ORIGINAL ARTICLE

Hypertension: Is it a concern only among the overweight and obese Garo women of Kamrup district, Assam?

Flora Rabha[1], Gulrukh Begum[1]

[1] Department of Anthropology, Gauhati University, Gauhati, Assam, India

Corresponding Author Flora Rabha **Email:** rabhaflora@gmail.com

Received: 9 May 2022 **Revised:** 25 June 2022 **Accepted:** 7 July 2022 **Available online:** September 2022
DOI: 10.55131/jphd/2022/200316

ABSTRACT

Hypertension is among the most important risk factors for cardiovascular diseases. It was found that subjects who do vigorous physical activity, have brought down mortality and lowered the danger of cardiovascular sicknesses and are termed to be physically fit. The present study estimates the blood pressure level among all the physically active Garo women who have self-claimed to be physically fit. The aim of this paper is to see whether the prevalence of hypertension is found among the physically fit individuals or is only confined to unfit individuals among the study population. Data for the present cross - sectional study involving 862 plain Garo women of 18-70 years were collected from villages in the district of Kamrup in Assam, India. Anthropometric measurements, including Height, Weight, circumferences (arm, chest, waist, hip, calf) and indices like body mass index, waist to height ratio, waist to hip ratio, conicity index, body adiposity index and Physiometric measures including blood pressure (Systolic/diastolic) were measured. The blood pressure (systolic/diastolic) correlated positively with age. There was a high prevalence of systolic (43.8%) and diastolic blood (43.75%) pressure in the age group 50 – 54 years. Height was found to have a significant negative correlation with systolic/diastolic blood pressure. The highest prevalence of hypertension [Systolic: 33.03% (BMI) and 36.95% (BAI); diastolic: 39.14%(BMI) and 42.86%(BAI)] was found in the overweight/obese category. Among the underweight and normal categories more than 15% and 20% prevalence respectively were seen. The results of the CCA indicate that the present model explained around 0.9031 proportion of variance of the physiometric measures from anthropometric variables. The model also depicts that the most significant predictors of physiometric measures were Body Adiposity Index, Weight Height Ratio and Waist Circumference. The Garo women despite being absolutely fit physically are still wrangled by the triple burden of underweight, overweight and hypertension.

Key words:
hypertension; underweight; overweight; physically fit; women.

Citation:
Flora Rabha, Gulrukh Begum. Hypertension: Is it a concern only among the overweight and obese Garo women of Kamrup district, Assam? J Public Hlth Dev. 2022;20(3):194-208
(https://doi.org/10.55131/jphd/2022/200316)

INTRODUCTION

A large waistline and high blood pressure (BP) are risk factors that if not addressed can increase the risk of non - communicable diseases (NCDs) like heart disease, stroke and diabetes.[1] Most NCDs are caused by activity behaviours which in turn cause changes in BP and adiposity status. One of the global targets for NCDs is to reduce the prevalence of hypertension by 33% between 2010 and 2030.[2]Nearly 63% of total deaths in India are due to NCDs, of which 27% are attributed to cardiovascular disease (CVD) which affects 45% of people in the 40-69 age group. Raised BP is among the most important risk factors for CVDs.[3]

During the last few decades, it has been found that subjects who do vigorous physical activity, have brought down mortality and lowered the danger of cardiovascular and metabolic sicknesses.[4]Physically active people are generally termed to be physically fit too. To be physically fit one should have a healthy body composition which is determined by the relative amount of body fat, muscle, bone mass, and flexibility.[5]Even though, in certain populations a considerable percentage of hypertension has been found to be present among the underweight/normal weight individuals and among people categorised in the no risk category. Hypertension, a direct indicator of CVD, has been strongly implicated in the increased prevalence of overweight/obesity[6-8] and undernutrition.[9,10]

The possible risk of CVD was found among both overweight/obese and underweight individuals of certain tribes in India by Kshatriya et al. [11] Lalnuneng, 2021 showed an age dependent rise in mean SBP and a gradual decrease in DBP.[12] Das et al. reported an inverse association between height and mean BP of the women, and higher prevalence of hypertension among short women.[13] Islam et al. and Norbert et al. found a divergent association between height with BP, among females and concluded that the calibre of coronary arteries in females is smaller than males which might increase the risk of having higher SBP among females.[14,15]Studies among an Asian population by Linderman reported a strong association between BMI and BP.[16]

Meshram et al. through their study found an increasing prevalence of overweight and hypertension among women from Northeast India, though it was lesser than the national average. Prevalence of hypertension was found to be 15% among the Khasi women in Meghalaya and 17% among the Chakesang women in Nagaland.[17] In another study by Meshram et al. prevalence of hypertension was found to be 18% among women from rural Northeast India (Arunachal Pradesh and Meghalaya).[18] Study carried out by Borah et al. among hill tribe of Mizoram reported 12% prevalence of hypertension.[19] In a study conducted in Manipur, overweight and obese were 7.39 times more likely to have stage II hypertension. [20]

As per NFHS – 5, 22.2% of women in Kamrup District (Rural) were found to be having elevated blood pressure (systolic ≥140 mm of Hg and diastolic ≥90 mm of Hg)[21].

Physically active individuals avoid hypertension only if fitness is high.[22]Fitness is a trait that reflects a combination of activity behaviours, genetic potential, and functional health of various organ systems.[23]Numerous cross-sectional studies have described a relationship between reduced fitness and blood pressure or hypertension.[24-26]Furthermore, large cohort studies have demonstrated that low fitness precedes new-onset of hypertension,[27-30] even in normotensive

populations,[31] and among persons with an elevated risk for hypertension.[32]

Thus the present study delves into estimating the BP status among all the physically active Garo women who have self claimed to be physically fit and do all their daily activities without any lethargy or tiredness. Apart from doing household chores and taking care of the family members, working in the agricultural fields, in the orchards or collecting firewood from nearby hills and walking to and from agricultural fields and the hills are also a major part of their daily activities. Keeping this in mind the main aim of this paper is to see whether the prevalence of hypertension is found among physically fit individuals or is only confined to unfit (overweight/obese) individuals among the study population.

