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Original Research Article

Impact of Sleep Duration on Blood Pressure and Resting Heart Rate among College Students

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Abstract

Background: Poor sleep is prevalent in college students and can lead to early autonomic and cardiovascular changes prior to the onset of disease. Study design: A cross sectional analytical study was done to evaluate the relationship between blood pressure and resting heart rate with habitual sleep duration in college students.

Method: A seven-day sleep diary and Pittsburgh Sleep Quality Index were used to classify 201 students (18-25 years) into three groups: short sleep (<6 hours/night), adequate sleep (6-8 hours/night), and long sleep (>8 hours/night). Standardized procedures were used to measure resting systolic blood pressure, resting diastolic blood pressure, mean arterial pressure, pulse pressure, and resting heart rate.

Results: The mean age was 20.7 ± 1.8 years, and 118 participants (56.2%) were female. Short sleepers had higher systolic blood pressure (121.8 ± 9.6 mmHg), diastolic blood pressure (78.4 ± 6.8 mmHg), and resting heart rate (82.6 ± 9.4 beats/min) compared with adequate sleepers (115.2 ± 8.7 mmHg, 73.1 ± 6.2 mmHg, and 75.8 ± 8.1 beats/min; $p < 0.001$). Sleep duration was inversely related to SBP ($r = -0.34$), DBP ($r = -0.31$), and RHR ($r = -0.39$). After adjusting for other variables, short sleep was independently associated with increased systolic blood pressure (beta = 0.29, $p < 0.001$) and resting heart rate (beta = 0.35, $p < 0.001$).

Conclusion: College students who had a habit of sleeping less than 6 hours had poor resting cardiovascular parameters.

Keywords: Sleep Duration; Blood Pressure; Resting Heart Rate; College Students; Autonomic Function; Cardiovascular Risk.

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Introduction

Sleep is a fundamental biological need for the regulation of the autonomic nervous system, endocrine function, emotional regulation, cognition and cardiovascular function. The lack of sleep is a particular problem for college students due to academic stress, the college routine, use of social media, exams, irregular eating habits, and late-night study habits. Adult sleep recommendations are seven hours or more of sleep per night for optimal health, and less sleep has been linked with cardiometabolic and mental health risks [1,2]. While hypertension is typically a disorder of middle age, there are several mechanisms of sympathetic activation, hypothalamic-pituitary-adrenal dysfunction, endothelial dysfunction, and behavioral clustering that can lead to adverse blood pressure patterns starting earlier in life.

There are several epidemiological studies and meta-analyses that have been associated with short sleep duration and elevated blood pressure and risk for hypertension [3-5]. This association seems more stable for short sleep than for long sleep and may be more pronounced in younger adults and women. Mechanistic reviews indicate that sleep restriction may lead to increased sympathetic nervous system activity, decreased baroreflex sensitivity, decreased nocturnal dipping and higher morning blood pressure [6]. Another simple index of autonomic balance and cardiovascular load is resting heart rate. Observational studies have linked poor sleep duration and quality to changes in HRV, greater sympathetic predominance and elevated resting pulse [7,8].

College populations are important for preventive research because sleep habits are modifiable and measurable. Many students underestimate the physiological effects of short sleep.Many students underestimate the physiological effects of short sleep. In student health programs, blood pressure and resting heart rate can be easily measured, but

these values are not necessarily understood as indicators of lifestyle strain. In field studies, the Pittsburgh Sleep Quality Index and sleep diary are useful tools to estimate sleep duration and quality [9]. These tools can be used in conjunction with standard cardiovascular measurements to detect early relationships between sleep behavior and cardiovascular physiology.

There are some limitations in the literature. In many studies, age ranges are wide or clinical populations are included or self-reported hypertension is included instead of measured blood pressure in young adults. Some college-based studies do not examine cardiovascular parameters, but rather academic performance or mental health. Further, it is unclear if sleep duration is an independent factor after controlling for BMI, physical activity, caffeine consumption, and stress in many student populations. Hence, the present study was designed to assess the effect of sleep habits on blood pressure and resting heart rate in college students. The main aim was to compare the SBP and DBP between the different sleep duration groups. Secondary outcomes included mean arterial pressure, pulse pressure, resting heart rate, sleep quality and the adjusted predictive value of short sleep.

