ORIGINAL RESEARCH ARTICLE

The Pattern of Blood Pressure Distribution and Analysis of Influencing Factors of Pre (Hypertension) Among Young Adults: A Cross-Sectional Survey in Western India

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DOI: 10.55489/njcm.141120233342

ABSTRACT

Background: Raised blood pressure is one of the significant preventable causes of cardiovascular diseases. The Global Burden of Diseases report 2019 has identified high systolic blood pressure as the leading risk factor for attributable deaths accounting for about 1.4 million deaths in India. The study aimed to determine the prevalence of prehypertension and hypertension, along with their associated risk factors, among young adults.

Methods: A cross-sectional study was conducted in urban science colleges in Gujarat. A multicomponent questionnaire comprised of demographic, dietary and lifestyle characteristics was administered to the participants (18-23 years). Data on weight, height and blood pressure were collected by trained field personnel. The categorical variables were tested by a chi-square test, while the t-test was used to compare quantitative variables.

Results: Overall, 415 participants (65% female) were included in the study, with a mean age of 19.5 years. The prevalence of prehypertension and hypertension was 23.4% and 4.8%, respectively. The multivariate analysis showed that the male gender, not being underweight, and overweight was found to be associated with elevated blood pressure.

Conclusions: There is a pressing need to identify cardiovascular risk factors at younger ages through regular screening, with more focus should be put on the adaptation of healthy lifestyles.

Keywords: Prehypertension, prevalence, non-communicable disease, young adults, India

ARTICLE INFO

Financial Support: None declared

Conflict of Interest: None declared

Received: 29-08-2023, **Accepted**: 10-09-2023, **Published**: 01-11-2023
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How to cite this article: Solanki R, Prajapati T, Shah H. The Pattern of Blood Pressure Distribution and Analysis of Influencing Factors of Pre (Hypertension) Among Young Adults: A Cross-Sectional Survey in Western India. Natl J Community Med 2023;14(11):730-737. DOI: 10.55489/njcm.141120233342

www.njcmindia.com | pISSN09763325 | eISSN22296816 | Published by Medsci Publications

Introduction

Hypertension, along with prehypertension, has been considered an independent risk factor for developing cardiovascular diseases (CVDs), Myocardial Infarction (MI) and stroke.[1] The Global Burden of Disease Report 2019 has identified high systolic blood pressure as the leading risk factor for attributable deaths accounting for over 10.8 million deaths globally and 1.4 million deaths in India.[2] The World Health Organization's (WHO) Global Action Plan for Prevention and Control of Non-Communicable Diseases (NCDs) in 2013 adopted nine global targets to be attained in 2025, including a 25% relative reduction in the prevalence of raised blood pressure or contain the prevalence of raised blood pressure.[3] WHO Health Statistics 2021 has reported a 25.8% age-standardized prevalence of raised blood pressure among individuals aged 18 years and above in India.[4] The National Family Health Survey-5 (NFHS-5) data from Gujarat have documented a higher prevalence of prehypertension and hypertension, which is 33.8%, and 5.6%, respectively, in 20–24-year-olds.[5]

Raised blood pressure is one of the significant preventable causes of CVDs. A large meta-analysis of observational studies has reported that 12% of CVDs, 13.2% of coronary heart diseases, 24.6% of MI and 19.1% of stroke cases could be prevented by effectively controlling prehypertension.[6] The CARDIA and other epidemiological studies have documented that prehypertension is a precursor of hypertension and is associated with preclinical and clinical cardiovascular conditions that include subclinical atherosclerosis, left ventricular hypertrophy and increased arterial stiffness and heart failure This risk is not only limited to individuals with the elevated blood pressure but also was observed among individuals with normal blood pressure. [7,8,9]

To better identify individuals who are at higher risk of developing hypertension and to educate them on early preventive interventions, the Seventh Report of the Joint National Committee (JNC7) on has introduced a new category with the term 'prehypertension' in 2003.[10]

There are very limited studies available in this region that evaluated prehypertension and raised blood pressure. Moreover, data on young adults, particularly among undergraduate students, are scarce; therefore, the present study was conducted to explore the distribution and determinants of prehypertension and hypertension among undergraduate university students.

