Original Research Article

# AN ANALYSIS OF BLOOD PRESSURE CATEGORIES: A RANDOMIZED CROSS-SECTIONAL PROSPECTIVE STUDY IN VARANASI

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## ABSTRACT

**Background:** Hypertension is a major global health concern and a leading risk factor for cardiovascular diseases (CVD) and stroke. This cross-sectional randomised clinical study was conducted in the Varanasi district, Uttar Pradesh, India, along the "PanchKoshi marg," a 25 km circular road, around Varanasi district, during the auspicious month of Shrawan (July) in 2024. The primary objective was to identify risk factors affecting blood pressure (BP) and develop a gender-specific predictive model for early diagnosis and preventive interventions.

**Material and Methods:** Blood pressure was measured using a standardized digital BP machine. Body weight, height, pulse rate, and circumferences of chest, waist, and hip were measured by standard procedures. A questionnaire was filled out to record the participant's demographics, lifestyle habits, family history, physical activity, sleep duration, food habits etc. Statistical analysis was performed by Excel and SPSS software for descriptive statistics, Pearson's correlation, and regression analysis.

**Results:** A significant population had normal (41.50%) and elevated hypertension (27.20%). Patients with Hypertension Stage 1 (14.50%) and stage-II categories (12.20%) and Hypertensive Crisis (4.70%) were limited. Anthropometric measurements represent the gender-specific variation in SBP. Regression analysis after data stratification for age, gender and severity of hypertension, presents a non-linear relationship between SBP and other variables. However, the low sample size for hip circumference, sleep duration, physical activity and pulse-rate, indicated inconsistent results and emphasised a separate study to have a clear picture.

**Conclusion:** The findings underscore the importance of early detection and management of hypertension to prevent cardiovascular complications in Varanasi, a district, situated in the Northern Indian geographical region.

**Keywords:** Hypertension, Blood pressure, Varanasi, Epidemiology, Heart disease, CVD.

## INTRODUCTION

Hypertension is a prevalent health concern worldwide, affecting millions of individuals. It is one of the leading risk factors for cardiovascular diseases and stroke. The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019 provided that high systolic blood pressure contributes to 10·8 million deaths (95% uncertainty interval [UI] 9·51–12·1), which is 19·2% [16·9–21·3] of all deaths in 2019. The WHO recommends population-based screening and management of hypertension as a cost-effective strategy to reduce the burden of cardiovascular diseases. Indian Genome Variation Consortium has highlighted the genetic diversity among various Indian populations and its potential impact on health outcomes, including hypertension.[1] India's genetic diversity is coupled with its varied geographical and sociocultural landscape, dietary patterns, physical activity levels and urbanisation, underscoring the critical need for geographically oriented studies to support the need to assess the heterogeneity of hypertension. Earlier reports suggest urbanisation is linked to a higher prevalence of hypertension.[2] Another study has reported a higher prevalence of hypertension in Southern states of India compared to certain northern regions.[3] Ethnic differences also play a significant role in the variability of hypertension. People in the north-Eastern states of India have been found to have distinct genetic predispositions, that influence their cardiovascular risk profiles, including hypertension.[4] Similarly, tribal populations in central India show lower hypertension prevalence.[5] A study of India's Hypertension Control Initiative (IHCI) highlighted regional variations in hypertension awareness, treatment, and control rates.[6]

These findings underscore the importance of tailoring public health interventions to address region-specific needs and disparities to understand the interplay of genetic, environmental, and lifestyle factors for actionable insights into region-specific policy and healthcare interventions. This study aims to assess hypertension categories' age and gender-specific patterns in a randomly selected population in Varanasi, Uttar Pradesh (UP), India, to contribute to public health interventions and clinical practice.

## MATERIALS AND METHODS

A cross-sectional survey was conducted along the "PanchKoshi marg", a 25 km circular road, during the Shrawan month (July 2024), an auspicious month dedicated to Lord Shiva. Health camps were organized at various locations, including four in the temple premises and two within the city. Participants were randomly selected a total of 572 individuals were registered of whom 564 had blood pressure measurements.

**Data Collection:** Blood pressure was measured using a standardized digital BP machine. Participants were categorized into 5 groups based on the American Heart Association's guidelines:

1. Normal (Systolic < 120 mmHg and Diastolic < 80 mmHg)
2. Elevated (Systolic 120-129 mmHg and Diastolic < 80 mmHg)
3. Hypertension Stage 1 (Systolic 130-139 mmHg or Diastolic 80-89 mmHg)
4. Hypertension Stage 2 (Systolic ≥ 140-159 mmHg or Diastolic ≥ 90 mmHg).
5. Hypertension Crisis (Systolic ≥ 160 mmHg or Diastolic ≥ 120 mmHg)

Other measurements included body weight, height, pulse rate, and circumferences, of chest, waist, and hip. A questionnaire was used to record the name, age, gender, food habits, daily physical activity, sleep quality, family history of diseases, and knowledge about existing non-communicable diseases (NCDs).

**Statistical Analysis:** Data were analysed using Excel and SPSS software. Outliers were removed using the Z-score method. Data stratification was done based on age, gender, hypertension categories and BMI to perform descriptive statistics, Pearson's Correlation and regression analysis, to define the influence of each predictor (variables) on SBP (Systolic blood pressure). Stepwise regression analysis was also done in four stages, sequentially removing variables not filled in by all participants, to avoid bias.

## RESULTS

**1A. Descriptive analysis of overall samples:** Descriptive analysis was carried out with SPSS to assess the pattern of hypertension, before and after removing the outliers based on SBP, by using the method of (Zscore±3), as described in (Table-1A).

**1B. Descriptive analysis of Continuous Variables:** We did statistical analysis separately for contentious and categorical variables to better understand the changes. The mean age of participants in the overall data was 41.90 years (±15.09), from 13 to 95 years. Blood pressure levels with the mean of systolic blood pressure (SBP) was 124.97 mmHg (±18.12) and for diastolic blood pressure (DBP) the mean value was 77.69 mmHg (±13.07). Notable limitations include the small sample sizes for variables like hip circumference (N = 30) and sleep duration (N = 150), which may impact statistical power and accuracy. Further, we performed Cohen's d calculation before and after removing the outliers, based on z score±3 to determine the impact of outliers. The results are given in (Table-1B). Cohen's d is used to measure the effect size between two groups (Original and Outlier). A small value of Cohen's d suggests that the difference in means between the two groups is negligible, while larger values indicate a more significant difference, as mentioned here (Small effect size: 0.20, Medium effect size: 0.50, Large effect size: 0.80). However, in our case, the calculated Cohen's d values for all variables are extremely low (close to zero), suggesting that the removal of outliers does not significantly affect the overall distribution of the variables.

**1C. Descriptive statistical analysis of categorical variables:** The analysis of categorical variables related to demographics, lifestyle and food habits, in terms of their % concerning a total number, as described in (Table-1C). Out of the total registered participants, there were 70.6% (N=404) males and 29.4% (N=168) females, with (58.4%, N=333) from urban-area and 41.6% (N=237) from rural areas. Regarding lifestyle factors, the majority of them reported no alcohol consumption (90.8%, N=355), while 6.4% (N=25) consumed alcohol regularly, and 2.6% (N=10) consumed it occasionally. Similarly, 89.7% (N=339) did not smoke, 7.1% (N=27) were smokers, and 3.2% (N=12) smoked occasionally. Health status data showed that 18.7% (N=107) of participants were already having hypertension, and 18.4% (N=107) had diabetes. Dietary preferences revealed that 76.1% (N=159) were vegetarian, while 23.9% (N=50) were non-vegetarian. A normal distribution of participants were observed from all the centers, with the highest attendance at Assi-ghat (23.5%, N=98) and Rameshwar (22.8%, N=95), followed by Kapildhara (18.9%, N=79), Bhimchandi (15.3%, N=64), Kandwa (14.9%, N=62), and BHU (4.6%, N=19). All these centres were the premises of Shiva temples, indicating persons inclined to spiritual views. These results provide a comprehensive overview of the study population and their distribution across various factors relevant to our research objectives, but with some limitations, as certain variables (e.g., physical activity, sleep duration, hip circumference, diabetes, and parents' history) have limited sample sizes, which may result in some bias in statistical analyses.

