratio (AOR), confidence interval (CI); Model adjusted for gender, race, BMI, employment status, smoking status, alcohol use, and insomnia symptoms.

overweight adults. Among long sleepers, overweight adults had higher adjusted odds of hypertension (OR: 1.50, 95% CI: 1.28–1.76) than adults with normal weight (OR: 1.45, 95% CI: 1.21–1.74). The relationship was not statistically significant in underweight and obese adults.

**Sensitivity analysis**

Sensitivity analysis showed that compared to adults who slept for 7–9 hours, adults that slept for <5 hours, 5–6 hours, 10–11 hours and > 11 hours had higher adjusted odds of hypertension (OR: 1.67, 95% CI: 1.34–2.09; OR: 1.30, 95% CI: 1.05–1.59; OR: 1.68, 95% CI: 1.11–2.54; OR: 1.93, 95% CI: 1.26–2.95, respectively).

The strength of the association between sleep duration and hypertension depended only on age with a significant *sleep* × *age* interaction (*P* = .0157). Among adults that slept <5 hours, adults aged 18–44 years had higher adjusted odds of hypertension (OR: 1.63, 95% CI: 1.34–2.00) than middle-aged adults aged 45–64 years (OR: 1.31, 95% CI: 1.13–1.53) and older adults aged ≥65 years (OR: 1.24, 95% CI: 1.01–1.52). Among adults that slept >11 hours, older adults aged ≥65 years had higher adjusted odds of hypertension (OR: 1.74, 95% CI: 1.35–2.23) than middle-aged adults aged 45–64 years (OR: 1.34, 95% CI: 1.03–1.75). In adults aged 18–44 years, this association was not statistically significant.

**Table 4**  
 Stratified analysis of sleep duration and hypertension

BMI categories	AOR (95% CI)	P
Underweight (n = 2261)		
7–9 h	1.00 (reference)	
<7 h	1.37 (0.92–2.04)	.1220
>9 h	1.45 (0.90–2.31)	.1246
Normal (n = 41,899)		
7–9 h	1.00 (reference)	
<7 h	1.21 (1.11–1.33)	<.0001
>9 h	1.45 (1.21–1.74)	<.0001
Overweight (n = 43,225)		
7–9 h	1.00 (reference)	
<7 h	1.04 (0.98–1.12)	.2201
>9 h	1.50 (1.28–1.76)	<.0001
Obese (n = 42,754)		
7–9 h	1.00 (reference)	
<7 h	1.16 (1.09–1.24)	<.0001
>9 h	1.12 (0.97–1.30)	.1288

Abbreviations: h, hours; AOR, adjusted odds ratio, CI, confidence interval; Model adjusted for age, gender, race, employment status, smoking status, alcohol use, and insomnia symptoms.

## Discussion

The two main findings of this cross-sectional study were, first, that sleep duration is associated with a higher prevalence of hypertension among US adults and this relationship was independent of sociodemographic, behavioral risk factors, and sleep quality. Second, there is combined interaction between sleep duration and age, sleep duration, and BMI on hypertension.

This analysis provides epidemiological evidence that adults who slept less than 7 hours a day had increased odds of hypertension compared to adults who slept between 7 and 9 hours daily. This result is consistent with previous studies that reported greater odds of hypertension among adults who reported not getting enough sleep.<sup>16,22</sup> In the current study, long sleep was also associated with a higher likelihood of hypertension, although this result was not statistically significant. Sensitivity analysis found that long sleep was significantly associated with hypertension. Also, a recent cross-sectional study by Grandner et al. using combined data from BRFSS and NHIS (n = 728,717) observed a significant association between long sleep and an increased prevalence of hypertension.<sup>10</sup>

After assessing interaction measures, we found that the prevalence of hypertension is dependent on, not just sleep duration but sleep duration and age. The OR of hypertension for short sleep was higher in younger adults than in the elderly population. Similar results were also found in sensitivity analysis where among those who slept <5 hours, young adults had higher odds of hypertension than middle-aged and elderly participants. These findings are consistent with the observations from other cross-sectional studies.<sup>10,16</sup> Although the relationship between long sleep and hypertension was not statistically significant in the total sample, after stratification by age, long sleepers who were middle-aged and elderly had statistically significant higher odds for hypertension. This finding may be explained by the fact that the total sample comprised of a higher proportion of younger adults (46%) with only 6% reporting a diagnosis of hypertension. Hence, the result observed in the whole sample (Table 2) even after the adjustment of covariates was perhaps a consequence of a dilution effect of age. Among adults who slept >11 hours, middle-aged and elderly adults also had higher OR for hypertension in sensitivity analysis. In fact, the degree of association in the sensitivity analysis was higher than in the overall analysis thus giving credence to the effect modification by age. While the spotlight in public health has been on the effects of sleep deprivation, the finding from this study on the relationship between long sleep and hypertension is clinically relevant. Middle-aged and elderly adults have a higher prevalence of comorbidities like coronary heart disease, stroke, and total cardiovascular diseases, all of which are associated with long sleep.<sup>23,24</sup> Also, long sleep may be a proxy marker of poor physical and mental health.<sup>25</sup>