Methodology

A cross-sectional survey was carried out in the year 2019-20 on a random stratified sample of 415 participants. Eligible participants were undergraduate university students aged between 18 and 23 years. The students attending various universities in the Anand and VV Nagar town locality and those enrolled in science stream degree courses like pharmacy, biology, chemistry, etc., were approached for their participation in the study. The sampling procedure was a two-stage stratified random sample design. For the first sampling stage, four colleges were randomly selected from the sampling frame that contains the list of science stream colleges located within the study area. In the second sampling stage, participants were recruited through selected colleges by stratified sampling considering the representation and the level of each year as a group. The sample size was calculated using the formula $z^2p\ (1\text{-}p)/d^2$.[11] Considering the prevalence of prehypertension 'p' at 25% and a permissible error 'd' of 5% with a 95% confidence interval, the minimum sample size was calculated as n = 288. However, to accommodate a non-response rate and take into account the study design, the final sample size was fixed at 415. A negligible number of participants had missing information for the various variables and were therefore excluded from the analysis. All participants were above 18 years of age, and all provided written informed consent after it was read to them.

The data collection methods comprised personal interviews, anthropometric (height and weight) and blood pressure measurements. A standardized, pretested, semi-structured, self-administered questionnaire was used to obtain information on sociodemographic, dietary patterns and lifestyles. Weight, height and blood pressure were measured by trained personnel using standard procedures of the WHO STEPwise approach to Surveillance.[12] To measure height, we instructed each participant to stand barefoot on a level hard floor, feet together, heels against the wall and knees straight, and to look straight ahead and not look up; eyes are at the same level as the ears. Height was measured to the closet 0.1 cm using a stadiometer. Weight was measured to the nearest 0.1 kg using a salter scale while wearing light clothes, with no shoes, standing still, facing forward, and with arms placed on the side. Blood pressure was recorded during morning hours on the college premises of the students in a quiet, relaxed and comfortable environment. The room temperature was neither hot nor cold. Participants were instructed to empty their bladder and abstain from caffeine and nicotine and exercise 30 minutes before their blood pressure measurements. After the participant had rested for five minutes in a sitting position with their feet on the floor, legs uncrossed and back supported, blood pressure was measured using Omron automated non-invasive electronic sphygmomanometer (Omron HEM7120). An appropriately sized cuff was used. The blood pressure readings were taken in triplicates at approximately two-minute intervals for each participant. The first and second blood pressure reading was discarded, and the last reading was recorded for both Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP). Categories of high blood pressure were defined according to the seventh report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of high blood pressure. Mean arterial blood pressure (MAP) was computed from DBP and SBP as follows: MAP = DBP + 1/3 (SBP-DBP).

Using the height and weight measurements, Body Mass Index (BMI) was calculated using the formula BMI = Weight (kg)/ [Height (m)]^2. According to the WHO guidelines for the Asia Pacific population, BMI cut-off values are <18.5 for underweight, 18.5 to 22.9 for normal, 23 to 24.9 for overweight), and >25 for obese.

Dietary patterns were measured using a pretested structured questionnaire with closed-ended responses. Participants responded to the following questions 'How often do you consume packaged food and snacks like *samosa, dal-vada,* potato chips*, ratlami-sev, moong-dal* (locally available energy-dense and deep-fried food items), etc.?' and 'How often do you consume soft drinks like Pepsi, Mirinda, Coke, 7-up, etc.'. Each item is provided five possible responses ranging from never or less than a month to 1-3 times a week. Participants replied with how often they consumed a certain amount of the specified food items or sweetened/carbonated drinks during the past six months. Physical activity was assessed with the question: 'During the past seven days, how many days were you physically active (running, cycling, etc.) for a total of 30 minutes per day?'. Response options were their respective number of days.

