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Original Article

Do Sleep Time and Duration Affect the Development of Prehypertension in Undergraduate Medical Students? An Experience from a Tertiary Care Hospital in Kolkata

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Sleep Sci

Abstract

Introduction and Objective Hypertension is an evolving public health challenge at present, and it is preceded by a prehypertensive stage. Irregular sleep duration and pattern have been found to be linked with cardiovascular diseases. Medical students are highly vulnerable to low quality sleep due to pressure regarding the academic curriculum and poor lifestyle. The present study aimed to estimate the prevalence of prehypertension, describe the risk factors and sleep patterns of undergraduate medical students, and determine the association, if any, involving sleep time and duration and prehypertension.

Materials and Methods Data was collected from 254 undergraduate medical students via the Pittsburgh Sleep Quality Index (PSQI) questionnaire and a self-structured questionnaire. The frequency of events was established and the Chi-squared and *t*-tests were applied to determine the association. Finally, regression analysis was performed to determine the correlation.

Results Male sex, high body mass index (BMI), poor sleep quality, and night sleep duration shorter than 5 hours were found to be significant risk factors for the development of prehypertensive condition (prevalence of 42.5%). However, there were no statistically significant associations regarding prehypertension and family history, junk food and salt intake, physical activity and daytime napping, bedtime, and wake-up time. Night sleep duration shorter than 5 hours presented an odds ratio of 4.713 ($p = 0.010$) for the development of prehypertension after adjusting for other risk factors, such as male sex, sleep quality, and high BMI.

Discussion and Conclusion A high prevalence of prehypertension (42.5%) was noted among undergraduate medical students. Night sleep duration shorter than 5 hours was a significant risk factor for the development of prehypertension, whereas sleep time was not significantly associated with prehypertension.

Keywords
- prehypertension
- sleep duration
- sleep time
- undergraduate medical student
- Kolkata

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Introduction

Hypertension is an evolving public health challenge in developing and developed countries, including India for the past few decades.[1] Prehypertension occurs before hypertension, as evidenced by prior cohort studies[2] demonstrating a 3-fold increase in the incidence of hypertension among the prehypertension participants relative to their counterparts. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) defines hypertension as blood pressure > 140/90 mmHg. Persons with blood pressure of 120 to 139 mmHg or diastolic blood pressure between 80 and 89mm Hg are defined as having prehypertension.[1] Hypertension is considered the largest attributable risk factor for cardiovascular disease (CVD) mortality.[3]

On the other hand, sufficient sleep is one of the crucial factors for the proper functioning of the human body. Adults should sleep for ~ 7 hours every night, according to the American Academy of Sleep Medicine (AASM) and the Sleep Research Society (SRS).[4] Both short and prolonged sleep durations have been found to be linked with CVDs and obesity.[5] Sleep initiation time is another essential aspect of sleep pattern (as well as sleep quality) that is frequently associated with various health parameters. Recent studies[6] have found that sleep time is linked to high blood pressure and hypertension prevalence.

Medical students are a special subgroup of the population that are considered vulnerable to low quality sleep. The high academic demand faced by this group causes significant stress, which leads to poor lifestyle that involves late sleeping and sleep deprivation.[7]

Therefore, it is evident that sleep duration and time are crucial factors for optimal health,[5,6] and prehypertension, which eventually leads to chronic hypertension, is currently one of the most important medical concerns.[1,2] Due to their high academic burden, medical students fall in the vulnerable group regarding sleep deprivation and low-quality sleep,[7] which increases their probability of developing prehypertension.

Thus, the aim of the present study was to find out if there is an association involving sleep duration and time with prehypertension among undergraduate medical students. In addition, it was very evident from other studies[8] that the development of prehypertension depends on other factors, such as age, sex, religion, body mass index (BMI), family history, salt and junk food intake, and physical activity. So, these factors were also taken into account as controlled covariates. Further, since overall sleep quality is an important risk factor for the development of prehypertension, it was also used as a covariate in the present study. There is a lack of studies about sleep time and its association with hypertension, as most studies, especially those conducted in India, focus on sleep duration and quality. Therefore, the present cross-sectional study was useful to fill this void, as we have estimated the prevalence of prehypertension among the undergraduate medical students and have also conducted a sleep quality analysis comprising the sleep pattern, overall sleep quality, bedtime and napping duration of the aforementioned group. Finally, the study determined the correlation regarding sleep timing and duration and prehypertension considering other potential confounding variables.

