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Sleep Deficit as a Risk Factor for Hypertension in Korean Adults

Mi-Joon Lee [1], Bum-Jeun Seo [1,*] and Inmyung Song [2]

[1] Department of Medical Information, Kongju National University, 56 Gongjudaehak-ro, Gongju-si 32588, Republic of Korea
[2] Department of Health Administration, Kongju National University, 56 Gongjudaehak-ro, Gongju-si 32588, Republic of Korea
* Correspondence: bjseo@kongju.ac.kr

Abstract: This study aims to evaluate the association between sleep duration and hypertension in Korean adults aged 30 and older. This is a population-based cross-sectional study using the 2020 Korean National Health and Nutritional Examination Survey data. Study subjects numbered 3984 after excluding people with missing data for key exposures and outcome variables. Of the study subjects, 18.8% (n = 748) sleep for less than 6 h a day. Increased risk for hypertension was associated with being male, of old age, unemployed, of low educational achievement, and overweight, as well as drinking, smoking, stress, and short sleep duration. The prevalence of sleep deficit was associated with sex, age, education level, income, and health insurance type. Logistic regression analyses were performed to identify whether sleep duration affects the risk of hypertension. In the unadjusted model, the odds ratio (OR) of having hypertension was lower among people sleeping for 7.0–7.9 h (OR = 0.52, 95% confidence interval (95% CI) = 0.42–0.64) than those sleeping for fewer than 6 h per day. After adjusting for sociodemographic factors (sex, age, education level, occupation, and health insurance), the OR for 7.0–7.9 h remained significant (OR = 0.74, 95% CI = 0.59–0.92). This association was not significant when the model was further adjusted for health-related factors (smoking, drinking, physical activity, BMI level, and stress). Measures to promote adequate sleep duration should be included in programs to prevent and manage hypertension.

Keywords: hypertension; sleep duration; adult; health behavior

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1. Introduction

Hypertension, if left untreated, can result in cerebrovascular and heart diseases. With a prevalence of 33% among Korean adults aged 30 years and older [1], hyper-tension is a leading cause of death and medical expenditure in Korea [2]. Therefore, the prevention and management of hypertension is a major public health issue requiring close attention in Korea based on thorough understanding of risk factors. So far, hypertension has been associated with a range of risk factors, such as family history, old age, low socioeconomic status, weight gain, stress, and lifestyle [3–5]. Among lifestyle factors were unhealthy diet, smoking, physical inactivity, and high-risk drinking [6]. Sleep duration is another factor associated with hypertension [7,8].

Quality of sleep helps overcome fatigue and restore physical strength and energy during the day [9]. Having a positive impact on quality of life, sleep is regarded as a marker of health status [10]. However, Koreans, on average, sleep less than inhabitants in other industrialized nations [11]. The proportion of people with sleep duration of less than 6 h per day in Korea was 16.5% according to a study in 2017 [12]. Sleep deficit can increase blood pressure at night by stimulating the sympathetic nervous system [5], and prolonged sleep debt can trigger hypertension by raising the heart rate and retention of body fluid [1]. There were several studies on the association between short sleep duration and hypertension in Korean adults. Some studies identified the factors related to sleep duration of adults in a community, investigated various risk factors for hypertension including sleep duration, and evaluated the difference between men and women in sleep duration [13–16]. In another previous study, hypertension-related factors included depression, diabetes, and stroke [17], but as these diseases may appear as a result of high blood pressure rather than a factor influencing hypertension, it is necessary to include stress in the analysis, which was not included in previous studies. Although previous studies have shown remarkable achievements, they also have a few limitations. For example, they focused on a single region or narrowly defined risk factors for hypertension. Therefore, there is a need to further the understanding of the association between sleep deficit and hypertension to overcome their limitations.

To fill the gap in knowledge of risk factors for hypertension, especially in regard to sleep duration, this study used a nation-wide large sample from the Korean population and confirmed the association between hypertension and sleep duration according to sociodemographic characteristics, health behaviors, and health status. In addition, this study showed the quantitative relationship between sleep duration and hypertension risk through an unadjusted crude model and models adjusted for sociodemographic and health-related factors, such as sex, age, education level, occupation and health insurance, smoking, alcohol consumption, physical activity, BMI level, and stress in Korean adults aged 30 years and older, using nationwide survey data.

2. Materials and Methods

2.1. Data

This study used data from the first year (2020) of the 8th wave of the Korea National Health and Nutrition Examination Survey (KNHANES). KNHANES is administered by the Korea Center for Disease Control and Prevention (KCDC) and approved by the KCDC Institutional Review Board (IRB No. 2018-01-03-C-A). Each participant voluntarily participated and provided a signed written consent before participating in the study. The KNHANES surveyed approximately 10,000 people residing in 4800 households selected from the Korean population in 2020 [18]. The KNHANES comprised of health survey, medical examination, and nutritional survey. The health survey collects information on household characteristics (number of family members, household type, income), health status (morbidity, medical care utilization, education level, economic status, physical activities, mental health), and health behaviors (smoking, drinking). Medical examination data include body measurements, blood pressure, and pulse rate. In the 2020 KNHANES, the health survey and medical examination were completed by 7359 respondents, of whom 5300 were aged 30 years and older. From the age group, 1316 individuals with missing data on variables of interest were excluded and 3984 were used for analysis (Figure 1). There was a sudden outbreak of coronavirus disease 2019 (COVID-19) and people were required to maintain social distancing in the public and private sectors. Despite the pandemic in 2020, KCDC conducted the annual survey by strictly taking precautionary measures to prevent infections. Interviewers and examiners were required to wear a K94 mask, sanitize hands for every examination, check body temperature, and exclude household members who have confirmed or suspected COVID-19. The participation rate in 2020 is 74.0%, which is similar to that of 74.7% in 2019 [19].