The higher prevalence of hypertension in younger sleep-deprived adults is well established in the literature<sup>10,16,26</sup> but an interesting finding in this study is that the prevalence of hypertension is dependent on sleep duration and BMI. Among short sleepers, adults with normal weight had higher odds of hypertension than obese adults. Among long sleepers, the odds of hypertension were higher in overweight adults than adults with normal weight. Prior literature has shown that increased BMI (overweight & obese) is strongly associated with hypertension.<sup>27,28</sup> The biologic mechanism underlying the association of sleep and hypertension remains elusive, but some studies have shown that short sleep increases the sympathetic activity of the nervous system and triggers an alteration in the hypothalamic–pituitary–adrenal axis resulting in increased cortisol levels, elevation of blood pressure and heart rate.<sup>29,30,31,32,33</sup> Another suggested mechanism is that inflammation of blood vessel walls triggered by poor sleep leads to endothelial dysfunction, stiffening,

increased resistance, and eventually hypertension.<sup>34</sup> Taken together, these findings illustrate a complex interaction between sleep duration, body function, and health.

The main strength of our study is the use of a large number of participants from a nationally-representative sample surveyed over several years. Another strength of this study is the use of new guidelines from the National Sleep Foundation to classify participants as short or long sleepers. This study also has a few limitations. First, due to the cross-sectional nature of the data, causality, and temporality of the association between sleep duration and hypertension cannot be ascertained. Second, since responses from participants were self-reported, the validity of the study measures are questionable, particularly sleep duration and hypertension diagnosis. Previous research has shown that sleep patterns may change because of school or work demands, retirement and also due to social reasons.<sup>35,36,37</sup> Additionally, millions of US adults have undiagnosed hypertension.<sup>38</sup> Thus, it is possible that some participants were unaware of their condition, leading to an underestimated prevalence of hypertension. Overall, these subjective measurements of sleep duration and hypertension could lead to some misclassification in our study. Finally, factors that may affect the relationship between sleep duration and hypertension such as sleep quality, sleep disorders (sleep apnea, excessive sleepiness), and family history of hypertension were not available in the NHIS.

## Conclusions

Our findings suggest that short sleep is associated with a higher prevalence of hypertension among US adults. In stratified analysis by age and BMI categories, the association of short sleep and hypertension was strongest in adults aged 18 to 44 years and adults with normal weight. Adults who are sleep deprived, have a healthy weight and also have a diagnosis of hypertension represent a vulnerable population that requires prompt clinical management to prevent future complications. Additional research is needed to understand the biologic mechanism underlying the impact of sleep duration on hypertension.

## Conflicts of interest

None declared.

## References

- Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2018;71(19):127–248.
- Chobanian AV, Bakris GL, Black HR, et al. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. *JAMA*. 2003;289(19):2560–2571.
- Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factors clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*. 2012;380(9859):2224–2260.
- Irvin MR, Booth III JN, Shimbo D, et al. Apparent treatment-resistant hypertension and risk for stroke, coronary heart disease and all-cause mortality. *J Am Soc Hypertens*. 2014;8(6):405–413.
- Benjamin EJ, Virani SS, Callaway CW, et al. Heart disease and stroke statistics – 2018 update: a report from the American Heart Association. *Circulation*. 2018;137(12):e67–e492.
- Dunbar SB, Khavjou OA, Bakas T, et al. Projected costs of informal care giving for cardiovascular disease, 2015 to 2035: a policy statement from the American Heart Association. *Circulation*. 2018;137(19):e558–e577.
- Reid CM, Thrift AG. Hypertension 2020: confronting tomorrow's problem today. *Clin Exp Pharmacol Physiol*. 2005;32(5–6):374–376.
- Youngstedt SD, Goff EE, Reynolds AM, et al. Has adult sleep duration declined over the last 50+ years? *Sleep Med Rev*. 2016;28:69–85.
- Ford ES, Cunningham TJ, Croft JB. Trends in self-reported sleep duration among US adults from 1985 to 2012. *Sleep*. 2015;38(5):829–832.

