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Research Article

Differential Blood Pressure among Overweight and Obese of Rural Varanasi, Uttar Pradesh, India

Ashok Kumar Yadav[1]*, Rajesh K Gautam[1] and Sarvendra Yadav[2]

[1]Department of Anthropology, Dr. Harisingh Gour Vishwavidyalaya (A Central University), Sagar, MP, India

[2]Department of Anthropology, Hemvati Nandan Bahuguna Garhwal University, Srinagar, Srinagar Garhwal, UK, India

***Corresponding Author:** Ashok Kumar Yadav, Department of Anthropology, Dr. Harisingh Gour Vishwavidyalaya (A Central University), Sagar, MP, India.

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Abstract

The escalating prevalence of overweight and obesity has become a global health concern. Particularly in developing regions, their association with cardiovascular diseases and hypertension is well-established. It is reported that there is a triple burden of nutritional disorders, with overweight individuals and those with cardiovascular disorders often found in the same household. However, limited research has focused on the differential blood pressure among overweight and obese individuals and its relationship with hypertension. Hence, this study aims to examine the differential blood pressure (BP) among overweight and obese adults in the rural areas of Varanasi, Uttar Pradesh, India, and explore its association with hypertension. To achieve this goal, a cross-sectional study was conducted in rural areas of Varanasi, Uttar Pradesh, India. A total of 998 respondents aged 18 years and above were recruited using a multi-stage random sampling technique. Anthropometric measurements, including height and body weight, were obtained. Blood pressure measurements were recorded using standard protocols. Overweight and obesity were determined using body mass index (BMI) categories, and the prevalence of hypertension was calculated using JNC-VIII classification protocols. Statistical analysis was performed to investigate the association between obesity and blood pressure outcomes. The overall prevalence of hypertension was 40.8%, which included 33.2% suffering from systolic hypertension and 48.4% suffering from diastolic hypertension. Gender-specific analysis further revealed that males exhibited higher hypertension rates than females within the same BMI categories. This gender disparity in BP suggests that males may be at a higher risk of developing hypertension and related cardiovascular complications. Significant positive associations were observed between obesity and both systolic and diastolic blood pressures ($p < 0.05$).

This study highlights a high prevalence of hypertension among the obese adult population in rural areas of Varanasi, Uttar Pradesh, India. Efforts to promote awareness about healthy lifestyles and the importance of weight management in rural communities can contribute to reducing the burden of obesity-related complications, including hypertension. Furthermore, it provides evidence of a significant association between obesity and elevated blood pressure outcomes, emphasizing the need for targeted interventions to address this public health concern.

Keywords: Obesity; Stature; Bodyweight; Blood Pressure; Nutritional Status; BMI

Abbreviations

SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; WHO: World Health Organizations; MCC: Multiple Chronic Conditions

Introduction

Overweight and obesity have become a global concern in the field of public health and are emerging as a serious issue in the 21st century [1]. The prevalence of overweight and obesity has increased significantly in recent decades [2]. In addition, previous studies have shown that the burden of nutritional disorders has tripled [3]. Individuals with obesity, malnutrition, and cardiovascular disorders can be found in the same household [4]. These conditions are associated with several health complications including cardiovascular diseases, type 2 diabetes, and hypertension [5]. In developing countries like India, rapid socio-economic changes have led to significant lifestyle changes, increasing the prevalence of overweight and obesity [6]. Despite being less urbanized, rural areas are not untouched by these trends. A substantial increase in the prevalence of overweight and obesity has been observed in the rural population of India [7]. This shift is due to dietary changes, low physical activity, and limited access to healthcare resources [8]. Understanding the prevalence and impact of overweight and obesity in these areas is important for developing effective public health strategies and interventions. Blood pressure is an important indicator of cardiovascular health, and its association with overweight and obesity is well documented [9]. High blood pressure, or hypertension, is a leading cause of morbidity and mortality worldwide, and its prevalence is increasing in rural India too [8]. Examining the relationship between body weight and blood pressure can provide insight into the broader effects of the obesity epidemic on cardiovascular health in rural areas. This study aims to find out the differential blood pressure among overweight and obese of rural areas of Varanasi, Uttar Pradesh, India, and to explore the association between body dimension, socio-demographic characteristics, and blood pressure. By identifying the extent of these issues and their interrelationship, the study seeks to inform targeted health interventions and policies to reduce health risks associated with overweight and obesity in rural India.