2.2. Outcome Measure

Outcome measure is the diagnosis of hypertension, which was defined as the systolic blood pressure of ≥140 mmHg, diastolic blood pressure of ≥90 mmHg, or being on antihypertensive medications [20]. In the KHNANES, participants rested for more than 5 min aboard a mobile examination vehicle where blood pressure was taken.

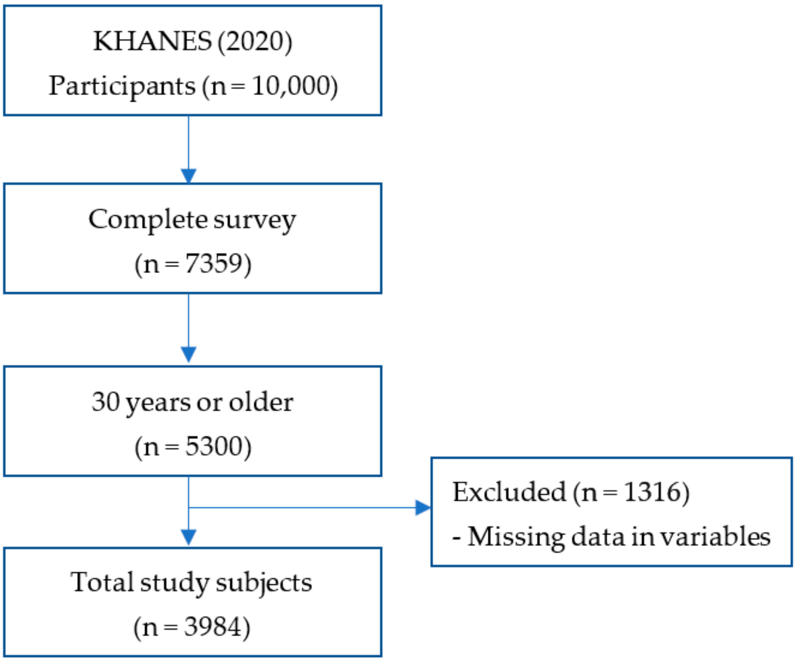

Figure 1. Flow chart for study population selection.

2.3. Sociodemographic Characteristics

This study examined sociodemographic characteristics of participants, such as sex, age, marital status, educational level, personal income level, employment status, and health insurance type. Age was grouped into 30–49, 50–69, and ≥70 years [21,22]. Marital status was categorized into the single and the married. The latter category was inclusive of the divorced, separated, and widowed. Educational level was divided into no or primary education, middle school, high school, and college or higher. Participants were grouped into income level quartiles based on personal income (lowest, lower middle, upper middle, and highest). Employment status was grouped into the employed and the unemployed. The health insurance type was divided into the employment-based, the self-employed (inclusive of the unemployed), and Medicaid, according to the financing mechanism [18,23].

2.4. Health-Related Characteristic

In the KNHANES, participants were asked, "on average, how many hours a day do you sleep?" Based on data collected, sleep duration was classified into <6, 6–6.9, 7–7.9, 8–8.9, and ≥9 h, as in a previous study [24]. Sleep deficit was defined as having sleep duration of <6 h per day and experts recommended 7–7.9 h as the sufficient sleep duration for adults [25].

Health behaviors comprised smoking status, drinking frequency, and physical activity. Smoking status was classified into non-smoker, current smoker, and ex-smoker. Drinking frequency was classified into never, rarely (less than once a month), occasionally (1–4 times a month), and frequently (2–4 times a week). Physical activity in the KNHANES was measured as the number of days the participant walked for at least ten minutes continuously at any given time during the past week. Based on the data, participants were classified into 0, 1–3, 4–6, and 7 days per week.

Health status was measured using obesity and stress level [26]. For obesity, participants were classified into underweight (body mass index in kg/m^2 [BMI] < 18.5), normal weight (18.5 ≤ BMI < 25), and overweight (25 ≤ BMI), according to the criteria set by the Korean Society for the Study of Obesity [27]. Stress level was categorized into 'rarely stressed', 'slightly stressed', 'quite stressed', and 'very stressed'.

