Original Research Article

A Study to evaluate BMI in relation to hypertension amongst Young Adults: A Cross-sectional Study

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Abstract

Background: Pre-hypertension (HTN) in adolescents and young adults is an important risk factor for developing HTN in future. Increased body mass index (BMI) and physical inactivity may have an adverse effect on blood pressure (BP) in adults which can lead to cardiovascular complications later in life. This study was conducted to assess BP in relation with different obesity indicators. **Aims:** To study BMI, waist-to-hip ratio (WHR), systolic BP-to-height ratio (SBPHR), diastolic BP-to-height ratio (DBPHR), and BP in medical students. **Materials and Methods:** A cross- sectional study was conducted on 222 medical students. All the students were interviewed with predesigned questionnaire; BP, weight, height, waist and hip circumference were measured. **Results:** In 73.9% of the subjects BP was normal, 26.1% were pre-hypertensive, and there was no case of HTN. Mean systolic BP was 115.37 ± 8.21 mmHg, and mean diastolic BP was 75.70 ± 7.00 mmHg. Mean BMI was 21.72 ±3.64 kg/m^2. 50% of the subjects were in the category of 0.85-1 WHR obese. For SBPHR (0.71 in male and 0.75 in female), sensitivity was 64.1%/68.4% and specificity was 80.8%/70.9%. And for DBPHR (0.46 in male and 0.49 in female), sensitivity was 64.1%/89.5% and specificity was 61.5%/67.4%, respectively. **Conclusion:** Out of 222 medical students, 2.7% were in obese Class I and 17.1% were in preobese/overweight category; 50% were in 0.85-1 WHR obese category, which indicates an alarming sign.We can propose SBPHR/DBPHR cutoff 0.71/0.46 in male and 0.75/0.49 in female.

Key words: Body Mass Index; Waist-to-hip Ratio; Systolic Blood Pressure-to-height Ratio; Diastolic Blood Pressure- to-height Ratio; Prehypertension

Introduction

The burden of noncommunicable diseases is rising globally. Of 56 million global deaths in 2012, 38 million (68%) deaths were due to noncommunicable diseases, of which around 17.5 million deaths (46%) were due to cardiovascular diseases[1].

Prehypertension (HTN) in adolescents and young adults is animportant risk factor for developing HTN in future. General population are alerted to this risk and encouraged to prevent and intervene early from pre-HTN and HTN[2]. HTN is one of the most common cardiovascular diseases with the global prevalence in adults ≥18 years around 22%[3].

HTN is defined as a systolic blood pressure (BP) and diastolicBP equal to or above 140/90 mmHg, respectively[4]. Joint National Committee 7 report has introduced a new classification that includes the term "pre-HTN" for those with BP ranging from 120 to 139 mmHg systolic and/or 80-89 mmHg diastolic; HTN Stage I-140-159/90-99 mmHg, HTN Stage II-160 or above/100 or above mmHg[5].

The prevalence of HTN is highest in low-income countries compared to middle income and high-income countries as public health interventions have reduced its prevalence in many high-income countries[6]. In India, according to the report of surveyconducted by ICMR in 2007-2008, the prevalence varied from17% to 21% in all the states included in the survey with marginalrural–urban differences[7-9].

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It has been shown that the presence of increased body mass index (BMI), high physical inactivity in youth may have an adverse effect on middle-aged adult's BP, increasing the likelihood of HTN, and related cardiovascular complicationslater in life[10].

Obese youths are more likely to have risk factors for cardiovascular conditions, such as HTN. Although BMI provides a simple, convenient measurement of obesity, it doesnot measure body fat distribution. Waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), SBP-to- height ratio (SBPHR) and DBP-to-height ratio (DBPHR) have been suggested to estimate obesity health risks. This study is aimed to explore the assessment and association of BP reading with different obesity indicators such as BMI, WC, HC, WHR, SBPHR, and DBPHR.

Pre-HTN, which is the starting point of cardiovascular disease continuum, is associated with detrimental heart changein young people. The age group 18-22 years is important physically, mentally, and emotionally; medical students represent this group[11].

In most persons, obesity and sedentary lifestyle appear to play a major role in causing essential HTN[12].

