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Original Research Article

To Determine the Influence of Body Mass Index on Blood Pressure in People with Hypertension

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Abstract

Aim: To evaluate the effect of body mass index on blood pressure in adults with hypertension

Methods: A Cross-sectional survey was conducted in the Department of pharmacology, Darbhanga medical college and hospital Laheriasarai, Darbhanga, Bihar, India, from July 2021 to August 2021. A total of 100 males and 100 females aged from 18 to 55 years were included in the present study. Anthropometric measurements including height, weight, circumferences (upper arm, calf), skin fold thicknesses (at triceps, biceps, subscapular, and suprailiac) and physiological dimensions like blood pressure were taken on each subject.

Results: The basic measurements of males and females and the difference between the two genders for the same. Mean values of height, weight, upper arm circumference, calf circumference, pulse rate, SBP, and DBP were found to be significantly higher in males as compared with females. Similarly mean values of BMI and fat percentage were also higher among females. Age was found to have positive and statistically significant correlation with both SBP ($r = 0.22$, $P < 0.01$) and DBP ($r = 0.19$, $P < 0.01$) among males and for females the correlation between age and blood pressure (SBP and DBP) was $r = 0.45$, $P < 0.01$ and $r = 0.28$, $P < 0.01$, respectively. The prevalence of underweight was more in females as compared with males. As assessed by SBP and DBP, maximum percentage of overweight males had prehypertension; for SBP it was 50% and for DBP it was 40%. Among females also, prehypertension was maximum in overweight females when SBP (52%) as well as DBP (39%)

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were considered. The differences in the various categories were found to be statistically significant (chi-square $P < 0.001$). The prevalence of prehypertension and stage-I hypertension increased 2.85 and 2.69 times, respectively, in overweight/obese males as compared with their non obese counterparts. Almost 9.02 times higher rate of stage II hypertension was observed in overweight/obese males as compared with their non obese counterparts. Among females also, the prevalence of prehypertension and hypertension increased more than 2 and 3.80 times, respectively, in overweight/obese subjects as compared with the non obese females.

Conclusion: The BMI being associated with prehypertension may suggest that such individuals are at increased risk of progressing to frank hypertension.

Keywords: BMI, hypertension, obese

Introduction

The proportion of people who are obese or overweight continues to increase, with obese adults and children currently accounting for 37% and 24% of the population worldwide, respectively.[1] In 2010, research on the global burden of disease showed that obesity or overweight were responsible for 3.9% of the years of life lost and 3.8% of the disability-adjusted life years and caused a global death toll of 3.4 million.[2] Body mass index (BMI) is an indicator used to systematically measure obesity and overweight status. BMI has been broadly applied in research relating to obesity and overweight because of its convenience of use. Research has shown that high BMI is a risk factor for hypertension and cardio vascular events (CVEs).[3-7] Hypertension and risk of CVEs are, respectively, 4.17 and 1.46 times higher among those who are obese, compared with those of normal weight.[3,6] Obesity and overweight are not only risk factors for hypertension; they are also related to changes in blood pressure (BP). Faramawi [8] found that, for every one-unit increase in BMI, short-term blood pressure variability (BPV) increased by 0.25. In addition to short-term BPV, BP also has long-term variability, which is caused by factors including the environment and be- haviors[9-11], but existing research on BMI and BPV have mainly focused on the impact of BMI on short-term BPV. To the best of our knowledge, there has been almost no research about the effect of BMI on long-term BPV. Assessing association between body mass index (BMI) and hypertension has important public health implications in South Asian countries, where the burden of hypertension is high and obesity is increasing at the population level. In addition, looking at the association in subgroups defined by sex, age, urban city, and socioeconomic status is crucial to understand how consistent the association between BMI and hypertension is across different groups. There is no study, to the best of our knowledge, which looked at the association of BMI with hypertension across different groups in nationally- representative samples from India.

Materials and methods

A Cross-sectional survey was conducted in the Department of Pharmacology, Darbhanga medical college and hospital, Laheriasarai, Darbhanga, Bihar, India, from July 2021 to August 2021. after taking the approval of the protocol review committee and institutional ethics committee.