It is necessary to identify individuals and populations at risk for implementing any strategies for controlling and preventing hypertension in both overweight and underweight. The present study would therefore provide a better insight into improving and understanding the association between BMI and BP.

METHODS

The Garos are a Tibeto-Burman ethnic group who call themselves *A·chik Mande* (literally *a·chik*"hill people"and*mande*"people")[33]. They are one of the few matrilineal tribes in the world. The Garos are mainly distributed in Meghalaya, districts of Assam (Kamrup, Goalpara, Karbi Anglong) bordering Meghalaya and Nagaland (Dimapur). Substantial numbers (about 200,000) are found in several districts of Bangladesh too. According to the Census of India, 2011 there are approximately 26,000 Garos in Kamrup (Rural)[34].

Data for the present cross- sectional study was collected from 862 plain Garo women with the age ranging from 18-70 years. Ten villages are included in the study. The villages are about 70-75 km away from Guwahati city which falls under the Kamrup district of Assam, India.

Purposive sampling has been used in the study to select the villages and anyone willing to participate as per their convenience and availability provided they fell within the inclusion criteria were included in the study. Pregnant and sick individuals were excluded from the survey. The sample size of the present study is a proportional representation of the total female Garo population of 12,759[34]calculated using Open Epi open-source software version 3.01, 2006. The sample of the present study falls under 99% confidence interval of the total population. The anticipated percentage frequency is 50%, design effect (DEFF) is 1.0 and precision is 5%. Anthropometric measurements were taken and interview was conducted after taking the written consent. Age of the women was collected after verifying the written record. For those women who did not have a birth record, their ages were estimated by referring to some important local events.

Blood pressure was measured using a standard Omron digital blood pressure monitor on the left arm using a calf of appropriate size with the subject in a sitting position. The American Heart Association classification was used to categorise the BP values[35]. Height was measured without shoes to the nearest 0.10 cm using an anthropometer. The weight (Wt) was measured with a portable analogue weighing machine to the nearest 0.5 kg. Circumferences were measured using a plastic coated non-stretchable measuring tape. MUAC simply known as arm circumference was taken at the point midway between the acromion and the radiale of the upper arm. Chest Circumference (CC) was measured by placing one end of the measuring tape at the fullest part of the bust and wrapping it around (under the armpits, around the shoulder blades, and back to the front). The

average between measurements taken during deep inspirium and deep expirium was recorded. Waist Circumference (WC) was measured at the minimum circumference between the last rib and the iliac crest. The cut off used for WC is 80 cm[36]. Hip Circumference (HC) was measured at the maximum protuberance of the buttocks. Calf Circumference (CC) was measured with tape at the maximum circumference in the plane perpendicular to the longitudinal line of the calf.

The indices such as Body Mass Index (BMI), Waist – Height Ratio (WHtR), Conicity Index (CI),[37]Waist – Hip Ratio (WHR), and Body Adiposity Index (BAI)[38] were also calculated. The cut-offs given by WHO for the Asian population was the classification used for BMI,[39]for WHtR 0.5 was used as cut-off[40,41], for CI cut-off for women was 1.18[42]and WHR cut-off for women was 0.85 cm[36]. For BAI the classification proposed by Gallagher et al.[43] for women was used.

Descriptive statistics were computed for all the physiometric and anthropometric measures. Pearson's correlation analysis and Canonical correlation analysis (CCA) were performed to understand the bivariate relationship and overall relationship between physiometric measures and anthropometric measurements of an individual respectively. CCA indicates the relationship between two sets of variables i.e. first set consists of physiometric measures and the second set consists of all anthropometric measurements and age. The first canonical function is chosen because it has the highest correlation value and can explain the majority of the variation in the dependent set. Canonical loadings depict the correlation between observed variables with the same set of canonical variates. On the other hand, canonical cross loadings show correlation between observed variables with the opposite set of canonical variables[44]. All the statistical analyses have been done using SPSS software 17.0 (SPSS Inc., Chicago, IL, USA) and SAS software 9.0 (SAS Institute Inc., Cary, NC, USA).

The ethical approval for this study was granted by Institutional Ethical Committee (IEC), Gauhati University (Reference no. GUIEC/2021/030).

RESULTS

The descriptive statistics of physiometric and anthropometric measures are described in Table 1. The mean SBP rises with age till 39 years maintaining a normal BP. After 40 years the women start exhibiting elevated SBP till 59 years and after reaching 60 years there is a sharp rise in SBP entering Hypertension Stage I (HS I). The mean DBP keeps on rising till 54 years then decreases gradually. Waist circumference remains normal till 49 years of age after which it slightly crosses the 80 cm cut-off mark. The women have normal BMI till 34 years of age, and then it starts to increase from 35 to 54 years and again comes back to normal in the later age groups. The overall mean values of WHR, WHtR, and CI are above the reference cut-off value. Except in the age group 18-19 years for WHR and CI and till 29 years of age for WHtR the rest of the mean values indicate that the women are at risk of metabolic and cardiovascular diseases. The BAI is normal for all age groups. Result of one way ANOVA shows that mean values of all the physiometric and anthropometric measurements are significantly heterogeneous over age groups.

Table 1: Age trends of physiometric measures and anthropometric measures.