## 2. Descriptive analysis after stratification as per age, gender, BMI and hypertension categories

To explore the insight into the relationship between SBP and other variables, we stratified the data into different categories, to understand if the regression coefficients are linear and dependent on age, BMI and gender. The age stratification was made in 6 categories (< 11, 11–24, 25–36, 37–48, 49–60 and >61 years) (Table-2A). Hypertension pattern was categorized into 5 categories (Normal, Elevated, Hypertension-Stage 1, Hypertension-Stage 2 and Hypertensive Crisis (Table-2B). Gender stratification was between males and females. the BMI was stratified in 2 categories with 27 as the cut-off value.

**2A. Stratification based on age:** The data across age groups (<11, 11–24, 25–36, 37–48, 49–60, >61 years) demonstrates a consistent progression in anthropometric and clinical parameters with age, validating the stratification and reflecting natural ageing trends. (Table-2A) provides the descriptive statistics (Mean ± SD) for various demographic, clinical, and lifestyle variables across different categories in the overall population and people in different age groups. SBP and DBP represent a gradual rise with increasing age. Physical activity indicates a progressive rise up to the age of 37-48, followed by a decline. Other parameters do not indicate any prominent change with an increase in age. The mean age of the overall population is 41.92 ± 14.95 years, (Fig-1)

**2B. Stratification based on gender:** The stratification based on gender (males and females) represented similar mean values in both genders. The severity of hypertension presented a mean of 37.76 ± 14.03 years falling in the Normal category for people of age 53.35 ± 13.60 years falling in the category of Hypertensive Crisis. The average physical activity level is 35.68 ± 22.57, with males reporting slightly higher levels than females (34.76 ± 15.12). (Table-2B). (Fig – 2)

**2 C. Stratification based on hypertension stages:** Variations across hypertension categories suggest a decline in activity as hypertension severity increases. The mean SBP is 124.42 ± 17.20 mmHg, with males showing higher values than females. SBP and DBP values increase consistently across hypertension stages, from 109.45 ± 8.76 mmHg and 71.97 ± 12.77 mmHg in the Normal group to 166.96 ± 5.03 mmHg and 92.50 ± 14.32 mmHg in the Hypertensive Crisis group. This trend underscores the validity of hypertension classification in the cohort. The overall pulse rate is 87.60 ± 13. 12 bpm, with females having slightly higher values, but it remains consistent across most categories and decreases slightly in the Hypertensive Crisis group. Under the Anthropometric Parameters, the average body weight (BW), chest circumference, waist circumference, hip circumference, and BMI demonstrate significant variations across gender and age groups. Males generally exhibit higher values for weight, chest, and waist circumferences, while females show slightly higher BMI values. Anthropometric parameters also increase with hypertension severity, reflecting their potential role in disease progression. The average height is 1.62 ± 0.11 m, in males, being a little higher than in females (1.53 ± 0.08 m) (Table-2B). Height differences across categories are minimal, indicating a relatively uniform distribution. (Fig – 3)

**Lifestyle Factors include** sleep duration (Average 6.56 ± 1.20 hours in females, reporting slightly longer durations than the males. Time to get up in the morning averages 6.14 ± 1.33 hours, with notable variations across categories. For instance, individuals in the Normal group tend to wake up later (6.38 ± 1.35 hours) compared to those in the Hypertension Stage 2 group (5.54 ± 1.26 hours). These observations provide a foundation for further statistical analysis and the development of predictive models to identify risk factors and interventions for hypertension management. The systolic blood pressure (SBP) demonstrates a critical trajectory from ages 24 to 61 targeting better screening and intervention strategies. In this age range, there is a progressive decline in the proportion of individuals with normal BP (from 56.2% to 29.4%) and a concurrent rise in Hypertension Stages 1 and 2 (cumulatively increasing from 15.7% to 39%). In the 11–24 age group, elevated BP is prominent (30.1%), with 12.3% to Hypertension Stages and 4.1% progressing to stage-2. Interestingly in the age group of 37–48 and 49–60 years, there is a marked increase in persons who have BP with Stage 1 (9.9%) and 2 (18.4%). Notably, in the 61+ age group, the highest proportion of Hypertension Stage 2 (25.9%) and Hypertensive Crisis (17.2%) is reported(Table-3A), underscoring a critical health risk in older adults. This analytical data suggests early detection to adopt preventive strategies to mitigate the escalating risk of hypertension-related complications.

We further did this analysis of hypertension categories, separately in males and females, to understand the gender-wise pattern of BP with age (Table-2B). Based on gender-specific stratification we found males **(**41.63 ± 14.94, N = 399) having SBP-126.24 ± 17.52 and DBP-78.67 ± 12.58). Females had higher age-mean (42.54 ± 15.45. N = 167) with lower SBP (121.95 ± 19.21) and DBP-(75.34 ± 13.94). the male/female ratio was by UP census 2011, where 100 females were reported over 109 males. Males and females show distinct blood pressure trends across age groups. Among children under 11 years, 50% of males had normal blood pressure compared to 100% of females. In the 11–24 age group, normal blood pressure was observed in 34.6% of males and 90.5% of females, with elevated levels more common in males (38.5% vs. 9.5%). In the 25–36 age group, normal levels declined for both genders but remained higher in males (50.5% vs. 69.8%). By 49–60 years, females showed a higher prevalence of Stage 1 hypertension (23.9% vs. 18.9% in males). For those 61 years and older, males had more hypertensive crises (16.7% vs. 18.8% for females). Overall, females had a higher proportion of normal blood pressure across all age groups (51.2% vs. 37.5%), while males exhibited greater prevalence in severe hypertension stages, particularly in older age groups. Results have been represented in the stacked bar chart (fig-4), which illustrates the percentage distribution of patients in various hypertensive categories across age groups (11–24, 25–36, 37–48, 49–60, and 61+) for males and females Males consistently exhibit a higher prevalence of hypertension stages (1, 2, and crisis) compared to females across all age groups. In the 11–24 age group, elevated blood pressure is more common in males (38.5%) than females (9.5%). Normal blood pressure is higher in females across all age groups, peaking at 100% under 11 and 90.5% in the 11–24 group. In older age groups (61+), males have 16.7% of hypertensive crisis compared to 18.8% in females (Table-3B). Thus, it could be summarized that the shift from normal to higher stages of hypertension is more pronounced in males as age increases, up to the age of 60 years, but later on the rise in BP is common in both genders.

**2D. Descriptive Statistics by BMI Categories:** Further, we explored the descriptive statistical analysis of the overall data, based on BMI stratification, because it is the most commonly used variable to predict the risk for cardiovascular diseases in humans. For Asian populations, the cut-off of BMI has been marked a little lower from the WHO markers, as they are more prone to CVD and diabetes. The study indicated that SBP and DBP were highest in obese and lowest in underweight individuals. Our data (Table-4) represented significant variation in body weight, with obesity averaging 83.94 ± 12.47 kg compared to 44.29 ± 6.91 kg in the underweight group. Similarly, BMI was highest in obese participants (34.25 ± 5.08) and lowest in the underweight group (17.02 ± 1.36). Obese individuals also had larger chest (100.65 ± 13.68 cm), waist (100.31 ± 14.52 cm), and hip (104.25 ± 6.40 cm) circumferences compared to other groups. Sleep duration showed minor variation, being slightly higher in the underweight group (7.33 ± 1.16 hours). Age-related BMI increases highlight the physiological differences associated with BMI categories and underscore the importance of early lifestyle interventions.