Materials and Methods

The current cross-sectional study was conducted with the undergraduate students at a tertiary medical college in Kolkata. Undergraduate students from the 1st to 4th years who provided written informed consent were included. Students with known CVD, hypertension, or those taking anti-hypertensive medications, as well as those who refused to provide consent, were excluded from the study. The study was conducted under the Indian Council of Medical Research Short-Term Studentship program. Approval of the institutional Ethics Committee in terms of the ethics clearance certificate was obtained prior to the conduction of the study.

The number of participants was calculated via the OpenEPI (open source) sample size calculator software, using a 33.06% prevalence of high blood pressure (including hypertension and prehypertension),[9] the total regular undergraduate student enrollment of 1 thousand, a 5% level of significance, and 5% margin of error. The final calculated number of participants was of 254. All variables of the present research are depicted in ►**Figure 1**.

A random sampling technique was applied to collect the data through a questionnaire comprising two sections: in one section, the Pittsburgh Sleep Quality Index (PSQI) questionnaire was used to collect data about sleep duration and time (sleep latency was taken into account as per the questionnaire used). Also, data to evaluate the overall sleep quality was also collected considering the PSQI global score; in the other section, a self-structured questionnaire was used

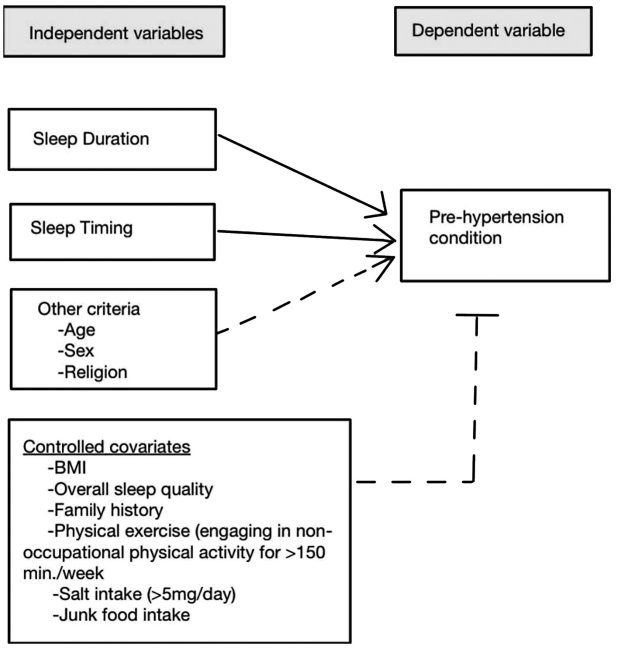

Fig. 1 Variables analyzed in the present study.

to collect data on demographic variables (such as age, sex, and religion) and on family history of hypertension, salt and junk food intake, physical exercise, and previous hypertensive conditions. moreover, daytime napping duration was also assessed through the questionnaire.

Sleep time was divided into before 12 am, from 12 to 1 am, from 1 to 2 am (which was considered the standard interval for the study sample), from 2 to 3 am, and after 3 am.[9] Wake-up time was divided into before 6 am, from 6 to 7 am, from 7 to 8 am (which was considered the standard), from 8 to 9 an, and after 9 am.[9] And night sleep duration was divided into < 6 hours, between 6 and 7 hours (the standard), and > 7 hours.[9]

Blood pressure was measured by the auscultatory method using a calibrated mercury column sphygmomanometer (MCP02, Medicare Products Inc., New Delhi, Delhi, India) with appropriate cuff size, circling at least 80% of the arm in the seated position, with the cuff supported at the level of heart, after 10 minutes of complete physical and mental rest, as per practicable. Three consecutive measurements were taken with a proper time gap in between them, and the average was recorded as the final measurement.

