

Observational Study on the Association Between Body Mass Index and Hypertension Among Adults of Jamia Nagar and Its Adjoining Areas

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Abstract

Hypertension is becoming the talk of the town nowadays. It has been found that persons with high BMI are more prone to hypertension. Research studies have found that there is an increase in the number of cases in the developing nations as well, when compared with the developed world. BMI, which is also known as Basal mass index help in measuring the leanness of a person, which helps in quantifying tissue mass and whether a person has a healthy body weight for their height. It has been seen that higher BMI is strongly and directly associated with increased risk of hypertension. This study aims to evaluate the correlation between BMI and SBP and DBP in the population of Jamia Nagar and its adjoining areas. A cross-sectional study was conducted among 247 adults of Jamia Nagar and its adjoining area. Their height and weight were measured to calculate BMI (kg/m²) along with sugar, pulse, and Hb. Data shows the mean age of respondents is 43.02 ± 13.60 years, with an average BMI of 28.64 ± 11.40 , indicating an overweight population. It was observed that weight had a positive significant ($p < 0.01$) relationship with both SBP ($r = 0.174$) and DBP ($r = 0.20$). While BMI had a weak positive nonsignificant correlation with SBP ($r = 0.082$) and DBP ($r = 0.068$). The findings of this study show that the population may have more muscle mass than absolute body weight or fat or adipose tissue, which is supposed to be the primary driver of the slight increase in both SBP and DBP.

Keywords: SBP, DBP, BMI, weight, hypertension, Hb

INTRODUCTION

It has been seen that the prevalence of hypertension is rising among all age groups. BMI or Body Mass Index is one of the important factors that is linked to elevated blood pressure. This is widely used to monitor body fat, which is based on person weight relative to their height. Many studies have shown that individuals with high BMI are more prone to developing hypertension regardless of age and gender [1]. It has been found that excess weight, especially visceral fat, causes 65% to 75% of primary hypertension risk; therefore, maintaining a healthy body weight is very important. It has been seen that each 1 kg/m² increase in BMI increases the risk of hypertension by about 17% [2–4]. Obesity is rapidly increasing and becoming a global epidemic, with approximately 1.9 billion people being overweight and 650 million classified as obese worldwide [5].

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Recent research findings suggest that hypertension [6] is related to the prevalence, pathophysiology, and morbidity caused by obesity. Surgical weight loss is one of the important procedures to manage hypertension in obesity, which leads to a reduction in blood pressure, decreasing organ damage in the patient population.

Recent scientific research shows that the development of hypertension is linked with multiple physio-pathological processes that cause

organ damage such as cardiovascular and chronic kidney disease. This process causes insulin resistance, oxidative stress, and inflammation, which lead to endothelial dysfunction that can alter the hemodynamics of the whole body, resulting in an increase in blood pressure [7–10].

It has been seen that obesity has become a significant health concern in both developed and developing countries across the world. As we know, India is one of the most populous countries in the world, which is experiencing a sharp rise in obesity due to urbanization, industrialization, and lifestyle changes [11]. It has been found that this prevalence is higher in females compared to males and is supposed to triple by 2040 [12, 13]. It has been found that overweight individuals are more susceptible to conditions, like type-2 diabetes, chronic renal disease, and cardiovascular disease, which includes hypertension, when compared to healthy individuals [14].

It has been found that body mass index (BMI) is one of the important measures of obesity, which can be used in clinical and public health guidelines [5]. Body mass index has certain limitations because it does not consider body shape or body fat distribution [15, 16]. Scientifically, it has been seen that BMI is less accurate in older adults as body fat is redistributed in the abdominal region with age [17]. Waist circumference is widely and inexpensive as well as reliable indicator for the identification of central obesity, which correlates with cardiovascular mortality.

It has been seen in the Western world that in both cross-sectional and longitudinal studies, there is a positive relationship between blood pressure and body weight, especially in children and in early adulthood [18]. Increased peripheral resistance, sympathetic nervous system activation, as well as changes in renal sodium handling, lead to high BMI and obesity, which is very important in the pathogenesis of high blood pressure. Therefore, the burden of both obesity and hypertension predicts future cardiovascular complications, which further pose a challenge for public health systems [19].

It has been found that Hypertension is increasing in India at a rapid pace, with nearly 1 in 4 adults affected by it, which may be due to an increase in overweight/obesity. This may be because of modern lifestyle, like consumption of processed food and less physical activity, which causes hypertension and heart disease [1, 19–22].