**3. Pearson's Correlation studies of SBP with different variables in the overall population of mixed gender**Further, Pearson correlation analysis were done to explore the interrelationships between physiological and anthropometric variables in a mixed-gender population, focusing on age-related changes. Understanding these associations is crucial for identifying risk factors for hypertension, obesity, and age-related health issues to develop population-oriented strategies for health screening to prevent the risk of cardiovascular diseases in society. Table-5 highlights age as a strong positive correlation with systolic blood pressure (r = 0.333, p < 0.001) in both genders. In males there is a comparatively weak positive correlation(R=0.264), compared to females (R=0.494), $^{**}$p < 0.001). Table 4 shows a correlation with other variables. SBP indicated a moderate correlation with diastolic blood pressure (r = 0.156, p < 0.001), suggesting an increase in blood pressure with ageing. The rise in SBP also indicated weak positive associations with BMI (r = 0.116, p = 0.038) and waist circumference (r = 0.130, p = 0.022), alongside an inverse correlation with height (r = -0.141, p = 0.004), reflecting typical age-related physiological changes. Body weight strongly correlates with chest circumference (r = 0.489, p < 0.001), waist circumference (r = 0.383, p < 0.001), and BMI (r = 0.796, p < 0.001), emphasizing its link with central obesity markers. Blood pressure parameters are closely interconnected, as evidenced by a strong correlation between systolic and diastolic BP (r = 0.498, p < 0.001). Sleep duration negatively correlates with age (r = -0.237, p = 0.003), highlighting reduced sleep as a potential ageing marker. Furthermore, strong correlations between waist and hip circumference (r = 0.682, p < 0.001) and chest and waist circumference (r = 0.449, p < 0.001) underscore the relevance of fat distribution to body composition. These findings provide valuable insights for interventions targeting obesity, hypertension, and age-related health changes. The data, given in Table-5 indicates that SBP has a higher coefficient value for age in females (0.494**) than in males (0.264, p < 0.01). In females a significant positive correlation is observed for BMI (0.231*), but insignificant for height, pulse, body weight and Waist (0.210). Interestingly, a significant positive correlation was found with the Hip circumference (0.764, p < 0.01), though the number of samples is very low, so it needs further study.

In males, a positive trend was observed with BMI (0.200, $p < 0.01$), Pulse (0.170, $p < 0.01$) and body weight (0.150, $p < 0.05$), in a gradual decreasing pattern. However, the correlation coefficient between SBP and hip circumference was insignificant (0.139) in the males. Further, a significant negative correlation was observed with height (-0.137, $p < 0.05$) in males, but not in females. Interestingly Pulse presents an opposite picture, as an insignificant -ve correlation in females (-0.015) but a significant positive correlation in males (0.170**). These data suggest that central body fat distribution might be playing a significant role in determining systolic blood pressure in females, which may be further clarified by doing the regression analysis. (Table-5)

**4: Regression analysis:** Further we did the regression analysis to understand the strength of influence of different variables on the change in SBP, which furnished interesting results. In males, the % of influence was 21.2%, and in females it was 39.7%. This difference may be attributed to the hormonal effect, changing with age in females, with an average age of 42.54 ± 15.45. The females show higher $R^2$ values for SBP and age, further indicating better protection from the influence of MS. This may be attributed to the high antioxidant and anti-inflammatory potentials of estrogen and other female hormones (7), (8), (9).

Earlier studies report that SBP tends to increase with age across both genders, but the Indian Heart Study has shown a gender disparity in SBP-age correlations, which might be attributed to differences in hormonal profiles and lifestyle factors (10). Estrogen provides a protective effect against arterial stiffening and hypertension by promoting vasodilation through nitric oxide release and by reducing vascular inflammation. Other contributing factors may include lifestyle, obesity prevalence, physical activity, and anthropometric variables.

**4A: Linear regression analysis with stratified hypertensive group:** The data on SBP, diastolic pressure, age, BMI, height, pulse, chest, waist, and weight, were split for male and female participants and separate multiple linear regression models were built for each gender using SPSS. The model summary is given below table 6Arepresents the overall performance of the predictive models for SBP and BMI in over all data. The $R^2$ (0.287 represents the proportion of variance in SBP, predicting28.7% variability in males. It indicates that all the variables (BMI, age, height, pulse, diastole, waist, chest, and weight) can collectively predict the change in SBP by 28.7% only, which represents a modest predictive power, as its adjusted $R^2$-is 0.244 only. In females, the 44.0% variability ($R^2$=0.440) was observed with adjusted $R^2$ is 0.342, indicating a stronger predictive power Regression analysis was done keeping SBP (dependent variable) with different sets of independent variables in an BMI stratified data with 2 groups (cut off of 27): **The results given in** Table 6A includes the model fitness data. It demonstrates the overall model performance, variance explained ($R^2$), and statistical significance (F and p-values). The overall linearity of the model is supported by the statistical significance of the F-values across all the 3 groups, indicating the level of significance as $p < 0.001$, suggesting the regression models as linear. It provides an understanding of how well the independent variables collectively explain the dependent variable, establishing the model's reliability. The results present the regression analysis of age, DBP, pulse, weight, height, and BMI. The $R^2$ values range from 0.259 to 0.307, indicating moderate variance explanation. All models are statistically significant with **$p < 0.001$**, highlighting the predictive strength of the selected variables. Since the data size for each variable was different, doing one regression analysis may not give the correct predictive value. The $R^2$ values indicate a moderate fitness of the models and suggest that the independent variables collectively explain a moderate portion of the variance in the dependent variable.

Further, with the above set of variables, the regression analysis was planned with SBP (dependent variable) in a set of stratified data based on BMI by a cut-off of 27, to explore, whether the value is linear or non-linear, based on the coefficient values**.** The regression results for the total population and subgroup analyses (BMI ≤27 years and BMI >27) indicate a non-linear correlation (Table-6B). In the overall total population, significant relationships are observed for Age, Diastole, and Pulse (all $p < 0.05$), but in people having BMI ≤ 27 years, only Age, Diastole, and Pulse show significant linear relationships ($p < 0.05$), and in the people having BMI > 27 years, only Diastole shows a significant linear relationship ($p < 0.01$). These results suggest that the regression model is mostly linear for certain variables but does not demonstrate strong linearity for others, particularly for Weight, Height, and BMI, as they do not show significant associations across subgroups or the total population

Further, we did the same regression analysis after the SBP-based stratification in 2 categories by choosing a cut-off of 130 mm pressure), to assess whether the regression coefficient shows a linear relationship or not. Interestingly, a non-linear correlation was found between SBP and its predictors like Age, weight, and height. They showed markedly different effects in hypertensive vs. normotensive populations (table, emphasizing the need for subgroup-specific analyses in clinical research. The table 6B shows regression coefficients (B values) and their significance levels **(**p-values) for the relationship between systolic blood pressure (SBP) and various independent variables **(**age, diastole, pulse, weight, height, and BMI**)** for: Total population (n = 260), Subgroup with SBP < 130 (n = 183) and Subgroup with SBP ≥ 130 (n = 77). The data indicates Non-linearity of Age, as it has a negligible effect on people having SBP < 130 group but has a strong impact on people having SBP ≥ 130 group. Similarly, a large negative coefficient for height in people of SBP ≥ 130 group and no evident effect in people having SBP < 130 group or in the overall population also suggests non-linearity. The weight also represents a Non-linearity with SBP as it is only significant in individuals with SBP ≥ 130 not in the other 2 groups.