Body weight was measured using a digital weighing scale (MCP Healthcare, Medicare Products Inc.) to the nearest 0.5 kg with the subject standing motionless on the scale wearing minimum outerwear. Height was measured (to the nearest 0.5 cm) with a stadiometer (Avery India Ltd., Faridabad, Haryana, India) following the standard procedure. The BMI (in kg/m^2) was calculated and classified as: < 18.5–underweight; 18.5 to 22.9–healthy weight; 23 to 27.5–overweight; and ≥ 27.5–obese.[10]

Data was collected at the physiology department as per the availability of the required instruments, and it was tabulated in a spreadsheet of the Microsoft Excel (Microsoft Corp., Redmond, WA, United States) software, version 2019. The statistical analysis was performed using the IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, United States), version 25.0. First, the frequency percentages were calculated for the categorical data, and mean and standard deviation (SD) values were calculated for the continuous data. Subsequently the relationship between the risk factors and level of prehypertension was analyzed with the help of the independent samples *t*-test and the Chi-squared test. Multivariate logistic regression was applied to check the fitness of the model.

Results

A total of 254 samples were collected. According to the exclusion criteria, participants with known hypertension conditions ($n = 5$) were excluded. Out of the 254 participants, 8 had hypertension (3.1%; they were unaware of its presence), and 108 had prehypertension (42.5%). The mean age of the participants was of 20.25 ($SD = \pm 1.16$; range $= 18$–25) years.

Most participants were male (62.2%), Hindu (78.7%), junk food consumers (53.5%), low salt consumers (79.9%), and physically inactive (66.5%). Male sex presented a significant odds ratio (OR) of 2.497 ($p = 0.001$) of being prehypertensive.

Sleep Quality

In total, 45.3% of the participants presented poor sleep quality. with a PSQI global score > 5, and this group of participants presented an OR of 1.991 (p 0.029) of being prehypertensive.

All the parameters are shown in ►**Table 1**.

Body Mass Index (BMI)

As for the BMI, 20 (7.9%) participants were underweight, 123 (48.4%) had healthy weight, 90 (35.4%) were overweight, and 21 (8.3%) were obese. The distribution of BMI among the participants with respect to prehypertensive condition is shown in ►**Table 1**. A significant correlation was observed between BMI and prehypertensive condition ($p = 0.002$). As per the logistic regression analysis, overweight participants presented an OR of 1.833, whereas obese participants, an OR of 6.562 of being prehypertensive ►**Table 2**).

Daytime Napping Duration

The mean napping duration of the participants was of 65 ($SD: \pm 49$) minutes. The distribution of the mean napping duration regarding prehypertensive condition is shown in ►**Table 3**. No significant correlation was found between napping duration and prehypertensive condition (two-sided *t*-test; $p = 0.564$).

Night Sleep Duration

Out of the total of 254 participants, 32 (12.6%) slept more than 7 hours, 83 (32.7%), between 6 and 7 hours, 98 (38.6%), between 5 and 6 hours, and 41 (16.1%) slept less than 5 hours. The distribution of night sleep duration regarding prehypertensive condition is shown in ►**Table 1**. Night sleep duration and prehypertensive condition were found to be significantly associated ($p = 0.009$). Further analysis of this variable was performed through logistic regression.

Bedtime

In total, 20 (7.9%) participants slept before 12 am, 78 (30.7%), between 12 and 1 am, 90 (35.4%), between 1 and 2 am, 43 (16.9%), between 2 and 3am, and 23 (9.1%) slept after 3 am. The distribution of bedtime regarding prehypertensive condition is depicted in ►**Table 1**, and no significant association was found between bedtime and prehypertensive condition ($p = 0.570$).

