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Original Article

Correlation of Pulse Transit Time, Respiratory Indices, Blood Pressure and Body Mass Index in Normotensive Adults: A Cross-Sectional Study

*Anil Kumar Gangwar[1], Anita Rawat[2], Sunita Tiwari[3], Ajay Verma[4], Kalpana Singh[5], Surya Kant[6]

[1]Department of Physiology, King George's Medical University, Lucknow, India, [2]Department of Physiology, Hind Institute of Medical Sciences, Barabanki, India, [3]Department of Physiology, Dr. Ram Manohar Lohia Institute of Medical Sciences, UP, Lucknow, India, [4]Department of Respiratory Medicine, Dr. Ram Manohar Lohia Institute of Medical Sciences, UP, Lucknow, India, [5]Department of Biochemistry, King George's Medical University, Lucknow, India, [6]Department of Respiratory Medicine, King George's Medical University, Lucknow, India

Abstract

Background: Poor sleep health may be a potential risk factor for cardiovascular diseases, if proper sleep hygiene is not maintained during young adult life-span. Objective was to assess the correlation of frequency of micro-arousals and blood pressure (BP) with body mass index (BMI) among normotensive young adults. Thus, this cross-sectional study examines PTT, respiratory indices, blood pressure, and BMI in normotensive adults to find early physiological indicators of cardiovascular risk.

Methodology: A total number of 80 subjects were enrolled and were divided into two groups according to BMI, after ethical approval **(No.: 2651/R.Cell-72)** from the institute. BMI and blood pressure were taken. Sleep quality was assessed by Pittsburgh sleep quality index (PSQI). Pulse transit time (PTT) indices and respiratory indices were measured by full night polysomnography.

Results: Subjects with high value of BMI showed poor sleep quality and high value of pulse transit time deceleration index compared to subjects with lower BMI and difference was statistically significant. Subjects with higher BMI had higher value of systolic BP (SBP) and diastolic BP (DBP). SBP and DBP were positively correlated with PTT deceleration index and correlation coefficient was 0.127, 0.634, respectively, and correlation of DBP with PTT deceleration index was statistically significant ($p < 0.001$), in subjects having higher BMI.

Conclusions: There is higher prevalence of poor sleep quality and higher frequency of micro-arousals in subjects with high BMI. PTT deceleration index is negatively correlated with body mass index and this correlation is statistically significant. BMI shows positive correlation with systemic blood pressure.

Keywords: Sleep quality; Micro-arousals; Pulse transit time; Blood pressure

***Correspondence:** Dr Anil Kumar Gangwar, Assistant Professor, Department of Physiology, King George's Medical University, Lucknow, India, Phone number: +91 9598488179, E-maill: anilkgmu12@gmail.com

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Introduction:

High blood pressure, diabetes, heart disease, and long-term lung difficulties are major causes of death and sickness worldwide[1],Thebehavioural and metabolic risk factors such smoking, drinking too much, not exercising, eating badly, and being overweight considerably increase non-communicable disease (NCD) risk [2,3]. Cardiovascular disorders kill most NCD patients world-wide[4,5].The Framingham Heart Study found that obesity, measured by body mass index (BMI), is an independent risk factor for hypertension and other cardiovascular outcomes[6]. Even in normotensives, excessive adiposity increases sympathetic nervous system activity, which may lead to hypertension[7]. Episodes of electroencephalogram (EEG) arousals, also known as micro-arousals are also associated with the increased body's sympathetic tone[8]. Pulse transit time (PTT), the time it takes a pressure wave to pass between two arteries, indicates autonomic system awakening. When sympathetic tone rises quickly, PTT drops.Blood pressure (BP) fluctuation must be monitored constantly to assess cardiovascular risk. Ambulatory blood pressure monitoring (ABPM) provides intermittent data but does not capture autonomic activity's rapid beat-to-beat fluctuations[9,10]. Several validation studies have compared PTT-derived BP measurements to mercury sphygmomanometer readings, supporting PTT as a reliable, non-invasive substitute for continuous BP estimation[11,12,13].Acute blood pressure surges and fluctuations are caused by unusual breathing patterns, sleep-disordered breathing (SDB), and intermittent oxygen desaturation events. These surges in blood pressure are typically better measured with beat-to-beat PTT-derived blood pressure indices than with ABPM[14,15].

