



Prediction of Hypertension Based on the Quantity and Quality of Sleep in Adults: Results of the First Phase of Shahedieh Cohort Study 2015-2016

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ABSTRACT

Background: The prevalence of high blood pressure is a serious concern in developing countries. The present study aimed to examine hypertension based on the quantity and quality of sleep in adults.

Methods: This descriptive study was conducted on the data of the first phase of Shahedieh cohort study in Yazd (Shahdieh, Zarch, and Ashkezar cities), Iran during 2015-2016. The variables of the study were assessed by the questions regarding the sleep status and blood pressure measurement. To analyze the data SPSS version 20 was used.

Results: The results showed that blood pressure in people who sleep less than 6 h at night was significantly higher than those who obtain 6-8 h night's sleep ($P = 0.001$). Moreover, the findings indicated systolic blood pressure is significantly related to taking naps during the day, using sleeping pills, and restless legs syndrome during sleep ($P < 0.001$). According to the results, 98% of the systolic blood pressure variance and 80% of the diastolic blood pressure variance were explained by the sleep-related variables.

Conclusion: Sleep duration at night is a strong predictor for systolic and diastolic blood pressure.

1. Introduction

Sleep is one of the basic human needs and an essential element for physical and mental health [1]. Humans spend about one-third of their lives sleeping. The need for sleeping in humans varies according to age and conditions. It is usually recommended that an adult individual needs about 8 h of sleep at night [2]. It should not be overlooked that,

modernization and the change in lifestyle, have decreased optimal sleep duration significantly.[3]. Insomnia is one of the most common sleep disorders which is defined as the feeling of insufficient sleep [2]. Symptoms of sleep disorders include drowsiness, difficulty falling asleep, waking up frequently during the night and early in the morning [4]. Sleep deprivation impairs the immune system and reduces the function of the hypothalamus, pituitary gland, adrenal



the function of the hypothalamus, pituitary gland, adrenal glands, and glucose tolerance. Furthermore, it leads to high blood pressure and cardiovascular diseases [5].

So far, more than 160 different sleep disorders such as snoring, sleep apnea, periodic limb movement in sleep (PLMS), nightmares, and delay in falling asleep, etc., have been identified [6]. Although, some of the mentioned disorders are treatable, but neglecting them has deleterious consequences. Sleep disorders are one of the most important disease prognoses and the most common reasons to visit a specialist [7]. Numerous studies have attempted to explain the connection between sleep and chronic diseases. Studies have also examined the relationship between sleep and diabetes, obesity, atherosclerosis, and hypertension [8, 9].

Chronic insufficient sleep may result in a high blood pressure. Nam et al. reported that people who sleep less than 6 h at night have higher mean blood pressure than those with 7-8 h night sleep [10]. High blood pressure is a common problem in the world and its prevalence is higher in developing countries compared to developed ones [3]. Some researchers believe that the relationship between sleep deprivation and psychological stress affects heart rate and consequently increases blood pressure. In addition, the risk of cardiovascular diseases will be increased [11]. In a study conducted by Sharma *et al.* (2006), results showed that insufficient sleep lead to blood pressure and increased autonomous system activity [12]. In a study that examined sleep disorders in patients with hypertension it was found that that, a large majority of the patients had poor quality and insufficient sleep [13]. In this regard, it seems necessary to conduct studies at the community level with high sample size. Therefore, this study aimed to assess the predictors of hypertension based on the quantity and quality of sleep in adults in Yazd, Iran.

2. Materials and Methods

The present study is a descriptive study conducted in Yazd, Iran.

2.1. Data Collection

The data of the study were obtained from the first (recruitment) phase of Shahedieh cohort in Shahedieh (n=4940), Ashkezar (n=1474), and Zarch (n=3780) cities located in Yazd, Iran on adults aged 35-70 years. Shahedieh cohort study is a part of the PERSIAN cohort Study (The Prospective Epidemiological Research Studies of the Iranian Adults -<http://persiancohort.com/cohortsites/yazd/>) to assess the prevalence of non-communicable, occupational diseases, and its related risk factors [14].