Its clinical importance suggests that for those who have SBP < 130, age, weight, and BMI have minimal impact on SBP, suggesting a different underlying mechanism for SBP regulation in normotensive individuals. However, in individuals with SBP ≥ 130, age, weight, and BMI are stronger predictors, indicating their greater relevance in managing and understanding hypertension. However, the height coefficient needs further investigation, because it has a large negative B value in the SBP ≥ 130 group but is not significant. This could be because of a high number of outliers, high variability or lower sample size. Regression analysis was done on 3 sets of variables and all the models were statistically significant as shown in Table #6B**4B: Stepwise Regression analysis of SBP (dependent variable) with different variables**

Finally, we did the stepwise regression analysis by selecting different groups of independent variables to explore the changing pattern of strength of different predictors of SBP. We also compared the coefficient value of individual predictors (Pearson's Correlation coefficient) and multivariant correlation coefficient (unstandardized B value) for different predictors, when they are in the group. The Regression Coefficients were determined in 4 sets, having different sets of variables. Group IV had the least number (n-15) as data related to the measurement of hip circumference was limited. A list of variables of each group, chosen for regression analysis given in table #7A along with the $R^2$ and F value, indicating the fitness and level of significance of each regression model. The data given in Table 7A represents the analysis of systolic blood pressure (SBP) reveals significant correlations and regression coefficients with key variables. Age exhibits a strong positive Pearson correlation with SBP ($r = 0.333$, $p < 0.001$), and regression analysis confirms its predictive value ($\beta = 0.342$, $p < 0.001$, $n = 260$). Diastolic BP also strongly correlates with SBP ($r = 0.487$, $p < 0.001$) and maintains significance in regression ($\beta = 0.418$, $p < 0.001$, $n = 260$). Weight and BMI show moderate positive correlations ($r = 0.179$, $p < 0.001$ and $r = 0.251$, $p < 0.001$, respectively). However, variables like sleep duration and pulse did not demonstrate significant predictive values in regression models. These findings highlight age, diastolic BP, and body weight as critical determinants of SBP. Table--. Variables such as physical activity ($r=0.079$, $\beta=-0.024$ to $0.046$), pulse ($r=-0.003$, $\beta=-0.183$ to $0.232$), and sleep duration ($r=-0.015$, $\beta=3.117$ to $3.872$) showed negligible correlations and insignificant regression coefficients, indicating minimal impact on SBP. In contrast, chest ($r=0.184r$) and waist circumference ($r=0.167$) had significant correlations, but their regression coefficients were inconsistent, suggesting their effects may be influenced by sample size or other variables. Height ($r=0.016$) demonstrated no meaningful association with SBP. Table 7B represents the data related to model fitness. Interestingly the first 2 models are significant, having a higher number of participants with a lesser number of independent variables, but the last 2 models were not significant, which may be attributed to lower number of samples and included parameters like Physical Activity, Sleep Duration (hours) and hip circumference. We have not used imputation to avoid any bias. Thus, it can be suggested chest and waist circumference show significant correlations with SBP, and may be considered as potential predictors for screening the cardiovascular risk. Table.

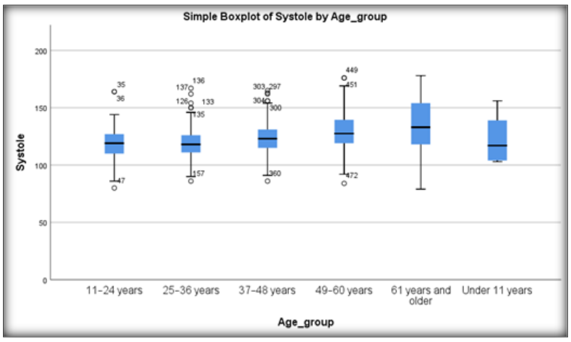

**Figure 1: Shows the distribution of systolic blood pressure (SBP) across age groups, alongside various demographic and health variables. The boxplot shows that SBP increases with age and the youngest group (11–24 years) exhibited the lowest SBP levels (118.59 ± 15.61 mmHg) and the oldest group (61 years and older) showed the highest (135.93 ± 23.46 mmHg). This trend underscores the age-related progression of hypertension risk**

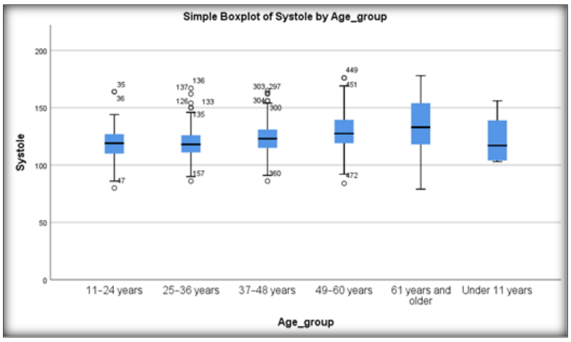

**Figure 2: Boxplot of systolic blood pressure (Systole) by Gender, comparing Male and Female groups. The boxes represent the interquartile range (IQR), with the horizontal line indicating the median systolic blood pressure for each gender. Whiskers extend to 1.5 times the IQR, and individual points outside the whiskers represent outliers. This plot highlights the distribution and central tendency of systolic blood pressure between males and females.**

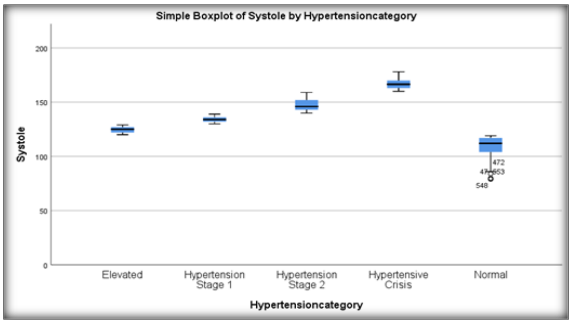

**Figure 3: This shows the distribution of systolic blood pressure (SBP) across hypertension categories alongside various demographic and health variables: The boxplot indicates a progressive increase in SBP from "Normal" to "Hypertensive Crisis" categories, reflecting the severity of hypertension. The mean SBP values range from 109.45 ± 8.76 mmHg (Normal) to 166.96 ± 5.03 mmHg (Hypertensive Crisis). The data also reveal distinct clustering of SBP within each category, with minimal overlap between stages.**

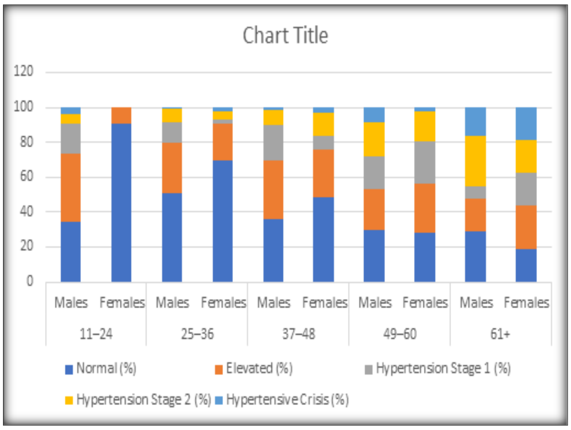

**Figure 4: Gender wise Presentation of hypertension categories in different age groups**

**Table 1A: Means, standard deviations (SD) of the Variables measured on a continuous scale, along with their ranges, in the original dataset and after removing the outlier**

| | Original Data | | | | After Removing Outlier (Z±3) | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **N** | **Mean ± SD** | **Min** | **Max** | **N** | **Mean ± SD** | **Min** | **Max** |
| Age | 566 | 41.90 ± 15.09 | 13 | 95 | 554 | 41.92 ± 14.95 | 13 | 86 |
| Physical Activity (min) | 164 | 35.68 ± 22.57 | 2 | 180 | 164 | 35.68 ± 22.57 | 2 | 180 |
| Systolic Blood Pressure (mmHg) | 564 | 124.97 ± 18.12 | 79 | 195 | 559 | 124.42 ± 17.20 | 79 | 178 |
| Diastolic Blood Pressure (mmHg) | 564 | 77.69 ± 13.07 | 17 | 157 | 559 | 77.52 ± 12.95 | 17 | 157 |
| Pulse (beats/min) | 430 | 87.63 ± 13.12 | 55.0 | 128.0 | 426 | 87.60 ± 13.12 | 55 | 128 |
| Weight (kg) | 411 | 67.87 ± 14.62 | 31.00 | 120.00 | 402 | 67.88 ± 14.65 | 31 | 120 |
| Chest Circumference (cm) | 311 | 94.91 ± 15.40 | 2.74 | 174.00 | 307 | 94.99 ± 15.48 | 2.74 | 174 |
| Waist Circumference (cm) | 312 | 94.28 ± 16.41 | 3 | 175 | 308 | 94.35 ± 16.49 | 3 | 175 |
| Hip Circumference (cm) | 30 | 96.77 ± 10.32 | 67 | 115 | 30 | 96.77 ± 10.32 | 67 | 115 |
| Height (m) | 415 | 1.62 ± 0.11 | 1.27 | 1.90 | 407 | 1.62 ± 0.11 | 1.27 | 1.90 |
| BMI (kg/m²) | 327 | 25.82 ± 5.02 | 13.78 | 43.88 | 319 | 25.87 ± 5.00 | 13.78 | 43.88 |
| Sleep Duration (hours) | 150 | 6.57 ± 1.20 | 3 | 12 | 148 | 6.56 ± 1.20 | 3 | 12 |
| Time to Get Up (AM) | 92 | 6.13 ± 1.32 | 4.0 | 10.0 | 91 | 6.14 ± 1.33 | 4 | 10 |