Descriptive analyses were performed for socio-demographic and other variables. The prevalence of prehypertension and hypertension was estimated. Continuous variables were presented as means and standard deviations, while categorical variables were expressed as frequencies or proportions. The associations between categorical variables were tested by performing a Pearson's chi-square test or Fisher exact test, where applicable, and a student's t-test was used to compare quantitative variables. A one-way analysis of variance (ANOVA) was performed to compare differences between blood pressure groups. Tukey's HSD test was applied for multiple comparisons whenever the F-ratio was significant. Logistic regression was performed to evaluate the association between prehypertension and hypertension with independent risk factors. The multivariable model was adjusted for age, gender, BMI, etc. The Odds Ratio (OR) and their corresponding 95% confidence intervals were calculated. A two-tailed p-value of < 0.05 was considered statistically significant. All statistical analyses were performed using STATA version 16.

RESULTS

Sociodemographic and anthropometric characteristics as per gender have been described in the **Table. 1**. The total sample included 415 participants, of which 270 (65%) were females. Their ages ranged from 18 to 23 years, with a mean age of 19.5 years (SD 1.6). There were significant differences between the height and weight of males and females (p < 0.001), but the mean Body Mass Index (BMI) remained almost the same for males and females (19.8 vs. 19.7).

Table 1: Demographic, anthropometric and clinical characteristics of the study population stratified by sex

Characteristics	Female (N = 270)	Male (N = 145)	Total (N = 415)	P-value
Demographic characteristics				
Age in years, mean ± SD	19.7±1.7	19.2±1.5	19.5±1.6	<0.01*
Age groups in years, n (%)				
18-19	113(41.9)	84(57.9)	197(47.5)	
20-21	101(37.4)	43(29.7)	144(34.7)	
>=22	56(20.7)	18(12.4)	74(17.8)	0.57
Mother's years of education, n (%)				
<7	23(8.5)	25(17.2)	48(11.6)	
7-12	165(61.1)	79(54.5)	244(58.8)	
12	82(30.4)	41(28.3)	123(29.6)	0.30
Father's years of education, n (%)				
<7	7(2.6)	15(10.3)	22(5.3)	
7-12	134(49.6)	66(45.5)	200(48.1)	
12	129(47.8)	64(44.1)	193(46.5)	0.63
Anthropometric characteristics				
Age, years, mean±SD	19.7±1.7	19.2±1.5	19.5±1.6	<0.01*
Weight, Kg, mean±SD	48.9±9.7	57±11.8	51.7±11.2	<0.01*
Height, Cm, mean±SD	157.5±6.5	169.2±8	161±9	<0.01*
BMI, Kg/m^2, mean±SD	19.7±3.8	19.9±4.1	19.8±3.9	0.58
Clinical characteristics				
SBP, mm of Hg, mean±SD	110.4±12	119.5±10.7	113.6±12.4	<0.01*
DBP, mm of Hg, mean±SD	67.8±11.2	68.6±10	68±10.7	0.49
MAP, mm of Hg, mean±SD	82±10.0	85.5±9.0	83.2±9.8	<0.01*

BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure; MAP, mean arterial pressure; SD, Standard Deviation; Data are expressed as the mean±SD and n%; *Test results are statistically significant

Table 2: Prevalence of prehypertension and hypertension by dietary and lifestyle factors among the participants