Wake-Up Time

Overall, 14 (5.5%) participants woke up before 6 am, 48 (18.9%), between 6 and 7 am0, 83 (32.7%), between 7 and 8 am, 63 (24.8%), between 8 and 9 am, and 46 (18.1%) woke up after 9 am. The distribution of wake-up time with respect to prehypertensive condition is shown in ►**Table 1**. No significant association was found between the wake-up time and prehypertensive condition ($p = 0.244$).

Regression Analysis

Logistic regression analysis was performed to test the associations regarding prehypertensive condition and night sleep duration and bedtime respectively.

Table 1 Comparison of the parameters of the present study.

Variables		Normotensive: n(%)	Prehypertensive: n(%)	Hypertensive: n(%)	*p*-value	Odds ratio (between prehypertensive and normotensive subjects)	Chi-squared test
Sample		138(54.3)	108(42.5)	8(3.1)			
Sex	Male	72(45.6)	79(50)	7(4.4)	0.001	2.497	13.585
	Female	66(68.8)	29(30.2)	1(1)			
Religion	Hindu	104(52)	88(44)	8(4)	0.167	1.438	3.585
	Muslim	34(63)	20(37)	0(0)			
Family history	Yes	60(50.4)	54(45.4)	5(4.2)	0.397	1.3	1.847
	No	78(57.8)	54(40)	3(2.2)			
Junk food intake	Yes	71(52.2)	60(44.1)	5(3.7)	0.713	1.18	0.677
	No	67(56.8)	48(40.7)	3(2.5)			
High salt intake	Yes	25(49)	25(49)	1(2)	0.535	1.361	1.252
	No	113(55.7)	83(40.9)	7(3.4)			
Physical activity	Yes	47(55.3)	35(41.2)	3(3.5)	0.935	0.928	0.135
	No	91(53.8)	73(43.2)	5(3)			
Body mass index	Underweight	15(75)	5(25)	0(0)	0.002		21.378
	Normal	77(62.6)	44(35.8)	21.6)			
	Overweight	42(46.7)	44(48.9)	4(4.4)			
	Obese	4(19)	15(71.4)	2(9.5)			
Global score on the Pittsburgh Sleep Quality Index	< 5	86(61.9)	49(35.3)	4(2.9)	0.029	1.991	7.098
	> 5	52(45.2)	59(51.3)	4(3.5)			
Night sleep duration	Below 5 hours	11(26.8)	29(70.7)	1(2.4)	0.009		17.003
	5 to 6 hours	57(58.2)	37(37.8)	4(4.1)			
	6 to 7 hours	49(59)	32(38.6)	2(2.4)			
	Above 7 hours	21(65.6)	10(31.3)	1(3.1)			
Bedtime	Before 12 am	14(70)	5(25)	1(5)	0.570		6.697
	12 to 1 am	44(56.4)	33(42.3)	1(1.3)			
	1 to 2 am	48(53.3)	39(43.3)	3(3.3)			
	2 to 3 am	21(48.8)	21(48.8)	1(2.3)			
	After 3 am	11(47.8)	10(43.5)	2(8.7)			
Wake-up time	Before 6 am	6(42.9%)	6(42.9%)	2(14.3%)	0.244		10.315
	6 to 7 am	27(56.3%)	21(43.8%)	0(0%)			
	7 to 8 am	40(48.2%)	40(48.2%)	3(3.6%)			
	8 to 9 am	36(57.1%)	25(39.7%)	2(3.2%)			
	After 9 am	29(63%)	16(34.8%)	1(2.2%)			

Table 2 Results of the logistic regression analysis of body mass index with respect to prehypertensive condition.

Body mass index	Odds ratio	95% confidence interval		*p*-value
		Lower	Upper	
Healthy weight	1			
Underweight	0.327	0.199	1.714	0.327
Overweight	1.833	1.045	3.216	0.035
Obese	6.562	2.050	21.007	0.002

Table 3 Distribution of mean daytime napping duration with respect to participants with prehypertensive condition.