WHR may be a better indicator of body fat than BMI, as it relates to the risk for the development of diseases. A WHR of >0.85 in women or 0.95 in men is linked to a significantly higher risk for the development of diabetes and cardiovascular disease[13].

WHR is an approximate index of intra-abdominal fat mass and total body fat. Changes in WC reflect changes in risk factors for cardiovascular disease and other forms of chronicdiseases. There is an increased risk of metabolic complications for men with a WC ≥102 cm, and women with a WC ≥88 cm.Over the last 10 years, it has been accepted that a high WHR (>1.0 in men and >0.85 in women)

indicates abdominal fat accumulation[7].

Even simplified indexes, such as SBPHR and DBPHR, havebeen used for easy interpretation of BP levels in the adolescent age group. The optimal thresholds for defining pre-HTNwere 0.73 in males and 0.71 in females for SBPHR, and 0.47 in males and 0.45 in females for DBPHR, respectively. The corresponding figures for HTN were 0.73, 0.71, 0.48, and 0.46, respectively[14].

The optimal thresholds of SBPHR/DBPHR for defining HTN(stage I) were 0.75/0.48 for boys and 0.78/0.51 for girls, and for defining HTN (stage II) were 0.81/0.57 for boys and 0.84/0.63 for girls[15].

Therefore the aim of this Study was to study BMI in pre-hypertensive and normo-tensive medical students and To assess WC, HC, WHR9, SBPHR, and DBPHR in pre-hypertensive and normotensive medical students.

Materials and methods

This prospective, cross-sectional study was conducted at the Department of Physiology, at Nalanda Medical College and Hospital, Patna, Bihar, India. The institutional ethics and scientific committee gave their approval to the project. The study was conducted from September 2020 to August 2021. Prior to the commencement of the study, informed and written consent was obtained from all the participating subjects.

A total 222 medical students (117 males and 105 females) were included in the study. Informed written consent to participate in this study was taken from all the participants.

Inclusion Criteria

Willing to give informed consent.

Exclusion Criteria

Students with renal disease, pheochromocytoma, Cushing syndrome, acromegaly, hypothyroidism, hyperparathyroidism

Pregnancy

Students with medications, i.e., oral contraceptive pill and anabolic steroids.

Participants were explained about the purpose of the study and were assured for privacy and confidentiality of the information provided by them. They were given a predesigned, semi- structured and pretested proforma to collect the information. Before starting the physical examination, students were briefed about the whole procedure.

Body weight was measured using a calibrated weighing scale, without shoes and lightly clothed, in standing posture in kilograms (kg). Height was measured using standard height meters, in standing upright position in centimeters (cm), and then it was converted into meters. BMI was calculated using the formula weight (kg)/height (m^2). Classification of adults based on BMI according to the World Health Organization[7,16] is as follows:

Classification	BMI (kg/m^2)	Risk of comorbidities
Underweight	<18.50	Low (but risk of other clinicalproblems increased)
Normal range	18.50-24.99	Average
Overweight	≥25.00	
Pre-obese	25.00-29.99	Increased
Obese Class I	30.00-34.99	Moderate
Obese Class II	35.00-39.99	Severe
Obese Class III	≥40.00	Very severe

WC was measured at the midpoint between the lower border of the rib cage and the iliac crest. HC was measured around the widest portion of the buttocks, in standing erect posture, arms on the sides, feet positioned close together, and weight evenly distributed across the feet. WHR was calculated by dividing WC with HC. Classification[7] based on WHR, more than 1.0 WHR in men and more than 0.85 WHR in women was considered as abdominal fat accumulation.

BP was measured in sitting posture using a standard sphygmomanometer on two different occasions, with at least 10 min gap between both the readings and the average reading was taken. Those with normal BP (systolic and diastolic <120/80 mm of Hg) were considered as "normal," and those between systolic 120-139 or diastolic 80-89 mm of Hg werelabelled pre-hypertensive and those in the hypertensive Stage I or II were supposed to be categorized as "hypertensive."