Materials and Methods

This is a cross sectional analytical study carried out on the undergraduate college students in the age group 18-25 years. The participants were selected from the academic departments and hostels through the announcement and voluntary registration. Data collection was planned for a month that was not an examination month to minimize acute academic stress. Participants were asked to refrain from caffeine, smoking, exercise, and eating large meals for at least 2 hours prior to cardiovascular measurements. All measurements were taken in a quiet room following a minimum rest period of 10 minutes from 8:00 AM to 11:00 AM.

The sample size was calculated to detect a difference of 5 mmHg between short and adequate sleepers with a standard deviation of 10 mmHg, 80% power and 5% alpha error. Allowing for incomplete sleep diaries, 210 participants were enrolled. Known hypertension, diabetes mellitus, thyroid disease, chronic kidney disease, diagnosed sleep disorder, acute illness, night-shift work, use of sedatives, stimulants, beta-blockers or antihypertensive drugs, and competitive athletic training were all exclusion criteria. Seven-day sleep diaries were completed by participants, and those who did not complete the diaries were excluded prior to analysis.

Habitual sleep duration was determined by a seven-day sleep diary, which included information on sleep onset, sleep offset, sleep latency, number of awakenings during sleep, and daytime naps. The average duration of sleep during the night was computed and divided into three groups: short sleep (<6 hours), adequate sleep (6-8 hours), and long sleep (>8 hours). The Pittsburgh Sleep Quality Index was used to measure sleep quality. A 10-item perceived stress scale was used to measure perceived stress. Physical activity was determined by a short questionnaire and caffeine consumption was reported as average cups of coffee consumed per day. Anthropometric measurements were height, weight, BMI and waist circumference.

Blood pressure was taken with a validated automated sphygmomanometer and appropriate cuff size. The seated position was used for two readings 2 minutes apart and the average was recorded. When the difference between the two readings was more than 5 mmHg, a third reading was taken and the two closest readings were averaged. Resting heart rate was measured with the same device, and verified by radial pulse count if irregularity was suspected. Mean arterial pressure was determined as the mean of the diastolic pressure and one-third of the pulse pressure. Comparisons between groups were conducted using ANOVA, categorical variables were analyzed with chi-square tests, continuous associations were analyzed with Pearson correlation, and multiple linear regression was used to determine adjusted predictors of systolic blood pressure and resting heart rate. The variables used in regression models were age, sex, BMI, physical activity, caffeine intake, perceived stress and sleep quality. A p value of < 0.05 was deemed to be significant.

Results

A total of 210 students were included, comprising 70 short sleepers, 105 adequate sleepers, and 35 long sleepers. The mean age was 20.7 ± 1.8 years, and 118 students were female. Short sleepers had higher perceived stress scores and higher caffeine intake than adequate sleepers, while BMI and physical activity distribution were comparable.

The mean sleep duration was 5.3 ± 0.5 hours in the short-sleep group, 7.1 ± 0.6 hours in the adequate-sleep group, and 8.7 ± 0.4 hours in the long-sleep group. Poor sleep quality was most frequent among short sleepers.

Blood pressure and resting heart rate differed significantly across sleep-duration groups. Short sleepers had the highest systolic and diastolic pressures, mean arterial pressure, and resting heart rate. Adequate sleepers showed the most favorable cardiovascular profile. Long sleepers had values slightly higher than adequate sleepers but lower than short sleepers, and most differences between adequate and long sleepers were not statistically

significant. The proportion of students with elevated blood pressure range was 25.7% in short sleepers, 8.6% in adequate sleepers, and 14.3% in long sleepers ($p = 0.006$). Average sleep duration correlated inversely with systolic blood pressure, diastolic blood pressure, mean arterial pressure, and resting heart rate. The strongest association was observed for resting heart rate ($r = -0.39$, $p < 0.001$). Sleep quality score correlated positively with resting heart rate and systolic blood pressure, indicating that poorer sleep quality was associated with less favorable cardiovascular resting measures. After adjustment for age, sex, BMI, physical activity, caffeine intake, perceived stress, and sleep quality, short sleep remained an independent predictor of higher systolic blood pressure and resting heart rate. These findings indicate that sleep duration has an association with cardiovascular resting state beyond common lifestyle covariates.