Materials and Methods

Study design and setting

This cross-sectional study was conducted in rural areas of Varanasi, Uttar Pradesh, India, from December 2021 to June 2022. The rural areas were chosen based on their demographic diversity and representation of the typical rural population in the region. The primary objective was to determine the prevalence of overweight and obesity among the adult population and to explore its association with blood pressure.

Study population and sampling

This study was conducted in the Sevapuri Development Block of the Rajatalab sub-division, located in the Varanasi district of Uttar Pradesh, India. Varanasi, also known as Banaras or Kashi, is one of the oldest living cities in the world. It is situated in the northern Indian state of Uttar Pradesh, on the banks of the river Ganges. Varanasi is considered the spiritual capital of India and is also known for its rich cultural heritage, vibrant festivals, and historical significance [10]. The study targeted adults aged 18 years and above residing in the selected rural areas. A multi-stage stratified random sampling method was employed to ensure a representative sample. Initially, ten villages were randomly selected from a comprehensive list of all villages in Varanasi. Within each selected village, households were chosen randomly, and one adult from each household was selected using a random selection grid.

The sample size was calculated to ensure adequate power for detecting significant differences and associations. Based on previous estimates of the prevalence of overweight and obesity in rural India [7], and assuming a prevalence rate of 30%, a confidence level of 95%, and a margin of error of 5%, the required sample size was determined to be 998 participants. This sample included 505 males and 493 females, reflecting the gender distribution in the rural population.

Data collection

Data was collected through a structured interview schedule. A comprehensive research schedule was developed to collect socio-demographic characteristics, economic status, and anthropometric, and physiological measurements. The research schedule was pre-tested in a pilot study and refined to ensure clarity and relevance. Standardized and validated tools were used throughout the data collection process to ensure consistency and reliability.

The socio-demographic section of the research schedule included questions about age, gender, category, religion, marital status, education level, occupation, household income, and socio-economic status. Anthropometric measurements including height, weight, and waist circumference were obtained. For physiological measurements, blood pressure was recorded using standard protocols. All measurements were taken following standardized procedures. Height was measured to the nearest 0.1 cm using a portable anthropometer rod, and weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale. Waist circumference was measured to the nearest 0.1 cm using a flexible, non-elastic tape measure, with the measurement taken at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). BMI categories were defined according to the World Health Organization (WHO) classification adapted for Asian populations: underweight (BMI < 18.5), normal weight (BMI 18.5–22.9), overweight (BMI 23.0–27.4), class-I obesity (BMI 27.5–32.4), class-II obesity (BMI 32.5–37.4), and class-III obesity (BMI ≥ 37.5) [1].

Blood pressure was measured using an automated digital sphygmomanometer, adhering to the Joint National Committee guidelines (JNC-VIII P). As per the JNC-VIII (2014) guidelines, hypertension is classified into several categories based on systolic and diastolic blood pressure readings. Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mm Hg and/or diastolic blood pressure (DBP) ≥ 90 mm Hg [11,12]. Participants were seated comfortably with their backs supported and feet flat on the floor for at least five minutes before the measurement. Three readings were taken at one-minute intervals on the left arm, with the arm supported at heart level. The average of the three readings was used for analysis.

Data quality control

The field investigator received extensive training in interview techniques, anthropometric measurements, and blood pressure assessments to ensure data quality and reliability. Calibration of equipment was conducted regularly. The supervisor conducted random checks and audits of the completed research schedule and measurements to promptly identify and rectify any inconsistencies or errors. Data entry was performed by trained researcher, who double-checked for accuracy. Any discrepancies were resolved through cross-referencing with the original data collection forms.

Statistical analysis

Data were entered into Microsoft Excel and subsequently analyzed using SPSS version 25.0. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize the socio-demographic characteristics, BMI, and blood pressure of the participants. The prevalence of hypertension was calculated as a percentage of the total study population. The association between male and female participants was assessed using Chi-squire statistics and BMI and blood pressure were examined using Pearson's correlation coefficient analysis. A p-value of <0.05 was considered statistically significant.

Results and Discussion

Results

Population structure and composition

Table 1 presents the frequency distribution of the socio-demographic characteristics of the respondents based on gender. A total of 12.3% of males and 8.1% of females were from the age group 18-29 years. Similarly, 27.9% of males and 22.3% of females were from the 30-39 years age group. Additionally, 29.5% of males and 32% of females were from the 40-49 years age group. Moreover, 25.9% of males and 28.6% of females were from the 50-59 years age group. Lastly, 4.4% of males and 8.9% of females were from the age group of 60 years and above.