Shahedieh region was selected according to the conditions such as the availability of the people, limited immigrants

from other cities, low ethnicity variation, and full cooperation. The study was initiated on 05 May 2015, and then the enrollment phase was concluded in Sep 2016.

The inclusion criteria of the study were the age of 35-70 years, permanent residence in the mentioned district over the last nine months, continuously, and willingness to participate in the study. First, eligible individuals were invited to the cohort center. Following that, information collected by a trained cohort team.

Interview, clinical examinations, blood test, urine tests, and preclinical tests were used to obtain the required information. The information collected through interviews, was in the following categories: demographic characteristics, socioeconomic status, employment status, of fuel consumed and location, lifestyle habits, history of chronic diseases history of family illnesses, history of smoking and drug use, oral health, sleep, and food habits. The information was collected by a general practitioner, nutritionist, and public health expert. The laboratory staff took the participants' blood, hair, nails, and urine samples.

2.2. Data Analysis

The variables of the study included systolic and diastolic blood pressure levels, sleep-related variables (routine bedtime, routine time of waking up in the morning, periodic limb movement in sleep (PLMS), daytime naps, and taking sleeping pills more than twice a week).

To measure blood pressure, Riester Exacta 1350 Sphygmomanometer was used in Shahedieh cohort centers. Blood pressure was measured in both arms. The first measurement was taken in the sitting position, after at least 5 min rest. Similarly, the second measurement was also performed around 10 min after the first one.

The classification of systolic and diastolic blood pressure in the present study was performed based on the eight Joint National Committee (JNC8) guidelines regarding the prevention, identification, evaluation, and treatment of hypertension [15]. Accordingly, normal blood pressure has a diastolic pressure below 80 mm Hg and a systolic pressure below 120 mm Hg. In Pre-hypertension the diastolic and systolic pressures are 89-80 and 139-120 mm Hg respectively. In addition, in stage 1 hypertension the pressure ranges from 99-90 159-140 and also in stage 2 hypertension the pressures are considered to be 100/160 mm Hg and above.

To analyze the statistical data, SPSS software (version 20.0) was used. Descriptive statistics including Chi-square, independent t-test, the analysis of variance (One-way ANOVA), and linear regression analysis were used. P-value less than 0.05 was considered significant.

Shahedieh cohort study was approved by the the Ethics committee of Shahid Sadoughi University of Medical Sciences in Yazd with the code No: IR.SSU.REC.1397.135.

Before collecting the information, the purpose of the study was explained to the participants, and then individuals participated in the study consciously. The information of the participants was kept confidential.

This article has an approval from the research Ethics committees of Shahid Sadoughi University of Medical Sciences, code IR.SSU.SPH.REC.1399.043.

3. Results and Discussion

The target population in this study consisted of 4768 males and 4768 females. The results revealed that, 8653 participants (90.8%) had normal diastolic blood pressure (DBP). Moreover, 496 cases (5.2%) were in the pre-hypertension stage, 289 cases (3%) were in stage 1 hypertension, and 94 cases (1%) were in stage 2 hypertension. In addition, systolic blood pressure (SBP) in 7475 cases (78.4%) was in normal range, 1458 cases (15.3%) in pre-hypertensive stage, 467 cases (4.9%) in stage 1 hypertension, and 133 cases (1.4%) in stage 2 hypertension. The results showed that systolic and diastolic hypertension were significantly higher in men, overweight, and obese people over 60 years. ($P < 0.001$) (Table1). The results of the ANOVA test indicated that SBP had a significant relationship with sleep duration at night ($P = 0.001$). According to the Tukey test, the difference was related to the sleep duration in people with normal blood pressure and pre-hypertension ($P = 0.001$). As indicated in Table 2, there was a significant association between DBP and sleep duration at night ($P = 0.001$). In addition, normal blood pressure was also related to stage 1 hypertension ($P = 0.01$).

Also, Further statistical tests revealed that SBP was significantly higher in men and women with sleep duration less than 6 hat night compared to those with 6 to 8 h ($P = 0.001$).Furthermore, DBP was significantly higher in women who sleep less than 6 h at night compared with those

who sleep 6 to 8 h ($P = 0.001$). (Table 3) The results of the Pearson correlation also showed that there was a significant inverse correlation between systolic and diastolic blood pressure with sleep duration at night ($R = -0.07, P = 0.001$). Additionally, there was a significant positive correlation between SBP and sleep latency ($R = 0.02, P = 0.03$).