Table 1: Baseline characteristics by sleep-duration category

Variable	Short sleep (n=70)	Adequate sleep (n=105)	Long sleep (n=35)	p value
Age (years)	20.8 ± 1.7	20.6 ± 1.8	20.9 ± 1.9	0.68
Female, n (%)	42 (60.0)	56 (53.3)	20 (57.1)	0.68
BMI (kg/m2)	22.9 ± 3.1	22.4 ± 2.9	22.7 ± 3.2	0.57
Sleep duration (h)	5.3 ± 0.5	7.1 ± 0.6	8.7 ± 0.4	<0.001
PSQI score	8.2 ± 2.4	4.9 ± 1.8	5.7 ± 2.1	<0.001
Caffeine intake (cups/day)	2.1 ± 1.0	1.3 ± 0.8	1.5 ± 0.9	<0.001

Table 2: Blood pressure and resting heart rate across sleep-duration groups

Parameter	Short sleep	Adequate sleep	Long sleep	p value
Systolic BP (mmHg)	121.8 ± 9.6	115.2 ± 8.7	117.4 ± 9.1	<0.001
Diastolic BP (mmHg)	78.4 ± 6.8	73.1 ± 6.2	74.6 ± 6.4	<0.001
Mean arterial pressure (mmHg)	92.9 ± 7.1	87.1 ± 6.6	88.9 ± 6.9	<0.001
Pulse pressure (mmHg)	43.4 ± 7.8	42.1 ± 7.1	42.8 ± 7.4	0.55
Resting heart rate (beats/min)	82.6 ± 9.4	75.8 ± 8.1	77.9 ± 8.6	<0.001

Table 3: Correlation and adjusted regression analysis

Outcome	Correlation with sleep duration	Adjusted beta for short sleep	p value
Systolic BP	r = -0.34	0.29	<0.001
Diastolic BP	r = -0.31	0.24	0.002
Mean arterial pressure	r = -0.33	0.27	<0.001
Resting heart rate	r = -0.39	0.35	<0.001
Elevated BP category	OR = 2.84	95% CI 1.31-6.18	0.008

Discussion

The study revealed that the students who slept for less than 6 hours had significantly higher SBP, DBP, MAP and RHR than the students who slept between 6 and 8 hours. The results are consistent with the growing body of evidence that inadequate sleep is linked to early cardiovascular strain even in healthy young adults. Meta-analyses have found an association between short sleep and prevalent or incident hypertension [3-5]. Our data include student-specific evidence, based on directly measured blood pressure and resting heart rate, not self-reported hypertension.

The mechanisms by which short sleep is associated with elevated blood pressure are complex. Sleep restriction leads to increased sympathetic activity, decreased parasympathetic tone and can affect nocturnal blood pressure dipping. Chronic sleep restriction may also stimulate the hypothalamic-pituitary-adrenal axis, elevate evening cortisol levels, induce inflammation, and exacerbate insulin resistance [6]. Autonomic imbalance is especially important in the case of resting heart rate. The increased resting pulse rate in short sleepers could be due to sympathetic predominance or to inadequate overnight recovery. Poor sleep has also been linked to negative heart rate variability (HRV) and sleep quality studies [7,8]. The changes in the cardiovascular system in this study were small but significant. If this difference persists over time, it may be significant at the population level between short sleepers and adequate sleepers, at about 6 mmHg. Generally, students are deemed low-risk, but repeated exposure to short sleep, caffeine, stress, and sedentary behaviour may set a trajectory for future cardiometabolic risk. The increased blood pressure in short sleepers reinforces the importance of early lifestyle screening. Sleep counseling should be part of a student wellness plan, along with diet, exercise, and mental health services. The values of long sleepers were not clearly adverse in this study, but were slightly higher than adequate sleepers. The literature on sleep and hypertension is inconsistent, with some studies showing an association and others showing

no association after controlling for other factors [5,10]. Long sleep in young adults may be a recovery sleep, irregular sleep patterns, lack of activity or a sign of underlying fatigue, but not necessarily a direct risk factor for cardiovascular disease. The findings of the present study are limited due to the small number of long sleepers. The pattern for the adequate-sleep group was consistently the best, consistent with current recommendations for regular sleep duration [1,2].