2.5. Statistical Analysis

Frequency and percentage were calculated to describe the sociodemographic and health-related characteristics of study subjects. The $\chi 2$ (chi-square) test and multiple linear regression were used to examine if there is a difference in the prevalence of hypertension and sleep duration by each characteristic. Logistic regression analysis was performed to identify factors affecting the diagnosis of hypertension. The dependent variable was the diagnosis of hypertension. Independent variables included sex, age, marital status, educational level, income level, employment status, health insurance type, smoking status, drinking status, physical activity, obesity, and stress level. Model fit was tested by using Hosmer and Lemeshow statistics at the significance level of 0.05 [28]. The Cox and Snell's R^2 and Nagelkerke's R^2 values were computed, which are equivalent to R^2 for ordinary linear squares regression. All statistical analyses were performed by using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). The Institutional Review Board of K National University approved the study protocol and waived the requirement for informed consent (reference No. KNU_IRB_2022-030).

3. Results

3.1. Prevalence of Hypertension by Sociodemographic and Health-Related Charactersitics

Table 1 presents the characteristics of subjects including their sleep duration and hypertension. Of the 3984 participants analyzed, 51.6% were female; 45.0% were aged 50–69 years old; 90.3% were married; 40.7% had at least college level education; 64.2% were employed; 65.0% were enrolled in health insurance as the primary member or a dependent of a salaried employee; 29.7% (the greatest proportion of participants) sleep for 7.0–7.9 h a day, 18.8% for less than 6 h day; 54.9% have never smoked; 32.5% drank occasionally; 29.7% performed physical activity for 1–3 days per week; 39.5% were overweight; 58.6% were slightly stressed; and 26.7% had hypertension.

Table 1. Prevalence of hypertension by sociodemographic and health-related characteristics (n = 3984).

Variable	Total	Hypertension		t, χ^2	*p*-Value
		Yes	No		
	***n* (%), Mean ± SD**				
Sex				42.400 ***	<0.001
Male	1927 (48.4)	605 (31.4)	1322 (68.6)		
Female	2057 (51.6)	458 (22.3)	1599 (77.7)		
Age [1]				636.773 ***	<0.001
30–49	1567 (39.3)	115 (7.3)	1452 (92.7)		
50–69	1794 (45.0)	590 (32.9)	1204 (67.1)		
≥70	623 (15.7)	358 (57.5)	265 (42.5)		
Marital status				62.304 ***	<0.001
Not married	387 (9.7)	38 (9.8)	349 (90.2)		
Married	3597 (90.3)	1025 (28.5)	2572 (71.5)		
Education level				394.323 ***	<0.001
≤primary education	634 (15.9)	329 (51.9)	305 (48.1)		
Middle school	425 (10.7)	183 (43.1)	242 (56.9)		
High school	1304 (32.7)	319 (24.5)	985 (75.5)		
≥College	1621 (40.7)	232 (14.3)	1389 (85.7)		
Income level				2.322	0.508
Low	921 (23.1)	253 (27.5)	668 (72.5)		
Low middle	1011 (25.4)	272 (26.9)	739 (73.1)		
Upper middle	1017 (25.5)	280 (27.5)	737 (72.5)		
High	1035 (26.0)	258 (24.9)	777 (75.1)		
Occupation				73.219 ***	<0.001
Unemployed	1426 (35.8)	495 (34.7)	931 (65.3)		
Employed	2558 (64.2)	568 (22.2)	1990 (77.8)		

Table 1. *Cont.*

Variable	Total	Hypertension		t, χ^2	*p*-Value
		Yes	No		
	n (%), Mean ± SD				
Health Insurance				68.370 ***	<0.001
Self-employed	1251 (31.4)	339 (27.1)	912 (72.9)		
Employment-based	2591 (65.0)	644 (24.9)	1947 (75.1)		
Medicaid	142 (3.6)	62 (43.7)	80 (56.3)		
Sleep duration [2]	6.75 ± 1.32	6.53 ± 1.47	6.83 ± 1.25	6.284 ***	<0.001
<6	748 (18.8)	273 (36.5)	475 (63.5)	49.856 ***	<0.001
6.0–6.9	1082 (27.1)	267 (24.7)	815 (75.3)		
7.0–7.9	1183 (29.7)	272 (23.0)	911 (77.0)		
8.0–8.9	771 (19.4)	191 (24.8)	580 (75.2)		
≥9	200 (5.0)	60 (30.0)	140 (70.0)		
Smoking				30.475 ***	<0.001
Non-smoker	2185 (54.9)	522 (23.9)	1663 (76.1)		
Current-smoker	714 (17.9)	184 (25.8)	530 (74.2)		
Ex-smoker	1085 (27.2)	357 (32.9)	728 (67.1)		
Drinking frequency				44.056 ***	<0.001
Never	917 (23.0)	311 (33.9)	606 (66.1)		
Rarely	816 (20.5)	189 (23.2)	627 (76.8)		
Occasionally	1294 (32.5)	289 (22.3)	1005 (77.7)		
Frequently	957 (24.0)	274 (28.6)	683 (71.4)		
Physical activity [3]				11.344 **	0.010
0	757 (19.0)	224 (29.6)	533 (70.4)		
1–3	1185 (29.7)	283 (23.9)	902 (76.1)		
4–6	956 (24.0)	243 (25.4)	713 (74.6)		
7	1086 (27.3)	313 (28.8)	773 (71.2)		
BMI [4]				155.849 ***	<0.001
Underweight	116 (2.9)	11 (9.5)	105 (90.5)		
Normal	2293 (57.6)	465 (20.3)	1828 (79.7)		
Overweight	1575 (39.5)	587 (37.3)	988 (62.7)		
Stress				47.255 ***	<0.001
Rarely stressed	566 (14.2)	213 (47.6)	353 (62.4)		
Slightly stressed	2335 (58.6)	612 (26.2)	1723 (73.8)		
Quite stressed	892 (22.4)	195 (21.9)	697 (78.1)		
Very stressed	191 (4.8)	43 (22.5)	148 (77.5)		
Diabetes				262.232 ***	<0.001
No	3527 (88.5)	797 (22.6)	2730 (77.4)		
Yes	457 (11.5)	266 (58.2)	191 (41.8)		

