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Original Research Article

Prevalence of Obesity and Its Association with Rate Pressure Product among the Rural Population: A Community-Based Cross-Sectional Study.

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Abstract: ***Background:*** Obesity is an emerging public health challenge and a major contributor to cardiovascular morbidity. Rate Pressure Product (RPP), derived from systolic blood pressure and heart rate, is a simple non-invasive indicator of myocardial oxygen demand and cardiac workload. Evidence regarding the association between obesity and RPP among the rural population remains limited. ***Objectives:*** To estimate the prevalence of obesity among the rural population using anthropometric indices and to assess its association with Rate Pressure Product. ***Materials and Methods:*** A community-based cross-sectional study was conducted among 300 adults aged ≥18 years residing in the Rural Health Practice Area of Index Medical College, Hospital and Research Centre, Indore after the approval from Institutional Ethical Committee (IEC/IMCHRC/2024/45). Participants were selected using a multistage random sampling technique from 10 randomly selected villages. A pre-tested semi-structured questionnaire was used to collect socio-demographic and clinical information. Anthropometric measurements including body mass index (BMI), waist circumference, and waist-hip ratio were recorded using standard procedures. Blood pressure and heart rate were measured under standardized conditions, and Rate Pressure Product was calculated as systolic blood pressure × heart rate. Data were analyzed using appropriate descriptive and inferential statistical tests, with $p<0.05$ considered statistically significant. ***Results:*** Among the 300 study participants, 21% were obese, 8% were overweight, and 62% had normal BMI. Increased waist-hip ratio suggestive of central obesity was observed in 42% of participants. Obese individuals had significantly higher systolic blood pressure, diastolic blood pressure, heart rate, and Rate Pressure Product than non-obese individuals ($p<0.001$). The prevalence of elevated RPP (≥7000) was 34% overall and increased substantially among obese participants. Positive associations were observed between obesity-related anthropometric indices and Rate Pressure Product. ***Conclusion:*** Obesity was common among the rural population and was significantly associated with increased Rate Pressure Product, indicating greater myocardial workload. Simple anthropometric assessment along with RPP estimation may be useful for early identification of individuals at increased cardiovascular risk in community settings.

Keywords: Obesity, Rate Pressure Product, Body Mass Index, Anthropometric Indices, Rural Population, Cardiovascular Risk.

INTRODUCTION

Excess body weight, often known as overweight and obesity, has emerged as a major public health concern in the modern age. It is now understood to be a multifaceted, chronic metabolic condition with considerable consequences for cardiovascular morbidity and mortality." Once seen to be a sign of wealth, obesity has spread to low- and middle-class nations, including India, due to rapid urbanization, sedentary or inactive lifestyles, harmful dietary changes, and psychological pressures.[4–6].

The World Health Organization (WHO) estimates that since 1970's, the global frequency of obesity has become nearly three times, with approx 600 million adults classified as obese[7]. In India, the load of obesity is snowballing at an alarming pace, particularly among youngsters and middle-aged adults, contributing noticeably to the intensifying prevalence of non-communicable diseases (NCDs)[8–10].

Obesity exerts a multilayered influence on cardiovascular functioning through structural, metabolic, and autonomic mechanisms. Excess adiposity is linked with amplified blood volume, raised cardiac output, heightened sympathetic activity, insulin resistance, systemic swelling, endothelial dysfunction, and arterial stiffness[11–14]. These pathophysiological modifications impose an augmented hemodynamic weight on the heart, disposing individuals to heart failure, coronary artery disease, hypertension and sudden cardiac death[15–17]. Therefore, detecting simple, consistent, and non-invasive pointers of cardiovascular stress in obese individuals is of chief rank for premature risk stratification and preventive intervention.