Table 1: Frequency and percentage distribution of Socio-demographic characteristics of the respondents

Variables	**Male**		**Female**	
Age Group (Years)	N	%	N	%
18-29	62	12.3	40	8.1
30-39	141	27.9	110	22.3
40-49	149	29.5	158	32.0
50-59	131	25.9	141	28.6
60 above	22	4.4	44	8.9
Social Category				
Unreserved	110	21.8	91	18.4
Other Backward Classes	325	64.4	335	68.0
Scheduled Caste	70	13.8	67	13.6

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Religion				
Hindu	466	92.3	471	95.5
Non-Hindu	39	7.7	22	4.5
Education				
Illiterate	24	4.8	76	15.4
Literate	181	35.8	230	46.7
Primary	71	14.1	54	11
Middle	43	8.5	82	16.6
Secondary	76	15	50	10.1
Higher Education	110	21.8	1	0.2
Occupation				
Government Service	20	4	5	1
Business	158	31.3	-	-
Agriculture	227	45	78	15.8
Labor	85	16.8	-	-
Housewife	-	-	409	83
Studying	15	3	1	0.2
Marital Status				
Unmarried	25	5	2	0.4
Married	480	95	491	99.6
Socio-economic Status				
Lower Class (V)	22	4.4	235	47.7
Upper Lower Class (IV)	185	36.6	220	44.6
Lower Middle Class (III)	249	49.3	32	6.5
Upper Middle Class (II)	49	9.7	6	1.2

Ethnic composition

Among the respondents, 21.8% of males and 18.4% of females belonged to the unreserved category. A majority, 64.4% of males and 68% of females were from the other backward classes (OBC), whereas, 13.8% of males and 13.6% of females belong to scheduled caste (SC).

It is evident that 92.3% of males and 95.5% of females were Hindu. Furthermore, 7.7% of males and 4.5% of females were non-Hindu.

Educational profile

Female respondents were found to be lagging behind in their educational profile. A total of 15.4% of females were illiterate as compared to 4.8% of the males. Further, a higher proportion of females (46.7%) were simply literate as compared to 35.8% of males. Primary education was completed by 14.1% of males and 11% of females, while middle school completion was higher among females (16.6%) compared to males (8.5%). Secondary education was found higher (15%) among males than females (10.1%), and the most striking finding is that 0.2% of the females attained higher education, whereas 21.8% of males attained higher education.

Occupational profile

The findings indicate that a small percentage of males (4%) and females (1%) were in service roles. Business was a prominent occupation among males (31.3%), whereas none of the females were found in this category of occupation. A total of 45% of males and 15.8% of females were engaged in agriculture. Labor was the primary occupation for 16.8% of males, whereas none of the females were found as laborers. Further 83% of females were housewives whereas none of the males were found in this category. Only 3% of males and 0.2% of females were studying.

Marital status

Marital status data shows that a vast majority of both males (95%) and females (99.6%) were married, with a small fraction of males (5%) and an even smaller fraction of females (0.4%) being unmarried.

Socio-economic status

The distribution as per socio-economic status indicates that a higher percentage of females (47.7%) were in the lower class (V) compared to males (4.4%). The upper-lower class (IV) included 36.6% of males and 44.6% of females. The lower middle class (III) comprised 49.3% of males and 6.5% of females, while the upper middle class (II) comprised 9.7% of males and 1.2% of females.

Table 2 presents the distribution of the respondents as per their nutritional status based on body mass index (BMI). It is evident

Table 2: Distribution of the respondents according to the level of nutrition and gender.
Frequency=N; Percentage=%; Chi-square=χ2
*Chi-square is significant at ($p < 0.05$).

Nutritional Status	Male		Female		Total		χ2	Cramer's-V	p-value
	N	%	N	%	N	%			
Overweight	7	1.4	6	1.2	13	1.3	24.961	0.158	0.001*
Obese-I	306	60.6	222	45	528	52.9			
Obese-II	192	38	265	53.8	457	45.8			
Total	505	100	493	100	998	100			

that almost a similar proportion i.e. 1.4% of males and 1.2% of females were overweight and that was a total of 1.3%. A total of 52.9% of respondents were obese-I, among them 60.6% were males and 45% were females. In the Obese-II category, 38% were males and 53.8% were females, whereas the total Obese-II was 45.8%. There is a significant difference in the nutritional status of male and female respondents ($\chi2 = 24.961$, Cramer's V = 0.158, p-value = 0.001).