The Chi-square test showed a significant relationship between SBP and taking a nap during the day without doing any specific activity ($P = 0.001$). By increasing SBP, napping rate accelerated.

Therefore, 22.4% of people with normal systolic blood pressure, 26.2% of people with prehypertension, 27.8% of people with stage 1 hypertension, and 32.3% with stage 2 hypertension took a nap during the day. Another important finding showed that the number of reported cases of people who take sleeping pills more than twice a week, increase as a result of increasing SBP ($P = 0.03$). According to the results, 7.3% of people with normal systolic blood pressure, 8.6% of people with prehypertension, 10.1% of people with stage 1 hypertension, and 11.3% with stage 2 hypertension use sleeping pills.

The Chi-square test showed a significant relationship between SBP and PLMS ($P = 0.002$). Increases in SBP, are associated with increased PLMS. To put it more simply, 10.7% of people with normal systolic blood pressure, 11.2% of people with prehypertension, 12.2% of people with stage 1 hypertension, and 13.5% with stage 2 hypertension had PLMS. In the case of diastolic blood pressure, none of these differences were statistically significant.

In the current study, linear regression analysis was used to assess the significance of the sleep variables in explaining the SBP and DBP (Table 4 and 5). As shown in Table 4 and 5, 98% of the SBP variance and 80% of the DBP variance were explained by the sleep-related variables. Sleep duration was considered as a strongest predictor for SBP and DBP ($P < 0.001$).

Table 1: Frequency of socio-demographic variables based on hypertension on adult Shahedieh residents aged 35-70 years in 2014-2015

Variable	Systolic hypertension		Pvalue	diastolic hypertension		Pvalue	
	Yes	No		Yes	No		
BMI	<18.5	9 (0.4)	105 (1.5)	$P < 0.001$	8 (0.5)	106 (1.4)	$P < 0.001$
	18.5-24.9	339 (13.6)	1732 (25.3)		172 (11.1)	1899 (24.4)	
	25-29.9	1001(40.2)	2963 (43.2)		604 (39.1)	3360 (43.1)	
	>30	1143 (45.9)	2051 (29.9)		761 (49.3)	2433 (31.2)	
Marital status	Married	7 (0.3)	30 (0.4)	0.18	3 (0.2)	34 (0.4)	0.39
	Single	2426 (95.4)	6691 (95.9)		1511 (95.8)	7606 (95.7)	
	Widow	94 (3.7)	230 (3.3)		53 (3.4)	271 (3.4)	
	Divorced	17 (0.7)	28 (0.4)		10 (0.6)	35 (0.4)	
Employment status	Yes	1097 (43.2)	3076 (44)	0.68	687 (43.5)	3486 (43.8)	0.83
	No	1447 (56.8)	3903 (56)		890 (56.5)	4460 (56.2)	
Gender	Men	1401 (55)	3367 (48.2)	$P < 0.001$	964 (61.1)	3804 (47.8)	$P < 0.001$
	Women	1146 (45)	3619 (51.8)		614 (38.9)	4151 (52.2)	
Age (year)	< 50	1372 (54)	4089 (58.6)	$P < 0.001$	869 (55.1)	4592 (57.8)	$P < 0.001$
	50-60	680 (26.8)	1849 (26.5)		413 (26.2)	2116 (26.6)	
	> 60	490 (19.3)	1037 (14.9)		294 (18.7)	1233 (15.5)	

Table 2: Frequency and mean sleep duration at night based on systolic and diastolic blood pressure on adult Shahedieh residents aged 35-70 years in 2014-2015