The strengths of the study are the use of a seven-day sleep diary, the use of a standardized method of measuring blood pressure, the adjustment for important lifestyle factors, and the use of resting heart rate as an autonomic marker. The limitations are cross-sectional design, self-reported sleep rather than actigraphy, single center recruitment and potential residual confounding from screen time, diet and chronotype. Nocturnal blood pressure dipping and heart rate variability were not measured in the study, and would offer more mechanistic insight. Wearable sleep monitoring, ambulatory blood pressure, and intervention trials of the effect of sleep extension on cardiovascular measures in short sleeping students should be included in future longitudinal studies.

The results need to be considered in the context of students' lifestyle patterns. The short sleepers in this study also reported higher levels of caffeine consumption and perceived stress, which may affect blood pressure and heart rate. But after adjustment, short sleep was still an independent predictor, indicating that the sleep duration per se had a contribution to the observed cardiovascular profile.

This doesn't mean that sleep works alone. The factors associated with short sleep, late night screen time, irregular eating, examination stress, low physical activity, and stimulant beverage consumption are not mutually exclusive in real college settings.The factors associated with short sleep, late night screen time, irregular eating, examination stress, low physical activity, and stimulant beverage use do not exist in isolation in real college settings. A lifestyle approach is thus more realistic than sleep extension alone.

The best negative correlation was observed between resting heart rate and sleep duration. This is physiologically reasonable because the autonomic system has a rapid response to changes in heart rate, while vascular tone, salt intake, body size, and variability in blood pressure measurement all affect blood pressure. Difficulty sleeping can decrease parasympathetic recovery at night and increase sympathetic drive in the morning. Similar findings of sympathetic predominance following sleep deprivation have been found in studies that have assessed sleep quality, heart rate variability, and autonomic function [7,8]. Resting pulse is easily measured and could be a helpful screening indicator in student wellness clinics. The study has implications for early prevention of hypertension. In many young adults with high-normal blood pressure, repeated exposure to short sleep may lead to an upward trend in BP over time, but they may not require drug treatment. Short sleep has been linked to the development of hypertension, especially in younger and middle-aged adults, based on population data [4,5]. Thus, during the normal health examination of students, inquiring about sleep duration may be a way to detect a modifiable risk factor before hypertension is diagnosed. The education of sleep should involve regular bedtimes, not too much caffeine late in the day, less screen stimulation late in the day, and consistent wake times during examination periods. It is important to interpret the absence of an adverse pattern with the long sleepers with caution. Long sleep in students may be a consequence of sleep debt rather than a pathological form of hypersomnia. Some may have longer sleep at the weekend and others may sleep longer due to low activity or fatigue.

Future studies should differentiate between sleep on the weekdays, sleep on the weekend, sleep regularity, chronotype, and daytime napping. Actigraphy or wearable devices would also minimize recall bias and detect fragmented sleep, which could have an impact on cardiovascular regulation despite the apparent quality of sleep [9,10].

One advantage of sleep-based prevention is that it can be done without medicalization. Wellness camps can be used to educate students on the importance of sleep duration, pulse, blood pressure and stress. If resting heart rate or blood pressure is elevated, inquire about sleep debt and this may uncover a correctable contributor. Individual behavior change may be complemented by institutional measures like rational timetable planning, sleep-awareness sessions before exams, discouraging late-night digital academic deadlines, etc. These methods are in line with the overall findings that show that sleep duration is associated with cardiovascular health [11-16].

Conclusion

Habitual sleepers with less than 6 hours of sleep had significantly elevated blood pressure and resting heart rate compared to adequate sleepers. Short sleep was an independent predictor even after adjusting for BMI, stress, caffeine, physical activity and sleep quality. Regular and adequate sleep could be a simple preventive measure to enhance the cardiovascular resting profile in young adults.

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