BMI and blood pressure are closely related, as there is a close association between them. Therefore, the study aims to study to see relationship between BMI, weight, Blood sugar, Pulse rate, blood pressure [20], and Hb among the participants, to see the relationship between weight and blood pressure, to compare clinical parameters across BMI categories, and to associate gender with BMI categories.

MATERIAL AND METHODS

247 people from Jamia Nagar and its adjoining areas were taken for this cross-sectional observational study. Participants were selected through simple random sampling from the health camp. Participants with cardiovascular diseases and using antihypertensive medication were excluded from the study to prevent false-positive tests.

First, informed consent was obtained from the participants, after which anthropometric measurements were recorded, including height and weight. The height of the participants was measured by a stadiometer, while weight was recorded by a digital weighing scale. Finally, BMI was calculated by using the formula:

$$\text{BMI} = \text{Weight (Kg)} \div (\text{Height})^2$$

A calibrated digital sphygmomanometer was used to measure blood pressure, which includes both systolic and diastolic blood pressure. The patient was asked to be seated in a relaxed position for 5 minutes before BP measurement. They are asked to keep their arm supported at heart level. Values of both SBP and DBP were recorded in mm Hg.

RESULTS

A stadiometer was used to measure height, while a digital weighing scale was used to measure weight, and accordingly, BMI was calculated using this formula:

$$\text{BMI} = \text{Weight (Kg)} / (\text{Height})^2$$

The subjects or participants were categorized into categories as per WHO guidelines, underweight ($<18.5 \text{ kg/m}^2$), Normal ($18.5\text{--}24.9 \text{ kg/m}^2$), Overweight ($25.0\text{--}29.9 \text{ kg/m}^2$) and Obese ($\geq 30.0 \text{ kg/m}^2$).

Calibrate digital sphygmometer was used to measure blood pressure in a quiet room. Every participant was asked to sit in a relaxed position for 5 minutes before the measurement with the arm supported at heart level. Systolic (SBP) and Diastolic blood pressure (DBP) were recorded at a 2-minute interval, with the average considered for analysis in mm Hg along with pulse.

Along with this, sugar was measured by SD code free (Biosensor), and Haemoglobin was measured by Hemo Cue Hb 201+ analyzer. A prick was made, and a fresh capillary whole blood sample from the fingertip was taken after discarding the first sample. The blood sample was applied to the test strip to measure blood sugar, delivering results in 5 seconds. HemoCue Hb 201+ analyzer was used during the study for measuring Hb, which is a standard in haemoglobin point of care testing, which is based on oxidation of haemoglobin to methemoglobin by sodium nitrite and the subsequent conversion of methemoglobin to hemiglobinazide by sodium azide.

RESULTS

Demographics and Clinical Characteristics of Respondents

Table 1 and Figures 1–2 show gender frequency, with most participants being female (70.9%) compared to 29.1% male, and the mean age of respondents was 43.02 ± 13.60 years. The average BMI was 28.64 ± 11.40 , including a tendency towards overweight (Figure 1). The mean systolic and diastolic blood pressure were 123.12 ± 20.42 and 78.92 ± 11.78 mm Hg, blood sugar 136.14 ± 52.60 , Haemoglobin 12.22 ± 1.84 , and pulse 85.53 ± 12.43 were reported.

Table 1. Clinical characteristics of respondents.

	Mean	STD
Age	43.02	13.60
Weight in Kg	67.85	13.99
Height in meter	1.56	0.12
BMI	28.64	11.40
Systolic BP	123.12	20.42
Diastolic BP	78.92	11.78
Blood sugar in mg/dl	136.14	52.60
Hb value in gm %	12.22	1.84
Pulse	85.53	12.43
<i>Gender (Frequency %)</i>		
Male	72	29.1%
Female	175	70.9%

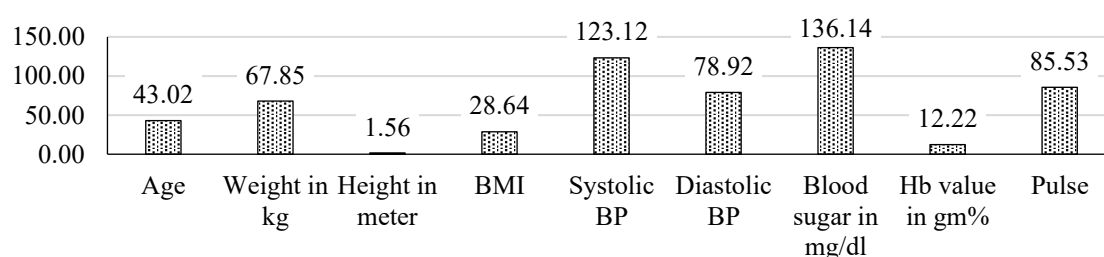


Figure 1. Clinical characteristics of respondents.