Variable	Sleep duration(h)			Pvalue*	Mean of Sleep duration(h)	Pvalue**	
	< 6	6-8	> 8				
Diastolic Blood Pressure	Normal	1152 (13.3%)	6403 (74%)	1098 (12.7%)	0.04	6.93 ± 1.3	0.001
	pre-hypertension	76 (15.3%)	378 (76.2%)	42 (8.5%)		6.74 ± 1.2	
	stage 1 hypertension	44 (15.2%)	219 (75.8%)	26 (9%)		6.68 ± 1.2	
	stage 2 hypertension	14 (14.9%)	71 (75.5%)	9 (9.6%)		6.77 ± 1.4	
Systolic Blood Pressure	Normal	957 (12.8%)	5555 (74.3%)	963 (12.9%)	0.001	6.95 ± 1.3	0.001
	pre-hypertension	241 (16.5%)	1057 (73.8%)	142 (9.7%)		6.76 ± 1.3	
	stage 1 hypertension	69 (14.8%)	342 (73.2%)	56 (12%)		6.8 ± 1.4	
	stage 2 hypertension	19 (14.3%)	100 (75.2%)	14 (10.5)		6.75 ± 1.3	

*Chi-square ** ANOVA

The results showed that people who sleep less than 6 h at night have higher systolic and diastolic blood pressure. According to the regression analysis, sleep duration at night was a significant predictor for diastolic and systolic blood pressure. St-onge *et al.* (2020) found that insufficient sleep during a night increases blood pressure and is strongly related to cardiovascular health. The risks of mortality and premature stroke can reduce by detecting and controlling the symptoms. [11]. Several studies have also reported that sleeping less than 6 h increases the risk of high blood pressure [16, 17]. Zhu *et al.* (2019) found that stable sleep is a protective factor toward reducing SBP at night, while unstable sleep is a risk factor for increasing SBP during the day [18]. Studies that have examined sleep by using polysomnography have shown that sleeping less than 6 h is associated with increased blood pressure [19, 20]. Makaren *et al.* (2019) have reported that short and long sleep duration could increase the risk of hypertension, but most studies have emphasized the association between short sleep duration and hypertension. It was also found that women were more likely to be affected by the harmful effects of short sleep and blood pressure than men [21], which is consistent with the present study.

Seemingly, sleep disorders and hypertension are combined problems; both issues should be considered

Table 3: Mean systolic and diastolic blood pressure based on sleep duration (hours) on adults 35-70 years

Gender	Sleep duration (hours)	Mean	SD	Pvalue*
Women	Diastolic blood pressure			
	<6	70.03	10.7	0.001
	6-8	69.78	10.7	
	>8	67.92	10.5	
	Systolic blood pressure			
	<6	112.9	15.5	0.05
6-8	112.3	16.3		
>8	110.64	17.01		
Men	Diastolic blood pressure			
	<6	67.53	10.4	0.001
	6-8	65.91	10.8	
	>8	65.51	10.5	
	Systolic blood pressure			
	<6	110.8	19.07	0.001
6-8	107.59	17.5		
>8	106.91	16.7		

* ANOVA

during the treatment. Therefore, it must be determined whether patients with hypertension suffer from sleep disorders or insomnia, and then offer an effective treatment. Interestingly, the relationship between blood pressure and sleep disorders is probably a two-way relationship. Insomnia can be a symptom that leads to high blood pressure or, conversely, high blood pressure can cause sleep disorders. However, most studies have shown that insomnia affects high blood pressure [5]. Insomnia increases the strength and speed of heart muscle contraction beside the need for oxygen. Furthermore, it increases the secretion of epinephrine, norepinephrine, activity of the sympathetic system, and heart rate [22]. Habitual short sleep in adults can also increase blood pressure by interfering with the circadian rhythm [6]. Some believe that the psychological stress caused by insomnia as well as salt retention in the body due to corticosteroid secretion, increases blood pressure [23].

The results of the present study also showed that sleep latency increases SBP, which is consistent with the study of McMahon *et al.* In their study, sleep latency more than 12 min increased the chances of SBP (OR = 1.9, P= 0.02) [24]. The current study found that an increase in SBP, associated with taking a nap during the day. Kazemi *et al.* (2016) showed that patients with hypertension suffer from sleep disorders [6].

The results of a similar study by Ghaffari *et al.* (2011) about examining the daytime sleepiness in hypertensive women, showed a significant relationship between daytime sleepiness and the severity of hypertension (P= 0.001).