The indexes SBPHR and DBPHR were computed using the following equations: SBPHR=SBP (mmHg)/height (cm) and DBPHR = DBP (mmHg)/height (cm)[14]. Different cutoff for SBPHR as 0.73 in males and 0.71 in females, for DBPHR as 0.47, 0.48 in males and 0.45, 0.46 in females were taken[14]. Some other cutoff as per one Chinese study[15] for SBPHR as 0.75, 0.81 in males and 0.78, 0.84 in females, for DBPHR as 0.48, 0.57 in males and 0.51, 0.63 in females were also taken. For all these cutoffs, sensitivity and specificity were calculated. Different cutoffs with permutations and combinations, one cutoff with good sensitivity and specificity(i.e., for SBPHR as 0.71 in males and 0.75 in females, and for

DBPHR as 0.46 in males and 0.49 in females) was calculated and proposed.

Statistical Analysis

The data were analyzed by SPSS software and presented by percentage, mean, and standard deviation. Chi-square test was applied as test of significance, wherever applicable.Sensitivity and specificity were calculated.

Results

In this study, out of 222 medical students, 164 students(73.9%) were normotensive and 58 students (26.1%)were pre-hypertensive, not a single case of HTN was detected. Mean of systolic BP of all MBBS students was 115.37 ± 8.21 mmHg, and Mean of diastolic BP of all MBBSstudents was 75.70 ± 7.00 mmHg.

Mean height was 164.17 ± 9.4 cm, mean weight was 57.77 ± 12.32 kg, mean BMI was 21.72 ± 3.64 kg/m^2, mean WCwas 79.59 ± 10.85 cm, and HC was 93.03 ± 9.12 cm (Table 1).

Table 1: Basic statistics of height, weight, BMI, WC, HC, WHR, SBPHR, and DBPHR (*n*=222)

Basic statistics	Height (in cm)	Weight (in kg)	BMI (in kg/m^2)	WC (in cm)	HC (in cm)	WHR	SBPHR	DBPHR
Mean± SD	164.17±9.40	58.77± 12.32	21.72± 3.64	79.59± 10.85	93.03± 9.12	0.86± 0.08	0.70± 0.0537	0.46± 0.0468
Median	165.00	57.00	21.12	80	92.5	0.86	0.70	0.46
Mode	165.0	55.0	18.49	80	94	0.83	0.67	0.50
Minimum	141.0	35.0	15.18	56	69	0.68	0.56	0.34
Maximum	184.0	105.0	32.86	113	122	1.26	0.87	0.60
3rd percentile	147.69	40.69	16.50	61.38	76.69	0.71	0.61	0.37

25th percentile	156.75	50.00	18.82	72.00	86.35	0.81	0.66	0.43
50th percentile	165.00	57.00	21.12	80.00	92.50	0.86	0.70	0.46
75th percentile	170.05	66.00	23.96	87.00	98.25	0.91	0.74	0.49
97th percentile	180.62	87.31	29.93	103.31	114.09	0.98	0.81	0.56
BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, WHR: Waist-to-hip ratio, SBPHR: Systolic blood pressure-to-heightratio, DBPHR: Diastolic blood pressure-to-height ratio, SD: Standard deviation								

It showed out of 222 medical students, 62 (49.5%) male and 64 (50.8%) female (total 126) were in age group 19-20 years. Age group wise distribution of male and female was statistically significant. In 161-170 cm height group maximum (59), male students were present, while maximum 60 femalewere in 151-160 cm height group. Height group of male andfemale was highly significant. Similarly, maximum (39) malewas in 55-65 kg weight group, while maximum (40) female was in 45-55 kg weight group. Weight group of male and female was also highly significant. Similarly, WC, WHR, andsystolic BP category of male and female were statistically highly significant (Table 2).

Table 2: Distribution of respondents by age, family members, height, weight, BMI, WC, HC, WHR, mean systolic bloodpressure and mean diastolic blood pressure category and gender (n=222)