**Table 1B: Cohen's d calculation between original mean and mean after removing outliers**

| Variable | Cohen's d | Interpretation |
|---|---|---|
| Age | -0.001 | Negligible difference |
| Physical Activity | 0.000 | No difference |
| Systole | 0.031 | Negligible difference |
| Diastole | 0.013 | Negligible difference |
| Pulse | 0.002 | Negligible difference |
| Weight | -0.001 | Negligible difference |
| Chest | -0.005 | Negligible difference |
| Waist | -0.004 | Negligible difference |
| Height | 0.012 | Negligible difference |
| BMI | -0.009 | Negligible difference |
| Sleep duration (in hours) | 0.008 | Negligible difference |
| Time to get up in morning (A.M.) | -0.010 | Negligible difference |

**Table 1C: Categorized Variables into distinct groups, presented with counts and percentages**

| Variable | Count (N) | Percentage (%) |
|---|---|---|
| **Gender** | Male: 404, Female: 168 | Male: 70.60%, Female: 29.40% |
| **Area (Rural/Urban)** | Rural: 237, Urban: 333 | Rural: 41.60%, Urban: 58.40% |
| **Alcohol Consumption** | No: 355, Yes: 25, Occasionally: 10 | No: 90.80%, Yes: 6.40%, Occasionally: 2.60% |
| **Smoking** | No: 339, Yes: 27, Occasionally: 12 | No: 89.70%, Yes: 7.10%, Occasionally: 3.20% |
| **Knowledge of having Hypertension** | Yes: 107, No: 465 | Yes: 18.70%, No: 81.30% |
| **Knowledge of having Diabetes** | Yes: 7, No: 31 | Yes: 18.40%, No: 81.60% |
| **Food Type** | Vegetarian: 159, Non-Vegetarian: 50 | Vegetarian: 76.10%, Non-Vegetarian: 23.90% |
| **Camp Attendance** | Kandwa: 62, Bhimchandi: 64, Kapildhara: 79, Rameshwar: 95, Assighat: 98, BHU: 19 | Kandwa: 14.90%, Bhimchandi: 15.30%, Kapildhara: 18.90%, Rameshwar: 22.80%, Assighat: 23.50%, BHU: 4.60% |

**Table 2A: Stratification based on age**

| Variable | Overall | Age Categories (years) | | | | | |
|---|---|---|---|---|---|---|---|
| | | < 11 | 11–24 | 25–36 | 37–48 | 49–60 | 61> |
| | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD |
| Age | 41.92 ± 14.95 | 0 | 20.70 ± 2.57 | 29.84 ± 3.61 | 42.52 ± 3.43 | 54.43 ± 3.85 | 68.26 ± 5.73 |
| Physical Activity | 35.68 ± 22.57 | 0 | 36.06 ± 14.73 | 33.52 ± 19.50 | 42.56 ± 34.98 | 29.74 ± 10.38 | 38.57 ± 19.37 |
| SBP | 124.42 ± 17.20 | 123.80 ± 23.12 | 118.59 ± 15.61 | 119.05 ± 13.56 | 123.64 ± 14.34 | 129.22 ± 17.42 | 135.93 ± 23.46 |
| DBP | 77.52 ± 12.95 | 69.40 ± 12.34 | 73.60 ± 10.82 | 76.17 ± 13.61 | 78.45 ± 11.62 | 79.28 ± 12.99 | 80.10 ± 15.29 |
| Pulse | 87.60 ± 13.12 | 0 | 89.26 ± 10.25 | 88.72 ± 13.32 | 86.94 ± 13.02 | 86.95 ± 13.38 | 86.31 ± 14.92 |
| Weight | 67.88 ± 14.65 | 76.56 ± 13.98 | 60.97 ± 16.04 | 68.02 ± 14.01 | 71.90 ± 13.71 | 67.65 ± 13.81 | 64.13 ± 15.82 |
| Chest Circumference | 94.99 ± 15.48 | 0 | 87.65 ± 10.83 | 95.79 ± 17.20 | 98.23 ± 12.50 | 94.78 ± 17.75 | 94.49 ± 15.04 |
| Waist Circumference | 94.35 ± 16.49 | 0 | 84.04 ± 17.11 | 94.50 ± 17.02 | 96.85 ± 13.43 | 97.06 ± 18.00 | 93.45 ± 13.70 |
| Hip Circumference | 96.77 ± 10.32 | 0 | 0 | 98.14 ± 3.93 | 95.33 ± 13.73 | 98.14 ± 6.99 | 99.00 ± - |
| Height | 1.62 ± 0.11 | 1.71 ± 0.15 | 1.62 ± 0.10 | 1.64 ± 0.10 | 1.61 ± 0.10 | 1.61 ± 0.11 | 1.58 ± 0.11 |
| BMI | 25.87 ± 5.00 | 25.94 ± 2.00 | 23.22 ± 5.28 | 25.17 ± 4.08 | 27.42 ± 4.67 | 26.40 ± 4.97 | 25.58 ± 6.26 |
| Sleep Duration | 6.56 ± 1.20 | 0 | 7.30 ± 1.06 | 6.75 ± 1.08 | 6.64 ± 1.23 | 6.18 ± 1.20 | 6.31 ± 1.32 |
| Time to Get Up in Morning | 6.14 ± 1.33 | 0 | 6.43 ± 1.13 | 6.24 ± 1.35 | 6.05 ± 1.33 | 6.06 ± 1.12 | 5.86 ± 2.28 |

**Table 2B: Stratification based on gender and hypertension stages**

| Variable | Gender | | Hypertension Categories | | | | |
|---|---|---|---|---|---|---|---|
| | Male | Female | Normal | Elevated | Hypertension Stage 1 | Hypertension Stage 2 | Hypertensive Crisis |
| | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD |
| Age | 41.75 ± 14.94 | 42.32 ± 15.02 | 37.76 ± 14.03 | 40.82 ± 13.88 | 44.93 ± 14.31 | 50.60 ± 15.37 | 53.35 ± 13.60 |
| Physical Activity | 35.99 ± 24.61 | 34.76 ± 15.12 | 32.76 ± 12.38 | 39.42 ± 26.85 | 29.64 ± 10.83 | 36.84 ± 36.49 | 37.50 ± 15.00 |
| SBP | 125.75 ± 16.65 | 121.21 ± 18.11 | 109.45 ± 8.76 | 124.49 ± 2.82 | 134.07 ± 2.82 | 147.53 ± 5.44 | 166.96 ± 5.03 |
| DBP | 78.53 ± 12.46 | 75.08 ± 13.78 | 71.97 ± 12.77 | 78.34 ± 9.55 | 81.36 ± 11.33 | 84.28 ± 11.79 | 92.50 ± 14.32 |
| Pulse | 86.80 ± 12.83 | 89.61 ± 13.67 | 86.60 ± 13.29 | 89.15 ± 13.91 | 87.21 ± 10.52 | 89.24 ± 13.45 | 82.40 ± 12.21 |
| Weight | 71.57 ± 14.06 | 59.42 ± 12.32 | 65.67 ± 14.78 | 67.74 ± 13.87 | 71.00 ± 13.68 | 72.03 ± 15.77 | 69.60 ± 16.31 |
| Chest Circumference | 96.72 ± 14.35 | 90.34 ± 17.45 | 93.02 ± 14.35 | 95.28 ± 12.97 | 96.27 ± 21.29 | 95.43 ± 12.41 | 105.00 ± 22.40 |
| Waist Circumference | 95.51 ± 15.27 | 91.20 ± 19.17 | 91.46 ± 15.18 | 95.32 ± 13.67 | 96.13 ± 23.69 | 96.05 ± 13.86 | 102.27 ± 20.11 |
| Hip Circumference | 96.62 ± 10.95 | 97.75 ± 5.32 | 95.20 ± 9.04 | 95.29 ± 11.38 | 103.25 ± 4.11 | 102.00 ± 18.39 | 0 |
| Height | 1.65 ± 0.09 | 1.53 ± 0.08 | 1.61 ± 0.11 | 1.63 ± 0.10 | 1.62 ± 0.10 | 1.59 ± 0.11 | 1.61 ± 0.13 |
| BMI | 26.07 ± 4.88 | 25.38 ± 5.29 | 25.08 ± 4.92 | 25.25 ± 4.53 | 26.62 ± 4.54 | 28.19 ± 5.78 | 29.10 ± 5.29 |
| Sleep Duration | 6.52 ± 1.15 | 6.66 ± 1.33 | 6.60 ± 1.08 | 6.59 ± 1.09 | 6.26 ± 1.37 | 6.64 ± 1.55 | 6.62 ± 1.06 |
| Time to Get Up in Morning | 6.20 ± 1.31 | 6.00 ± 1.38 | 6.38 ± 1.35 | 5.92 ± 1.27 | 6.57 ± 1.56 | 5.54 ± 1.26 | 6.00 ± 0.89 |