** $p < 0.01$, *** $p < 0.001$. [1] Units expressed as years. [2] Units expressed as hours. [3] Units expressed as days per week. [4] Units expressed as kg/m^2 and underweight (<18.5), normal (18.5–24.9), overweight (≥25.0).

Table 1 also shows that prevalence of hypertension was higher in men than in women (31.4% vs. 22.3%), in the married than in the single (28.5% vs. 9.8%), and in the unemployed than in the employed (34.7% vs. 22.2%). The prevalence was highest in people aged 70 years and older (57.5%), with no or primary education (51.9%), Medicaid beneficiaries (43.7%), ex-smokers (32.9%), never drinkers (33.9%), people with sleep duration of <6 h (36.5%), with no physical activity (29.6%), who were overweight (37.3%), and who were rarely stressed (47.6%), and who have diabetes (58.2%). Except income level, all sociodemographic and health-related covariates differed at statistical significance in the presence or absence of hypertension. Figure 2 demonstrates that the prevalence of hypertension is higher in the case of sleep deficit (36.5%) compared to the cases of sufficient sleep duration (7–7.9 h) (23.0%).

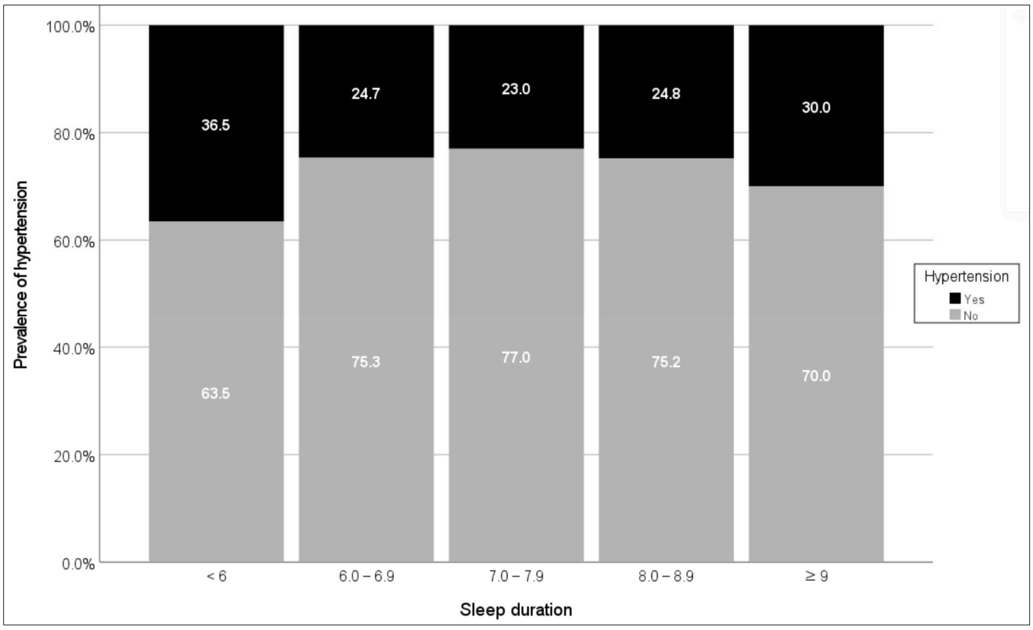

Figure 2. Prevalence of hypertension by sleep duration.

3.2. Comparison of Sleep Duration According to Sociodemographic Characteristics

In Table 2, the prevalence of sleep deficit was higher in men (19.3%) than in women (18.3%) and in the unemployed (22.2%) than in the employed (16.8%). The prevalence was highest in individuals aged 70 years and older (27.4%), with no or primary education (29.8%), in the lowest income quartile group (21.8%), and in Medicaid beneficiaries (33.8%). Except for marital status, all other sociodemographic covariates differed at statistical significance among the sleep duration categories.

Table 2. Comparison of sleep duration according to sociodemographic characteristics (n = 3984).