Variables	Gender, *N* (%)			X^2	D.f.	*P* value	Interpretation
	Male	Female	Total				
Age group (in years)							
17-18	21 (42.9)	28 (57.1)	49 (22.1)	10.778	3	0.013	*P*<0.05, significant
19-20	62 (49.2)	64 (50.8)	126 (56.7)				
21-22	31 (70.5)	13 (29.5)	44 (19.8)				
>23	3 (100)	0 (0)	3 (1.4)				
Family members							
<3	10 (58.8)	7 (41.2)	17 (7.8)	4.679	4	0.322	*P*>0.05, not significant
4-5	76 (50.3)	75 (49.7)	151 (68.0)				
6-7	21 (58.3)	15 (41.7)	36 (16.2)				
8-9	3 (33.3)	6 (66.7)	9 (4.0)				
>10	7 (77.8)	2 (22.2)	9 (4.0)				
Height (in cm)							
141-150	0 (0)	15 (100)	15 (6.8)	109.831	4	0.000	*P*<0.05, highly significant
151-160	8 (11.8)	60 (88.2)	68 (30.6)				
161-170	59 (67.8)	28 (32.8)	87 (39.2)				
171-180	44 (95.7)	2 (4.3)	46 (20.7)				
181-190	6 (100)	0 (0)	6 (2.7)				
Weight (in kg)							
35-45	4 (12.9)	27 (87.1)	31 (14.0)	36.542	5	0.000	*P*<0.05, highly significant
45-55	32 (44.4)	40 (55.6)	72 (32.4)				
55-65	39 (61.9)	24 (38.1)	63 (28.4)				
65-75	24 (68.6)	11 (31.4)	35 (15.8)				
75-85	11 (84.6)	2 (15.4)	13 (5.8)				
>85	7 (87.5)	1 (12.5)	8 (3.6)				
BMI							
Underweight<18.5	27 (56.3)	21 (43.7)	48 (21.6)	0.331	3	0.954	*P*>0.05, not significant
Normal range 18.5-24.99	67 (51.5)	63 (48.5)	130 (58.6)				
Pre-obese 25-29.99	20 (52.6)	18 (47.4)	38 (17.1)				
Obese Class I 30-34.99	3 (50)	3 (50)	6 (2.7)				
WC (in cm)							
50-60	0 (0)	6 (100)	6 (2.7)	23.986	5	0.000	*P*<0.05, highly significant
60-70	12 (27.9)	31 (72.1)	43 (19.4)				
70-80	40 (56.3)	31 (43.7)	71 (31.9)				
80-90	43 (62.3)	26 (37.7)	69 (31.1)				
90-100	18 (72)	7 (28)	25 (11.3)				
>100	4 (50)	4 (50)	8 (3.6)				
HC (in cm)							
65-75	4 (80)	1 (20)	5 (2.3)	11.618	5	0.040	*P*<0.05, significant
75-85	13 (34.2)	25 (65.8)	38 (17.1)				
85-95	49 (51.0)	47 (49.0)	96 (43.2)				
95-105	42 (63.6)	24 (36.4)	66 (29.7)				
105-115	8 (61.5)	5 (38.5)	13 (5.9)				
>115	1 (25)	3 (75)	4 (1.8)				
WHR							
Up to 0.85	40 (37.7)	66 (62.3)	106 (47.7)	18.619	2	0.000	*P*<0.05, highly significant
0.85 to 1, obese if female	73 (65.8)	38 (34.2)	111 (50.0)				
>1, abd fat accumulation	4 (80)	1 (20)	5 (2.3)				
Systolic blood pressure							
80-90	0 (0)	1 (100)	1 (0.5)	23.582	5	0.000	*P*<0.05, highly significant
90-100	0 (0)	9 (100)	9 (4.1)				

100-110	32 (42.1)	44 (57.9)	76 (34.2)				
110-120	51 (56.7)	39 (43.3)	90 (40.5)				
120-130	30 (75)	10 (25)	40 (18.0)				
130-140	4 (66.7)	2 (33.3)	6 (2.7)				
Diastolic blood pressure							
55-60	3 (27.3)	8 (72.7)	11 (5)	9.926	6	0.128	*P*>0.05, not significant
60-65	1 (14.3)	6 (85.7)	7 (3.2)				
65-70	25 (47.2)	28 (52.8)	53 (23.9)				
70-75	16 (53.3)	14 (46.7)	30 (13.5)				
75-80	52 (59.1)	36 (40.9)	88 (39.6)				
80-85	11 (61.1)	7 (38.9)	18 (8.1)				
85-90	9 (60)	6 (40)	15 (6.7)				
BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, WHR: Waist-to-hip ratio							

Table 3 showed the distribution of normotensive andpre-hypertensive between different BMI category of medicalstudents versus male and female students among 222 medicalstudents (male students–117 and female students–105).39 (33.3%) male students and 19 (18.1%) female students were pre-hypertensive, 22 pre-hypertensive among male students and 10 pre-hypertensive among female students were from normal BMI category. 10 in pre-obese and 3 in obese Class I in male students and 4 in pre-obese and 3 in obese Class I in female students were pre-hypertensive.