Age groups			Total mean	18 - 19	20 – 24	25 – 29	30 – 34	35 – 39	40 – 44	45 – 49	50 – 54	55 – 59	60 - 70	ANOVA
Total			**862**	**60**	**100**	**100**	**93**	**100**	**82**	**86**	**80**	**80**	**81**	
Physio-metric measur	SBP	$\bar{X}\pm$	120.85	111.98	112.25	114.29	115.74	119.34	122.90	123.85	126.15	129.51	134.85	F=19.378
		SD	± 17.41	± 11.79	± 10.32	± 13.03	± 12.03	± 13.82	± 18.05	± 18.03	± 17.39	± 19.14	± 22.89	p < 0.001
	DBP	$\bar{X}\pm$	76.31 ±	71.25 ±	71.35 ±	73.34 ±	74.35 ±	77.53 ±	77.69 ±	79.24 ±	80.43 ±	78.10 ±	77.30 ±	F=9.773
		SD	10.66	8.97	7.92	9.66	8.11	9.37	11.46	11.90	10.49	9.97	13.48	p < 0.001
	Height	$\bar{X}\pm$	148.88	150.28	150.39	149.61	149.28	149.00	149.00	148.66	148.46	147.05	146.87	F=4.340
		SD	± 5.23	± 5.26	± 4.90	± 4.85	± 5.03	± 5.23	± 4.54	± 5.02	± 7.00	± 5.89	± 4.69	p < 0.001
	Weight	$\bar{X}\pm$	49.90 ±	45.50 ±	47.16 ±	48.11 ±	51.21 ±	51.54 ±	51.18 ±	51.45 ±	53.26 ±	49.09 ±	48.62 ±	F=5.876
		SD	9.39	7.99	7.96	8.03	9.60	8.87	9.70	9.70	10.21	8.82	10.44	p < 0.001
	Arm	$\bar{X}\pm$	25.99 ±	23.96 ±	24.56 ±	25.22 ±	26.77 ±	26.79 ±	26.80 ±	27.10 ±	27.17 ±	26.03 ±	25.53 ±	F=11.794
		SD	3.04	2.16	2.29	2.96	2.93	3.26	2.87	3.08	3.13	2.65	3.04	p < 0.001
Circumferences	Chest	$\bar{X}\pm$	87.26 ±	84.14 ±	84.20 ±	85.49 ±	88.91 ±	88.95 ±	88.95 ±	88.96 ±	90.93 ±	86.48 ±	86.35 ±	F=5.049
		SD	8.48	5.35	6.85	7.46	8.53	8.08	8.54	9.04	9.46	8.86	9.75	p < 0.001
	Waist	$\bar{X}\pm$	77.18 ±	69.98	72.18	73.25 ±	77.38	77.94	77.59	79.63	82.79	80.76	80.05	F=12.562
		SD	10.72	± 6.98	± 7.85	8.34	± 10.97	± 9.99	± 10.14	± 10.99	± 11.90	± 11.48	± 11.42	p < 0.001
	Hip	$\bar{X}\pm$	89.20 ±	83.76	85.31	85.80 ±	90.15	90.51	90.24	90.41	90.53 ±	90.07	90.01	F=12.692
		SD	8.47	± 6.05	± 6.31	6.58	± 8.61	± 8.12	± 8.10	± 8.51	8.91	± 8.68	± 9.37	p < 0.001
	Calf	$\bar{X}\pm$	32.19 ±	31.51 ±	31.65	31.93	32.05	32.57	32.68	32.83	33.57	32.02	30.85	F=4.586
		SD	3.02	2.45	± 2.77	± 3.03	± 2.94	± 2.78	± 2.95	± 3.03	± 3.36	± 2.90	± 3.26	p < 0.001
	BMI	$\bar{X}\pm$	22.51 ±	20.15 ±	20.85 ±	21.49 ±	22.98 ±	23.05 ±	23.22 ±	23.28 ±	24.16 ±	22.70	22.54 ±	F=8.622
		SD	3.94	3.43	3.14	3.32	3.95	3.75	3.95	4.55	4.23	± 3.37	4.11	p < 0.001
Indices	WHtR	$\bar{X}\pm$	0.52 ±	.47 ±	.48 ±	.49 ±	.52 ±	.52 ±	.52 ±	.54 ±	.56 ±	.55 ±	.55 ±	F=5.596
		SD	0.07	.05	.05	.05	.07	.07	.07	.08	.08	.07	.08	p < 0.001
	WHR	$\bar{X}\pm$	0.86 ±	.84 ±	.85 ±	.85 ±	.86 ±	.86 ±	.86 ±	.86 ±	.91 ±	.90 ±	.90 ±	F=15.888
		SD	0.06	.07	.06	.53	.06	.05	.05	.05	.06	.07	.07	p < 0.001
	CI	$\bar{X}\pm$	1.22 ±	1.17 ±	1.18 ±	1.19 ±	1.22 ±	1.21 ±	1.22 ±	1.24 ±	1.27 ±	1.27 ±	1.28 ±	F=13.809
		SD	0.10	.09	.08	.08	.09	.09	.08	.11	.10	.13	.11	p < 0.001
	BAI	$\bar{X}\pm$	31.10 ±	27.47 ±	28.26 ±	28.89 ±	31.62 ±	31.57 ±	31.62 ±	31.87 ±	32.04 ±	32.51 ±	32.57 ±	F=18.993
		SD	4,85	3.42	3.53	3.64	4.69	4.66	4.39	5.36	5.03	4.47	4.85	p < 0.001

P < 0.05 is significant

The prevalence of systolic hypertension keeps on increasing from lower to higher age group as shown in Table 2. Women aged 60-70 years show the highest prevalence followed by age group 50–54 years. Prevalence of diastolic hypertension also increases with age. The age group 50–54 years shows the highest prevalence followed by the age group 40 – 44 years. No women fell in the hypertensive crisis category.

Table 2: Prevalence of different levels of blood pressure by age

Variables	Category	No. of women	18 - 19	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 70
	Total	**862**	**60**	**100**	**100**	**93**	**100**	**82**	**86**	**80**	**80**	**81**
SBP	Low	6(.7)	3(5.0)	1(1.0)	1(1.0)	1(1.1)	-	-	-	-	-	-
	Normal	478(55.5)	43(71.7)	75(75.0)	70(70.0)	61(65.6)	59(59.0)	40(48.8)	40(46.5)	31(38.6)	36(45.0)	23(28.4)
	Elevated	161(18.7)	8(13.3)	17(17.0)	17(17.0)	20(21.5)	19(19.0)	19(23.2)	20(23.3)	14(17.5)	13(16.3)	14(17.3)
	Hypertension	217(25.2)	6(10.0)	7(7.0)	12(12.0)	11(11.8)	22(22.0)	23(28.1)	26(30.2)	35(43.8)	31(38.8)	44(54.3)
	Hypertensive crisis	-	-	-	-	-	-	-	-	-	-	-
DBP	Low	25(2.9)	5(8.3)	9(9.0)	4(4.0)	2(2.15)	1(1.0)	1(1.23)	1(1.16)	-	1(1.25)	1(1.23)
	Normal	573(66.5)	45(75.0)	74(74.0)	74(74.0)	71(76.34)	65(65.0)	48((58.53)	52(60.46)	45(56.25)	50(62.5)	49(60.49)
	Elevated	-	-	-	-	-	-	-	-	-	-	-
	Hypertension	264(30.6)	10(16.7)	17(17.0)	22(22.0)	20(21.51)	34(34.0)	33(40.24)	33(38.37)	35(43.75)	29(36.25)	31(38.27)
	Hypertensive crisis	-	-	-	-	-	-	-	-	-	-	-