Characteristics	Normal (%)	Prehypertension (%)	Hypertension (%)	P-value
Prevalence	298(71.8)	97(23.4)	20(4.8)	
SBP, mm of Hg, mean±SD	108.6±9.2	124.8±6.4†	133.7±18.7	<0.001*
DBP, mm of Hg, mean±SD	64.8±9.0	75±8.4†	84.0±13.8	<0.001*
MAP, mm of Hg, mean±SD	79.3±7.8	91.6±5.4†	100.6±8.0	<0.001*
Age Group, years				
18-19	141(71.6)	49(24.9)	7(3.6)	0.574
20-21	106(73.6)	31(21.5)	7(4.9)	
>=22	5(68.9)	17(23)	6(8.1)	
Sex				
Females	211(78.1)	48(17.8)	11(4)	<0.01*
Males	87(60)	49(33.8)	9(6.2)	
Preference for food				
Vegetarian	225(72.8)	69(22.3)	15(4.9)	0.691
Mix	73(68.9)	28(26.4)	5(4.7)	
Number of days physically active during the last seven days				
None	125(76.7)	28(17.2)	10(6.1)	0.065
1-3/week	99(72.8)	33(24.3)	4(2.9)	
>3/week	74(63.8)	36(31)	6(5.2)	
Average consumption of soft drinks				
Monthly or less	179(73)	53(21.6)	13(5.3)	0.577
1-3 times/week	81(66.9)	34(28.1)	6(5)	
>3 times/week	38(77.6)	10(20.4)	1(2)	
Average consumption of packaged food or snacks				
Monthly or less	78(70.9)	24(21.8)	8(7.3)	
1-3 times/week	152(72.4)	47(22.4)	11(5.2)	0.240
>3 times/week	68(71.6)	26(27.4)	1(1)	
Body Mass Index (BMI) Categories				
Underweight	152(84.4)	23(12.8)	5(2.8)	<0.001*
Normal	112(71.3)	38(24.2)	7(4.5)	
Overweight or Obesity	34(43.6)	36(46.2)	8(10.3)	
BMI, kg/m^2, mean±SD	19.0±3.2	21.9±4.7†	22.0±4.4	<0.001*
Sleep duration in hours				
<7	75(68.2)	31(28.2)	4(3.6)	0.280
7-8	180(72.6)	57(23)	11(4.4)	
>9	43(75.4)	9(15.8)	5(8.8)	
Family History				
Yes	193(72)	65(24)	11(4)	0.564
No	105(72)	32(22)	9 (6)	

*Test values are statistically significant; †denotes significance compared to normal blood pressure group

The mean Systolic Blood Pressure (SBP) remained higher among males (119.5) compared to the females (110.4) with a p-value <0.001, while no such significant gender difference has been observed for the mean Diastolic Blood Pressure (DBP). Among all the participants, 43.3 % were underweight, 14.5 % were overweight, and 4.3% were obese, with no significant difference between males and females.

The distribution of dietary and lifestyle characteristics stratified by blood pressure is described in **Table 2.** The overall burden of prehypertension and hypertension among the participants was 23.4% and 4.8%, respectively. Tukey's HSD Test for multiple comparisons revealed that the mean value of MAP differed significantly between normotensive and prehypertensive participants. (p<0.001). The prevalence of prehypertension was higher among males than females (33.8% vs. 17.8%, respectively), and a similar trend has also been observed for hypertension (6.2% vs. 4.1%, respectively). A lower prevalence of prehypertension (16%) with a higher prevalence of hypertension (8%) was observed among those who slept for nine hours or more compared to those sleep less than nine hours.

The distribution of prehypertension and hypertension varies across the BMI categories; it increases with an increase in BMI (p < 0.001). The prevalence of prehypertension and hypertension was 46.2% and 10.8%, respectively, in the combined overweight and obese category of BMI classification for Asian people (BMI>23.5). The prevalence of prehypertension and hypertension in the underweight category is only 13% and 3 %, respectively.

Prehypertension was more prevalent among physically active males (43%) than less active males (27.8%) (p = 0.07). The rate of prehypertension and hypertension is higher (28% and 5%, respectively) for those who consume soft drinks less than three times a week (p = 0.58). No significant differences have been observed in the frequency of snack intake and the prevalence of prehypertension. The prevalence did not vary significantly with a family history of hypertension.