Table 3: BMI category and sex wise distribution of pre-hypertensive/normotensive medical students

BMI category	**Sex**						
	Male[α] *n*=117 (%)			**Female[β] *n*=105 (%)**			**Total[μ]**
	Pre-hypertensive	**Normotensive**	**Total**	**Pre-hypertensive**	**Normotensive**	**Total**	
Underweight	4 (14.8)	23 (85.2)	27 (56.25)	2 (9.5)	19 (90.5)	21 (43.75)	48 (21.6)
Weight in normal range	22 (32.8)	45 (67.2)	67 (51.54)	10 (15.87)	53 (84.13)	63 (48.46)	130 (58.6)
Preobese/Overweight	10 (50.0)	10 (50.0)	20 (52.6)	4 (22.2)	14 (77.8)	18 (47.4)	38 (17.1)
Obese Class I	3 (100.0)	0 (0.0)	3 (50.0)	3 (100.0)	0 (0.0)	3 (50.0)	6 (2.7)
Total	39 (33.3)	78 (66.7)	117 (52.7)	19 (18.1)	86 (81.9)	105 (47.3)	222
[α](χ^2=12.674, df=3, *P*=0.005, *P*<0.05, significant); [β](χ^2=15.037, df=3, *P*=0.002, *P*<0.05, significant); [μ](χ^2=23.998, df=3,						*P*=0.000, *P*<0	.05, highly significant).

BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, WHR: Waist-to-hip ratio

Chi-square value for different BMI category of medical students for normotensive and pre-hypertensive among male students was 12.674 with 3 degree of freedom, P value was 0.005, which is significant; among female students was 15.037 with 3 degree of freedom, P value was 0.002, which was significant and among total students was 23.998 with 3 degree of freedom, P value was 0.000, which was highly significant.

Table 4 showed SBPHR with different cutoff values in male and female distribution of pre-hypertensive and normotensive of 222 medical students (male = 117, female = 105). In male students, with cutoff value of SBPHR 0.73, sensitivity was 51.3% and specificity was 91%; with SBPHR cutoff 0.75, sensitivity was 30.8% and specificity was 94.9%; with SBPHR cutoff 0.81, sensitivity was 2.5% and specificity was 100%; with proposed SBPHR cutoff 0.71, sensitivity was 64.1% and specificity was 80.8%. In female students, with cutoff value of SBPHR 0.71, sensitivity was 89.5% and specificity was 44.2%; with SBPHR cutoff 0.78, sensitivity was 57.9% and specificity was 93.0%; with SBPHR cutoff 0.84, sensitivity was 10.5% and specificity was 100%; with proposed SBPHR cutoff 0.75, sensitivity was 68.4% and specificity was 70.9%.

Table 4: SBPHR distribution with different cutoff value for male and female in pre-hypertensive/normotensive medicalstudents