Variable	Normotensive	Prehypertensive	Hypertensive	*p*-value*
Mean daytime napping duration (in minutes)	63 ± 47	66 ± 50	82 ± 54	0.564

Note: *Between prehypertensive and normotensive subjects in the independent samples *t*-test- (two-sided *p*-value).

Table 4 Results of the logistic regression analysis of prehypertension regarding night sleep duration and bedtime respectively.

Variables		Odds ratio (95% confidence interval)	*p*-value	Adjusted odds ratio (95% confidence interval)*	*p*-value
Night sleep duration	Above 7 hours	1		1	
	6 to 7 hours	1.371 (0.572–3.290)	0.479	1.003 (0.390–2.582)	0.995
	5 to 6 hours	1.363 (0.577–3.219)	0.480	1.070 (0.417–2.742)	0.889
	Below 5 hours	5.536 (1.988–15.416)	0.001	4.713 (1.458–15.236)	0.010
Bedtime	1 to 2 am	1		1	
	12 to 1 am	0.923 (0.497–1.713	0.800	1.282 (0.646–2.545)	0.477
	Before 12 am	0.440 (0.146–1.327)	0.145	0.620 (0.183–2.100)	0.443
	2 to 3 am	1.231 (0.588–2.574)	0.581	1.184 (0.535–2.622)	0.676
	After 3 am	1.119 (0.431–2.907)	0.818	1.080 (0.387–3.019)	0.883

Note: *Odds ratio adjusted for sex, body mass index, and sleep quality.

Prehypertension versus Night Sleep Duration

The OR for being prehypertensive rather than normotensive is provided in Table 4 for the following sleep intervals: 6 to 7 hours, 5 to 6 hours, and < 5 hours; sleep duration > 7 hours was deemed healthy, with an OR of 1. When the night sleep duration was < 5 hours, the OR showed a significant increase (OR: 5.536, 95% confidence interval [95%CI]: 1.988–15.416). The OR for sleep duration after adjustment for other attributing risk factors (sex, BMI, and sleep quality) is also shown in ►**Table 4**.

Prehypertension versus Bedtime

The logistic regression analysis between prehypertensive condition and bedtime showed no significant correlation ($p = 0.545$); the ORs for the two variables are depicted in ►**Table 4**. After adjusting for other attributable variables (sex, BMI, and sleep quality), no association was found between prehypertensive condition and bedtime ($p = 0.812$).

Discussion

The present study aimed to achieve four specific objectives: the first one was to estimate the prevalence of prehypertension among the study group. After analyzing the population, a prevalence rate of 42.5% of prehypertension was observed, and 3.1% of the participants had hypertension (but were unaware of it). So, a total of 45.6% of the population had the presence of prehypertensive or hypertensive conditions. In terms of sex distribution, 50% of the male participants and 30.2% of the female participants were found to be prehypertensive. This suggests that male subjects were more likely to be hypertensive compared with female subjects ($p = 0.001$). The second objective was to describe the sleep pattern of the undergraduate medical students. Most students (38.6%) slept between 6 and 7 hours per night, and only 12.6% slept > 7 hours per night. Also, a significant percentage of the population (16.1%) slept < 5 hours per night. Therefore, a significant percentage of the population presented low night sleep duration.

In terms of bedtime, most of the population (35.4%) slept between 1 and 2 am, and only 7.9% had a habit of sleeping before 12 am, suggesting a tendency towards late bedtime. Most of the sample (32.7%) woke up between 7 and 8 am, only 5.5% woken up before 6 am, and 18.1% woke up after 9 am, which shows that most participants were late risers. Out of the total population, 45.3% presented poor sleep quality (global PSQI score < 5).