Variable	Sleep Duration [1], n (%)					χ^2	p-Value
	<6	6.0–6.9	7.0–7.9	8.0–8.9	≥9.0		
Sex						10.850 *	0.028
Male	372 (19.3)	522 (27.1)	600 (31.1)	353 (18.3)	80 (4.2)		
Female	376 (18.3)	560 (27.2)	583 (28.3)	418 (20.3)	120 (5.8)		
Age [2]							
30–49	204 (13.0)	440 (28.1)	517 (33.0)	324 (20.7)	82 (5.2)	104.838 ***	<0.001
50–69	373 (20.8)	504 (28.1)	512 (28.5)	342 (19.1)	63 (3.5)		
≥70	171 (27.4)	138 (22.2)	154 (24.7)	105 (16.9)	55 (8.8)		
Marital status						8.652	0.070
Not married	53 (13.7)	103 (26.6)	126 (32.5)	85 (22.0)	20 (5.2)		
Married	695 (19.3)	979 (27.2)	1057 (29.4)	686 (19.1)	180 (5.0)		
Education level						119.251 ***	<0.001
≤primary education	189 (29.8)	153 (24.1)	140 (22.1)	105 (16.6)	47 (7.4)		
Middle school	106 (24.9)	109 (25.6)	100 (23.5)	87 (20.6)	23 (5.4)		
High school	222 (17.0)	354 (27.2)	393 (30.1)	263 (20.2)	72 (5.5)		
≥College	231 (14.3)	466 (28.7)	550 (33.9)	316 (19.5)	58 (3.6)		
Income level						24.781 *	0.016
Low	201 (21.8)	255 (27.7)	238 (25.8)	173 (18.8)	54 (5.9)		
Low middle	186 (18.4)	243 (24.0)	320 (31.7)	209 (20.7)	53 (5.2)		
Upper middle	193 (19.0)	291 (28.6)	303 (29.8)	182 (17.9)	48 (4.7)		
High	168 (16.2)	293 (28.3)	322 (31.1)	207 (20.0)	45 (4.4)		
Occupation						70.790 ***	<0.001
Unemployed	317 (22.2)	337 (23.6)	366 (25.7)	296 (20.8)	110 (7.7)		
Employed	431 (16.8)	745 (29.1)	817 (31.9)	475 (18.6)	90 (3.6)		
Health Insurance						31.436 ***	<0.001
Self-employed	242 (19.3)	339 (27.1)	359 (28.7)	240 (19.2)	71 (5.7)		
Employment-based	458 (17.7)	712 (27.5)	798 (30.8)	504 (19.4)	119 (4.6)		
Medicaid	48 (33.8)	31 (21.8)	26 (18.3)	27 (19.1)	10 (7.0)		

* p < 0.05, *** p < 0.001. [1] Units expressed as hours. [2] Units expressed as years.

Table 3 shows the results of linear regression analysis for sociodemographic factors associated with sleep duration. People aged 50–69 years (p-value < 0.001) and aged 70 years and older (p-value = 0.001) were inversely associated with the sleep duration. Sleep duration had a positive correlation with individuals who attained the education level of high school (p-value < 0.001) and college and higher (p-value < 0.001). Medicaid beneficiaries had shorter sleep duration than the self-employed (p-value = 0.009). The married or the employed had shorter sleep duration, although the results were not statically significant.

Table 3. Multiple linear regression analysis for the association between sociodemographic factors and sleep duration (n = 3984).

Variable	Coefficient	95% CI		t	p-Value
		Min	Max		
Sex					
Male	Ref				
Female	0.049	−0.036	0.135	1.129	0.259
Age [1]					
30–49	Ref				
50–69	−0.300	−0.402	−0.199	−5.790 ***	<0.001
≥70	−0.279	−0.436	−0.121	−3.466 ***	<0.001
Marital status					
Not married	Ref				
Married	−0.135	−0.282	0.011	−1.815	0.070
Education level					
≤primary education	Ref				
Middle school	0.158	−0.005	0.322	1.896	0.058
High school	0.308	0.167	0.449	4.296 ***	<0.001
≥College	0.266	0.118	0.414	3.522 ***	<0.001
Income level					
Low	Ref				
Low middle	0.148	0.029	0.266	2.447 *	0.014
Upper middle	0.071	−0.050	0.191	1.149	0.251
High	0.128	0.006	0.250	2.062 *	0.039
Occupation					
Unemployed	Ref				
Employed	−0.049	−0.142	0.044	−1.037	0.300
Health Insurance					
Self-employed	Ref				
Employment-based	0.029	−0.060	0.119	0.641	0.522
Medicaid	−0.309	−0.542	−0.076	−2.595 **	0.009

* p < 0.05, ** p < 0.01, *** p < 0.001. Ref: reference category. [1] Units expressed as years.

3.3. Comparison of Sleep Duration According to Health-Related Characteristics

In Table 4, the prevalence of sleep deficit was highest in current-smokers (21.3%), never drinkers (21.5%), people with no physical activity (21.0%), who were overweight (22.0%), very stressed (34.6%), and diabetic (35.5%). Except for smoking (p = 0.061) and drinking frequency (p = 0.138), the remaining health-related covariates differed significantly among the sleep duration categories.