Table 3: Distribution of the respondents as per their Blood pressure.

Blood Pressure Status	Male		Female		Total	
Systolic Blood Pressure (SBP)	N	%	N	%	N	%
Normal	105	20.8	127	25.8	232	23.2
Pre-hypertension	235	46.5	199	40.4	434	43.5
Stage-1 Hypertension	114	22.6	105	21.3	219	21.9
Stage-2 Hypertension	51	10.1	62	12.6	113	11.3
Total	505	100	493	100	998	100
Diastolic Blood Pressure (DBP)						
Normal	96	19	93	18.9	189	18.9
Pre-hypertension	159	31.5	167	33.9	326	32.7
Stage-1 Hypertension	154	30.5	135	27.4	289	29.0
Stage-2 Hypertension	96	19	98	19.9	194	19.4
Total	505	100	493	100	998	100

The distribution of the respondents as per blood pressure category is presented in Table 3.

Systolic blood pressure (SBP)

A total of 23.2% of the respondents have a normal SBP, whereas it varies among males and females as 20.8% of males and 25.8% of females have normal SBP. A large proportion of respondents 43.5% were pre-hypertensive (46.5% of males and 40.4% of females). Further 21.9% of the respondents consisting of 22.6% of males and 21.3% of females were in stage-1 Hypertension. And, 11.3% of the total respondents including 11.3% of males and 12.6% of females were in stage-2 of Hypertension. For further elucidation and visual presentation, a bar diagram is drawn (Figure 2).

Diastolic blood pressure (DBP)

A total of 18.9% of the respondents have normal DBP and the prevalence is equal in both genders. Almost a similar proportion i.e. 31.5 % of males and 33.9% of females were pre-hypertensive whereas the prevalence of pre-hypertensive for pooled data was 32.7%.

The prevalence of hypertensive stage-1 was 29% for the pooled data; the prevalence of males was slightly higher in this category (30.5%) as compared to the females (27.4%). As per pooled data, 19.4% of the respondents were in the stage-2 of hypertension and there was almost no difference among genders. A bar diagram is drawn for further elucidation and visual presentation (Figure 3).

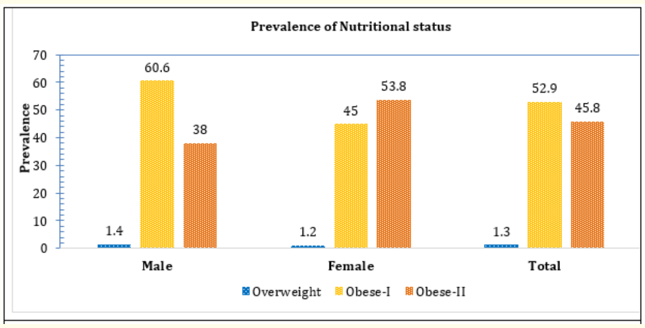

Figure 1: Shows the percentage of nutritional status of respondents.

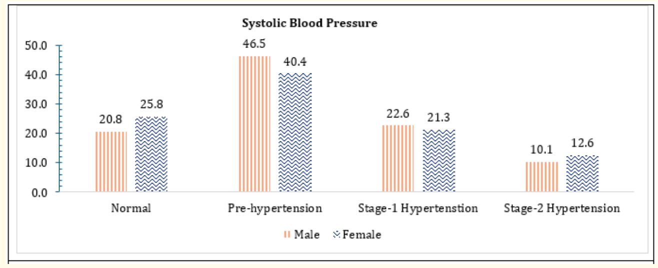

Figure 2: Bar diagram showing the distribution of respondents as per Systolic Blood Pressure.

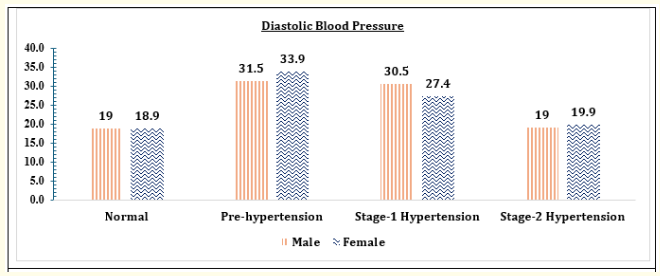

Figure 3: Shows the percentage of Diastolic Blood Pressure of respondents.

Table 4: Distribution of hypertension as per level of nutrition and gender.