SBPHR A, B, C, different cutoff for male	**Male *n*=117 (%)**			**SBPHR D, E, F cutoff for female**	**Female *n*=105 (%)**		
	Pre-hypertensive	**Normo-tensive**	**Total**		**Pre-hypertension**	**Normo-tensive**	**Total**
A-M	Sensitivity=51.3%, Specificity=91%			D-F	Sensitivity=89.5%, Specificity=44.2%		
≥0.73	20 (74.1)	7 (25.9)	27 (23.1)	≥0.71	17 (26.2)	48 (73.8)	65 (61.9)
Up to 0.72	19 (21.1)	71 (78.9)	90 (76.9)	Up to 0.70	2 (5.0)	38 (95.0)	40 (38.1)
Total	39 (33.3)	78 (66.7)	117 (52.7)	Total	19 (18.1)	86 (81.9)	105 (47.3)
B-M	Sensitivity=30.8%, Specificity=94.9%			E-F	Sensitivity=57.9%, Specificity=93.0%		
≥0.75	12 (75)	4 (25)	16 (13.7)	≥0.78	11 (64.7)	6 (35.3)	17 (16.2)
Up to 0.74	27 (26.7)	74 (73.3)	101 (86.3)	Up to 0.77	8 (9.1)	80 (90.9)	88 (83.8)
Total	39 (33.3)	78 (66.7)	117 (52.7)	Total	19 (18.1)	86 (81.9)	105 (47.3)
C-M	Sensitivity=2.5%, Specificity=100%			F-F	Sensitivity=10.5%, Specificity=100%		
≥0.81	1 (100)	0 (0)	1 (0.9)	≥0.84	2 (100)	0 (0)	2 (1.9)
Up to 0.80	38 (32.8)	78 (67.2)	116 (99.1)	Up to 0.83	17 (16.5)	86 (83.5)	103 (98.1)
Total	39 (33.3)	78 (66.7)	117 (52.7)	Total	19 (18.1)	86 (81.9)	105 (47.3)
Proposed	Sensitivity=64.1%, Specificity=80.8%			Proposed	Sensitivity=68.4%, Specificity=70.9%		
≥0.71	25 (62.5)	15 (37.5)	40 (34.2)	≥0.75	13 (34.2)	25 (65.8)	38 (36.2)
Up to 0.70	14 (18.2)	63 (81.8)	77 (65.8)	Up to 0.74	6 (9.0)	61 (91.0)	67 (63.8)
Total	39 (33.3)	78 (66.7)	117 (52.7)	Total	19 (18.1)	86 (81.9)	105 (47.3)
(A-M, D-F) [21]; (B-M, C-M, E-F, F-F) [22]. SBPHR: Systolic blood pressure-to-height ratio							

Table 5 showed DBPHR with different cutoff values in male and female distribution of pre-hypertensive and normotensive of 222 medical students (male = 117, female = 105). In male students, with cutoff value of DBPHR 0.47, sensitivity was 48.7% and specificity was 73.1%; with DBPHR cutoff 0.48, sensitivity was 48.7% and specificity was 82.1%; with DBPHR cutoff 0.57, sensitivity was 0% and specificity was 100%; with proposed DBPHR cutoff 0.46, sensitivity was 64.1% and specificity was 61.5%; H-M and I-M cutoffs were same. In female students, with cutoff value of DBPHR 0.45, sensitivity was 100% and specificity was 29.1%; with DBPHR cutoff 0.46, sensitivity was 100% and specificity was 43.0%; with DBPHR cutoff 0.51, sensitivity was 57.9% and specificity was 79.1%; with DBPHR cutoff 0.63, sensitivity was 0% and specificity was 100%; with proposed DBPHR cutoff 0.49, sensitivity was 89.5% and specificity was 67.4%.

Table 5: DBPHR distribution with different cutoff value for male and female in pre-hypertensive/normotensive medicalstudents