BMI, BP, respiratory habits, and PTT have all been associated to cardiovascular risk, although their links in young people are unclear.PTT is documented as a surrogate marker for autonomic activity and blood pressure surge. But its relationship with BMI and sleep related respiratory parameters in adults remains poorly defined. Previous studies examined these parameters in isolation or in diseased individuals. Early adulthood is crucial for prevention since lifestyle changes can greatly impact cardiovascular outcomes[16,17].Thus, this cross-sectional study examines PTT, respiratory indices, blood pressure, and BMI in normotensive adults to find early physiological indicators of cardiovascular risk.

Materials and Methods

In this cross-sectional study, a total number of 80 subjects were enrolled on the basis of inclusion and exclusion criteria. All study subjects were divided into two groups group 1 (n= 40, BMI < 22.9) and group 2 (n= 40, BMI > 23) according to body mass index (BMI). Revised Indian guidelines of BMI were used to define the study groups. According to revised Indian guidelines of BMI, 18.5 kg/m2 - <22.9 kg/m2 is categorized as normal, 23 kg/m2 – 24.9 kg/m2 as overweight and ≥25 kg/m2 is categorized as obese [18].Indian BMI cut-offs were used because literature indicates that Indian and South Asian populations exhibit similar ethnic and metabolic characteristics. And they have increased cardiometabolic risk at lower BMI values; thus, for identifying risk in this group, Indian cut-offs offer better sensitivity than WHO criteria.Subjects with any known sleep problem, oro-nasal disease, head injury and not willing to participate in the study were excluded from the study. Subjects with known case of any chronic illness (like diabetes, hypertension, chronic respiratory disease, etc.) were also excluded from study. Written consent was taken from all subjects after ethical clearance**(No.: 2651/R.Cell-72)** from institutional ethical committee.

The sample size was calculated using the formula $n = z^2pq / e^2$, considering the prevalence of subjective poor sleep quality (p) as 3%[19]. q as (1−p), an estimated error (e) of 5%, and a differential coefficient (z) of 1.96, as the frequency of PTT arousals or microarousals reflects sleep quality.

Data collection: Data collectors and outcome assessors were blinded that is they were unaware of whether a participant is a case or a control. Complete clinical evaluation of subjects was done on the basis of preformed proforma. Anthropometric measurements like height, weight, BMI and BP were taken by trained nursing staff. Sleep quality was assessed by Pittsburgh sleep quality index (PSQI) [20]. PTT indices and respiratory indices were measured by full night polysomnography. Day time sleepiness was measured by Epworth sleepiness score (ESS) [21].

Data analysis: The Statistical Package for Social Sciences (SPSS, version 21) was used for data analysis. Data were summarized as mean ± SD. Karl-Pearson's correlation coefficient between PTT indices and respiratory indices with BMI was calculated with a p-value < 0.05 considered significant.

Results

Baseline characteristics of study subjects according to their BMI are presented in table 1. Though the mean age of group 1 was slightly higher than group 2 but not differed (p> 0.05) statistically. The statistically significant difference (p< 0.05) was found in weight and pulse transit time deceleration index in study subjects of both groups. Mean value of PSQI score was higher in subjects with high BMI that is subjects with high BMI showing poor quality of sleep. Mean value of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were higher in subjects with high BMI. Moreover, the respiratory indices were not significantly different (Supplementary material).