The Rate Pressure Product (RPP), also stated to as the double product, is calculated as the product of heart rate (HR) as well as blood pressure of systolic component(SBP) and aids as an indirect guide of myocardial oxygen consumption (MVO_2)[18,19]. Since myocardial oxygen demand is principally determined by heart rate, wall stress and contractility, RPP delivers a practical and non-invasive substitute measure of myocardial capacity both at rest and during presence of triggers or stress[20]. Under resting circumstances, a normal RPP typically ranges up to 12 ($\times 10^3$), while values may surge significantly during physical or psychological activity or stress[21]. Raised up RPP at rest has been related with augmented cardiovascular risk, subclinical myocardial straining, and contrary cardiovascular consequences even in apparently healthy people[22–24].

From a physiological standpoint, RPP imitates the internal effort of the myocardium, as contrasting to external work measured during exercise performance[25]. Its reproducibility, simplicity and strong connection with direct measures of myocardial oxygen consumption have made RPP a valuable parameter in both research settings and clinical practice[26]. There is substantial clinical and public health significance to comprehending the connection between RPP and obesity. Numerous longitudinal studies have established the predictive value of RPP in forecasting cardiovascular morbidity and mortality in healthy people as well as in patients with ischemic heart disease[27–29]. Research on the relationship between Rate Pressure Product (RPP) and anthropometric indices in Indian populations is still comparatively rare, despite the growing body of data connecting obesity to adverse cardiovascular outcomes. Thus, the present study aims to estimate the prevalence of obesity among the rural population using anthropometric indices and to assess its association with Rate Pressure Product.

Objectives

1. To estimate the prevalence of obesity among the rural population using anthropometric indices.
2. To assess the association between obesity and Rate Pressure Product (RPP) among the rural population.

MATERIALS AND METHODS

STUDY DESIGN: Community based Cross-sectional study.

STUDY CENTRE: This study was conducted in Rural Health practice area of Index Medical College, Hospital and Research Centre, Indore.

DURATION OF THE STUDY: Duration of study was 18 months after clearance from the Institutional Ethical Committee.

STUDY POPULATION:

This was a Community Based Cross sectional study, where the study population was randomly selected from general population covered under Rural Health field practice area of Index Medical College, Hospital and Research Centre Indore.

Inclusion Criteria

- Age: >18 yrs.
- Both male and female subjects
- For obese subjects: BMI ≥25 and for non obese subjects: BMI 18.5 to 24.9
- Study subjects with Co morbid conditions like Hypertension, Diabetes etc
- Study subjects who gave consent to participate in the study.

Exclusion Criteria

- Age: <18 yrs
- Subjects with BMI < 18.5
- Study subjects having diseases other than mentioned in inclusion criteria.
- Study subjects who did not provide consent to participate in the study.

SAMPLE SIZE:
From previous study, the sample size was calculated using the prevalence of Obesity in India which was 24.9 %
(reference-doi: 10.1177/0972753120987465)
Sample size is calculated using the standard formula:

$$n_0 = \frac{Z^2 \cdot p \cdot (1-p)}{e^2}$$

Here
- z= Critical value forgiven α.
- p= Prevalence of obesity.
- e= Desired margin of error.

We have
- z= 1.96
- p= 0.249 (24.9%)
- e=0.05 (5%)

The final sample size for the given study was 300

SAMPLING METHOD:
Multistage Random Sampling technique was used.
Total 30 villages are covered by the Rural Health practice area of Index Medical College, Indore.
Using simple random sampling technique, 10 villages were selected.
From each of the selected village, 30 subjects were selected from each village by using simple random sampling technique from voter list of the respective villages.

DATA COLLECTION AND METHODS:
- Informed written consent and ethical clearance was obtained prior to data collection.
- Study protocol was explained to the study subjects.
- A pre-tested, pre-designed semistructured questionnaire comprising of sociodemographic details, Medical history and relevant clinical examination was used to collect data from those participants fulfilling the study inclusion criteria.
- Blood pressure and other clinical praameters measurement and anthropometric measurements were done as per the standard protocol.
- The subjects were matched for age and sex and were classified into
- Underweight (< 18.5)
- normal BMI from (18.5 to 22.9),
- overweight (BMI from 23 to 24.9) and
- obese (BMI >25) using WHO Asia Pacific guidelines for classification of obesity.