DBPHR G, H, I, J different cutoff for male	Male *n*=117 (%)			DBPHRK, L, M, N cutoff for female	Female *n*=105 (%)		
	Pre-hypertensive	Normo-tensive	Total		Pre-hypertensive	Normo-tensive	Total
G-M	Sensitivity=48.7%, Specificity=73.1%			K-F	Sensitivity=100%, Specificity=29.1%		
≥0.47	19 (47.5)	21 (52.5)	40 (34.2)	≥0.45	19 (23.7)	61 (76.3)	80 (76.2)
Up to 0.46	20 (26)	57 (74)	77 (65.8)	Up to 0.44	0 (0)	25 (100)	25 (23.8)
Total	39 (33.3)	78 (66.7)	117 (52.7)	Total	19 (18.1)	86 (81.9)	105 (47.3)
H-M	Sensitivity=48.7%, Specificity=82.1%			L-F	Sensitivity=100%, Specificity=43.0%		
≥0.48	19 (57.6)	14 (42.4)	33 (28.2)	≥0.46	19 (27.9)	49 (72.1)	68 (64.8)
Up to 0.47	20 (23.8)	64 (76.2)	84 (71.8)	Up to 0.45	0 (0)	37 (100)	37 (35.2)
Total	39 (33.3)	78 (66.7)	117 (52.7)	Total	19 (18.1)	86 (81.9)	105 (47.3)
I-M	Sensitivity=48.7%, Specificity=82.1%			M-F	Sensitivity=57.9%, Specificity=79.1%		
≥0.48	19 (57.6)	14 (42.4)	33 (28.2)	≥0.51	11 (37.9)	18 (62.1)	29 (27.6)
Up to 0.47	20 (23.8)	64 (76.2)	84 (71.8)	Up to 0.50	8 (10.5)	68 (89.5)	76 (72.4)
Total	39 (33.3)	78 (66.7)	117 (52.7)	Total	19 (18.1)	86 (81.9)	105 (47.3)
J-M	Sensitivity=0%, Specificity=100%			N-F	Sensitivity=0%, Specificity=100%		
≥0.57	0 (0)	0 (0)	0 (0)	≥0.63	0 (0)	0 (0%)	0 (0)
Up to 0.56	39 (33.3)	78 (66.7)	117 (100)	Up to 0.62	19 (18.1)	86 (81.9)	105 (100)
Total	39 (33.3)	78 (66.7)	117 (52.7)	Total	19 (18.1)	86 (81.9)	105 (47.3)
Proposed	Sensitivity=64.1%, Specificity=61.5%			Proposed	Sensitivity=89.5%, Specificity=67.4%		
≥0.46	25 (45.5)	30 (54.5)	55 (47.0)	≥0.49	17 (37.8)	28 (62.2)	45 (42.9)
Up to 0.45	14 (22.6)	48 (77.4)	62 (53.0)	Up to 0.48	2 (3.3)	58 (96.7)	60 (57.1)
Total	39 (33.3)	78 (66.7)	117 (52.7)	Total	19 (18.1)	86 (81.9)	105 (47.3)

(G-M, K-F, H-M, L-F) [21]; (I-M, M-F, J-M, N-F) [22]. DBPHR: Diastolic blood pressure-to-height ratio

Discussion

In this study, out of 222 medical students, 164 students(73.9%) were normotensive, and 58 students (26.1%) were pre-hypertensive, not a single case of HTN was detected. A similar finding was in one study conducted in Karnataka by Shetty et al[8]. showed that there was no case of HTN in medical students of coastal Karnataka, whereas pre-hypertensive were 55.4% which is much higher than this study. One another study[9] in Andhra Pradesh in 275 medical students showed pre-hypertensive were 37.45% and HTN 3.63%. Another study[17] at Davangere HTN and pre-HTN were 67%.

In our study, mean of systolic BP of all MBBS students was 115.37 ± 8.21 mmHg and mean of diastolic BP of all MBBS students was 75.70 ± 7.00 mmHg. A similar finding was in one study[18] mean systolic reading was 116.9 ± 12.4 mmHg and mean diastolic reading was 68.0 ± 8.7 mmHg in primary school children. In another study[17], among medical students in Davangere, mean systolic BP was 117.68 ± 7.16 mmHg and mean diastolic BP was 77.3 ± 7.93 mmHg.

In our study, out of 222 medical students, 2.7% were in obese Class I and 17.1% in pre-obese/overweight category while in one other study[19] in 1249 health science students, around 17% of the overall population were classified as overweight and 3% as obese, this finding is quiet similar to our study. In one another study[20], obesity was diagnosed in 2.4% and overweight in 13% of subjects, respectively, in 1472 18-year-old high-school students (780 men and 692 women).

In our study, Table 3 showed that 22 (56.4%) pre-hypertensive among male students and 10 (52.6%) pre-hypertensive among female students were from normal BMI category. 10 (25.6%)in pre-obese and 3 (7.7%) in obese Class I in male students and 4 (21%) in pre-obese and 3 (15.8%) in obese Class I in female students were pre-hypertensive. Out of total 58 pre- hypertensive, 32 (55.2%) were in normal BMI category, 14 (24.1%) in pre-obese and 6 (10.3%) in obese Class I and 6 (10.3%) were underweight. Another study[19] showed in overall population, the prevalence of HTN was impressively higher in overweight (32.5%) and obese participants (64.1%) compared to normal-weight subjects (7.3%).