The average napping duration was found to be of 65 minutes, and it was not associated with the occurrence of prehypertensive condition. Our objective to analyze the data based on different anthropometric measurements and demographic variables suggested that certain parameters were potential risk factors for the development of prehypertensive condition. The Chi-squared analysis showed that male sex (PR = 2.497; $p = 0.001$), high BMI (overweight: OR = 1.833; $p = 0.035$; obese: OR = 6.562; $p = 0.002$, in the regression analysis), poor sleep quality (OR = 1.991; $p = 0.029$), and night sleep duration < 5 hours (OR = 5.536; $p = 0.001$, in the regression analysis) were the statistically significant risk factors for developing prehypertensive condition. Other variables considered in the study, such as religion, family history of hypertension, frequent junk food intake, high daily salt intake, the practice of non-occupational physical activity, daytime napping duration, bedtime, and wake-up time were not found to be correlated with prehypertensive condition (p-values > 0.05)

As per our objective to determine the correlation involving sleep time and duration and prehypertension, we performed a regression analysis, which showed that short night sleep

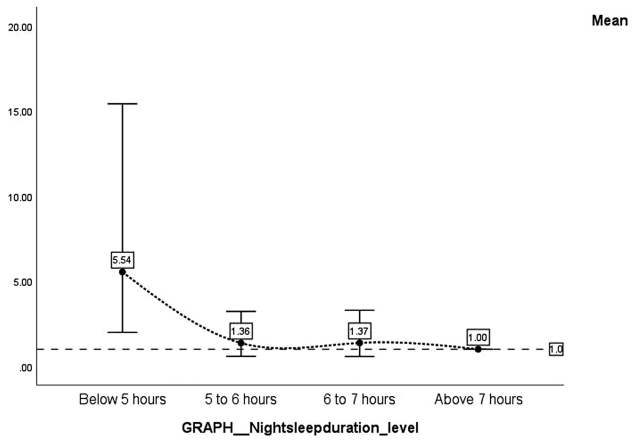

Fig. 2 Plot showing odd ratios with 95% confidence intervals of night sleep duration with respect to prehypertensive condition.

duration was a statistically significant risk factor for the development of prehypertensive condition. Night sleep duration below 7 hours up to 5 hours presented an OR greater than the one for the occurrence of prehypertension, but this was not statistically significant. But night sleep duration < 5 hours was a significant risk factor for the development of prehypertension (OR: 5.536; $p = 0.001$; ►**Figure 2**). When we adjusted for the other risk factors (male sex, poor sleep quality, and high BMI), the OR for night sleep duration was of 4.713 ($p = 0.01$; ►**Figure 3**). This suggests that night sleep duration < 5 hours was still a significant risk factor for the development prehypertensive condition.

When we performed the logistic regression analysis between prehypertension and bedtime, no statistically significant correlation was found ($p = 0.545$), so bedtime was not a statistically significant risk factor for the development of prehypertensive condition.

The present study showed a 42.5% prevalence of prehypertension among students at a tertiary medical college in Kolkata, a rate relatively higher than those found in previous studies from Kolkata[8] (19.18%) and Andhra Pradesh[11] (15.9%). But studies from Chennai [12] (37.2%), Agartala[13] (45%), Dehradun[14] (58.75%), and Karnataka[15] (55.4%) showed similar prevalence rates of prehypertensive condition. The present study also pointed out the tendency of late sleep habits and low night sleep duration among college students, as found in previous studies.[7] Several previous studies have also pointed out similar findings of male sex,[11,15] poor sleep quality [16,17] and high BMI [11,13,15] as a positive risk factors for the development of prehypertension. Family history of hypertension, junk food intake, high daily salt intake, and the practice of physical activities were found to be positive risk factors for the development of prehypertension as per several previous studies.[8] However, the findings of the present study showed no significant associations involving these factors and prehypertensive condition. Several studies[18–20] on the association between sleep duration and blood pressure have been published, and most suggested a positive relationship between short night sleep duration and prehypertensive condition, which is in line with the findings of the current study. There is a lack of research on sleep time and the development of prehypertensive condition. Some studies[6,21] have pointed out a positive correlation between the two. However, the findings of the present study showed the absence of any statistically significant relationship between them.