Socio-Demographic Details
Age, gender, marital status, socioeconomic status etc.

Anthropometric measurements:
Assessment of Weight (kg) was done in light clothing without shoes using calibrated weighing machine to the nearest 0.5 kg. Hip circumference (HC) was measured transversely around the widest portion of the buttocks.

Calculation of Anthropometric indices of Obesity:
The following obesity indices were calculated using the following formula:
- Body Mass Index (BMI) = Weight (kg) / Height (m2)
- Waist to Hip ratio (WHR)= WC (cm)/HC (cm)
- Blood Pressure measurements:

For determination of RPP, Blood pressure (BP) was measured after 5 minutes of rest in a seated position using standardized and calibrated sphygmomanometer with appropriate size of cuff applied to the right upper arm. Two readings with an interval of one minute were recorded. Mean of last two readings was used as final measurement.
- Calculation of HR:

It was recorded in supine position with continuous electrocardiographic (ECG) on standard limb lead-II. The R-R interval was measured on ECG with a ruler,
- Calculation of Rate Pressure Product (RPP):

The following formula was used for its calculation:
RPP = HR × SBP
SBP: Systolic BP in mmHg
HR: Heart rate in beats per minutes
The value thus obtained was expressed as mmHg beats per min.

RESULTS
Majority of participants were in the **18–39 years age group (46%)**, reflecting a younger adult population in the rural field practice area. The study population had a **slightly higher proportion of males (52%)**. About **two-thirds of the subjects were married (66%)**, Unmarried participants (34%) were mostly in younger age groups (18–29 years). Majority of the rural participants belonged to **lower middle (34%) and upper lower (30%) SES.**

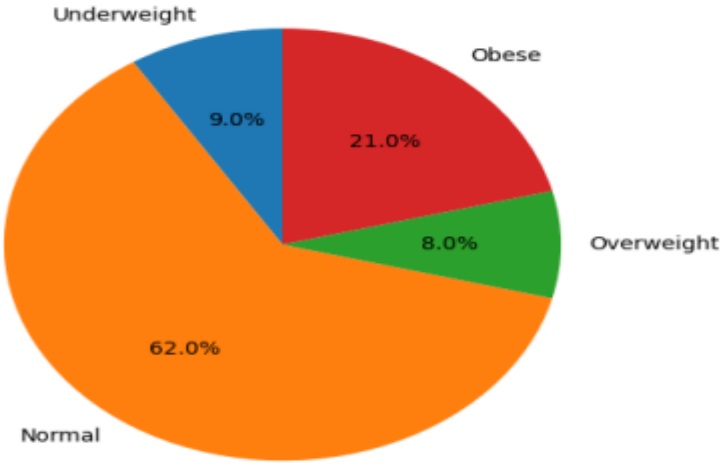

Figure 1: Distribution of study subjects according to the BMI (Asia-pacific classification)

Interpretation: Majority of rural adults (62%) had normal BMI. Obesity prevalence was **21%**, and overweight 8%, consistent with published rural Indian studies. Underweight (9%) represents a smaller but notable rural population.

Majority (66%) had WC <90 cm, within normal/low-risk limits. Elevated WC ≥90 cm seen in **38%**, corresponding mostly to overweight/obese subjects. HC ≥100 cm was 18%, mostly in obese group. 42% had increased WHR, indicating central obesity and higher risk for cardiovascular complications.

Table 1: Systolic Blood Pressure (SBP) Classification (as per WHO) (n=300)

SBP Category (mmHg)	Frequency	%
Normal (<120)	120	40
Pre-Hypertension (120–139)	96	32
Stage 1 HTN (140–159)	54	18
Stage 2 HTN (≥160)	30	10
Total	300	100

Interpretation: 28% of rural adults had SBP ≥140 mmHg (Stage 1 + Stage 2), indicating significant hypertension prevalence. Normal SBP was seen in 40%, and pre-hypertension in 32%.