**Table 2C: Crosstab with age, gender and hypertension**

| Age Group (Years) | Sex | Normal (%) | Elevated (%) | Hypertension Stage 1 (%) | Hypertension Stage 2 (%) | Hypertensive Crisis (%) |
|---|---|---|---|---|---|---|
| Under 11 | Males | 50.0 | 0.0 | 25.0 | 25.0 | 0.0 |
| | Females | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11–24 | Males | 34.6 | 38.5 | 17.3 | 5.8 | 3.8 |
| | Females | 90.5 | 9.5 | 0.0 | 0.0 | 0.0 |
| 25–36 | Males | 50.5 | 29.1 | 11.7 | 7.8 | 1.0 |
| | Females | 69.8 | 20.9 | 2.3 | 4.7 | 2.3 |
| 37–48 | Males | 35.6 | 33.7 | 20.2 | 8.7 | 1.9 |
| | Females | 48.6 | 27.0 | 8.1 | 13.5 | 2.7 |
| 49–60 | Males | 30.0 | 23.3 | 18.9 | 18.9 | 8.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Females | 28.3 | 28.3 | 23.9 | 17.4 | 2.2 |
| 61+ | Males | 28.6 | 19.0 | 7.1 | 28.6 | 16.7 |
| | Females | 18.8 | 25.0 | 18.8 | 18.8 | 18.8 |
| **Total** | Males | 37.5 | 28.9 | 15.9 | 12.7 | 5.1 |
| | Females | 51.2 | 23.2 | 11.0 | 11.0 | 3.7 |

**Table 3A: Pattern of population as % of overall population, falling in different hypertension categories, after Age stratification in terms of SBP**

| Age Group (Years) | Normal (%) | Elevated (%) | Hypertension Stage 1 (%) | Hypertension Stage 2 (%) | Hypertensive Crisis (%) |
|---|---|---|---|---|---|
| **Under 11** | 60.0% | 0.0% | 20.0% | 20.0% | 0.0% |
| **11–24** | 50.7% | 30.1% | 12.3% | 4.1% | 2.7% |
| **25–36** | 56.2% | 26.7% | 8.9% | 6.8% | 1.4% |
| **37–48** | 39.0% | 31.9% | 17.0% | 9.9% | 2.1% |
| **49–60** | 29.4% | 25.0% | 20.6% | 18.4% | 6.6% |
| **61+** | 25.9% | 20.7% | 10.3% | 25.9% | 17.2% |

**Table 3B: Crosstab with age, gender and hypertension**

| Age Group (Years) | Sex | Normal (%) | Elevated (%) | Hypertension Stage 1 (%) | Hypertension Stage 2 (%) | Hypertensive Crisis (%) |
|---|---|---|---|---|---|---|
| **Under 11** | Males | 50.0 | 0.0 | 25.0 | 25.0 | 0.0 |
| | Females | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **11–24** | Males | 34.6 | 38.5 | 17.3 | 5.8 | 3.8 |
| | Females | 90.5 | 9.5 | 0.0 | 0.0 | 0.0 |
| **25–36** | Males | 50.5 | 29.1 | 11.7 | 7.8 | 1.0 |
| | Females | 69.8 | 20.9 | 2.3 | 4.7 | 2.3 |
| **37–48** | Males | 35.6 | 33.7 | 20.2 | 8.7 | 1.9 |
| | Females | 48.6 | 27.0 | 8.1 | 13.5 | 2.7 |
| **49–60** | Males | 30.0 | 23.3 | 18.9 | 18.9 | 8.9 |
| | Females | 28.3 | 28.3 | 23.9 | 17.4 | 2.2 |
| **61+** | Males | 28.6 | 19.0 | 7.1 | 28.6 | 16.7 |
| | Females | 18.8 | 25.0 | 18.8 | 18.8 | 18.8 |
| **Total** | Males | 37.5 | 28.9 | 15.9 | 12.7 | 5.1 |
| | Females | 51.2 | 23.2 | 11.0 | 11.0 | 3.7 |

**Table 4: Descriptive Statistics by BMI Stratification**

| Variable | Mixed | Normal Weight | Obese | Overweight | Underweight |
|---|---|---|---|---|---|
| | Mean±SD | | | | |
| **N** | 244 | 125 | 62 | 114 | 21 |
| **Age (years)** | 40.90 ± 14.808 | 40.13 ± 16.004 | 46.06 ± 13.922 | 43.83 ± 13.890 | 41.29 ± 19.708 |
| **Physical Activity** | 34.48 ± 15.296 | 37.56 ± 29.377 | 33.00 ± 12.649 | 37.25 ± 29.642 | 34.38 ± 15.222 |
| **Systole (mmHg)** | 125.01 ± 18.033 | 122.89 ± 17.011 | 130.31 ± 19.654 | 125.38 ± 17.394 | 118.65 ± 22.342 |
| **Diastole (mmHg)** | 77.71 ± 12.726 | 76.06 ± 12.009 | 83.66 ± 16.451 | 78.11 ± 11.358 | 66.55 ± 12.779 |
| **Pulse (bpm)** | 86.46 ± 12.949 | 87.68 ± 13.559 | 89.59 ± 13.928 | 87.96 ± 12.065 | 90.50 ± 15.576 |
| **Weight (kg)** | 67.93 ± 14.183 | 59.78 ± 9.697 | 83.94 ± 12.470 | 72.71 ± 9.492 | 44.29 ± 6.908 |
| **Chest (cm)** | 95.10 ± 15.045 | 91.83 ± 13.048 | 100.65 ± 13.680 | 94.83 ± 17.823 | 84.00 ± 12.600 |
| **Waist (cm)** | 95.69 ± 16.946 | 90.47 ± 14.073 | 100.31 ± 14.516 | 93.56 ± 17.218 | 77.56 ± 11.159 |
| **Hip (cm)** | 85.00 ± 15.122 | 91.90 ± 8.020 | 104.25 ± 6.397 | 102.25 ± 5.429 | - |
| **Height (m)** | 1.60 ± 0.106 | 1.63 ± 0.112 | 1.58 ± 0.097 | 1.63 ± 0.102 | 1.61 ± 0.110 |
| **BMI** | - | 22.45 ± 1.663 | 34.25 ± 5.081 | 27.18 ± 1.312 | 17.02 ± 1.364 |
| **Sleep Duration (hrs)** | 6.26 ± 0.849 | 6.70 ± 1.266 | 7.05 ± 1.471 | 6.61 ± 1.368 | 7.33 1.155 |

**Table 5: Pearson Correlations of SBP with other Variables in overall population**

| Variable | Female (r, N) | Male (r, N) |
|---|---|---|
| Age | 0.494**, (167) | 0.264**, (394) |
| Physical Activity | 0.126, (41) | 0.069, (123) |
| Diastole | 0.468**, (165) | 0.503**, (394) |
| Pulse | -0.015, (124) | 0.170**, (306) |
| Weight | 0.148, (125) | 0.150*, (280) |

| | | |
|---|---|---|
| Chest | 0.102, (85) | 0.155*, (226) |
| Waist | 0.210, (85) | 0.077, (227) |
| Hip | 0.764**, (4) | 0.139, (26) |
| Height | 0.034, (118) | -0.137*, (292) |
| BMI | 0.231*, (95) | 0.200**, (227) |
| Sleep Duration | 0.119, (45) | -0.190, (105) |

Notes: ** indicates significance at p<0.01p, * indicates significance at p<0.05p. Gender-specific correlations for "Age-Systole" are included for clarity.