Systolic Blood Pressure (mm Hg)	Male						Female					
	Overweight		Obese		Total		Overweight		Obese		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Normal	2	28.60	103	20.70	105	20.80	1	16.70	126	25.90	127	25.80
Pre-hypertension	5	71.40	230	46.20	235	46.50	3	50.00	196	40.20	199	40.40
Stage-1 Hypertension	0	0.00	114	22.90	114	22.60	0	0.00	105	21.60	105	21.30
Stage-2 Hypertension	0	0.00	51	10.20	51	10.10	2	33.30	60	12.30	62	12.60
Total	7	100	498	100	505	100	6	100	487	100	493	100.00
Diastolic Blood Pressure (mm Hg)												
Normal	2	28.60	94	18.90	96	19.00	0	0.00	93	19.10	93	18.90
Pre-hypertension	3	42.90	156	31.30	159	31.50	3	50.00	164	33.70	167	33.90
Stage-1 Hypertension	1	14.30	153	30.70	154	30.50	1	16.70	134	27.50	135	27.40
Stage-2 Hypertension	1	14.30	95	19.10	96	19.00	2	33.30	96	19.70	98	19.90
Total	7	100	498	100	505	100	6	100	487	100	493	100

The distribution of the respondents as per the level of nutrition and blood pressure is presented in Table 4.

Systolic blood pressure (SBP)

Among the male respondents, the prevalence of various blood pressure categories was analyzed in both overweight and obese individuals. In the overweight group, the prevalence of normal blood pressure was 28.60%, while pre-hypertension had the highest prevalence at 71.40%. Notably, there were no cases of Stage-1 Hypertension or stage-2 Hypertension among the overweight males. Conversely, in the obese group, the prevalence of normal blood pressure was 20.70%. Pre-hypertension was 46.20%, Stage-1 Hypertension (22.90%), and Stage-2 Hypertension (10.20%). Overall, the total prevalence of normal blood pressure for all males was 20.80%, pre-hypertension 46.50%, Hypertension stage-1 was 22.60%, and Hypertension stage-2 was 10.10%.

Among overweight females, the prevalence of normal blood pressure was 16.70%, pre-hypertension 50.00%. There were no cases of Stage-1 Hypertension among the overweight females, but Stage-2 Hypertension was found among 33.30% of overweight females. In the obese category, normal blood pressure was found among 25.90% of the females. Pre-hypertension was among 40.20%, Stage-1 Hypertension (21.60%), and Stage-2 Hypertension (12.30%).

As per pooled data of females 25.80% had normal blood pressure, 40.40% had pre-hypertension, 21.30% had Stage-1 Hypertension, and 12.60% had Stage-2 Hypertension.

Diastolic blood pressure (DBP)

Among the males, the prevalence of different diastolic blood pressure for both overweight and obese respondents is evident from Table 4. In the overweight cohort of males, the prevalence of normal diastolic blood pressure was 28.60%, while pre-hypertension was 42.90%. Stage-1 Hypertension and Stage-2 Hypertension were found equally i.e. 14.30% respectively. Among the obese males, the prevalence of normal diastolic blood pressure was 18.90%. Pre-hypertension was found among 31.30%, Stage-1 Hypertension among 30.70%, and Stage-2 Hypertension among 19.10%.

As per pooled data for males, the normal diastolic blood pressure was 19%, pre-hypertension and Stage-1 Hypertension were equally distributed i.e. 31.50%, and Stage-2 Hypertension was 19%.

Table 5: Shows the Descriptive statistics and correlation analysis between anthropometric variables and blood pressure. **Sig. (0.01 level); *Sig. (0.05 level)

Gender	Characteristics	Mean	S. D.	Age	Height	Weight	BMI	SBP	DBP
				Pearson's Correlation coefficient					
Male (505)	Age (in years)	42.39	10.59	1					
	Height (cm.)	164.27	8.27	-0.027	1				
	Weight (Kg.)	79.29	10.24	0.074	.610**	1			
	BMI	29.42	3.16	.112*	-.227**	.624**	1		
	SBP (mmHg)	134.56	18.56	.164**	0.083	.162**	.111*	1	
	DBP (mmHg)	90.43	12.25	.097*	0.026	.122**	.112*	.707**	1
Female (493)	Age (in years)	44.53	10.03	1					
	Height (cm.)	152.52	5.04	-.091*	1				
	Weight (Kg.)	71.38	9.48	-0.004	.535**	1			
	BMI	30.72	3.48	0.055	0.010	.832**	1		
	SBP (mmHg)	134.91	21.76	.338**	-0.040	0.054	0.086	1	
	DBP (mmHg)	90.89	13.24	.160**	-0.005	0.060	0.072	.710**	1

Among the females, normal diastolic blood pressure was not found in the cohort of overweight females whereas pre-hypertension was found among 50%, Stage-1 Hypertension was 16.70%, and Stage-2 Hypertension was 33.30%.