The relative importance of MUAC, WC, WHtR, WHR, CI, BMI, and BAI as predictors of systolic hypertension (SH) and diastolic hypertension (DH) are shown

in Table 3. The prevalence of SH and DH were found to be more among women who were at risk of developing metabolic complications, calculated as per WC, WHtR, WHR, and CI than those who were not at risk. The prevalence of SH and DH was found to be highest among overweight/ obese women than in other categories, as calculated by BMI and BAI. Though the prevalence of hypertension among the women in the underweight and normal categories cannot be ignored as they showed more than 15% and more than 20% prevalence respectively as calculated by MUAC, BMI, and BAI.

Table 3: Prevalence of blood pressure (SBP and DBP) by various anthropometric parameters.

		SBP				Total	DBP			
		Low	Normal	Elevated	Hypertension		Low	Normal	Elevated	Hypertension
MUAC	Under-nourished	-	40(64.52)	11(17.74)	11(17.74)	62	3(4.84)	43(69.35)	-	16(25.81)
	normal	6(0.75)	438(54.75)	150(18.75)	206(25.75)	800	22(2.75)	530(66.25)	-	248(31.00)
WC	No risk	6(1.07)	346(61.90)	96(17.17)	111(19.86)	559	22(3.94)	390(69.77)	-	147(26.30)
	Increased risk/ Substantially Increased risk	-	132(43.56)	65(21.45)	106(34.98)	303	3(0.99)	183(60.40)	-	117(38.61)
WHtR	Normal	5(1.28)	257(65.90)	66(16.92)	62(15.90)	390	17(4.36)	278(71.28)	-	95(24.36)
	High	1(0.21)	221(46.82)	95(20.13)	155(32.84)	472	8(1.69)	295(62.5)	-	169(35.81)
WHR	No risk	4(1.14)	218(62.29)	58(16.51)	70(20.00)	350	11(3.14)	247(70.57)	-	92(26.29)
	Substantially Increased risk	2(0.39)	260(50.78)	103(20.12)	147(28.71)	512	14(2.73)	326(63.67)	-	172(33.59)
CI	Normal	4(1.38)	196(67.82)	45(15.57)	44(15.22)	289	7(2.42)	218(75.43)	-	64(22.15)
	High	2(0.35)	282(49.21)	116(20.24)	173(30.19)	573	18(3.14)	355(61.95)	-	200(34.90)
BMI	Underweight	1(0.87)	71(61.74)	23(20.00)	20(17.39)	115	6(5.22)	78(67.83)	-	31(26.96)
	Normal	5(1.19)	258(61.43)	68(16.19)	89(21.19)	420	18(4.29)	297(70.71)	-	105(25.00)
	Overweight/ obese	-	149(45.57)	70(21.41)	108(33.03)	327	1(0.31)	190(58.10)	-	128(39.14)
Total		6	478	161	217	862	25	573	-	264
BAI	Underweight	-	1(50)	1(50)	-	2	-	2(100)	-	-
	Healthy	3(0.51)	350(58.92)	106(17.85)	135(22.73)	594	19(3.20)	409(68.86)	-	166(27.95)
	Overweight/ obese	-	82(40.39)	46(22.66)	75(36.95)	203	1(0.49)	115(56.65)	-	87(42.86)
Total		**3**	**433**	**153**	**210**	**799***	**20**	**526**	**-**	**253**

**the total number of women is less than the other indices because in the BAI classification ages form 20 to 79 years are considered.*

The results of Pearson's correlation co-efficients (r) between physiometric measurements and anthropometric measurements including age among the Garo women show a statistically significant positive correlation between age and SBP and DBP (Table 4). On the other hand, a statistically significant positive correlation was found between all anthropometric measurements and physiometric measurements except height. WHtR is strongly correlated with SBP and DBP among all the other anthropometric measurements followed by BAI and WC.

Table 4: Pearson's correlation co-efficient (r) between physiometric (dependent) and anthropometric (independent) measurements including age among the Garo women.

	Parameters	SBP	DBP
	Age	0.412**	0.279**
	Height	-0.088**	-0.049
	Weight	0.205**	0.175**
Circumferences	Arm	0.216**	0.187**
	Chest	0.222**	0.188**
	Waist	**0.300****	**0.248****
	Hip	0.282**	0.229**
	Calf	0.107**	0.107**
	BMI	0.250**	0.206**
Indices	WHtR	**0.319****	**0.259****
	WHR	0.204**	0.173**
	CI	0.258**	0.207**
	BAI	**0.317****	**0.247****

***correlation is significant at the 0.01 level (2-tailed)*
**correlation is significant at the 0.05 level (2-tailed)*

The results of CCA between two sets of variables are described in Table 5. The CCA is restricted to deriving two functions because the dependent set contained two variables. The first and second canonical functions show 0.42272 and 0.14658 correlations and represented 0.9031 and 0.0968 proportion of variance respectively. Function one is statistically significant with the p value < 0.001.

Table 5: Canonical Correlation Analysis (CCA) of physiometric measurements and anthropometric measurements including age of Garo women.