Table 3: Univariate and Multivariate odds ratio (OR) correlates for prehypertension and hypertension versus normotensive

Variables	UOR	95% CI	AOR	95% CI
Age Group, years				
18-19	Reference		Reference	
20-21	0.90	0.56-1.46	1.00	0.59-1.70
>=22	1.14	0.63-2.00	1.41	0.74-2.69
Sex				
Females	Reference		Reference	
Males	2.38	1.54-3.70	2.55	1.56-4.15
Body Mass Index (BMI)				
Normal	Reference		Reference	
Underweight	0.46	0.27-0.77	0.45	0.26-0.78
Overweight or Obesity	3.22	1.83-5.67	3.40	1.89-6.11
Number of days physically active during the last seven days				
None	Reference		Reference	
1-3/week	1.23	0.73-2.00	1.03	0.58-1.82
>3/week	1.87	1.10-3.15	1.55	0.88-2.74
Sleep duration in hours				
7-8	Reference		-	
<7	1.24	0.76-2.00		
>9	0.86	0.44-1.67		
Average consumption of soft drinks				
Monthly or less	Reference		-	
At least once a week	1.16	0.75-1.79		
Average consumption of packaged food or snacks				
Monthly or less	Reference		-	
At least once a week	0.94	0.58-1.52		

The multivariate model included age, sex, BMI and physical activity; UOR- Unadjusted Odds Ratio; AOR- Adjusted Odds Ratio; CI- Confidence Interval

About quarter-fourths of students had consumed snacks (salty, deep-fried and high-calorie foods like *samosa*, *pakoda,* etc. and other packaged food) on average one to three times a week during the last six months. About one-fourth of the participants had inadequate sleep (< 7 hours). Around 163 (38.8%) students were not physically active for at least 30 minutes a day during the last seven days.

For regression analyses, we have combined the two categories, prehypertension and hypertension, as we had fewer participants for hypertension (around 4.3%). The unadjusted and adjusted odds ratios are presented in Table 3. In unadjusted analysis- the male gender, not being underweight, overweight and obese and having high physical activity was associated with prehypertension and hypertension. Comparing the risk factors for prehypertension and hypertension, multivariate analysis showed that the male gender, not being underweight, overweight and obese, were meaningful correlates of elevated blood pressure.

Discussion

The overall burden of prehypertension and hypertension among the participants were 23.4% and 4.8%, respectively, according to the eighth report of the JNC. The National Family Health Survey 5 (NFHS 5) findings from Gujarat have documented a 33.8% prevalence of prehypertension and 5.6% for hypertension in 20–24-year-olds, which is relatively higher than our study results. Similarly, two previous studies by Rai et al.[13] and Ramakrishnan et al.[14] also stated a higher prevalence of prehypertension than ours in similar age groups. Selected Asian countries have reported significant variations in the prevalence of prehypertension among university students, ranging from 11.3 % in Indonesia to 32.8% in Thailand.[15] The high prevalence of prehypertension reported in this study is relevant, considering that prehypertension itself is harmful [16] and the associated risk of transition to hypertension.[17]

It has been reported from several studies that gender differences occur in the distribution of prehypertension and hypertension. We observed a higher prevalence of prehypertension among males (33.4%) compared to females (17.4%). A similar trend has also been observed for hypertension. The nationwide NFHS-5 survey from India and Gujarat has also reported a higher prevalence of prehypertension and hypertension among males.[5] These results are consistent with several other studies in which a higher prevalence of raised blood pressure was observed in males.[8,18] Karl Peltzer et al. also reported a significantly higher prevalence of prehypertension among males than females in undergraduate university students of selected Asian countries.[15] These gender differences could be partially explained by the interaction of the biological sex [19] and different cultural and social conditions for males and females.[20]

In our study, higher BMI values are significantly associated with prehypertension and hypertension even after controlling for other risks such as age, gender, etc. A linear relationship has been observed between BMI and blood pressure, and it is identified as an independent and important risk factor for raised blood pressure. It has been concluded from numerous studies that higher BMI is positively associated with prehypertension and hypertension. [8,21] A meta-analysis by Guo et al. reported higher body mass indices among individuals with prehypertension.[22] Similar findings were also observed by Parthaje et al. in urban adults of South India.[23] A double burden of malnutrition (DBM) (simultaneous presence of undernutrition, overweight and obesity) exists in this region, as reported by past studies and surveys.[5,24,25] Similarly, we have also observed about 43.3 % of underweight and 18.8% of overweight or obese participants in our study. The DBM adds an additional layer of complexity and contributes to a relatively rapid transition from underweight to overweight and obese. The excess body fat in overweight and obese people was associated with an elevated risk of metabolic syndrome and would make them more susceptible to developing prehypertension and hypertension.[26,27]