We have evolved with proposed SBPHR cutoff 0.71 formale, in which sensitivity was 64.1% and specificity was 80.8%; and for female 0.75, whose sensitivity was 68.4% and specificity was 70.9%. In one study[14] conducted in 5738students in Iran with cutoff values of SBPHR 0.73 in male had sensitivity 82% and specificity 81%, and SBPHR 0.71 infemale had sensitivity 79% and specificity 74% for pre-HTN. With cutoff value of SBPHR 0.73 in male had sensitivity 82% and specificity 82%, and SBPHR 0.71 in female had sensitivity 75% and specificity 75% for HTN.

We have evolved with proposed DBPHR cutoff 0.46 for male, in which sensitivity was 64.1% and specificity was 61.5%; and for female 0.49, whose sensitivity was 89.5% and specificity was 67.4%. In one study[14] conducted in 5738 students in Iran with cutoff values of DBPHR 0.47 in male had sensitivity 79% and specificity 78%, and DBPHR 0.45 infemale had sensitivity 70% and specificity 70% for pre-HTN. With cutoff value of DBPHR 0.48 in male had sensitivity 79% and specificity 80%, and DBPHR 0.46 in female had sensitivity 73% and specificity 72% for HTN.

In one another cross-sectional population based study[15], of 3136 adolescents aged 13-17 years with optimal thresholds of SBPHR/DBPHR for defining HTN (Stage I) - 0.75/0.48 for boys and 0.78/0.51 for girls showed sensitivity and specificity both >90% (91.0-99.1%), and for defining HTN (Stage II) - 0.81/0.57 for boys and 0.84/0.63 for girls showed sensitivity 100% for both, specificity 98.6% for boys and 99.1% for girls.

Table 6: WHR obese category and sexwise distribution of pre-hypertensive/normotensive medical students							
WHR obesecategory	Sex						
	Male[α] *n*=117 (%)			Female[β] *n*=105 (%)			Total[μ]
	Pre-hypertensive	Normotensive	Total	Pre-hypertensive	Normotensive	Total	
Up to 0.85	10 (25)	30 (75)	40 (37.7)	14 (21.2)	52 (78.8)	66 (62.3)	106 (47.7)
0.85-1, obese if female, N if male	29 (39.7)	44 (60.3)	73 (65.8)	5 (13.2)	33 (86.8)	38 (34.2)	111 (50)
>1, abd fat accumulation, inmale also	0 (0)	4 (100)	4 (80)	0 (0)	1 (100)	1 (20)	5 (2.3)
Total	39 (33.3)	78 (66.7)	117 (52.7)	19 (18.1)	86 (81.9)	105 (47.3)	222

[α](χ^2=4.592, df=2, *P*=0.101, *P*>0.05, Not significant); [β](χ^2=1.279, df=2, *P*=0.528, *P*>0.05, Not significant); [μ](χ^2=3.602, df=2, *P*=0.165 , *P*>0.05, Not significant). WHR: Waist-to-hip ratio

Table 6 showed, total 111(50%) were in 0.85-1 WHR obese category, while 29 (74.4%) out of 39 male pre-hypertensive and 5 (26.3%) out of 19 female pre-hypertensive were in 0.85-1 WHR obese category. 10 (25.6%) male and 14 (73.7%) female pre-hypertensive were in less than 0.85 WHR obese category. This observation showed that we should relook for the lower cutoff 0.80 for women and 0.95 for men[21] or someother new cutoff should be evolved.

Conclusion

Out of 222 medical students, 73.9% were normotensive,26.1% were pre-hypertensive, no case of HTN was present. Mean height was 164.17 ± 9.4 cm; mean weight was 57.77 ± 12.32 kg, mean BMI was 21.72 ±3.64 kg/m^2, mean WC was 79.59 ± 10.85 cm and HC was 93.03 ± 9.12 cm for 17-26 years old 222 medical students. 2.7% were in obese Class I and 17.1% in pre-obese/overweight category out of 222 Medical Students as per BMI. 50% were in 0.85-1 WHR obese category. We can propose SBPHR cutoff 0.71 for male and for female 0.75 and DBPHR cutoff 0.46 for male and forfemale 0.49.

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