Methodology

A total of 100 males and 100 females aged from 18 to 55 years were included in the present study. Anthropometric measurements including height, weight, circumferences (upper arm, calf), skinfold thicknesses (at triceps, biceps, subscapular, and suprailiac) and physiological

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dimensions like blood pressure were taken on each subject. A standardized protocol was followed while taking measurements.[12] BMI (weight/height2) and fat percentage were calculated. BMI was classified according to the proposed criteria of World Health Organization (WHO) (CED III <16, CED II = 16-16.9, CED I = 17-18.49, underweight < 18.5, normal = 18.5-24.5, overweight = 25.0-29.9, and obese ≥30.00.[15] In the present study, all the subjects having BMI ≥30 were taken as obese. Normal blood pressure was taken as < 120 mmHg (SBP) and <80 mmHg (DBP). Blood pressure values of 120–139 mmHg (SBP) and 80-89 mmHg (DBP) were classified as prehypertensive. Stage-I hypertension was taken as 140–159 mmHg (SBP) and 90-99 mmHg (DBP), whereas blood pressure of >160 mmHg (SBP) and >100 mmHg (DBP) were classified as stage II hypertension (JNC2003). Body fat percentage was also computed. Body fat percentage is total body fat expressed as a percentage of total body weight. (Siri's equation). Body fat percentage = (4.95/D-4.50) × 100 where D = Density.

Statistical analysis

SPSS version 22.0 statistical software package was used to carry out statistical analysis. Descriptive statistics of mean and standard deviation, standard error were used to examine the data. Pearson moment correlation was used to find correlation between anthropometric measures and blood pressure. Regression analysis and cross tabulation was also carried out to see relationship between the variables.

Results

Table 1 shows the basic measurements of males and females and the difference between the two genders for the same. Mean values of height, weight, upper arm circumference, calf circumference, pulse rate, SBP, and DBP were found to be significantly higher in males as compared with females. The mean values of all the skinfold thicknesses, that is, biceps, triceps, subscapular, and suprailiac were higher among females than males. Similarly mean values of BMI and fat percentage were also higher among females.

Age was found to have positive and statistically significant correlation with both SBP ($r = 0.22$, $P < 0.01$) and DBP ($r = 0.19$, $P < 0.01$) among males and for females the correlation between age and blood pressure (SBP and DBP) was $r = 0.45$, $P < 0.01$ and $r = 0.28$, $P < 0.01$, respectively. There was statistically significant positive correlation between blood pressure (both SBP and DBP) and anthropometric measurements, pulse rate, fat percentage, and BMI as shown in Tables 2 and 3 among males and females, respectively.

The prevalence of overweight/obesity is presented in Table 4. The prevalence of underweight was more in females as compared with males. More females were obese as compared with males. The prevalence of overweight was higher among males as compared with females.

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Table 1: Significance of the gender difference between various measurements

Parameters	Males Mean ± S.D	Females Mean ± S.D	*P* value
Height (cm)	166.7±14.73	155.9±5.88	<0.001
Weight (kg)	67.5±13.14	63.5±52.10	<0.001
Upper arm circumference (cm)	25.5±3.04	24.6±3.84	0.065
Calf circumference (cm)			
Skinfold thickness Biceps (mm)	32.1±5.06	30.3±3.53	<0.05
Triceps (mm)	7.8±4.18	11.1±5.27	<0.001
Subscapular (mm)	10.7±5.22	15.4±6.22	<0.001
Suprailiac (mm)	16.1±7.13	18.8±6.37	<0.001
Pulse rate (per min)	18.3±6.37	20.8±5.64	<0.05
Systolic blood pressure (mmHg)	83.6±10.09	82.9±10.20	0.67
Diastolic blood pressure (mmHg)	123.9±11.05	114.2±11.67	<0.001
	82.6±8.45	78.1±7.78	<0.001
Body mass index (kg/m2)	25.8±17.60	27.7±4.60	<0.001
Fat percentage	21.1±6.19	31.3±4.74	<0.001

Table 2: Correlation between systolic and diastolic blood pressure with various anthropometric measurements, pulse rate, fat percentage and BMI. Males

	Height	Weight	Upper arm **circumference**	**Calf circumference**	**Triceps Skinfold thickness**	**Biceps Skinfold thickness**	**Subscapsular Skinfold thickness**	**Suprailiac**	Pulse rate	Fat %	BMI
Systolic blood pressure	**0.33	**0.51	**0.46	**0.34	**0.34	**0.28	**0.43	**0.38	**0.19	**0.43	0.27
Diastolic blood Pressure	**0.31	**0.53	**0.51	**0.36	**0.43	**0.37	**0.49	**0.44	0.12	**0.51	**0.33

Table 3: Correlation between systolic and diastolic blood pressure with various anthropometric measurements, pulse rate, fat percentage and BMI. Female