Table 2: Diastolic Blood Pressure (DBP) Classification (as per WHO) (n=300)

DBP Category (mmHg)	Frequency	%
Normal (<80)	156	52
Pre-Hypertension (80–89)	84	28
Stage 1 HTN (90–99)	42	14
Stage 2 HTN (≥100)	18	6
Total	300	100

Interpretation: Elevated DBP (≥90 mmHg) was seen in **20% of participants**, mostly corresponding to obese subjects. Pre-hypertension (28%) indicates a high-risk group for future cardiovascular complications.

Table 3: Heart Rate (HR) Distribution (n=300)

HR (bpm)	Frequency	%
<70	72	24
70–79	102	34
80–89	84	28
≥90	42	14
Total	300	100

Interpretation: Mean HR in rural adults was higher in obese subjects (84.6 bpm) vs non-obese (76.8 bpm). 14% had tachycardia (≥90 bpm), reflecting increased sympathetic activity in obese/rural adults with comorbidities.

Table 4: Rate Pressure Product (RPP) Distribution (n=300)

RPP Category	Frequency	%
<7000	198	66
≥7000	102	34
Total	300	100

Interpretation: 34% of participants had **elevated RPP (≥7000)**, indicating increased myocardial oxygen demand and cardiac workload. High RPP prevalence is higher in obese subjects (approx. 60% of obese participants) vs non-obese (20%).

Table 5: Mean Hemodynamic Parameters: Obese vs Non-Obese

Parameter	Non-Obese (n=213)	Obese (n=63)	p-value
Mean SBP (mmHg)	122.4 ± 10.5	138.8 ± 12.6	<0.001
Mean DBP (mmHg)	78.6 ± 8.2	86.4 ± 9.1	<0.001
Mean HR (bpm)	76.8 ± 9.2	84.6 ± 10.1	<0.001
Mean RPP	6548 ± 820	7856 ± 950	<0.001

Interpretation: Obese subjects had significantly higher SBP, DBP, HR, and RPP than non-obese **(p<0.001).** These findings confirm that obesity in rural adults is associated with increased cardiac workload and cardiovascular risk.

DISCUSSION

The present community-based cross-sectional study was conducted among 300 rural adults to determine the Rate Pressure Product (RPP) and assess its association with obesity. In the present study, the majority of participants belonged to the younger and middle-aged groups. Approximately 24% of participants were in the 18–29 year age group. Age-wise analysis revealed that the prevalence of elevated RPP increased progressively with advancing age, rising from 16.7% in the 18–29 year group to 33.3% among individuals aged 50–59 years. This finding indicates that myocardial workload tends to increase with age even in apparently healthy individuals. Aging is associated with physiological changes such as arterial stiffness, endothelial dysfunction, and autonomic imbalance, which contribute to increased systolic blood pressure and myocardial oxygen demand. Similar observations were reported by Singh et al.[21], who found that older adults demonstrated significantly higher resting myocardial workload due to reduced arterial compliance and increased vascular resistance. Likewise, Kannel et al.[16] reported in the Framingham Heart Study that advancing age is strongly associated with increased prevalence of hypertension and cardiovascular disease.

These findings indicate that obesity is no longer confined to a specific gender group in rural populations. Rapid lifestyle transitions, including reduced occupational physical activity and increased consumption of energy-dense foods, have contributed to the rising prevalence of obesity among both men and women. Comparable findings were reported by Misra et al.[5,28], who noted that obesity prevalence among Indian adults is increasingly similar between males and females due to shared environmental and lifestyle factors. Similarly, Prentice et al.[6] observed that developing countries undergoing nutritional transition show comparable obesity prevalence in both genders.

In the present study, BMI classification revealed that a substantial proportion of participants belonged to the overweight and obese categories. The findings indicate that the prevalence of overweight and obesity in the rural population is gradually increasing, reflecting the ongoing epidemiological and nutritional transition occurring in India. Furthermore, analysis demonstrated that participants with higher BMI showed a significantly greater proportion of elevated Rate Pressure Product compared with individuals with normal BMI. This suggests that obesity contributes to increased myocardial oxygen demand and cardiac workload even in individuals without diagnosed cardiovascular disease.