Canonical function	Canonical correlation	Eigen value	Proportion	Cumulative proportion	F-value	P value
1	0.42272	0.20477	0.9031524	0.9031524	7.14121	<0.001
2	0.14658	0.02196	0.0968476	100	1.55170	0.101

The loadings and cross loadings of the variables for the first canonical function in CCA of the Garo women are shown in Table 6. The loadings of the variables for the first function reveal that the most important variable for the anthropometric set was BAI (loading: 0.7393) followed by WHtR (loading: 0.7388) and WC (loading: 0.6866). On the other hand, loading values of the variables for the first function reveal that SBP and DBP more or less contribute equally to the set of dependent variables (SBP loading: 0.9842 and DBP loading: 0.7375). The cross loadings of the variables for first function reveal that the most important variables for physiometric measurements were the following anthropometric measurements – BAI (loading: 0.3152), WHtR (loading: 0.3149) and WC (loading: 0.2927)

Table 6: The loadings and cross loadings of the variables for the first canonical function in canonical correlation analysis

		Variables	Loadings	Cross-loadings
Dependent variable	Physiometricmeasures	SBP	0.9842	0.4195
		DBP	0.7375	0.3144
Independent variable	Circumferences	Height	-0.2258	-0.0963
		Weight	0.4625	0.1971
		Arm	0.4894	0.2086
		Chest	0.5036	0.2147
		Waist	**0.6866**	**0.2927**
		Hip	0.6501	0.2771
		Calf	0.2255	0.0961
	Indices	BMI	0.5709	0.2434
		WHtR	**0.7388**	**0.3149**
		WHR	0.4624	0.1971
		CI	0.5951	0.2537
		BAI	**0.7393**	**0.3152**

DISCUSSION

The present study estimates the BP status among all the physically active Garo women who have claimed to be physically fit and seeks to understand whether the prevalence of hypertension is only confined to the overweight or is found among the normal and underweight too. The findings reveal that with an increase in age SBP increases, while DBP keeps on rising till the mid-50s and then decreases gradually. A high prevalence of SBP/DBP is seen in the age group 50-54 years. Prevalence of hypertension is found not only among the overweight/obese but also among the underweight and normal individuals as calculated by MUAC, BMI, and BAI. Height was found to have a significant negative correlation with SBP/DBP. Indices that take height into account were revealed to be the best predictors of hypertension.

As age advances blood vessels become stiff and increase BP. The large artery stiffness causes the rise in SBP but lowers DBP.[45]The overall mean SBP and DBP are almost close to the findings of other studies.[46, 47] Meshram et al. showed a similar mean DBP of 76.9 ± 10.6 in their study.[48]

The high prevalence of SBP and DBP in the age group 50 – 54 years (Table 2) could be because that is the age around which women generally undergo menopause and BP tends to increase in women after menopause due to the loss of oestrogens.[49]Though high prevalence of hypertension (54.3%) is seen among the women above 60 years, the mean value (134.85 mmHg) falls in the initial stages of HS I.

Height was found to have a significant negative correlation with SBP. This meant that with the decrease in height the BP increases. Less height also meant shorter arterial lengths which resulted in earlier pressure wave reflections and greater summation of reflected pressure.[50]The women in Meghalaya are found to be the shortest in India.[51] The Garos are predominantly found in

Meghalaya and the Garos of the present study, though they live in plain areas of Assam bordering Meghalaya are not physically different from them. Though the Garos of the present study stand quite short at 148.88 cm than the national average for Indian women 160.02 cm[52], their BP reaches the hypertension stage I only after they cross 60 years which is normal in elderly people irrespective of their height. A study on women in India from the National Family Health Survey – 4 also found an inverse association between height and mean BP of the women and shorter women had a higher prevalence of hypertension.[13] Another analysis among the Bangladeshi adults also highlighted a divergent association between height and SBP among females only.[14]A relatively smaller number of studies found no significant association between height and blood pressure at all. Smith et al. did not find any statistically significant relationship between height, leg length, and trunk length versus blood pressure in a cross-sectional study of 2,512 men. [53] No relationship between height and hypertension was found in a cross-sectional study of 2,000 Nigerian men and women by Olatunbosun and colleagues.[54]

Significant positive correlation has been found between SBP/DBP and BMI. This means with the increase in BMI, BP also increases. In the study population, the highest prevalence of hypertension (SBP and DBP) was found in the overweight/obese category, which goes in conformity with the previous sentence. Obesity has been found to be associated with increased arterial stiffness that may contribute to hypertension.[55,56]Dua et al. also found a significant positive correlation between BMI, and blood pressure both SBP as well as DBP.[57]Positive associations between BMI and hypertension have been well reported in studies conducted among different Asian ethnic groups and Asian populations and had a much stronger association between BMI and blood pressure.[16]On the other hand, Koh et al. mentioned in their paper that several studies have reported the inverse trend of increasing BMI with decreasing BP. [58]The capability of BMI to predict the risk of hypertension and CVD was doubted by few studies. [59.60]

Though, we cannot ignore the fact that the underweight category also reported cases of SH (17.39%) and DH (26.96%). Similar findings have also been found by Kshatriya and Acharya in 2016 who concluded that the alarming trend of an increasing prevalence of overweight/obesity, under nutrition, and hypertension is observed among indigenous populations of India.[11]Another study reported that the percentage of haemo-dialysis patients with systolic hypertension was higher among the underweight than among the normal or overweight individuals [61].

The results of the CCA indicate that the present model explained around 0.9031 proportion of variance of the physiometric measures from anthropometric variables. The model also depicts that the most significant predictors of physiometric measures were BAI, WHtR and WC. It can be seen that indices that take height into account (BAI, WHtR) are the best predictors of hypertension. BAI as the most significant predictor of hypertension also detects the highest prevalence of hypertension (SBP and DBP) among all the other parameters.

BMI is not a good predictor as it cannot distinguish between a person with excess fat and a person with high muscle mass which might again lead to misreporting of cardiovascular risk.[62]WC alone did not account for differences in height as several studies have reported that individuals with the same WC but with different heights were unlikely to have the same cardio-metabolic risks.[63]Moreover, WHR might be inaccurate in individuals who have lost weight, because both WC and HC can decrease proportionately, thus

the ratio sometimes changes very little.[64, 65]While BMI, WC, WHR and WHtR were found to be useful predictors of high blood pressure among adults of rural residents of southern Ethiopia. [66]

Cameron et al. found a complex relationship between WC and HC and the risk of death. In his study both WC and HC simultaneously identified almost 20% more people as being at higher risk of death compared with using WC alone, and is a simple and cost-effective way of identifying body shapes associated with increased risk of premature death.[67]On the contrary, though Garo women in the present study showed an increasing WC as their ages increased and mean WHtR, WHR and CI were in the risk category, no cases of life threatening NCDs among the women were reported and the majority of women claimed to be physically fit when asked to self report their health status. And on further investigation, the local pharmacies and health centres also have not reported any case which might be remotely linked to increased waist and hip circumferences. This must be because of the amount of physical activity the women engage in. Until and unless the women are bedridden even the elderly do not remain sedentary. Since these women are moderate to vigorous workers the increasing waistline may not be a concern as they burn calories while working. Despite this, hypertension may be a silent threat in the population that needs to be addressed by initiating intervention programs to modify the risk factors associated with hypertension.