10. Grandner M, Mullington JM, Hashmi SD, Redeker NS, Watson NF, Morgenthaler TL. Sleep duration and hypertension: analysis of > 700,000 adults by age and sex. *J Clin Sleep Med*. 2018;14(06):1031–1039.
11. Newman AB, Enright PL, Manolio TA, Haponik EF, Wahl PW. Cardiovascular health study research group. Sleep disturbance, psychosocial correlates, and cardiovascular disease in 5201 older adults: The cardiovascular health study. *J Am Geriatr Soc*. 1997;45(1):1–7.
12. Gangwisch JE, Malaspina D, Boden-Albala B, Heymsfield SB. Inadequate sleep as a risk factor for obesity: Analyses of the NHANES I. *Sleep*. 2005;28(10):1289–1296.
13. hall MH, Smagula SF, Boudreau RM, et al. Association between sleep duration and mortality is mediated by markers of inflammation and health in older adults: The health, aging and body composition study. *Sleep*. 2015;38(2):189–195.
14. Hirshkowitz M, Whitton K, Albert SM, et al. National Sleep Foundation's sleep time duration recommendations: Methodology and results summary. *Sleep Health*. 2015;1(1):40–43.
15. Tochikubo O, Ikeda a Miyajima E, Ishii M. Effects of insufficient sleep on blood pressure monitored by a new multibiomedical recorder. *Hypertension*. 1996;27(6):1318–1324.
16. Gangwisch JE, Heymsfield SB, Boden-Albala B, et al. Short sleep duration as a risk factor for hypertension: Analyses of the first National Health and nutrition examination survey. *Hypertension*. 2006;47(5):833–839.
17. Brown CD, Higgins M, Donato KA, et al. Body mass index and the prevalence of hypertension and dyslipidemia. *Obesity*. 2000;8(9):605–619.
18. Van Itallie TB. Health implications of overweight and obesity in the United States. *Ann Intern Med*. 1985;103(6\_Part\_2):983–988.
19. Backinger CL, Lawrence D, swan J, et al. Using the National Health Interview Survey to understand and address the impact of tobacco in the United States: Past perspectives and future considerations. *Epidemiol Perspect Innov*. 2008;5(1):8.
20. expert P. Executive summary of the clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. *Arch Intern Med*. 1998;158:1855–1867.
21. Roth T. Insomnia: Definition, prevalence, etiology, and consequences. *J Clin sleep med*. 2007;3(5 Suppl):S7–S10.
22. Stranges S, Dorn JM, Cappuccio FP, et al. A population-based study of reduced sleep duration and hypertension: The strongest association may be in premenopausal women. *J Hypertens*. 2010;28(5):896–902.
23. Schellevis FG, van der Velden J, van de Lisdonk E, et al. Comorbidity of chronic diseases in general practice. *J Clin Epidemiol*. 1993;46(5):469–473.
24. Cappuccio FP, Cooper D, D'Elia L, et al. Sleep duration predicts cardiovascular outcomes: A systematic review and meta-analysis of prospective studies. *Eur. Heart J*. 2011;32(12):1484–1492.
25. Stamatakis KA, Punjabi NM. Long sleep duration: A risk to health or a marker of risk? *Sleep Med. Rev*. 2007;11(5):337.
26. fang J, Wheaton AG, Keenan NL, Greenlund KJ, Perry GS, Croft JB. Association of sleep duration and hypertension among US adults varies by age and sex. *Am J Hypertens*. 2012;25(3):335–341.
27. Papathanasiou G, Zerva E, Zacharis I, et al. Association of high blood pressure with body mass index, smoking and physical activity in healthy young adults. *Open Cardiovasc Med J*. 2015;9:5.
28. Hu G, Barengo NC, Tuomilehto J, Lakka TA, Nissinen a Jousilahti P. Relationship of physical activity and body mass index to the risk of hypertension: A prospective study in Finland. *Hypertension*. 2004;43(1):25–30.
29. Tochikubo O, Ikeda a Miyajima E, Ishii M. Effects of insufficient sleep on blood pressure monitored by a new multibiomedical recorder. *Hypertension*. 1996;27(6):1318–1324.
30. Lusardi P, Mugellini a, Preti P, Zoppi a, Derosa G, Fogari R. Effects of a restricted sleep regimen on ambulatory blood pressure monitoring in normotensive subjects. *Am J Hypertens*. 1996;9(5):503–505.
31. Gottlieb DJ, redline S, Nieto FJ, et al. Association of usual sleep duration with hypertension: The sleep heart health study. *Sleep*. 2006;29(8):009–1014.
32. Leproult R, Copinschi G, Buxton O, et al. Sleep loss results in an elevation of cortisol levels the next evening. *Sleep*. 1997;20(10):865–870.
33. Spiegel K, Leproult R, Van Cauter E. Impact of sleep debt on metabolic and endocrine function. *Lancet*. 1999;354(9188):1435–1439.
34. Miller MA, Cappuccio FP. Inflammation, sleep, obesity and cardiovascular disease. *Curr Vasc Pharmacol*. 2007;5(2):93–102.
35. Buboltz Jr W, Jenkins SM, Soper B, Woller K, Johnson P, Faes T. Sleep habits and patterns of college students: An expanded study. *J Coll Couns*. 2009;12(2):113–124.
36. Hagen EW, Barnet JH, Hale L, Peppard PE. Changes in sleep duration and sleep timing associated with retirement transitions. *Sleep*. 2016;39(3):665–673.
37. Asaoka S, Komada Y, Fukuda K, Sugiura T, Inoue Y, Yamazaki K. Exploring the daily activities associated with delayed bedtime of Japanese university students. *Tohoku J Exp Med*. 2010;221(3):245–249.
38. Wilper AP, Woolhandler S, Lasser KE, McCormick D, Bor DH, Himmelstein DU. Hypertension, diabetes, and elevated cholesterol among insured and uninsured US adults. *Health Affairs*. 2009;28(6):w1151–w1159.