Table 5 shows the results of linear regression analysis for health-related factors. Increased stress in daily life was significantly associated with short sleep duration, although other factors did not show significant results. The diagnosis of chronic diseases, such as diabetes mellitus, had a negative correlation with sleep duration but it was not significant.

Table 4. Comparison of sleep duration according to health-related characteristics (n = 3984).

Variable	Sleep Duration [1], n (%)					χ^2	p-Value
	<6	6.0–6.9	7.0–7.9	8.0–8.9	≥9.0		
Smoking						20.322	0.061
Non-smoker	393 (18.3)	594 (27.2)	620 (28.4)	465 (21.3)	113 (5.2)		
Current-smoker	152 (21.3)	194 (27.2)	229 (32.1)	104 (14.6)	35 (4.9)		
Ex-smoker	203 (18.7)	294 (27.1)	334 (30.8)	202 (18.6)	52 (4.8)		
Drinking frequency						17.329	0.138
Never	197 (21.5)	222 (24.2)	260 (28.4)	183 (20.0)	55 (6.0)		
Rarely	132 (16.2)	228 (27.9)	251 (30.8)	158 (19.4)	47 (5.8)		
Occasionally	227 (17.5)	379 (29.3)	383 (29.6)	252 (19.5)	53 (4.1)		
Frequently	192 (20.1)	253 (26.4)	289 (30.2)	178 (18.6)	45 (4.7)		
Physical activity [2]						73.958 ***	<0.001
0	159 (21.0)	189 (25.0)	218 (28.8)	146 (19.3)	45 (5.9)		
1–3	218 (18.4)	342 (28.9)	322 (27.2)	237 (20.0)	66 (5.6)		
4–6	171 (17.9)	270 (28.2)	305 (31.9)	174 (18.2)	36 (3.8)		
7	200 (18.4)	281 (25.9)	338 (31.1)	214 (19.7)	53 (4.9)		
BMI [3]						19.394 *	0.013
Underweight	19 (16.4)	27 (23.3)	39 (33.6)	26 (22.4)	5 (4.3)		
Normal	383 (16.7)	605 (26.4)	712 (31.1)	478 (20.8)	115 (5.0)		
Overweight	346 (22.0)	450 (28.6)	432 (27.4)	267 (17.0)	80 (5.1)		
Stress						29.226 ***	<0.001
Rarely stressed	88 (15.5)	133 (23.5)	168 (29.7)	137 (24.2)	40 (7.1)		
Slightly stressed	388 (16.6)	652 (27.9)	737 (31.6)	447 (19.1)	111 (4.8)		
Quite stressed	206 (23.1)	252 (28.3)	240 (26.9)	154 (17.3)	40 (4.5)		
Very stressed	66 (34.6)	45 (23.6)	38 (19.9)	33 (17.3)	9 (4.7)		
Diabetes						75.546 ***	<0.001
No	676 (17.9)	1049 (27.7)	1146 (30.3)	735 (19.4)	175 (4.6)		
Yes	72 (35.5)	33 (16.3)	37 (18.2)	36 (17.7)	25 (12.3)		

* p < 0.05, *** p < 0.001. [1] Units expressed as hours. [2] Units expressed as days per week. [3] Units expressed as kg/m^2 and underweight (<18.5), normal (18.5–24.9), overweight (≥25.0).

Table 5. Multiple linear regression analysis for the association between health-related factors and sleep duration (n = 3984).

Variable	Coefficient	95% CI		t	p-Value
		Min	Max		
Smoking					
Non-smoker	Ref				
Current-smoker	−0.077	−0.195	0.040	−1.287	0.198
Ex-smoker	−0.028	−0.127	0.072	−0.542	0.588
Drinking frequency					
Never	Ref				
Rarely	0.123	−0.002	0.248	1.929	0.054
Occasionally	0.086	−0.027	0.199	1.494	0.135
Frequently	0.070	−0.055	0.196	1.103	0.270
Physical activity [1]					
0	Ref				
1–3	0.057	−0.064	0.177	0.921	0.357
4–6	−0.005	−0.131	0.121	−0.074	0.941
7	0.019	−0.104	0.142	0.304	0.761
BMI [2]					
Underweight	Ref				
Normal	−0.049	−0.295	0.197	−0.389	0.697
Overweight	−0.215	−0.464	0.035	−1.688	0.092

Table 5. *Cont.*

Variable	Coefficient	95% CI		t	*p*-Value
		Min	Max		
Stress					
Rarely stressed	Ref				
Slightly stressed	−0.130	−0.251	−0.009	−2.100 *	0.036
Quite stressed	−0.302	−0.441	−0.163	−4.250 ***	0.000
Very stressed	−0.549	−0.766	−0.332	−4.971 ***	0.000
Diabetes					
No	Ref				
Yes	−0.101	−0.231	0.028	−1.534	0.125

* $p < 0.05$, *** $p < 0.001$. Ref: reference category.[1] Units expressed as days per week. [2] Units expressed as kg/m^2 and underweight (<18.5), normal (18.5–24.9), overweight (≥25.0).