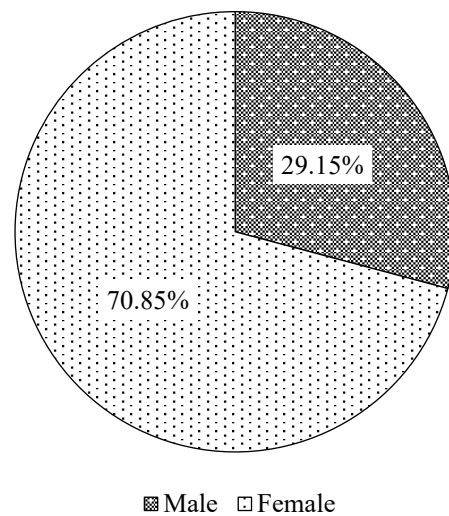


Figure 2. Gender distribution in the study.

Table 2 represents the relationship between multiple variables such as BMI, Blood Sugar, Pulse, Blood pressure, and Hb. It was found that the correlation between pulse and blood sugar was significant at the level 0.01 ($r = 0.182$), while the correlation with systolic ($r = 0.012$) and Diastolic BP ($r = 0.045$), along with Hb, was non-significant.

Observation findings during this study also suggested a significant correlation at the level of 0.05 between Pulse and diastolic blood pressure ($r = 0.133$). These research findings also suggest a non-significant correlation between pulse and systolic blood pressure ($r = 0.042$) and Hb ($r = 0.123$). Besides this, a correlation between systolic and diastolic blood pressure was found significant at the 0.01 level ($r = 0.484$), while the relationship between Hb and systolic as well as diastolic blood pressure was non-significant ($r = 0.103$), ($r = 0.106$).

Table 2. Relationship between BMI, blood sugar, pulse rate, blood pressure, and Hb among participants.

	BMI	Blood sugar in mg/dl	Pulse	Systolic BP	Diastolic BP	Hb (gm %)
BMI	1					
Blood sugar in mg/dl	-0.047	1				
Pulse	0.059	0.182**	1			
Systolic BP	0.082	0.012	0.042	1		
Diastolic BP	0.068	0.045	0.133*	0.484**	1	
Hb (gm%)	-0.076	0.119	0.123	0.103	0.106	1

Note: ** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level.

Table 3 shows the relationship between weight and blood pressure, sugar, pulse, and Hb. Recent findings suggest a positive non-significant correlation between weight and sugar ($r = 0.061$), pulse ($r = 0.55$), while a non-significant negative correlation was observed between weight and Hb ($r = -0.067$). Besides this correlation between blood sugar and Pulse, Diastolic and Systolic BP, as well as Hb, were recorded during this study. It was found that the correlation between Pulse and sugar was significant at the level 0.01 ($r = 0.182$), while with others, i.e., Systolic BP ($r = 0.012$), diastolic BP ($r = 0.045$), and Hb ($r = 0.119$).

The relationship of pulse with systolic and diastolic BP, along with HB, was also studied, as mentioned in Table 3. There was a positive non-significant relationship between Pulse and Systolic BP

($r = 0.042$) and a significant relationship with diastolic BP ($r = 0.133$) at the 0.05 level. While pulse and Hb were non-significantly and negatively related ($r = -0.123$). Table 3 also showed a positive and significant correlation at the level 0.01 between systolic and diastolic BP ($r = 0.484$) while positive non-significant correlation was observed between systolic BP and Hb ($r = 0.103$), as well as between Diastolic BP and Hb ($r = 0.106$).

Table 3. Relationship between weight and blood pressure.

	Weight in kg	Blood sugar in mg/dl	Pulse	Systolic BP	Diastolic BP	Hb (gm %)
Weight in kg	1					
Blood sugar in mg/dl	0.061	1				
Pulse	0.055	.182**	1			
Systolic BP	.174**	0.012	0.042	1		
Diastolic BP	.201**	0.045	.133*	.484**	1	
Hb (gm%)	-0.067	0.119	-0.123	0.103	0.106	1

Note: Correlation is significant at the 0.01 level. Correlation is significant at the 0.05 level.