	Height	Weight	Upper arm **circumference**	**Calf circumference**	**Triceps Skinfold thickness**	**Biceps Skinfold thickness**	**Subscapsular Skinfold thickness**	**Suprailiac**	Pulse rate	Fat %	BMI
Systolic blood pressure	0.07	*0.18	**0.45	**0.26	**0.32	**0.28	**0.36	**0.38	**0.26	**0.47	**0.40
Diastolic blood pressure	0.13	*0.17	**0.44	**0.19	**0.25	**0.32	**0.37	**0.35	**0.18	**0.43	**0.36

Correlation significant at: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

Table 4: Age adjusted prevalence of overweight/ obesity among males and females

BMI classification	Males no. (%)	Females no. (%)
Normal weight	45 (45)	45 (45)
Underweight	12(12)	15 (15)
Overweight	28 (28)	21 (21)
Obese	17 (15)	19 (19)

BMI and Gender, chi-square = 2.41 (non significant)

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Table 5: Prevalence of hypertension among adult males and females

Blood pressure	Males		Females	
	Percentage/(Number)		Percentage/(Number)	
	SBP(mmHg)	DBP(mmHg)	SBP(mmHg)	DBP(mmHg)
Normal	15 (15)	21 (21)	60 (60)	47(47)
Prehypertension	81 (81)	50 (50)	38 (38)	43 (43)
Hypertension	4 (4)	29 (29)	2 (2)	10 (10)

SBP and Gender chi-square = 42.44*** (P<0.001), DBP and Gender chi-square = 23.23*** (P<0.001)

Table 5 shows the age adjusted prevalence of hypertension among adult males and females. The prevalence of prehypertension as well as hypertension was higher in males as compared with females.

As assessed by SBP and DBP, maximum percentage of overweight males had prehypertension; for SBP it was 50% and for DBP it was 40%. Similarly when DBP is concerned, 20% of adult males had Stage I hypertension [Table 6]. Among females also, prehypertension was maximum in overweight females when SBP (52%) as well as DBP (39%) were considered. The differences in the various categories were found to be statistically significant (chi-square P < 0.001) [Table 7].

The prevalence of prehypertension and stage-I hypertension increased 2.85 and 2.69 times, respectively, in overweight/obese males as compared with their non obese counterparts. Almost 9.02 times higher rate of stage II hypertension was observed in overweight/obese males as compared with their non obese counterparts. Among females also, the prevalence of prehypertension and hypertension increased more than 2 and 3.80 times, respectively, in overweight/obese subjects as compared with the non obese females. Similar was the status of stage II hypertension. Almost 9.02 times higher rate of hypertension was observed as compared with those who were in normal BMI category Those who were underweight were less likely to have higher SBP and DBP than those who were in other BMI category.

Table 6: Distribution of systolic and diastolic blood pressure of adult males (18-50 years) according to different BMI categories

BMI	Systolic blood pressure			
	Pre-hypertension	Stage I	Stage II	Normal
Underweight	20	1.2	2.3	50
Overweight	50	0.8	2.9	20
Normal	30	0.0	2.4	30

Chi-square = 45.29*** (P<0.001)

BMI	Diastolic blood pressure			
	Prehypertension	Stage I	Stage II	Normal
Underweight	25	8.9	0.0	50
Overweight	40	25.3	3.8	10
Normal	35	17.9	0.8	40

Chi-square = 47.09*** (P<0.001

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Table 7: Distribution of systolic and diastolic blood pressure of adult females (18-50 years) according to different BMI Categories

BMI	Systolic blood pressure			
	Prehypertension	Stage I	Stage II	Normal
Underweight	20	0.0	0.0	53
Overweight	52	0.9	1.9	17
Normal	28	0.0	2.3	30

Chi-square = 39.66*** (P<0.001)

BMI	Diastolic blood pressure			
	Prehypertension	Stage I	Stage II	Normal
Underweight	18	7.7	0.0	52
Overweight	39	27.5	2.8	12
Normal	43	13.3	0.0	36

Discussion

Age was positively correlated with blood pressure (both SBP and DBP). The relationship between blood pressure and age was found to be significant and was stronger in women than men in the present study. Many studies have found the relationship between blood pressure and age (both SBP and DBP) to be significant among both males and females.[13-14] In general, blood pressure rises as people get older. Age is known risk factor for high blood pressure.[15-17] Both SBP and DBP were found to be significantly higher among men as compared with women in the present study. Gender differences in blood pressure are detectable during adolescence and persist through adulthood. In all ethnic groups, men tend to have higher mean SBP and DBP than women, and through middle age, the prevalence of hypertension is higher among men than women.[18] Premenopausal women have quantitatively more lipoprotein lipase (LPL) and higher LPL activity in gluteal and femoral subcutaneous regions, which contain fat cells larger than those in men but these differences disappear after menopause.[19] Men show minimal regional variation in fat cell size or LPL activity. These differences may explain the tendency for premenopausal women to deposit fat preferentially in lower body fat depots. The higher level of intra-abdominal tissue found in men compared with premenopausal women seems to explain, in part, the greater prevalence of dyslipidaemia and Chronic Heart Disease (CHD) in men than in premenopausal women.