3.4. Odds Ratio in Logistic Regression Analysis for Hypertension According to Sleep Duration

To estimate the relationship between hypertension and sleep duration, logistic regression analysis was performed excluding covariates unrelated to sleep duration, such as marital status, smoking, and drinking. Table 6 shows that sleep deficit is associated with increased hypertension risk. In the crude model, the odds ratios of hypertension were almost half in those who sleep for a sufficient duration with 6.0–6.9 h per day (OR = 0.57, $p < 0.001$), 7.0–7.9 h of sleep (OR = 0.52, $p < 0.001$), and 8.0–8.9 h (OR = 0.57, $p < 0.001$), compared to those who sleep below 6 h. Those who sleep more than 9 h also showed a lower risk of hypertension (OR = 0.75) but it was not statistically significant. After adjusting for sociodemographic covariates such as sex, age, education level, income level, and health insurance, the odds ratios of hypertension is still significantly lower in those who sleep 6.0–6.9 h per day (OR = 0.78, $p < 0.05$), 7.0–7.9 h of sleep (OR = 0.74, $p < 0.001$), and 8.0–8.9 h (OR = 0.76, $p < 0.05$), compared to those who sleep for fewer than 6 h. In the final model, sleep duration did not show a significant association with the risk of hypertension when it was further adjusted for health-related covariates including physical activity, BMI level, stress, and diabetes. The OR for hypertension was significantly lower in females (OR = 0.63) and those in high school (OR = 0.68) or college or higher education (OR = 0.46). The OR was significantly higher in Medicaid beneficiaries (OR = 1.95), in the overweight (OR = 5.10), and in those with diabetes (OR = 2.53). According to the Hosmer–Lemeshow goodness-of-fit test, all three logistic regression models showed a good degree of fit with *p*-value greater than 0.05.

Table 6. Odds ratio in logistic regression analysis for hypertension according to sleep duration ($n = 3984$).

Variable	Crude Model [1]			Adjusted Model 1 [2]			Adjusted Model 2 [3]		
	OR	95% CI		OR	95% CI		OR	95% CI	
		Min	Max		Max	Max		Min	Max
Sleep duration [4]									
<6	1.00			1.00			1.00		
6.0–6.9	0.57 ***	0.47	0.70	0.78 *	0.63	0.98	0.82	0.65	1.04
7.0–7.9	0.52 ***	0.42	0.64	0.74 **	0.59	0.92	0.79	0.63	1.00
8.0–8.9	0.57 ***	0.46	0.71	0.76 *	0.60	0.98	0.80	0.62	1.04
≥9	0.75	0.53	1.04	0.81	0.55	1.19	0.77	0.51	1.14
Sex									
Male				1.00			1.00		
Female				0.57 ***	0.48	0.67	0.63 ***	0.53	0.75
Age [5]									
30–49				1.00			1.00		
50–69				4.60 ***	3.66	5.77	4.56 ***	3.60	5.79
≥70				8.55 ***	6.37	11.49	9.12 ***	6.67	12.48

Table 6. *Cont.*

Variable	Crude Model [1]			Adjusted Model 1 [2]			Adjusted Model 2 [3]		
	OR	95% CI		OR	95% CI		OR	95% CI	
		Min	Max		Max	Max		Min	Max
Education level									
≤primary education				1.00			1.00		
Middle school				0.85	0.65	1.10	0.97	0.73	1.28
High school				0.60 ***	0.48	0.76	0.68 **	0.53	0.88
≥College				0.41 ***	0.32	0.53	0.46 ***	0.35	0.60
Income level									
Low				1.00			1.00		
Low middle				1.08	0.86	1.36	1.05	0.83	1.33
Upper middle				1.17	0.92	1.47	1.14	0.90	1.45
High				1.16	0.91	1.47	1.11	0.86	1.42
Occupation									
Unemployed				1.00			1.00		
Employed				0.85	0.71	1.01	0.84	0.70	1.01
Health Insurance									
Self-employed				1.00			1.00		
Employment-based				1.08	0.91	1.29	1.06	0.89	1.27
Medicaid				2.21 ***	1.48	3.31	1.95 **	1.28	2.96
Physical activity [6]									
0							1.00		
1–3							1.00	0.79	1.28
4–6							1.03	0.80	1.32
7							1.07	0.84	1.35
BMI [7]									
Underweight							1.00		
Normal							1.91	0.95	3.82
Overweight							5.10 ***	2.54	10.24
Stress									
Rarely stressed							1.00		
Slightly stressed							0.88	0.71	1.10
Quite stressed							0.94	0.71	1.23
Very stressed							0.93	0.59	1.44
Diabetes									
No									
Yes							2.53 ***	2.02	3.17
Cox & Snell R^2/Nagelkerke's R^2	0.012/0.017			0.181/0.264			0.227/0.330		
χ^2(df), *p*-value	47.811(4), <0.001			795.14(16), <0.001			1024.227(25), <0.001		
Hosmer–Lemeshow Test χ2(df), *p*-value	0.000(3), 1.000			14.767(8), 0.064			13.138(8), 0.106		

* $p < 0.05$, ** $p < 0.01$ *** $p < 0.001$. OR: odds ratio for hypertension. CI: confidence interval. [1] Crude model: includes only sleep duration. [2] Adjusted model 1: adjusted for sociodemographic covariates including sex, age, education level, occupation and health insurance. [3] Adjusted model 2: adjusted for sociodemographic and health-related covariates including sex, age, education level, occupation, health insurance, physical activity, BMI, stress, and diabetes. [4] Units expressed as hours. [5] Units expressed as years. [6] Units expressed as days per week. [7] Units expressed as kg/m^2 and underweight (<18.5), normal (18.5–24.9), overweight (≥25.0).