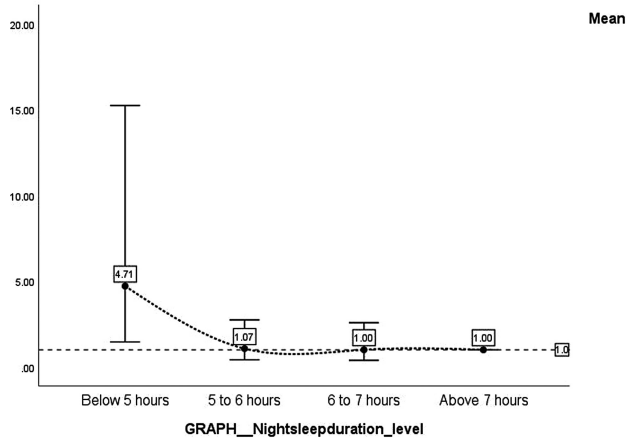

Fig. 3 Plot showing adjusted odd ratios (for sex, body mass index, and sleep quality) with 95% confidence intervals of night sleep duration with respect to prehypertensive condition.

Among the strengths of the current study, we have controlled for a wide range of covariates in the analysis, including age, sex, BMI, salt intake and exercise practice. A limitation of the study resides in the properties of the cross-sectional design and the recall bias of self-reported sleep related questions. Moreover, blood pressure was measured at random, and diurnal variations in blood pressure were ignored.

The biological mechanisms underlying the association of sleep duration with the development of hypertension are complex and not well understood. Some studies[22] have indicated a lower level of sympathetic nerve activity and blood pressure during deep non-rapid eye movement (NREM) sleep. In REM sleep, there is an increase of sympathetic activity resulting in surges of blood pressure that may be associated with the development of hypertension.[22] Sleep can also interfere with certain neurocognitive functions and impair overall attention to health-associated cues such as eating healthy food and being physically active.[23] Prolonged exposure to short sleep periods can raise the 24-hour hemodynamic load and cause structural adaptation, such as remodeling of the left ventricle or artery, which eventually results in the entire cardiovascular system operating under a high-pressure balance.[24] Short sleep duration has been found to be associated with elevated cortisol levels, which results in increased blood pressure.[25] Recent studies[26] have found that sleep deprivation might affect the reactions of blood pressure to stress, resulting in an increased risk of CVDs. In addition, overactivity of the renin angiotensin aldosterone system, renal impairment, and endothelial dysfunction may also be associated with short sleep duration, which results in elevated blood pressure.[18]

The primary unsettled challenge remains to manage these patients in an effective manner. Lifestyle changes are highly suggested for all patients with prehypertension, as they significantly reduce the chances of cardiovascular events. Presently, no pharmacological therapy is indicated in case of prehypertensive patients. However, pharmacological solutions are recommended for patients with prehypertension and specific comorbidities, such as chronic kidney disease, coronary artery disease, and diabetes mellitus.[27] Furthermore, improving lifestyle, that is, improving sleep quality and duration, and maintaining a healthy BMI, is advised to the sample of undergraduate medical students of the present study to prevent future complications of prehypertensive conditions and to promote a better cardiovascular health for the future healthcare pillars of the society.

Conclusion

A high prevalence of prehypertension (108 in number, 42.5%) was noted among undergraduate medical students. Short night sleep duration, late bedtime and late wake-up time, and poor sleep quality contributed to the poor sleep patterns of undergraduate medical students. Prehypertension was observed to be significantly more likely to develop in male subjects with a high BMI and poor sleep quality. Bedtime had no significant association with prehypertension; however, night sleep duration of < 5 hours was found to be a significant risk factor for the development of prehypertension. Therefore, improving night sleep duration and quality, along with lifestyle changes, is highly recommended to cope with the emerging public health challenge that is prehypertension.

Further multicentric studies can be performed to determine sleep pattern, prevalence of prehypertension, and their possible correlation among the community of medical students.

Disclosure Statement

With the submission of this manuscript the authors would like to declare that:

- The contents of this manuscript have not been copyrighted or published previously.
- The contents of this manuscript are not currently under consideration for publication elsewhere.
- The authors have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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