

## A comparative analysis of rate pressure product between prehypertensives and normotensives and its correlation with body mass index

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### Abstract

**Introduction:** An escalating global epidemic of overweight and obesity had contributed to a significant increase in the prevalence of prehypertension wide across the nation. While the autonomic imbalance in pre-hypertensives has been extensively studied, the association of rate pressure product as a marker of myocardial oxygen consumption, with cardiovascular dysfunction in pre-hypertensives has received less attention. The present study aimed at comparing the rate pressure product between prehypertensives and normotensives and to measure its correlation with body mass index.

**Materials and methods:** About 100 male study participants in the age group of 18-23 years were recruited for the present cross sectional study and were classified into pre-hypertensives and normotensives depending on their blood pressure measurements. Rate pressure product was measured as a product of systolic blood pressure and heart rate. The results were compared between pre-hypertensives and normotensives and also within the subgroups based on their body mass index.

**Results:** The rate pressure product was significantly higher among pre-hypertensives compared to the normotensives, with a highest value among overweight pre-hypertensives ( $p < 0.0001$ ). The rate pressure product also showed a significant positive correlation with body mass index only in pre-hypertensives.

**Conclusion:** Thus rate pressure product, as a simple non-invasive measure of myocardial oxygen consumption, could be used for early detection of hemodynamic stress in young individuals with prehypertension and the cardiovascular risk with prehypertension may be linked to the rate pressure product and level of body mass index.

**Keywords:** Body mass index, Normotensives, Pre-hypertensives, Rate Pressure Product

### Introduction

Hypertension and obesity are the major modifiable risk factors for cardiovascular diseases. The prevalence of high blood pressure and high body mass index in India has been estimated around 25.4 % and 18.9% respectively and the World Health Organization has aimed at 25% reduction in the mortality due to cardiovascular diseases<sup>[1]</sup>. The Seventh Report of the Joint National Committee (JNC) on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC-7), defined a new category based on blood pressure (BP) level, called Pre-hypertension<sup>[2]</sup>. Prehypertension can be considered as a precursor of clinical hypertension, and this was defined to create awareness and to motivate life style modification among the general population, thereby prevent the onset of hypertension. With the increasing epidemic of overweight and obesity, the prevalence of prehypertension had shown a gradual rise wide across the nation, particularly among the younger age group<sup>[3,4]</sup>. Compared to the normotensives, prehypertensives are more likely to progress to established hypertension and experience premature clinical cardiovascular disease<sup>[5]</sup>. Body mass index has been attributed as an independent risk factor for cardiovascular diseases in pre-hypertensives<sup>[6]</sup>. Thus

prehypertension can be considered as an emerging risk factor for adverse cardiovascular events.

The rate pressure product (RPP) is a reliable index that best correlates with the myocardial oxygen demand and blood flow<sup>[7,8]</sup>. It is a simple non-invasive method of measuring the oxygen demands of the heart. It has also been considered a reliable determinant of cardiovascular diseases in patients with hypertension<sup>[9]</sup>. Prehypertension has been identified to be associated with increased arterial stiffness, left ventricular hypertrophy and increased peripheral resistance even at a younger age group<sup>[10]</sup>. These hemodynamic changes in the pre-hypertensives may compromise their myocardial oxygen consumption and blood flow<sup>[11]</sup>, which may be made evident by the measurement of rate pressure product. Increased adiposity as recorded with higher body mass index has also been suggested to be associated with higher rate pressure product<sup>[12,13]</sup>.

Thus prehypertension is an emerging social threat, which is associated with autonomic and hemodynamic changes. While the autonomic dysfunction has been extensively studied in the pre-hypertensives<sup>[14,15]</sup> the variation in rate pressure product as a marker of myocardial oxygen demand in prehypertension has received less attention. Coincident prehypertension and higher body mass index always carry an increased risk of cardiovascular morbidity. So the present study aimed

to compare the rate pressure product between pre-hypertensives and normotensives and their correlation with the body mass index in young individuals.