The traditional dietary patterns of this region are mainly characterized by healthier staple food items that include more vegetables, fruits, whole grains and flour, cereals, pulses, and limited dairy products and animal-origin foods. With economic development and increasing urbanization, this region has also been progressing through the lifestyle and nutrition transition stages that include an increase in the consumption of an unhealthy diet, characterised by a higher energy-dense diet with a greater proportion of fat and added sugars in food.[28,29] These dietary changes are further impacted by a progressive lifestyle shift towards more sedentary patterns with reduced physical activity.[30]

The findings from our study have also indicated that young college students were gradually adopting more unhealthy lifestyles and dietary patterns. Processed foods with high-fat content and salt and deep-fried snacks are increasingly preferred. Almost three-fourths of the participants consumed these food items at least once to thrice a week. Similarly, an increasing trend of consuming carbonated drinks, which contain high sugar and energy, was also observed; less than half of the participants reported consuming carbonated beverages at least one to three times a week.

The present study findings reported a lack of association between elevated blood pressure and unhealthy dietary patterns. This might be due to our study participants being in late adolescence and early adulthood and the impact of unhealthy lifestyles yet to develop. However, adolescence has been identified as a critical period for the development and clustering of risk factors and the cultivation of healthy and unhealthy lifestyles that stay throughout life. It was found to be associated with the development of overweight or obesity and atherosclerosis during young adulthood and, consequently, the risk of cardiovascular diseases, including hypertension, later in life.[31] We have observed an inverse relationship between physical activity and prehypertension, particularly among males, but no statistically significant difference was observed. The lack of association between prehypertension and physical activity may be due to several reasons. Firstly, the low prevalence of physical activity amongst underweight participants. Secondly, participants might have started participating in physical activity after perceiving themselves as overweight or obese. Lastly, due to the inaccuracy of self-reported physical activity data. Similar results were also reported by Dyer et al.[32] and Shikha Singh et al.[33]

Several epidemiological studies have established that attaining and maintaining normal blood pressure from younger to middle age is crucial to prevent future cardiovascular events.[34,35] Pletcher et al. demonstrated that prehypertension exposure, particularly before age 35, strongly correlates with coronary calcium and increases the risk of coronary heart disease and other cardiovascular diseases in middle age.[16] The CARDIA study reported that Long-term exposure to elevated blood pressure in the age group 18-30 years is associated with cardiac dysfunction in later life. Similarly, a systemic review and meta-analysis by Dongling Luo stated that young adults with prehypertension had an increased risk of cardiovascular events compared with those with normal blood pressure.[36]

Our study has several limitations, it was a cross-sectional study and the temporal relationships between the risk factors, and the development of high blood pressure could not be determined by such a study. This also implies that blood pressure was measured during a single visit and subject to misclassification across different blood pressure categories. This may have resulted in an overestimation of blood pressure because some of the high blood pressure recordings could have been due to momentary blood pressure elevations. Despite that, due to logistic reasons, several studies have been conducted using a similar methodology. It is important to note that physical activity and dietary assessment data were self-reported and subjected to measurement error and related biases. We had limited or no data available on several risk factors that contribute to the development or are interrelated with elevated blood pressure, including smoking, alcohol consumption, salt intake, serum lipid profile, diabetes, and other undiagnosed conditions. The present study investigated undergraduate university students; this may limit the generalizability of the study findings to other young adults with limited access to the education system.

The strengths of the present study include the accuracy of the anthropometric and blood pressure measurements, which were collected in the field by trained field personnel rather than in clinical settings. The data were collected using standardized techniques and instruments.

Conclusion

The study reveals a high prevalence of prehypertension among young college students and the clustering of crucial risk factors like overweight or obesity, unhealthy dietary patterns and limited physical activity. This study further underscores the need for identifying cardiovascular risk factors and elevated blood pressure at younger ages through regular screening, with more emphasis on encouraging the adaptation of healthy lifestyles.

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