Table 1: Baseline characteristics of study groups

	Group1(BMI<22.9) (n=40)	Group2(BMI>23) (n=40)	p-value
Age(yrs)	20.60±1.78	20.16±0.98	0.190
Height(cm)	168.58±8.418	169.00±7.925	0.817
Weight(kg)	58.975±5.924	71.65±8.45	<0.001*
Smoking			
Yes	21(52.5%)	25(62.5%)	0.497
No	19(47.5%)	15(37.5%)	
Tobacco			
Yes	8(20%)	9(22.5%)	0.785
No	32(80%)	31(77.5%)	
Alcohol			
Yes	26(65%)	23(57.5%)	0.646
No	14(35%)	17(42.5%)	
PTTdecindex	59.80±23.55	72.37±20.55	0.013*
AveragePTT(ms)	291.55±15.099	297.10±15.88	0.113
ESS	8.55±4.5457	8.65±4.365	0.920
PSQIScore	7.025±2.3148	8.90±2.1815	<0.001*
SBP(mmHg)	123.50±5.95	126.40±7.58	0.061
DBP(mmHg)	78.35±5.83	80.75±5.52	0.063
MAP(mmHg)	93.6±5.09	95.97±4.72	0.040*

Data are represented as mean ± standard deviation and n (%); *significant (p < 0.05); BMI: Body mass index; PTT dec index: Pulse transit time decelerationindex; Res PTT Index: Respiratorypulse transit time index; ESS: Epworth sleepiness score; PSQI: Pittsburgh Sleep Quality Index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; Yrs: Years; cm: centimetre; hrs: hours; kg: kilograms; ms: millisecond; mmHg: millimeters of mercury.

Supplementary Material

Respiratory indices between groups

	Group1(BMI<22.9) (n=40)	**Group2(BMI>23) (n=40)**	**p-value**
ResPTT Index	14.91±19.295	12.895±19.887	0.647
Flowlimitation PTT Index	0.115±0.354	0.1375±0.390	0.788
SnorePTTIndex	36.13±19.052	27.787±18.83	0.052
Aponeaindex	3.43±8.053	7.24±15.445	0.171
Hpopneaindex	25.755±29.007	21.565±21.37	0.464
Flowlimitationindex	0.6175±0.9818	0.8025±1.10	0.430
Numberof Desaturation<90%	74.3250±118.818	69.625±126.918	0.865

There was a significant negative correlation (p=0.035) between the PTT dec index and body mass index. Whereas was Average PTT (ms), Res PTT Index, Flow limitation PTT Index was not significantly correlated with body mass index (Table 2)

Table 2: Correlation between Pulse transit time indices and Body mass index

	Karl-Pearson'scorrelationcoefficient	**p-Value**
PTTdecindex	-0.237*	0.035
AveragePTT(ms)	0.138	0.223
ResPTT Index	-0.045	0.691
Flowlimitation PTTIndex	0.179	0.113

***Correlation is significant at the 0.05 level (2-tailed); PTT dec index: Pulse transit time deceleration index; Res PTT Index: Respiratory pulse transit time index; ms: millisecond**

Hypopnea index was negatively correlated with BMI. Aponea index, flow limitation index and number of desaturations < 90% per hour were positively correlated with BMI but the correlation was not significant. More is BMI of a subject higher is the number of aponea and SpO2< 90% per hour (Table 3).

Table 3: Correlation between Respiratory indices and Body mass index

	Karl-Pearson's correlation coefficient	**p-Value**
Aponea index	0.162	0.152
Hypopnea index	-0.051	0.651
Flow limitation index	0.184	0.102
Number of Desaturation <90%	0.01	0.928

Table 4 shows the correlation between blood pressure indices and BMI. SBP, DBP and mean arterial pressure (MAP) were not significantly correlated with BMI in group 1 and group 2.

Table 4:Correlation between blood pressure and body mass index

	Group 1		**Group 2**	
	Karl-Pearson's correlation coefficient	**p-Value**	**Karl-Pearson's correlation coefficient**	**p-Value**
SBP (mmHg)	-0.087	0.592	-0.106	0.516
DBP (mmHg)	-0.130	0.425	0.137	0.399
MAP (mmHg)	-0.107	0.512	0.050	0.758

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; MAP: Mean arterial

Pressure; mmHg: millimeters of mercury

Table 5 shows the correlation between Blood pressure indices and PTT deceleration index. SBP and DBP were positively and significantly ($p < 0.05$ and $p < 0.001$ respectively) correlated with PTT deceleration index whereas MAP was negatively correlated with PTT deceleration index but this correlation was not statistically significant in group 1. In group 2 SBP, DBP and MAP were positively correlated with PTT deceleration index and correlation of DBP with PTT deceleration index was statistically significant ($p < 0.001$).