**Table 6A: Regression analysis of SBP (dependent variable) with different sets of independent variables in BMI based stratification Test of Regression model in case of SBP and BMI**

| SBP | | | | |
|---|---|---|---|---|
| **N** | **Independent Variables** | **$R^2$** | **F** | **Model Significance** |
| 260 | Age, DBP, Pulse, Weight, Height, BMI | 0.285 | 16.824 | $p < 0.001$ |
| 183 | Age, DBP, Pulse, Weight, Height, BMI | 0.137 | 4.640 | $p < 0.001$ |
| 77 | Age, DBP, Pulse, Weight, Height, BMI | 0.300 | 5.001 | $p < 0.001$ |
| **BMI** | | | | |
| **N** | **Independent Variables** | **$R^2$** | **F** | **Model Significance** |
| 260 | Age, DBP, Pulse, Weight, Height, BMI | 0.285 | 16.824 | $p < 0.001$ |
| 161 | Age, DBP, Pulse, Weight, Height, BMI | 0.307 | 11.348 | $p < 0.001$ |
| 99 | Age, DBP, Pulse, Weight, Height, BMI | 0.259 | 5.367 | $p < 0.001$ |

**Table 6 B: Regression analysis of SBP (dependent variable) in subjects classified under different categories of BMI Test of Regression model in case of SBP and BMI**

| SBP | | | | | | |
|---|---|---|---|---|---|---|
| | **Age** | **Diastole** | **Pulse** | **Weight** | **Height** | **BMI** |
| Total Population (n-260) | | | | | | |
| Unstandardized | 0.342 | 0.418 | -0.048 | 0.079 | -2.581 | 0.155 |
| Sig. (p-value) | 0.000 | 0.000 | 0.475 | 0.88 | 0.953 | 0.908 |
| SBP< 130 (n-183) | | | | | | |
| Unstandardized | 0.057 | 0.252 | 0.020 | -0.074 | 16.458 | 0.167 |
| Sig. (p-value) | 0.244 | 0.000 | 0.710 | 0.861 | 0.636 | 0.879 |
| SBP ≥ 130 (n-77) | | | | | | |
| Unstandardized | 0.360 | 0.212 | 0.034 | 1.605 | -139.77 | -3.793 |
| Sig. (p-value) | 0.000 | 0.049 | 0.730 | 0.049 | 0.060 | 0.067 |
| **BMI** | | | | | | |
| | **Age** | **Diastole** | **Pulse** | **Weight** | **Height** | **BMI** |
| Total population (n-260) | | | | | | |
| Unstandardized | 0.342 | 0.418 | -0.048 | 0.079 | -2.581 | 0.155 |
| Sig. (p-value) | 0.000 | 0.000 | 0.475 | 0.88 | 0.953 | 0.908 |
| BMI ≤ 27 (n-161) | | | | | | |
| Unstandardized | 0.311 | 0.468 | -0.070 | -1.177 | 83.52 | 3.726 |
| Sig. (p-value) | 0.00 | 0.00 | 0.379 | 0.223 | 0.251 | 0.139 |
| BMI > 27 (n-99) | | | | | | |
| Unstandardized | 0.453 | 0.348 | 0.036 | 0.403 | -22.27 | -0.452 |
| Sig. (p-value) | 0.001 | 0.003 | 0.769 | 0.768 | 0.870 | 0.897 |

**Table 7A: Stepwise regression analysis of SBP (dependent variable) with different sets of independent variables and their comparison with the Pearson Correlations Coefficient**

1-Age, 2-Physical Activity, 3-Diastole, 4-Pulse, 5-Body Weight, 6-Chest circumference, 7- Waist circumference, 8-Hip circumference, 9-Height, 10-BMI, 11-Sleep duration (in hour)

| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pearson Correlations | | | | | | | | | | | |
| N | 554 | 164 | 559 | 426 | 402 | 307 | 308 | 30 | 407 | 319 | 148 |
| Pearson Correlation | $.333^{**}$ | .079 | $.487^{**}$ | -.003 | $.179^{**}$ | $.184^{**}$ | $.167^{**}$ | .143 | .016 | $.251^{**}$ | -.015 |
| Sig. (2-tailed) | .000 | .312 | .000 | .950 | .000 | .001 | .003 | .451 | .753 | .000 | .861 |
| Regression Coefficient (n-15) | | | | | | | | | | | |
| Unstandardized | -0.016 | 0.024 | 0.578 | -0.183 | 1.178 | -0.327 | 1.891 | -0.571 | -62.22 | -5.091 | 3.117 |
| Sig. (p-value) | 0.982 | 0.877 | 0.674 | 0.893 | 0.89 | 0.313 | 0.214 | 0.845 | 0.94 | 0.816 | 0.714 |
| Regression Coefficient (n-20) | | | | | | | | | | | |
| Unstandardized | 0.75 | 0.046 | 0.037 | 0.232 | 1.509 | -0.226 | 0.168 | | -105.45 | -4.878 | 3.872 |
| Sig. (p-value) | 0.074 | 0.549 | 0.926 | 0.427 | 0.579 | 0.19 | 0.63 | | 0.644 | 0.54 | 0.386 |
| Regression Coefficient (n-192) | | | | | | | | | | | |
| Unstandardize | 0.305 | | 0.406 | - | 0.25 | -0.02 | 0.11 | | - | - | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| d | | | | 0.048 | 3 | | 9 | | 21.747 | 0.387 | |
| Sig. (p-value) | 0.000** | | 0.000** | 0.53 | 0.714 | 0.812 | 0.137 | | 0.713 | 0.83 | |
| Regression Coefficient (n-260) | | | | | | | | | | | |
| Unstandardized | 0.342 | | 0.418 | -0.048 | 0.079 | | | | -2.581 | 0.155 | |
| Sig. (p-value) | 0.000** | | 0.000** | 0.475 | 0.88 | | | | 0.953 | 0.908 | |

**Table 7B: Names of variables used in different regression models for SBP and their model fitness**

| Sr. No. | N | Independent Variables | $R^2$ | F | Model Significance |
|---|---|---|---|---|---|
| 1 | 260 | Age, DBP, Pulse, Weight, Height, BMI | 0.285 | 16.824 | $p < 0.001$ |
| 2 | 192 | Age, DBP, Pulse, Weight, Height, BMI Chest, Waist, | 0.282 | 8.987 | $p < 0.001$ |
| 3 | 20 | Age, DBP, Pulse, Weight, Height, BMI, Chest, Waist, Physical Activity and Sleep Duration (hours) | 0.596 | 1.329 | P = 0.340 |
| 4 | 15 | Age, DBP, Pulse, Weight, Height, BMI, Chest, Waist, Physical Activity, Sleep Duration (hours), Hip, | 0.798 | 1.079 | P = 0.540 |

## DISCUSSION

This study reveals a high prevalence of hypertension in the Varanasi region, with over half of the participants having elevated blood pressure or hypertension. The distribution of blood pressure categories is consistent with global trends, emphasizing the need for public health interventions. The finding that 41.12% of individuals have normal blood pressure, 13.08% have elevated blood pressure, 28.35% have hypertension stage 1 and 14.02% have hypertension stage 2 is important for health planning in the community. This can be further summarized that about 55.45% of the participants had either elevated blood pressure or in the category of Hypertension Stages 1 or 2. These findings are consistent with findings from other developing and developed countries that align with global trends indicating a significant prevalence of hypertension across various populations.