### Materials and Methods

The present cross sectional study was carried out at the research laboratory in the department of physiology of our institution. After obtaining permission from the institutional ethical committee, 100 male study participants in the age group of 18-23 years were recruited for the study, based on the inclusion and exclusion criteria. Females, subjects with systolic blood pressure >140 mmHg, diastolic blood pressure > 90 mmHg, subjects with ongoing medical illness or any drug treatment were excluded from the study. As cardiovascular functioning is known to show variation with various phases of menstrual cycle<sup>[16]</sup>, females were excluded from the present study. Informed consent was obtained from all the study participants. After obtaining medical history, a thorough physical examination was performed on all the study participants. All demographic details were recorded through a structured questionnaire. Then the anthropometric measurements like height, weight were recorded in all the study participants. Body Mass Index (BMI) was calculated as the ratio of weight and square of height in meters, using Quetelet Index. Blood pressure was measured in the right arm in the supine position using a standard mercury sphygmomanometer after a 10-minute rest period. Three measurements were taken at 5 minutes interval and the mean of three measurements was considered for analysis. ECG was recorded in Lead II in all the study participants (using CARDIOART 6108, BPL ltd, Kerala) and heart rate was calculated as 1500/RR interval. Rate pressure product (RPP) was calculated using the formula SBP (systolic blood pressure) x heart rate. Individuals with systolic blood pressure (SBP) <120mmHg, diastolic blood pressure (DBP) < 80mmHg were classified as normotensives. Individuals with systolic blood pressure between 120-139mmHg and/ or diastolic blood pressure between 80-89mmHg were classified as pre-hypertensives.

Based on the blood pressure measurements the study participants were divided into two groups as follows:

Group 1: Normotensives

Group 2: Prehypertensives

Each group was further divided into two subgroups based on their body mass index as with normal BMI (18.5 -24.99) and high BMI (Overweight - 25 -29.99).

**Statistical analysis of the data:** Results were expressed as Mean±S.D. The level of significance was tested between prehypertensives and normotensives using unpaired t test. One way ANOVA was used for comparison of means between the subgroups. The association between BMI and RPP was assessed by Pearson's correlation test among prehypertensives and

normotensives. p value <0.05 was considered statistically significant. SPSS version 20 was used for statistical analysis.

### Results

Table 1 displays the basal characteristics of the study participants. The mean age of the study participants was 20.06±1.93 and the mean BMI was 23.23±2.85.

Table 2 shows the comparison of the measured variables between the normotensives and pre-hypertensives. All the measured parameters like BMI, SBP, DBP, HR and RPP except age were significantly higher among the pre-hypertensives compared to the normotensives (p < 0.0001).

Table 3 shows the comparison of the variables between normotensives and pre-hypertensives with normal and higher BMI (Overweight). SBP and DBP were significantly higher in overweight pre-hypertensives compared to the normotensives with normal and higher BMI (p < 0.0001). However there was no statistically significant difference between the SBP and DBP between normal and overweight pre-hypertensives. RPP was significantly higher among the overweight pre-hypertensives compared to the normal and overweight normotensives. However there was no statistically significant difference in the RPP between normal and overweight normotensives. Similar results were observed with the heart rate.

Table 4 shows the correlation between BMI and RPP in pre-hypertensives and normotensives. A positive correlation was observed between RPP and BMI in both normotensives and pre-hypertensives however it was statistically significant only with pre-hypertensives.

**Table 1: Baseline characteristics of the study participants**

Variables	Values
n	100
Age (yrs)	20.06±1.93
BMI	23.23±2.85
SBP (mmHg)	115.66±9.74
DBP (mmHg)	75.64±6.89
HR (Beats/min)	73.15±7.41
RPP	8494.82±1347.91

Values expressed in Mean ± S.D. n – Number of study participants, BMI –Body mass index, SBP – Systolic blood pressure, DBP – Diastolic blood pressure, HR – Heart rate, RPP – Rate pressure product

**Table 2: Comparison of the variables between the prehypertensives and the normotensives**

Variables	Normotensives	Prehypertensives
n	62	38
Age (yrs)	19.95±1.87	20.23±2.03
BMI	22.41±2.88	24.57±2.26*
SBP (mmHg)	110.41±7.49	124.21±6.35*
DBP (mmHg)	71.64±5.30	82.15±3.23*
HR (Beats/min)	69.09±3.37	79.76±7.47*
RPP	7634.45±634.24	9898.57±966.42*

Values expressed in Mean ± S.D. \* p < 0.0001

n – Number of study participants, BMI –Body mass index, SBP – Systolic blood pressure, DBP – Diastolic blood pressure, HR – Heart rate, RPP – Rate pressure product

**Table 3: Comparison of the variables between the prehypertensives & the normotensives with normal & higher BMI**

Groups	n	SBP	DBP	HR	RPP
1a	47	108.97 ± 7.98	71.27 ± 5.34	69.23 ± 3.45	7552.17 ± 674.37
1b	15	114.93 ± 2.49*	72.80 ± 5.17	68.66 ± 3.17	7892.26 ± 405.63
2a	22	123.54 ± 5.95*#	82.45 ± 3.26*#	77.77 ± 5.98*#	9600.36 ± 766.82*#
2b	16	125.12 ± 6.96*#	81.75 ± 3.25*#	77.77 ± 5.98*#	10308.62 ± 1082.04*##