Comparison of Clinical Parameters Across BMI Categories

When clinical parameters were compared with BMI categories, it was found that weight, height, systolic blood pressure, and Hb differed significantly across BMI categories ($p < 0.05$). Weight and systolic BP increased with higher BMI, while Hb levels slightly decreased in overweight and obese groups. However, age, diastolic BP, blood sugar, and pulse did not show significant differences across BMI categories ($p > 0.05$) (Table 4).

Table 4. Difference in clinical parameters across BMI categories.

	Underweight	Normal	Overweight	Obesity	F	p
Age	37.92 ± 18.94	43.82 ± 14.31	42.4 ± 12.6	43.76 ± 13.12	0.822	0.483
Weight in kg	41.15 ± 11.68	57.35 ± 7.52	68.15 ± 8.7	79.41 ± 10.05	113.26	0.000
Height in m	1.62 ± 0.09	1.6 ± 0.1	1.57 ± 0.09	1.5 ± 0.13	14.17	0.000
Systolic BP	121.15 ± 21.16	115.92 ± 18.7	123.44 ± 21.91	128.48 ± 18.68	4.96	0.002
Diastolic BP	76.46 ± 7.21	77.31 ± 13.66	78.63 ± 13.42	80.76 ± 8.65	1.32	0.268
Blood sugar in mg/dl	126.23 ± 42.46	135.82 ± 63.53	142.1 ± 57.41	132.31 ± 38.7	0.65	0.582
Hb value in gm %	12.24 ± 1.97	12.79 ± 1.72	12.06 ± 1.77	11.93 ± 1.91	3.10	0.027
Pulse	84.15 ± 8.32	82.95 ± 12.1	86.52 ± 12.48	86.72 ± 13	1.43	0.233

The multiple comparison analysis (**Error! Reference source not found.**) depicts that the weight of the respondents significantly differed between all BMI categories ($p < 0.001$), with weight increasing progressively from underweight to obesity. Height was significantly higher in the underweight, normal, and overweight groups compared to the obese group. Systolic BP was significantly higher in the obese group than the normal BMI group, and Hb levels were significantly lower in the obese group compared to the normal BMI group.

Association of Population with BMI Categories

Although a slightly higher population was found to be overweight and obese compared to the underweight and normal BMI categories (Table 6).

DISCUSSION

Various findings suggest that India is one of the most densely populated countries in the world. Due to globalization and changes in lifestyle, along with food habits, these factors are creating a bad impact on the human population, resulting in hypertension or an increase in Systolic and Diastolic blood

pressure. Recent findings have suggested an overall prevalence of hypertension in India to be 22.6%, with Indian men having a slightly higher prevalence (24.1%) than women (21.2%). It has also been found that its prevalence increased with age, which was about 48.4% of individuals who are aged 60 or above. The urban population displayed a slightly higher prevalence (25%) when compared with the rural population (21.4%), displaying rapid spread across the population. Regional variations were also observed in recent findings, suggesting the highest prevalence in Sikkim, accounting for 37.9%, and the lowest in Rajasthan (16.5%). Published findings also suggest that the population belonging to the upper class or the richest quintile is more likely to have hypertension [19].

Table 5. Multiple comparison table.

(I) BMI cate	(J) BMI cate	Mean difference (I–J)	Sig.	95% CI	
				Lower bound	Upper bound
Weight in kg					
Underweight	Normal	–16.200*	0.000	–23.34	–9.06
	Overweight	–26.992*	0.000	–34.01	–19.97
	Obesity	–38.260*	0.000	–45.25	–31.27
Normal	Overweight	–10.792*	0.000	–14.70	–6.89
	Obesity	–22.060*	0.000	–25.91	–18.21
Overweight	Obesity	–11.267*	0.000	–14.89	–7.65
Height (m)					
Underweight	Obesity	.12096*	0.001	0.04	0.20
Normal	Obesity	.10173*	0.000	0.06	0.15
Overweight	Obesity	.07406*	0.000	0.03	0.12
Systolic BP					
Normal	Obesity	–12.560*	0.001	–21.02	–4.10
Hb value in gm%					
Normal	Obesity	.860*	0.022	0.09	1.63

Table 6. Association of study population with BMI categories.