LIMITATION

1. There may be chances that changes in BMI may be independently associated with the incidence of hypertension which in the present study could not be studied because of its cross sectional nature.
2. The causal association between BMI and BP was not studied in the present context which may have been acting as factors and some of them could also be modifiers. An increased BMI may be a result of diet or activity, or because of a genetic predisposition combined with diet and/or activity.
3. Demographic variables were not correlated with hypertension which might have given an in-depth purview into the prevalence of hypertension. But due to the word limit constraint of this paper it has been left out.

CONCLUSION

The study revealed that hypertension among the Garo women is not only found among the overweight/obese/ at risk individuals but also the underweight/normal/no risk status as per the indices. Despite being active in their daily activities, more than 25% of them were found to be in the high-risk category as detected by WC, WHR, CI and WHR but with a self-reported claim of being physically fit. Indices that took height into account are more significant predictors of BP as analysed by CCA. The Garo women, therefore, despite being absolutely fit physically are still wrangled by the triple burden of NCDs – underweight, overweight and hypertension.

RECOMMENDATION

Future research may be done to understand various intervention strategies to control and prevent hypertension and to delineate the specific biological pathways by which underweight individuals also suffer from the risk of hypertension.

ACKNOWLEDGEMENT

I thank UGC for funding my doctoral research through their Junior Research Fellowship Scheme and the Department of Anthropology, Gauhati University for providing the instruments required for the anthropometric measurements.

REFERENCES

1. National Heart, Lung, and Blood Institute (NHLBI). What Is Metabolic Syndrome? - Metabolic Syndrome [Internet]. 2019. [cited 2022 Feb 16] Available from: https://www.nhlbi.nih.gov/health-topics/metabolic-syndrome.
2. World Health Organisation. Noncommunicable diseases: Risk factors [Internet]. 2021. [cited 2022 Feb 16]. Available from: https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/ncd-risk-factors.
3. World Health Organisation. Hypertension [Internet]. 2021. [cited 2022 Feb 16]. Available from https://www.who.int/india/health-topics/hypertension.
4. Toukola TM, Kauppila JP, Pakanen L, Kortelainen ML, Martikainen M, Huikuri HV, et al. Characteristics and Prognosis of Exercise-Related Sudden Cardiac Arrest. Front Cardiovasc Med. 2018;5:102. doi=10.3389/fcvm.2018.00102
5. Seemant F. Does physically active mean the same as physically fit? [Internet]. 2015. [cited 2022 Apr 11]. Available from: https://www.ithacajournal.com/story/life/2015/07/10/physically-active-versus-physically-fit/29958269/
6. Kannel WB. Risk stratification in hypertension: new insights from the Framingham Study. Am J Hypertens. 2000;13(1 Pt 2):3s-10s. doi: 10.1016/s0895-7061(99)00252-6.
7. Hall JE. Louis K. Dahl Memorial Lecture. Renal and cardiovascular mechanisms of hypertension in obesity. Hypertension. 1994;23(3):381-94. doi: 10.1161/01.hyp.23.3.381.
8. Díaz ME. Hypertension and obesity. J Hum Hypertens. 2002;16 Suppl 1:S18-22.. doi: 10.1038/sj.jhh.1001335.
9. Sawaya AL, Sesso R, Florêncio TM, Fernandes MT, Martins PA. Association between chronic undernutrition and hypertension. Matern Child Nutr. 2005;1(3):155-63. doi: 10.1111/j.1740-8709.2005.00033.x.
10. Galal OM. The nutrition transition in Egypt: obesity, undernutrition and the food consumption context. Public Health Nutr. 2002;5(1a):141-8. doi: 10.1079/PHN2001286
11. Kshatriya GK, Acharya SK. Triple Burden of Obesity, Undernutrition, and Cardiovascular Disease Risk among Indian Tribes. PLOS ONE. 2016; 11(1):e0147934. doi: 10.1371/journal.pone.0147934.
12. Lalnuneng A. Age variation in blood pressure: Rural-urban and sex differences among the Hmar adults of Manipur, Northeast India. Am J Hum Biol. 2022;34(3):e23656. doi: 10.1002/ajhb.23656.
13. Das M, Verma M, Shri N, Singh M, Singh RR. Relationship between height and hypertension among women in India: Evidence from the fourth round of National Family Health Survey. Diabetes Metab Syndr. 2022;16(1): 102384. doi: 10.1016/j.dsx.2021.
14. Islam MT, Siraj MS, Hassan MZ, Nayem M, Chandra Nag D, Islam MA, et al. Influence of height on blood pressure and hypertension among Bangladeshi adults. Int J Cardiol Hypertens. 2020;5:100028. doi: 10.1016/j.ijchy.2020.100028.
15. Stefan N, Häring HU, Hu FB, Schulze MB. Divergent associations of height