Similar findings were reported by Misra et al.[5,28], who observed that the prevalence of overweight and obesity has increased significantly among Indian adults over the past two decades. The authors reported that approximately one-third of adults in many Indian communities now fall into overweight or obese categories. They attributed this rise to rapid urbanization, changes in dietary habits, and reduced levels of physical activity. Similar observations were reported by Fox et al.[22], who demonstrated that elevated resting heart rate is significantly associated with increased risk of cardiovascular events and all-cause mortality. The authors suggested that resting heart rate reflects underlying autonomic imbalance and metabolic stress, both of which contribute to cardiovascular risk.

Likewise, Palatini et al.[23] reported that individuals with higher resting heart rate showed greater incidence of

hypertension and cardiovascular disease during long-term follow-up. Increased sympathetic activity and reduced vagal tone were proposed as possible mechanisms linking elevated heart rate with cardiovascular risk. Similar conclusions were drawn by Robinson et al.[18], who first described the concept of Rate Pressure Product as a reliable indicator of myocardial oxygen consumption during physical activity and stress testing. Their work demonstrated that RPP correlates closely with myocardial metabolic demand and can be used as a practical clinical indicator of cardiac workload.

CONCLUSION

In order to ascertain the Rate Pressure Product (RPP) and assess its correlation with obesity and associated cardiometabolic risk factors in rural adults, a community-based cross-sectional study was carried out. A straightforward yet physiologically important measure of myocardial oxygen consumption and cardiac workload is the Rate Pressure Product, which is computed as the product of systolic blood pressure and heart rate. The current study's findings demonstrate the rising prevalence of obesity and its significant effects on cardiovascular physiology, especially in rural populations that appear to be in good health.

The study showed that obesity has become a significant public health issue in rural areas as well and is no longer limited to urban populations. According to Asia-Pacific BMI criteria, 21% of participants in the current study were obese, while an additional 8% were overweight. These results suggest that rural communities are undergoing a continuous epidemiological and lifestyle shift marked by decreased physical activity, dietary modifications, and an increase in metabolic risk factors. While 62% of patients had normal BMIs, a significant percentage showed central obesity, and 42% showed an elevated waist-hip ratio. This finding emphasizes how abdominal and widespread obesity can coexist in groups that are typically thought of as physically active.

Increased myocardial oxygen demand is caused by both sympathetic hyperactivity and decreased parasympathetic tone, which are reflected in elevated resting heart rate. Since the Rate Pressure Product incorporates both heart rate and systolic blood pressure, concurrent increases in these parameters led to a markedly increased myocardial workload in obese people. Depending on the analytical classification, the prevalence of increased RPP (≥7000) varied from roughly one-fourth to one-third of the research population. Crucially, as BMI rose, the prevalence of high RPP increased dramatically. Just 11% of participants who were underweight showed higher RPP, compared to 19% of those with normal BMI, 25% of those who were overweight, and up to 52% of those who were obese.

This steady increase clearly shows that obesity is a significant factor in elevated myocardial oxygen demand. These results were further supported by comparing the mean hemodynamic parameters of obese and non-obese individuals. The mean systolic and diastolic blood pressure, heart rate, and RPP values were all significantly higher in obese people ($p<0.001$). In rural healthcare settings with minimal resources, RPP is a popular screening tool due to its ease of calculation using frequently measured measures like blood pressure and heart rate. Therefore, the results of this study highlight that obesity has important hemodynamic effects that impact cardiac workload and is not just a cosmetic or metabolic issue. Early detection of people with increased RPP through community screening programs may enable prompt lifestyle intervention, such as blood pressure control, dietary changes, and weight loss. Long-term cardiovascular morbidity and mortality may be considerably decreased by such preventive measures. The current study concludes that among rural adults, obesity and elevated cardiac workload are strongly and statistically significantly correlated.

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