4. Discussion

Based on nationwide survey data, this study showed that only 29.7% of Korean adults aged 30 years and older sleep for 7.0–7.9 h a day, as recommended by the National Sleep Foundation in the United States [29]. In other words, a great majority of Koreans experience either insufficient or too much sleep. The proportion of people with a sleep duration of fewer than 6 h per day in this study based on 2020 data was 18.8%, which is an increase from 16.5% in 2017 [12]. Similarly, an increasing trend in the prevalence of sleep deficit was observed in the United States [25]. This is problematic because too short or too long sleep durations were shown to be associated with increased risk for hypertension [30–32]. Consistent with the findings, this present study showed that the risk of hypertension was highest in people experiencing less than 6 h of sleep per day. Improving sleep health and communicating the importance of experiencing enough sleep may be necessary in an effort to manage the risk of hypertension.

In the present study, the prevalence of people suffering from sleep deficit increased with advancing age, which was consistent with the findings of previous studies [1,33]. Sleep duration decreases with older age; deep sleep duration, in particular, decreases with more frequent and longer hours of waking up at night, which lowers sleep efficiency and leads to insomnia among older adults [34]. All these findings suggest that efforts to improve sleep duration, especially among older adults, should be included in public health programs to lower the risk of hypertension.

This study showed that the prevalence of hypertension was associated with sociodemographic characteristics, such as sex, age, marital status, educational level, income, and employment status, which was consistent with the findings of a previous study [31]. It is similar to the results of a previous study which found that people with higher education levels have sufficient sleep durations compared to those with less educational achievement [3]. These findings suggest that strategies to maintain adequate sleep duration among an increasing number of patients with hypertension be developed based on the sociodemographic characteristics of individuals.

In this study, the prevalence of hypertension increased with physical inactivity (walking 10 min continuously for less than one day a week) and obesity; this was similar to the findings of a previous study that self-reported physical activity as inversely associated with the development of hypertension [35]. Conversely, our study indicates that the risk of hypertension increased with more physical activity, albeit statistically insignificantly. In this study, the prevalence of hypertension also increased with a history of smoking and the status of being rarely stressed. Based on the findings, we recommend that intervention programs should include smoking cessation, physical activity, obesity, and stress as markers of hypertension management.

The definition of hypertension as having blood pressure of over 140/90 mmHg, which was made by the Joint National Committee in its fourth guidelines in 1988, has been considered the gold standard for a long time [36]. However, in 2017, the American Heart Association, in collaboration with the American College Cardiology and the American Society of Hypertension, published new hypertension guidelines in which the definition of hypertension was revised as having blood pressure of over 130/80 mmHg [37]. Despite the change, the majority of hypertension guidelines, including those of the Korean Society of Hypertension and the European Society of Hypertension, have retained the traditional definition [38]. As the KHNANES used in this study followed the guideline of the Korean Society of Hypertension, we applied its definition; therefore, it is likely that the results of this study may change if the new guideline is applied to define hypertension.

In sum, using nationwide survey data, this study showed that short sleep duration was significantly associated with increased risk for hypertension, and that the association persisted after adjusting for sociodemographic factors. The association was not significant when it was further adjusted for health-related factors. These findings can inform health promotion policies to manage the risk of hypertension in Korean adults. It is recommended that sleep duration be considered a lifestyle risk factor in the prevention and management of hypertension. However, the results of this study should be interpreted with caution in light of the following limitations. First, this study is based on a cross-sectional design where the outcome and exposure are examined at the same time [39]. For this reason, the relationship between sleep duration and risk of hypertension cannot be interpreted as a causal one. Second, as this study used only one year of KNHANES data, further research should pool multiple years of data to improve its statistical power and obtain more sufficient information. Third, this study used self-reported survey data and health checkup results rather than doctors' diagnosis, which may not fully reflect actual information about the subjects' chronic conditions. Sleep duration was also self-reported but not measured by monitoring the sleep status of participants. As a result, the measurements may not fully reflect actual sleep duration [40]. Future research should closely examine the association between hypertension and sleep duration by using actual sleep data based on an experimental study design.

5. Conclusions

In conclusion, this study showed that sleep deficit can be a significant factor in increasing the risk of hypertension after adjusting for sociodemographic factors such as sex, age, education level, occupation, and health insurance type. Therefore, efforts to promote adequate sleep duration in adults are recommended to prevent and manage the risk of hypertension.

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Data Availability Statement: All original data are publicly available free of charge from the KNHANES website (http://knhanes.cdc.go.kr/ (accessed on 5 March 2022)) for the purposes of academic research.

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