The results of their study showed that women with higher SBP had more daytime drowsiness. Furthermore, it was concluded that 39.6% of women with hypertension had mild drowsiness during the day, 19.3% had moderate drowsiness, and 5.3% had severe drowsiness [2].

The current study found that there was a significant association between SBP and PLMS. Therefore, PLMS are related to an increase in SBP during sleep. Restless Legs Syndrome (RLS) is a sensorimotor disorder defined by the irresistible urge to move the legs. The movement of the legs gets worse when a person is at rest and is relieved by movement. In addition, the intensity of the unconscious leg movements increase at night [25].

Table 4: Linear regression analysis to predict systolic blood pressure based on sleep variables

Predictor	Standardized coefficients β	Unstandardized coefficients β	t	Pvalue	f	R ²
Constant	-	115.17	80.48	0.001		
Sleep duration	-0.07	-0.9	-7.03	0.001		
Sleep latency	0.017	0.008	1.62	0.1		
Taking a nap during the day	0.06	2.41	5.8	0.001	18.34	0.98
Taking sleeping pills	0.017	1.08	1.63	0.1		
PLMS*	0.003	0.16	0.29	0.77		

* Periodic limb movement in sleep

Studies have showed that more than 80% of the RLS patients have PLMS [26]. RLS increases the activity of the sympathetic nervous system and can cause a temporary increase in blood pressure and heart rate [25]. Some researchers have studied sleep-related movement disorders and their effect on blood pressure. In a study by Sieminski *et al.* (2017) blood pressure in RLS patients and healthy individuals was measured. The results of their study showed that the blood pressure mean in RLS and healthy cases were in the normal range, but in RLS patients was slightly higher. The researchers concluded that higher blood pressure in RLS patients during the day and night was more likely to be related to PLMS [27]. In a similar study, Pennestri *et al.* (2013) concluded that SBP, DBP and, heart rate were higher in RLS patients than in healthy individuals [28].

Ferini *et al.* (2014) believed that many RLS patients do not seek treatment or are unaware of the disease until the symptoms become severe or affect different aspects of their lives. Meanwhile, the adverse effects of RLS may affect heart rate, blood pressure, and the development of cardiovascular disease. Therefore, the relationship between PLMS and sleep disorders should be considered by physicians in order to prevent clinical consequences [29]. The main weakness of this study was the lack of access to polysomnography. Further research is needed to determine the relationship between sleep and blood pressure with a high sample size in healthy people and patients with hypertension clinically. One of the strengths of the present study was a large number of samples, which leads to more accurate results.

Table 5: Linear regression analysis to predict diastolic blood pressure based on sleep variables

Predictor	Standardized coefficients β	Unstandardized coefficients β	t	Pvalue	f	R ²
Constant	-	71.72	78.59	0.001		
Sleep duration	- 0.079	- 0.628	-7/7	0.001		
Sleep latency	- 0.01	- 0.003	- 0.92	0.35		
Taking a nap during the day	0.01	0.28	1.05	0.29	12.26	0.08
Taking sleeping pills	0.007	0.28	0.66	0.5		
PLMS*	0.006	0.227	0.62	0.53		

* Periodic limb movement in sleep

4. Conclusion

According to the results, sleep is a strong predictor of systolic and diastolic blood pressure. In general, insufficient sleep at night is a modifiable risk factor for hypertension. As a result, short sleep duration leads to an increase in systolic and diastolic blood pressure in adults, followed by sleep disorders (such as taking a nap during the day and taking sleeping pills). In this regard, the cooperation of physicians and psychiatrists is essential. Therefore, it is suggested that nurses and other medical groups pay more attention to the pattern and quality of sleep in patients with hypertension when evaluating and obtaining a history of the disease. The long-term result of the preventive measures can reduce the burden of cardiovascular disease.

Authors' Contributions

M.M., and H.F., conceived and developed the idea for the article; M.M., L.F., prepared numerous drafts; H.F., contributed to the

statistical analysis; M.M., L.F, H.F., and M.M., revised the manuscript. All the authors discussed and commented on the final manuscript.

Conflicts of Interest

The Authors declare that there is no conflict of interests.

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