with cardiometabolic disease and cancer: epidemiology, pathophysiology, and global implications. Lancet Diabetes Endocrinol. 2016;4(5):457-67. doi: 10.1016/S2213-8587(15) 00474-X.
16. Linderman GC, Lu J, Lu Y, Sun X, Xu W, Nasir K, et al. Association of Body Mass Index With Blood Pressure Among 1.7 Million Chinese Adults. JAMA Netw Open. 2018;1(4):e181271. doi: 10.1001/jamanetworkopen.2018. 1271.
17. Meshram I, Boiroju NK, Longvah T. Prevalence of overweight/obesity, hypertension and its associated factors among women from Northeast India. Indian Heart J. 2022;74(1):56-62. doi:10.1016/j.ihj.2021.12.009.
18. Meshram, II, Vishnu Vardhana Rao M, Sudershan Rao V, Laxmaiah A, Polasa K. Regional variation in the prevalence of overweight/obesity, hypertension and diabetes and their correlates among the adult rural population in India. Br J Nutr. 2016;115(7):1265-72. doi: 10.1017/S0007114516000039.
19. Borah PK, Mahanta J, Kalita HC, Bhattacharjee CK. Distribution of hypertension subtypes in a hill tribe of Mizoram, Northeast India. Indian Heart J. 2020;72(5):398-402. doi: 10.1016/ j.ihj.2020.08.003.
20. Mungreiphy NK, Kapoor S, Sinha R. Association between BMI, Blood Pressure, and Age: Study among Tangkhul Naga Tribal Males of Northeast India. Journal of Anthropology. 2011;2011:748147. doi: https://doi.org/10.1155/2011/748147.
21. International Institute for Population Sciences (IIPS) and ICF. National Family Health Survey (NFHS-5), 2019-21. India: Mumbai: IIPS; 2021.
22. Nainggolan L. Physically active avoid hypertension only if fitness is high. Medscape. [Internet]. 2010. [Cited 2022 Apr 11]. Available from: https://www. medscape.com/viewarticle/723152
23. Carnethon MR, Gidding SS, Nehgme R, Sidney S, Jacobs DR, Jr., Liu K. Cardiorespiratory fitness in young adulthood and the development of cardiovascular disease risk factors. JAMA. 2003;290(23):3092-100. doi: 10.1001/jama.290.23.3092.
24. Cocks M, Shaw CS, Shepherd SO, Fisher JP, Ranasinghe AM, Barker TA, et al. Sprint interval and endurance training are equally effective in increasing muscle microvascular density and eNOS content in sedentary males. J Physiol. 2013;591(3):641-56. doi: 10.1113/jphysiol.2012.239566.
25. Ogunleye AA, Sandercock GR, Voss C, Eisenmann JC, Reed K. Prevalence of elevated mean arterial pressure and how fitness moderates its association with BMI in youth. Public Health Nutr. 2013;16(11):2046-54. doi: 10.1017/ S1368980012004466.
26. Cardoso CR, Maia MD, de Oliveira FP, Leite NC, Salles GF. High fitness is associated with a better cardiovascular risk profile in patients with type 2 diabetes mellitus. Hypertens Res. 2011; 34(7):856-61. doi: 10.1038/hr.2011.50.
27. Chase NL, Sui X, Lee DC, Blair SN. The association of cardiorespiratory fitness and physical activity with incidence of hypertension in men. Am J Hypertens. 2009;22(4):417-24. doi: 10.1038/ajh.2009.6.
28. Carnethon MR, Evans NS, Church TS, Lewis CE, Schreiner PJ, Jacobs DR, Jr., et al. Joint associations of physical activity and aerobic fitness on the development of incident hypertension: coronary artery risk development in young adults. Hypertension. 2010; 56(1):49-55. doi: 10.1161/ HYPERTENSIONAHA.109.147603.
29. Banda JA, Clouston K, Sui X, Hooker SP, Lee CD, Blair SN. Protective health factors and incident hypertension in men. Am J Hypertens. 2010;23(6):599-605. doi: 10.1038/ajh.2010.26.

30. Williams PT. Vigorous exercise, fitness and incident hypertension, high cholesterol, and diabetes. Med Sci Sports Exerc. 2008;40(6):998-1006. doi: 10.1249/MSS.0b013e31816722a9.
31. Jae SY, Heffernan KS, Yoon ES, Park SH, Carnethon MR, Fernhall B, et al. Temporal changes in cardiorespiratory fitness and the incidence of hypertension in initially normotensive subjects. Am J Hum Biol. 2012; 24(6):763-7. doi: 10.1002/ajhb.22313.
32. Shook RP, Lee DC, Sui X, Prasad V, Hooker SP, Church TS, et al. Cardiorespiratory fitness reduces the risk of incident hypertension associated with a parental history of hypertension. Hypertension. 2012;59(6):1220-4. doi: 10.1161/HYPERTENSIONAHA.112.191676.
33. Playfair A. The Garos. Gauhati: United Publishers; 1975.
34. Census of India, Office of the Registrar General & Census Commissioner, India. Basic Population Figures of India, States, Districts, Sub-District and Village, 2011 [Internet]. 2011 [cited 2022 Feb 18]. Available from: https://ceensusindia.gov.in/census.website/data/population-finder
35. American Heart Association. Understanding blood pressure readings [Internet]. [cited 2022 Feb 18]. Available from: https://www.heart. org/en/health-topics/high-blood-pressure/understanding-blood-pressure-readings
36. WHO Expert Consultation. Waist circumference and Waist-Hip ratio: Report. Geneva: 2008.
37. Valdez R, Seidell JC, Ahn YI, Weiss KM. A new index of abdominal adiposity as an indicator of risk for cardiovascular disease. A cross-population study. Int J Obes Relat Metab Disord. 1993;17(2):77-82.
38. Bergman RN, Stefanovski D, Buchanan TA, Sumner AE, Reynolds JC, Sebring NG, et al. A better index of body adiposity. Obesity (Silver Spring). 2011;19(5):1083-9. doi: 10.1038/oby.2011.38.
39. WHO Expert Consultation. Appropriate body mass index for Asian population and its implications for policy and intervention strategies. Lancet. 2004; 363(9403):157-63. doi: 10.1016/S0140-6736(03)15268-3.
40. Son YJ, Kim J, Park HJ, Park SE, Park CY, Lee WY, et al. Association of Waist-Height Ratio with Diabetes Risk: A 4-Year Longitudinal Retrospective Study. Endocrinol Metab (Seoul). 2016;31(1):127-33. doi: 10.3803/EnM.2016.31.1.127.
41. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. Int J Food Sci Nutr. 2005;56(5):303-7. doi: 10.1080/09637480500195066.
42. Pitanga FJ, Lessa I. [Anthropometric indexes of obesity as an instrument of screening for high coronary risk in adults in the city of Salvador--Bahia]. Arq Bras Cardiol. 2005;85(1):26-31. doi: 10.1590/s0066-782x2005001400006.
43. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Am J Clin Nutr. 2000;72(3):694-701. doi: 10.1093/ajcn/72.3.694.
44. Fedelis I, Anthonia MA. Canonical Correlation Analysis, A Sine Quanon for Multivariant Analysis in Educational Research. IJHSSE. 2018; 5(7):117-126. doi: http://dx.doi.org/10.20431/2349-0381.0507013
45. Sesso HD, Stampfer MJ, Rosner B, Hennekens CH, Gaziano JM, Manson JE, et al. Systolic and diastolic blood pressure, pulse pressure, and mean arterial pressure as predictors of cardiovascular disease risk in Men.