A study in Kerala reported a hypertension prevalence of 36.7% among adults aged 18 years and above, emphasizing a higher prevalence among urban populations compared to rural areas.[11] Similarly, a survey conducted in urban Chennai showed a prevalence of 31.5% among the adult population, highlighting urbanization and lifestyle changes as contributing factors.[12] In contrast, a study in the rural regions of Rajasthan found a lower prevalence of 20.5%, which may be attributed to different dietary patterns, physical activity levels, and socioeconomic status compared to urban areas.[13] These regional variations within India highlight the influence of localized factors such as dietary patterns, urbanization, and stress levels.

The WHO emphasizes the importance of monitoring and reducing hypertension through public health interventions such as salt reduction in diets, increasing physical activity, and promoting access to essential medicines.[14] The American Heart Association (AHA) also notes that nearly half of adults in the United States have hypertension, underscoring the need for widespread public health measures and effective management strategies.[15] In comparison to a study conducted in China, which reported a hypertension prevalence of 23.2% among adults, our results indicate a higher prevalence of hypertensive individuals.[16] Similarly, a study from the United States found that approximately 46% of the adult population had hypertension, which is close to our findings. These discrepancies may be attributed to differences in lifestyle, diet, genetic predispositions, and healthcare access.[17]

The genetic biodiversity in the Indian population plays a crucial role in the variation of hypertension prevalence across different states, having wide ethnic variations. A study by the Indian Genome Variation Consortium highlighted the genetic diversity among various Indian populations and its potential impact on health outcomes, including hypertension.[18] Additionally, a study conducted in North India found that the prevalence of hypertension was higher among populations with a genetic predisposition to salt sensitivity, suggesting that genetic factors may influence the body's response to dietary salt intake.[19] This is consistent with findings from our survey in Varanasi, where the high prevalence of hypertension could be influenced by genetic factors, dietary habits, and lifestyle choices prevalent in the region.

The gender differences, particularly the higher proportion of males with hypertension, are noteworthy. These differences could be attributed to lifestyle, food habits, and endocrinological variations. The higher percentage of normal blood pressure in females suggests a protective mechanism, potentially linked to estrogen. The study showed an increasing trend of SBP with age, reflecting the cumulative effects of ageing on vascular health.

The correlation analysis showed a significant positive correlation between age and systolic blood pressure. Regression analysis further confirmed that age and diastolic blood pressure were significant predictors of SBP for both genders, with age being a stronger predictor in females. Interestingly, hip circumference had a significant correlation with SBP in females, suggesting that central body fat distribution might play a significant role in determining systolic blood pressure in females. While weight and BMI showed moderate correlations with SBP, they were not statistically significant predictors in regression models which could be due to small sample sizes for these variables.

The findings of this study are consistent with the WHO recommendations for population-based screening and management of hypertension to reduce cardiovascular diseases. Community-based programs that promote lifestyle changes, such as increased physical activity, dietary changes, and stress management, should be implemented to reduce hypertension. The results also align with other studies in India which found a varying prevalence of hypertension across the country, reflecting genetic variability and socio-economic differences. These regional variations highlight the need for localized interventions.

The study had some limitations. Firstly, it did not include all relevant variables and had low participant numbers for some of them and also did not use imputation for missing values. This limitation led to some inconsistencies in the regression models. For instance, physical activity, pulse, and sleep duration did not show significant associations with SBP, which is not in line with other published literature. This could be due to measurement inconsistencies or a limited range of variability in these factors.

This analysis underscores age, diastolic BP, and body weight as robust predictors of systolic blood pressure, with strong correlations and consistent regression coefficients. While chest and waist circumference show significant correlations, their regression inconsistencies suggest potential confounding effects. In contrast, variables such as physical activity, pulse, and sleep duration exhibit negligible correlations and regression coefficients, indicating minimal influence on SBP, which is unusual and needs further exploration. This may be attributed to low sample size, high range of variability in physical activity, misclassification or imprecise measurement of physical activities. Earlier reports indicate an inverse correlation between physical activity and SBP, attributed to its improved vascular function, reduced arterial stiffness and enhanced cardiac efficiency.

We did several ways of stratification, before doing the regression analysis, which seemed to be of importance to improve the scientific importance of SBP and its non-linear relationship with its predictors. The population of different SBP categories highlight associations between SBP and other variables in those people, who have different stages of disease pathogenesis, lifestyle issues and age. Stratification has also reduced the confounding factors by isolating the effect of each variable within subgroups, depicting better associations between dependent and independent variables. Our results have indicated that the power of coefficient for age, DBP, height and weight is changes in different stratified groups, based on SBP, BMI, age and gender. It would help make better strategies of health screening, tailored to specific population groups. This has been further validated by comparing the powers of coefficients of Pearson correlation and regression analysis, as they respectively predict the power of prediction of different independent variables, individually and collectively. We have found a nonlinear relationship between age, gender and people having normal SBP (<130) or hypertensive (>130). It has helped identify the thresholds/cut-off points for risk identification in specific population groups by making tailored recommendations.

Pearson’s correlation and regression analysis can provide comprehensive answers to relationships among variables. Regression analysis reveals the gender-specific influence of different variables on SBP change as it was 21.2%, in males and 39.7% in females, antioxidant and anti-inflammatory potentials of female hormones.[7,8,9] The SBP is also reported to rise with increasing age in both genders. In addition to female hormones other contributing factors may include lifestyle, obesity prevalence, physical activity, and anthropometric variables.[10]

The high prevalence of hypertension in our study population underscores the urgent need for public health interventions in Varanasi. Implementing regular screening programs in primary healthcare settings can aid in identifying individuals at risk and providing timely interventions. Our findings would be helpful in making gender, age and lifestyle-oriented, tailored strategies for screening and timely interventions in Varanasi. Community-based programs focusing on lifestyle modifications, such as lifestyle modifications, increased physical activity, dietary changes and stress management, and reducing salt intake could be effective in managing the burden of hypertension. Additionally, enhancing public awareness about the risks of uncontrolled hypertension and the importance of regular blood pressure monitoring is crucial.

The positive correlation between the pulse rate and SBP is due to heightened sympathetic nervous activity. This wrong presentation of our data may be attributed to measurement inconsistencies, wrong timing of pulse recording or low sample size with high data distribution patterns. Similarly, our study has indicated a negative correlation between sleep duration and SBP, which also appears to be wrong as short sleep durations are associated with higher SBP due to increased sympathetic tone and reduced nocturnal dipping. Sleep works through the involvement of circadian rhythm and stress hormone modulation. The observed negligible effect again may be attributed to the small sample size and underrepresentation of individuals with extreme sleep durations.

The contradictory information in our study needs a more systemic study with a larger and more diverse sample size and robust questionnaire to address each objective. This would ensure a relationship between these variables and SBP in the population of Varanasi region in a gender-specific manner.

## CONCLUSION

This study highlights a significant prevalence of hypertension in Varanasi and emphasizes the importance of considering genetic biodiversity and regional differences in developing tailored public health strategies. The findings underscore the need for targeted interventions and public health strategies to manage and prevent hypertension and its associated complications. Specifically, there is a need for gender-specific strategies, considering that age is a stronger predictor of SBP for females than for males. Further research is needed to explore the underlying genetic and environmental factors, effect of sleep quality and duration, amount and type of physical activity, and pulse rate contributing to hypertension in the Varanasi region and to design effective interventions.

### Limitations and Future Directions

- The study acknowledges that some variables, such as physical activity and sleep duration, did not show the expected correlations with SBP, which may be attributed to sample-specific limitations and measurement errors.
- The study calls for further research with more robust measurement tools, larger and more diverse samples, and multivariable adjustments to better understand the relationships between these variables and SBP.
- This study provides valuable insights into the prevalence and factors associated with hypertension in Varanasi, India, and underscores the need for targeted public health interventions and further research to address this health concern.

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