BMI categories	Population
Underweight	13 (5.26%)
Normal	65 (26.3%)
Overweight	82 (33.19%)
Obesity	87 (35.22%)

It has been found that most of the population density is towards the obese population, which is creating a big impact on society which is causing a big impact on medical infrastructure which is affecting national economy as well. Keeping that in mind, a cross-sectional or observational study has been designed on the population of Jamia Nagar to analyse the correlation between BMI (Body Mass Index) and SBP and DBP. A health camp was organised, and participants were taken from it for the study.

The present study demonstrated a positive and significant ($p < 0.01$) correlation between weight and systolic ($r = 0.174$) and diastolic ($r = 0.20$) blood pressure, while a positive, non-significant correlation ($p > 0.05$) between BMI and both systolic ($r = 0.082$) and diastolic blood pressure was reported. Research findings suggest that there is a strong correlation between body weight and both systolic and diastolic blood pressure [20].

Several mechanisms can explain this association. It has been seen that increased body weight results in an increase in SBP and DBP, which further makes body weight a greater risk factor for hypertension [21–23]. The accumulation of visceral fat in the body leads to the release of free fatty acids into the systemic circulation, which in turn leads to insulin resistance and reduced endothelial nitric oxide (NO)

secretion [6, 24]. Nitric oxide, or NO, is known as a potent vasodilator that plays an important role in blood pressure regulation.

Research findings suggest that Angiotensin-converting enzyme (ACE), aldosterone levels, along with renin activity, in the obese population are found to be higher than in normal-weight people [25, 26]. Increased angiotensin II production causes systemic vasoconstriction due to the renin–angiotensin–aldosterone system (RAAS). It has been found that a major role of Angiotensin II is fluid retention along with sodium reabsorption inside the kidneys, which results in intravascular volume expansion as well as hypertension. Further, RAAS helps in raising blood pressure by increasing sympathetic nervous system activity along with sympathetic tone [25]. Research findings suggested that obesity is linked with complications like Iron deficiency anemia [26]. The high prevalence of obesity with iron deficiency suggests an association between obesity and iron status, which was seen in this observational study as well.

It was scientifically documented that this association between obesity and iron deficiency results in increased hepcidin levels, which is because of chronic inflammation. It has been found that Hepcidin, which is a small peptide hormone, functions as a negative regulator of intestinal iron absorption. It has been observed during this study that loss in body weight in overweight or obese participants reduces chronic inflammation and serum hepcidin levels, resulting in improved iron status due to increased iron absorption [27].

These findings also support the research findings that weight often shows a stronger correlation with blood pressure (BP) than Body Mass Index (BMI). This may be due to limitations of BMI, which cannot differentiate between body fat and muscle mass. It has been seen that absolute body weight acts as a better proxy for the total volume of adipose tissues, which contributes to the physical load placed on the cardiovascular system.

So, it can be said that excess body fat or visceral fat is the primary driver of obesity related hypertension.

As we know, elevated blood pressure is most of the time linked with increased adiposity. It has been found that obesity causes increased sympathetic nervous activity along with sodium retention and Insulin resistance, which further result in elevated blood pressure levels. Besides this, it has been found that adipose tissues in the body act as an endocrine organ, which further releases inflammatory cytokines and adipokines, which promote vascular dysfunction as well as endothelial impairment, which causes increased hypertension risk [27, 28].

Since the increase is marginal in both SBP and DBP in the obese population, it can be said that increased muscular mass in the population is contributing to weight gain, but absolute body weight in this population is in proportion, which is leading to a marginal increase in SBP and DBP [29].

CONCLUSION

While concluding, as we can see from the research findings, there is a positive and significant relationship between basal metabolic index and blood pressure, which includes both SBP and DBP. On the other hand, it has been found that the findings of this observational study reinforce a significant relationship between weight and blood pressure. We have also seen that there was a marginal increase in both the SBP and DBP, or we can say it is the muscle mass that is contributing to the weight gain in this population, which is finally resulting in a marginal increase in SBP and DBP.

Therefore, it can be inferred that maintaining proper body weight is very important along with regular exercise, which contributes to muscle mass, hence helping to maintain SBP and DBP. It emphasizes the urgent need for an integrated prevention approach to maintain weight and blood pressure.

Conflict of Interest

No potential competing interest was reported by the authors.

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