In the obese cohort of females, normal diastolic blood pressure was found among 19.10%, pre-hypertension was among 33.70%, Stage-1 Hypertension was 27.50%, and Stage-2 Hypertension was 19.70%.

As per the pool data of females, 18.90% had normal diastolic blood pressure, 33.90% had pre-hypertension, 27.40% had Stage-1 Hypertension, and 19.90% had Stage-2 Hypertension.

Table 5 shows the Pearson correlation coefficients and reveals notable differences in physical and physiological measurements and their interrelationships.

It is evident that the male respondent's mean age of the sample was 42.39 ± 10.59 years. The average height was found to be 164.27 ± 8.27 cm. The mean weight of the participants was 79.29 ± 10.24 kg. The Body Mass Index (BMI) had an average value of 29.42 ± 3.16. The mean systolic blood pressure (SBP) was 134.56 ± 18.56 mm Hg, while the mean diastolic blood pressure (DBP) was 90.43 ± 12.25 mm Hg.

It is apparent from correlation analysis that there is a weak positive correlation of age with BMI ($r = 0.112$, $p < 0.05$) and DBP ($r = 0.097$, $p < 0.05$), and a slightly stronger positive correlation with SBP ($r = 0.164$, $p < 0.01$).

Height had a weak and negative correlation with BMI ($r = -0.227$, $p < 0.01$) and weight ($r = -0.027$), and showed no significant correlation with SBP ($r = 0.083$) and DBP ($r = 0.026$). Contrarily, bodyweight has positively correlated with BMI ($r = 0.624$, $p < 0.01$), SBP ($r = 0.162$, $p < 0.01$), and DBP ($r = 0.122$, $p < 0.01$). BMI demonstrated significant positive correlations with SBP ($r = 0.111$, $p < 0.05$) and DBP ($r = 0.112$, $p < 0.05$). SBP had a strong correlation with DBP ($r = 0.707$, $p < 0.01$), indicating that increases in systolic blood pressure were associated with increases in diastolic blood pressure also.

For female respondents, the mean age of the respondents was 44.53 ± 10.03 years. The average height was 152.52 ± 5.04 cm. The mean body weight of the participants was 71.38 ± 9.48 kg. The Body Mass Index (BMI) had an average value of 30.72 ± 3.48. The mean systolic blood pressure (SBP) was 134.91 ± 21.76 mm Hg, while the mean diastolic blood pressure (DBP) was 90.89 ± 13.24 mm Hg.

It is evident from the correlation matrix that among females age has a significant and positive correlation with SBP ($r = 0.338$, $p < 0.01$) and DBP ($r = 0.160$, $p < 0.01$), and a weak negative correlation with height ($r = -0.091$, $p < 0.05$).

Height had a moderate positive correlation with body weight ($r = 0.535$, $p < 0.01$) and no significant correlation with BMI ($r = 0.010$), SBP ($r = -0.040$), or DBP ($r = -0.005$). Contrarily, body weight has a positive correlation with BMI ($r = 0.832$, $p < 0.01$) and no significant correlation with SBP ($r = 0.054$) and DBP ($r = 0.060$). BMI demonstrated a strong positive correlation with bodyweight ($r = 0.832$, $p < 0.01$) and no significant correlation with SBP ($r = 0.086$) or DBP ($r = 0.072$). SBP had a strong correlation with DBP ($r = 0.710$, $p < 0.01$), indicating that increases in systolic blood pressure were associated with increase in diastolic blood pressure.

These findings indicate gender-specific differences in the correlation matrix of anthropometric measurements and blood pressure, suggesting that higher body weight and BMI are more strongly associated with higher blood pressure in males than females.