Values expressed in Mean ± S.D. \*p < 0.0001, \* - Between 1a and 1b,2a,2b, #p < 0.0001 - Between 1b and 2a, 2b, †p < 0.0001 - Between 2a and 2b, 1a – Normotensives with normal BMI, 1b – Overweight normotensives, 2a – Prehypertensives with normal BMI, 2b - Overweight prehypertensives, n – Number of study participants, SBP – Systolic blood pressure, DBP – Diastolic blood pressure, HR – Heart rate, RPP – Rate pressure product

**Table 4: Correlation between BMI & RPP in prehypertensives & normotensives**

Groups	RPP	
	r	p value
Normotensives	0.248	0.05
Prehypertensives	0.378	0.019*

## Discussion

In the present study about 38% of the study participants had prehypertension. The mean BMI of the prehypertensives were significantly higher than the normotensives. Further 42% of the prehypertensives in our study population were overweight individuals. These results indicate that a higher body mass index may significantly contribute to prehypertension in young individuals<sup>[6]</sup>. The basal heart rate was significantly higher among the prehypertensives compared to the normotensives. This may be a sign of reduced vagal tone among the prehypertensives compared to the normotensives. Similar results were

observed by Pal GK et al in his two studies, where they concluded that vagal withdrawal was predominant in prehypertensives with higher BMI<sup>[15,17]</sup>. Similarly in our study, analysis of the variables within the subgroups revealed a higher heart rate in the overweight prehypertensives compared to the other three groups, despite the absence of significant difference in the SBP and DBP between normal and overweight prehypertensives.

Rate pressure product is an indirect yet a reliable measure of the oxygen consumption of the heart in normal as well as individuals with ischemic heart disease<sup>[7,8]</sup>. It is obtained as the product of systolic blood pressure and heart rate and thus is a sign of work load of the heart. Further rate pressure product may be used as a surrogate marker for heart rate variability, in the absence of HRV indices<sup>[18]</sup>. The results of the present study revealed a significant increase in rate pressure product in the prehypertensives compared to the normotensives. These results were consistent with that of other studies<sup>[15,17,19]</sup>. This increased rate pressure product indicates a heightened myocardial oxygen demand in prehypertensives. The enhanced myocardial oxygen demand could be attributed to the increased arterial stiffness and ventricular hypertrophy in the prehypertensives<sup>[10,11]</sup>. These hemodynamic derangements in the prehypertensives may pose them with an increased cardiovascular risk in the future.

A significant positive correlation was observed between the body mass index and rate pressure product in prehypertensives, compared to the normotensives. Parkhad SB observed a significant positive correlation between BMI and RPP in both the genders<sup>[12]</sup>. However Ravisankar P et al observed a modest statistically insignificant positive correlation between body mass index and rate pressure product<sup>[20]</sup>. Also in our study the increase in rate pressure product was predominantly higher in overweight prehypertensives compared to the other three subgroups. These results convey a significant influence of body mass index on rate pressure product, particularly in prehypertensives. Studies by Anupama N et al and Kanthe PS et al had shown similar results<sup>[21,22]</sup>.

Higher body mass index may play an important role in the pathogenesis of autonomic dysfunction<sup>[23]</sup>. Excess adiposity may cause accumulation of lipids in the non-adipose tissue and may cause cardiac dysfunction through lipotoxicity<sup>[24]</sup>. Rajalakshmi R et al had observed an increased rate pressure product in overweight and obese individuals signifying increased myocardial oxygen consumption in these individuals even at rest<sup>[25]</sup>. Thus prehypertension with coexistent higher body mass index is significantly associated with increased myocardial oxygen consumption and hence more vulnerable to cardiovascular risks. As yoga, regular exercise training has been reported to enhance the vagal tone,<sup>[11,26]</sup> intervention in the form of life style

modifications may be suggested for the prehypertensives.

### Conclusion

The results of the present study indicate a higher rate pressure product in the prehypertensives, particularly in those with higher body mass index. Thus it can be concluded that prehypertensives experience a larger hemodynamic stress compared to the normotensives even at rest, with a significant contribution from higher body mass index. These subtle hemodynamic changes need to be taken into concern to prevent overt cardiovascular complications in the future. Thus rate pressure product could be considered a sensitive non-invasive index of the status of coronary perfusion and the competency of the myocardium in young individuals. Further it is suggested that the young individuals should be subjected to frequent screening for prehypertension, and the high risk individuals need to be suggested with interventional programs like Yoga to achieve a better autonomic homeostasis.

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**Conflict of interest:** Nil

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