In the present study, we found statistically significant positive correlation between all the anthropometric measures and SBP and DBP. Studies in various populations also showed strong relationship between different anthropometric indicators and blood pressure levels.[20-24] Body composition variables such as weight, skinfold thicknesses, etc. have been shown to be significantly correlated with blood pressure in adults.[25] The significant association of BMI with SBP and DBP is also evident from the values of Pearson's correlation coefficient among males and females of the present study. These findings are in agreement with other studies,[24,26] which support a strong relationship between BMI and blood pressure across developed and developing countries.[15-17]Strong relationship of fat percentage with both SBP and DBP among both males and females was also observed in the present study.

Several studies have been done in different parts of India on factors affecting cardiovascular functions.[27] Obesity or excess relative weight is found to be associated with increased risk of disease morbidity and mortality.[28] BMI is widely accepted as one of the best indicator of

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nutritional status in adults.[29-32]The importance of BMI and skinfolds has been recognized for estimating cardiovascular disease (CVD) risk factors, particularly due to their positive association with hypertension.[33] Linear regression showed BMI and waist circumference (WC) as important predictors of hypertension.[34] Subcutaneous abdominal tissue was more consistently related to CVD risk than peripheral skinfolds. Linear correlations between both SBP and DBP for all anthropometric measurements among males were found to be significant in the adult Brazilian men and blood pressure increased with higher BMI, WC, and various skinfold locations.[25] Many investigators have earlier reported significant positive correlation of BMI with SBP and DBP.[33-37]
The prevalence of obesity was greater in adult females (19%) as compared with males (15%) in the present study. Similar gender differences in adiposity have been reported.[39] Greater responsiveness of blood pressure in women to gain in relative weight or abdominal deposition has also been documented.[28]

Our study documents the high prevalence of both hypertension and prehypertension, and their association with other cardiovascular risk factors, among the Punjabi adults of Delhi, India. The prevalence of obesity was higher among females, however, the prevalence of prehypertension and hypertension was higher among males. This has also been previously reported among Baniya population[26] and Jamaican population. In addition, there was a high prevalence of prehypertension in our study, among males as well as females. This was similar to that reported from industrialized economies.[34] In Indians, among urban residents >18 years living in Chennai, the prevalence of prehypertension was reported as 47%.[24] Even in the rural population in Assam, 54% of subjects had prehypertension and one-third had hypertension.[39] The prevalence of prehypertension in the present study was higher as compared with other studies.

In the present study, the males mostly belonged to businessmen category, involved in transport business. This may be attributable to differences in dietary habits, socio-economic status, sedentary life style, intake of alcohol, and rates of obesity. They did jobs that involved more of mental strain in spite of the fact that they were more or less sedentary (they have drivers and helpers to carry out the various jobs), than the other categories of occupation such as professionals and those doing office work. They were also found to have higher mean values of weight, almost all anthropometric measurements and skinfold thicknesses. The lower levels of blood pressure among women may be attributable to a protective effect of estrogen smoking, and alcoholic status; most of the women were premenopausal and all of them were nonsmokers and nondrinkers.

The prevalence of hypertension has been increasing in India, both in rural and in urban regions. The public health burden of people with prehypertension is worthy of serious evaluation as these subjects are unaware of their condition and if a population approach to disease prevention is applied, we could expect that a small reduction in mean population blood pressure will result in relatively large reduction in overall disease risk.

In the present study, prevalence of high blood pressure was greater in those with high BMI, which was also reported by other studies.[40,41] Relationship between prehypertension and overweight and obesity as observed in the present study has also been observed in other studies.[38] Individuals in the urban environment did not only show higher prevalence of obesity but also more elevated blood pressure level. Doll *et al.*[22] explained obesity-associated hypertension as an inadequate vasodilatation in the presence of increased blood volume and

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cardiac output, which are natural consequences of an increased mass. Among both males and females, overweight/obesity has been found to be risk factor, more for DBP, which is more dependent on peripheral resistance. Since, DBP is closely correlated with SBP, the factors that increase DBP may thereby also increase SBP. Hypertension has been characterized as a "disease of civilization" resulting from an incompatible interaction between a modern affluent lifestyle and paleolithic genes.[36]

Conclusion

The present study concluded that the BMI being associated with prehypertension may suggest that such individuals are at increased risk of progressing to frank hypertension.

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