Discussion

This investigation is particularly pertinent given the rising incidence of non-communicable diseases in rural areas, where lifestyle factors such as diet and physical activity are responsible for this change. Hence, the primary aim of this study was to investigate the differential blood pressure levels among overweight and obese adults in rural Varanasi, Uttar Pradesh, India, and to explore the association between body dimension, socio-demographic characteristics, and blood pressure. Over the past four decades, national surveys and various sporadic studies have highlighted nutritional transition among the Indian adult population. It is being witnessed that there is an increase in malnutrition and at the same time there is a rise in the incidence of overweight and obesity [13-15]. Our findings indicate a socio-demographic determinant and differential blood pressure among the overweight and obese respondents of rural areas of district Varanasi.

The current study was conducted among overweight and obese participants of the rural population. Using the WHO's nutritional status classification for the Asian population, a total of 998 individuals were recruited which, constitute 1.3% overweight, 52.9% obese-I, and 45.8% obese-II, respectively.

To achieve the goal, the prevalence of blood pressure was assessed using the JNC-VIII classification among the respondents. The overall prevalence of hypertension was 40.8% which included 33.2% suffering from systolic hypertension and 48.4% suffering from diastolic hypertension. These findings indicate a high prevalence of hypertension among study participants. These findings corroborate with Goswami and Chandel [16] according to which 41.14% Jain population of rural areas of Sagar district, Madhya Pradesh were hypertensive.

A lower prevalence of hypertension was reported for the urban area of Varanasi (32.9%) [17], a community-based cross-sectional study from the Madurai district (25%) [18], and among Bengali women (21.8%) [19].

Furthermore, some studies have found notably higher prevalence rates of hypertension than our study viz. Josephine and Thenmozhi [20] reported 63% of hypertension among the adult drivers of urban areas of Chennai city.

Similarly, internationally reported studies have found notably higher prevalence rates of hypertension compared to the present one. For instance, Sharma., *et al*. [21] have reported a prevalence rate of 71% among the black rural African population. Similarly, Wang., *et al*. [22] have reported 49.8% hypertension among the Chinese population.

Conversely, some studies have reported lower prevalence rates of hypertension compared to our study. For example, Koroma., *et al*. [23] 27.64% of adults in Sierra and Kurnianto., *et al*. [24] observed 20.2% among adolescents in Palembang, South Sumatra, Indonesia.

In this way, there is variation in the prevalence rate of hypertension across the populations, regions, and countries.

Further, in terms of the prevalence of systolic and diastolic hypertension, our study identified that both systolic and diastolic hypertension were present roughly in one-third of the participants. Comparing these findings with other studies viz. Kumar and Gautam [25] they have reported that a significant portion of the Bidi workers in Sagar, M.P. suffered from both types of hypertensions i.e. systolic and diastolic (27.7% systolic and 17.1% diastolic), it is slightly less than our study. Contrarily, Ahirwar., *et al*. [26] found a higher prevalence of systolic hypertension and a lower prevalence of diastolic hypertension among the elderly population of Sagar i.e. 46.4% and 27.8% respectively.

The increased prevalence of hypertension in different regions may be due to multiple factors, including the convergence of hypertension between urban and rural areas in India [27]. This convergence can be attributed to the rapid urbanization of rural populations, leading to lifestyle changes such as increased sedentariness and higher salt, sugar, and fat intake. These changes, in turn, contribute to rising rates of overweight and obesity [28] as well as hypertension too. To address this issue, hypertension prevention, screening, and control policies and programs must be broadly implemented, particularly in rural areas. The data clearly show that increasing overweight and obesity corresponds with a rise in adult hypertension in rural areas.

When comparing hypertension prevalence between males and females, our study showed that hypertension was more prevalent in males (41.1%) than in females (40.6%). This trend is consistent with other Indian studies. For example, Goswami and Chandel [16] found that 51.72% of males and 30.68% of females in rural areas of the Sagar district, Madhya Pradesh, had hypertension. Additionally, Geevar., *et al*. [29] documented that 41.4% of males and 37.2% of females in Kerala were hypertensive. Singh., *et al*. [17] reported that in urban Varanasi, 40.9% of males and 26% of females were hypertensive.

Conversely, Singh and Dixit [30] reported that 59% of females and 41% of males were hypertensive, and Saju., *et al*. [31] found that 43.7% of females and 41.4% of males in the SWADES study were hypertensive. Similarly, Kshatriya and Acharya [32] reported a similar finding among tribal populations, with 14.2% of females and 9.3% of males were hypertensive. These differences highlight the need for targeted hypertension management strategies that consider gender-specific risk factors.