Table 5:Correlation between Blood pressure and PTT deceleration index

	Group 1		Group 2	
	Karl-Pearson's correlation coefficient	**p-Value**	**Karl-Pearson's correlation coefficient**	**p-Value**
SBP (mmHg)	0.481*	0.002	0.127	0.433
DBP (mmHg)	0.707*	<0.001	0.634*	<0.001
MAP (mmHg)	-0.096	0.556	0.00	0.996

* Correlation is significant at the 0.05 level (2-tailed); SBP: Systolic blood pressure; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; mmHg: millimeters of mercury

Discussion

In the present study, subjects with higher BMI had higher mean systemic BP values compared with those having lower BMI. The Framingham Heart Study's risk estimates indicate that BMI directly contributes to the development of essential hypertension in both men and women[22]. The marked sympathetic activation observed in obese individuals may be one of the factors facilitating long-term development of hypertension[23,24,25]. Mean PSQI values were higher in Group 2 subjects, i.e., individuals with high BMI. Previous studies have confirmed a strong association between poor sleep quality, elevated BP, and higher BMI[26,27,28]. We discovered a positive correlation between all respiratory indices and BMI, with the exception of the hypopnea index. A strong association of high blood pressure and respiratory indices with BMI—among both adults and children—has been well documented in earlier literature, and such an association is attributed to micro-arousals associated with apnea or hypopnea, which trigger transient bursts of sympathetic activity that elevate BP[25]. Our findings are consistent with recent evidence from PTT-based sleep research. A previous study demonstrated that the pulse transit time (PTT) arousal index increases proportionately with sleep-disordered breathing severity and correlates strongly with the apnea-hypopnea index (AHI) and respiratory disturbance index (RDI), confirming that PTT is a sensitive marker of autonomic surges during respiratory events[29]. Similarly, a study found that the PTT drop index shows strong correlations with AHI, the arousal index, and the oxygen desaturation index and significantly improves with CPAP therapy, emphasizing its diagnostic usefulness[30]. A previous study established a significant inverse relationship between PTT and SBP, with considerable variability in the slope among individuals, indicating differences in vascular characteristics[31]. The heightened arterial stiffness and sympathetic activation reduce pulse transit time (PTT) by increasing pulse wave velocity, which aligns with the patterns identified in our BMI groups[32]. Finally, the intricate relationships between BMI and blood pressure in young adults occasionally reveal negative correlations with pulse pressure attributed to vascular remodeling[33], which corresponds with the subtle blood pressure trends observed in our study. Although there was a negative correlation between the PTT deceleration index and the BMI in general, the findings of the study indicated that the mean PTT deceleration index was greater in those who had a higher BMI. A negative correlation exists between BMI and the PTT deceleration index; this inverse relationship indicates underlying vascular and autonomic adaptations rather than a consistent directional change. In individuals with elevated BMI, initial increases in arterial stiffness and baseline sympathetic tone decrease pulse transit time, leading to reduced PTT values and thereby contributing to the negative correlation[33,34].There was a positive correlation between increased blood pressure and both a greater body mass index (BMI) and a higher PTT deceleration score. The repeated sympathetic surges associated with sleep arousals are responsible for the higher mean PTT deceleration index[34]. Since both higher BMI and micro-arousals are linked to increased sympathetic activity, it may be suggested that young adults presenting with high BMI should undergo a thorough subjective sleep health evaluation, and if clinically indicated, full-night polysomnography should be advised to identify micro-arousals. Such early detection may help prevent the future development of hypertension.

Limitations: The present study was not without limitations. First, as the sample was limited to an urban population, its generalization to a rural population is restricted. Second, the present study has a relatively smaller sample size. Third, it was a single-center study. Therefore, we need multicentric studies with large sample sizes to further generalize the results.

Conclusions

In conclusion, the present study has demonstrated that subjects with higher BMI show poor sleep quality, higher frequency of micro- arousals as demonstrated by PTT indices and positive correlation with systemic blood pressure. Based on the above findings, screening for sleep-related disturbances may be advisable in normotensive adults with increased BMI to facilitate early detection and intervention.

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