Hypertension. 2000;36(5):801-7. doi: 10.1161/01.hyp.36.5.801.
46. Ramakrishnan S, Zachariah G, Gupta K, Shivkumar Rao J, Mohanan PP, Venugopal K, et al. Prevalence of hypertension among Indian adults: Results from the great India blood pressure survey. Indian Heart J. 2019;71(4):309-13. doi: 10.1016/j.ihj.2019.09.012.
47. Misra PJ, Mini GK, Thankappan KR. Risk factor profile for non-communicable diseases among Mishing tribes in Assam, India: results from a WHO STEPs survey. Indian J Med Res. 2014;140(3):370-8.
48. Meshram I, Boiroju NK, Longvah T. Prevalence of overweight/obesity, hypertension and its associated factors among women from Northeast India. Indian Heart J. 2022;74(1):56-62. doi: 10.1016/j.ihj.2021.12.009.
49. Reckelhoff JF. Gender differences in the regulation of blood pressure. Hypertension. 2001;37(5):1199-208. doi: 10.1161/01.hyp.37.5.1199.
50. McEniery CM, Yasmin, Hall IR, Qasem A, Wilkinson IB, Cockcroft JR. Normal vascular aging: differential effects on wave reflection and aortic pulse wave velocity: the Anglo-Cardiff Collaborative Trial (ACCT). J Am Coll Cardiol. 2005;46(9):1753-60. doi: 10.1016/j.jacc.2005.07.037.
51. Nayak CK. Some north easterners getting shorter. The Shillong Times [Internet]. 2019 [Cited 2022 Mar 19]. Available from: https://theshillongtimes.com/2019/04/19/some-northeasterners-getting-shorter-study/.
52. ICMR-NIN Expert group on nutrient requirement for Indians. Recommended dietary allowances (RDA) and Estimated average requirements (EAR) [Internet]. 2020 [cited 2022 May 6]. Available from: https://www.nin.res.in/RDA_short_Report_2020.html.
53. Smith GD, Greenwood R, Gunnell D, Sweetnam P, Yarnell J, Elwood P. Leg length, insulin resistance, and coronary heart disease risk: the Caerphilly Study. J Epidemiol Community Health. 2001;55(12):867-72. doi: 10.1136/jech.55.12.867.
54. Olatunbosun ST, Bella AF. Relationship between height, glucose intolerance, and hypertension in an urban African black adult population: a case for the "thrifty phenotype" hypothesis? J Natl Med Assoc. 2000; 92(6):265-8.
55. de Simone G, Devereux RB, Chinali M, Best LG, Lee ET, Welty TK. Association of blood pressure with blood viscosity in american indians: the Strong Heart Study. Hypertension. 2005;45(4):625-30. doi: 10.1161/01.HYP.0000157526.07977.
56. Iannuzzi A, Licenziati MR, Acampora C, Salvatore V, De Marco D, Mayer MC, et al. Preclinical changes in the mechanical properties of abdominal aorta in obese children. Metabolism. 2004;53(9):1243-6. doi: 10.1016/j.metabol.2004.03.023.
57. Dua S, Bhuker M, Sharma P, Dhall M, Kapoor S. Body mass index relates to blood pressure among adults. N Am J Med Sci. 2014;6(2):89-95. doi: 10.4103/1947-2714.127751.
58. Koh HB, Heo GY, Kim KW, Ha J, Park JT, Han SH, et al. Trends in the association between body mass index and blood pressure among 19-year-old men in Korea from 2003 to 2017. Scientific Reports. 2022;12(1):6767. doi: 10.1038/s41598-022-10570-9.
59. Flegal KM, Graubard BI. Estimates of excess deaths associated with body mass index and other anthropometric variables. Am J Clin Nutr. 2009; 89(4):1213-9. doi: 10.3945/ajcn.2008.26698.

60. Pischon T. Commentary: Use of the body mass index to assess the risk of health outcomes: time to say goodbye? Int J Epidemiol. 2010;39(2):528-9. doi: 10.1093/ije/dyp388.
61. Salahudeen AK, Fleischmann EH, Bower JD, Hall JE. Underweight rather than overweight is associated with higher prevalence of hypertension: BP vs BMI in haemodialysis population. Nephrol Dial Transplant. 2004; 19(2):427-32. doi: 10.1093/ndt/gfg523.
62. Yajnik CS, Yudkin JS. The Y-Y paradox. Lancet. 2004;363(9403):163. doi: 10.1016/S0140-6736(03)15269-5.
63. Hsieh SD, Yoshinaga H. Do people with similar waist circumference share similar health risks irrespective of height? Tohoku J Exp Med. 1999; 188(1):55-60. doi: 10.1620/tjem.188. 55.
64. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0·5 could be a suitable global boundary value. Nutr Res Rev. 2010;23(2):247-69. doi: 10.1017/ S0954422410000144.
65. Xu Z, Qi X, Dahl AK, Xu W. Waist-to-height ratio is the best indicator for undiagnosed type 2 diabetes. Diabet Med. 2013;30(6):e201-7. doi: 10.1111/ dme.12168.
66. Tesfaye TD, Temesgen WA, Kasa AS, Yismaw YS. Prevalence and associated factors of hypertension in Amhara regional state city and its' surrounding rural districts: a community-based cross-sectional study. Afr Health Sci. 2019;19(3):2580-90. doi: 10.4314/ahs. v19i3.34.
67. Cameron AJ, Romaniuk H, Orellana L, Dallongeville J, Dobson AJ, Drygas W, et al. Combined Influence of Waist and Hip Circumference on Risk of Death in a Large Cohort of European and Australian Adults. J Am Heart Assoc. 2020;9(13):e015189. doi: 10.1161/JAHA.119.015189.