Internationally, the trend also varies. Wang., *et al*. [22] reported a higher prevalence in males (55.8%) than in females (45.5%)

among the Chinese population. Similarly, Kurnianto., *et al*. [24] found higher rates among males (51%) than females (39.7%) in Indonesian populations. Defianna., *et al*. [33] and Koroma., *et al*. [23] reported similar findings, with 42% of males versus 38% of females, and 25.11% of males versus 24.11% of females, respectively were hypertensive.

In contrast, In Bangladesh, Rahman., *et al*. [34] found that hypertension prevalence was slightly higher in females (76%) compared to males (71%).

Although men are generally more susceptible to hypertension due to various physiological, behavioral, and lifestyle factors [33,35] they are more likely to engage in behaviors such as smoking and excessive alcohol consumption, which are significant risk factors for hypertension [26]. Additionally, men typically consume more salt and have lower levels of physical activity, both of which contribute to elevated blood pressure [36].

Differences in fat distribution between males and females also play a crucial role. Men tend to accumulate visceral fat, which is closely associated with hypertension, while women generally accumulate subcutaneous fat. Visceral fat is more significantly linked to metabolic disturbances, including insulin resistance and increased sympathetic nervous system activity, both of which are associated with higher blood pressure [37,38]. Hormonal differences further contribute to hypertension. Testosterone in men is associated with increased blood pressure, whereas estrogen in premenopausal women has a protective effect on cardiovascular health. However, postmenopausal women experience a sharp increase in blood pressure due to the decline in estrogen levels, which narrows the gender gap in hypertension prevalence as age increases [39,40].

This trend has been consistently observed in several studies, highlighting significant gender differences in hypertension progression. Overall, the prevalence of hypertension is higher in men than in women, suggesting that gender disparities in hypertension widen with age, possibly due to a combination of genetic, hormonal, and environmental factors.

These differences underscore the importance of implementing gender-specific hypertension management strategies.

The relationship between weight gain, obesity, and hypertension is well established, with extensive research indicating that increased body weight substantially affects blood pressure levels. Obesity is a major risk factor for hypertension because it induces various physiological changes that collectively increase blood pressure. Several studies suggest a strong relationship between body mass index (BMI) and hypertension, with individuals with higher BMI being at significantly higher risk of developing hypertension [41]. The underlying mechanisms include increased activity of the sympathetic nervous system, alterations in renal sodium handling, and activation of the renin-angiotensin-aldosterone system (RAAS), all contributing to hypertension [42]. Obesity is strongly associated with higher systolic and diastolic blood pressure, which are elevated in obese individuals compared to their non-obese counterparts [43].

Previous studies have identified several determinants of hypertension in obese individuals, including dietary factors, physical inactivity, genetic predisposition, metabolic syndrome, psychological stress, and sleep apnea [44]. High salt intake is linked to hypertension in obese individuals, as excessive dietary sodium can lead to fluid retention and increased blood pressure. Diet with high saturated fat and sugars are associated with obesity and hypertension, contributing to increased body weight and metabolic disturbances. A sedentary lifestyle is also a significant determinant of hypertension in obese individuals, as lack of physical activity contributes to weight gain and adverse metabolic profiles [45,46]. Genetic factors play a role in both obesity and hypertension, with certain genetic polymorphisms increasing susceptibility to hypertension in obese individuals [47]. Metabolic syndrome, which includes insulin resistance, dyslipidemia, and abdominal obesity, is a strong predictor of hypertension in obese individuals [48]. High levels of stress and poor mental health are also associated with hypertension, as obese individuals often experience mental stress, contributing to hypertension through various physiological pathways [49]. Lastly, obstructive sleep apnea, which is more prevalent in obese individuals, is an important determinant of hypertension, leading to intermittent hypoxia and sympathetic nervous system activation, resulting in increased blood pressure [50].

Conclusion

In conclusion, this study examined the variations in blood pressure levels among overweight and obese individuals living in rural areas of Varanasi, Uttar Pradesh, India. It explored the relationships between body dimensions and blood pressure. The study found that the overall prevalence of hypertension was 40.8%, with slight variation among males (41.1%) and females (40.6%). The prevalence of systolic and diastolic hypertension was 33.2% and 48.4%, respectively. The findings highlight the relationship between obesity and elevated blood pressure among adults. Addressing these health challenges through targeted interventions can improve health outcomes and quality of life in rural communities. Effective public health strategies are essential for mitigating the impact of obesity and hypertension. It is also essential to cope up with the challenges of the future like a higher prevalence of multiple chronic conditions (MCC).

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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