Bio-social Correlates of Blood Pressure in Tribal Population: A Study on the Mising Adults of Assam

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ABSTRACT: Incidences of increasing adiposity and its resultant cardiovascular risks are on a rise in developing countries like India due to the rapid urbanization and modernization processes. As such, the occurrences of elevated adiposity and hypertension are inevitable even among the tribal populations of India. Our objective was to assess sex differences in different anthropo-physiological variables, with special emphasis on the association of adiposity indicators and selected bio-social factors with blood pressure. A cross-sectional study was conducted among the Mising tribe of Dhemaji district of Assam in north-east India. The total sample consists of 208 adults (101 males and 107 females) aged between 18 and 40 years. Mising males exhibited higher adiposity and blood pressure levels than the females. In adiposity indicators, sex differences were observed in waist-to-height ratio (WHtR), waist-to-hip ratio (WHR) and mid-upper arm circumference (MUAC). The prevalence of hypertension was significantly higher in males than in females. MMR analyses showed significant ($p<0.001$) association of gender, age, body mass index (BMI), waist circumference (WC), alcohol consumption and level of education with blood pressure. Gender, BMI, and level of education were found to be the most important correlates of blood pressure in Mising adults.

INTRODUCTION

Biological anthropologists and human biologists have been continuously involved in the study and understanding of the 'quality of human health' and its eco-cultural correlates as they are reflected in human health processes. They have recognized the importance of bio-social factors as the foreground in affecting human health. According to Lovegrove *et al.* (2015), health in adulthood is generally represented by an energy and nutrient balance, with constant height and weight and similar body composition over extended period of time, consistent with physical, mental, intellectual and social activities. Once considered as one of the major health issues only among developed countries and affluent societies, overweight and obesity has now reached the stage of epidemic globally (WHO, 2000). Elevated body mass index (BMI) accounts for approximately 2.8 million deaths each year (WHO, 2010). While, high blood pressure is estimated to cause 7.1 million deaths worldwide, especially among the middle-aged and elderly adults (WHO, 2002).

The association of adiposity indicators with blood pressure has long been the interest of scientists in the field of epidemiological research. Numerous studies on adiposity and blood pressure have reported sex differences (Everett and Zajacova, 2015; Ghosh, 2011; Gogoi and Saraswathy, 2020) and association of adiposity with blood pressure in different ethnic populations (Dzudie *et al.,* 2021; Ghosh *et al.,* 2016; Tesfaye *et al.,* 2007). Nonetheless, the association of adiposity indicators with blood pressure is not

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consistent across human populations. For instance, among the Cameroonians, waist circumference (WC), waist-to-height ratio (WHtR), and body roundness index were strongly associated with blood pressure and found to be a better predicted hypertension risk factor (Dzudie *et al.,* 2021). However, in another study among Africans and Asians, body mass index (BMI) was found to have a significant correlation with both systolic blood pressure (SBP) and diastolic blood pressure (DBP), and that, the risk of hypertension is much higher among the overweight and obese population (Tesfaye *et al.,* 2007). In developing countries like India, overweight and obese individuals are significantly increasing despite the high prevalence of undernutrition (Brewis, 2011). Rural Indians are no exception in this secular trend due to nutritional transition and change in lifestyle (Khandelwal and Reddy, 2013).

Majority of the tribal populations belongs to low socio-economic status living in harsh environmental conditions. Therefore, lower cases of obesity and hypertension may be expected among such indigenous populations. In North-East India, many ethnic populations have a high prevalence of undernutrition and associated morbidities (Khongsdier, 2001, 2002; Rengma *et al.,* 2016). However, recent studies have documented a prevalence of hypertension and obesity in different tribal populations of the region (Khual and Limbu, 2019; Limbu and Khual, 2020; Riamei and Ghosh, 2019; Tsukru *et al.,* 2021). This transition is probably because of the speedy pace of urbanization and modernization processes which has led to major transition in the diet and lifestyle of many tribal communities.

Although a few studies on the Mising tribe have formerly reported the prevalence of obesity and hypertension (Lohe and Ghosh, 2021; Misra *et al.*, 2014), this population has not been explored in terms of the association of adiposity indicators with blood pressure. Also, it is theoretically known that adiposity and blood pressure are greatly influenced by socio-environmental factors like ethnicity, lifestyle, nutrition, income, occupation and place of residence. Thus, there is a need to explore and understand the bio-cultural spectrum of cardiovascular risk factors among the Mising population. With these details and the panorama of current research trends in mind, the present paper aims to understand sex differences in adiposity indicators and blood pressure among the adult Misings of North-East India, with special reference to the association of certain adiposity indicators and selected bio-social factors with blood pressure.

MATERIALS & METHODS

The Misings

'Misings' or 'Mishings' literally means 'man of the soil'. They are also known as *'Miris'* by the Assamese people, as listed in the Indian Constitution. The Misings as they would love to be addressed belongs to the Mongoloid group (Bhandari, 1984). They are one of the major tribal groups of North-East India and the second largest tribe in Assam, after the Bodos. According to Census of India (2011), the population of Mising in Assam is 680,424 of which 345,786 are male and 334,638 are female, with a sex ratio of 967 per 1000 males. It is said that the Misings are originally a hill tribe of the Himalayan region of North Eastern India, and that, the Misings of Assam have migrated from Arunachal Pradesh and settled along the bank of the river Brahmaputra and its tributaries (Kakoti, 2017). They now spread over a wide range of plains and are found in the district of North Lakhimpur, Dhemaji, Dibrugarh, Sivasagar, Golaghat, Sonitpur and Tinsukia of Assam, north-east India (Kakoti, 2017). In course of time, they have assimilated and developed a good deal of resemblance with the culture of the Assamese people. They basically practice primitive technology-based agriculture to sustain their livelihood.

Data Collection: A cross-sectional study was conducted in January 2018 on the adult Mising population from two villages of Dhemaji district, Assam. Anthropometric, physiological, socio-demographic and dietary pattern data were collected from a sample of 208 adults (101 males and 107 females) aged between 18 and 40 years. Prior to data collection, consent was obtained from the respective village Headmen and all the participants. Study objectives and protocols were carefully narrated to the participants. Care was taken to include only healthy participants for the study. This study was approved by the Department of Anthropology, North-Eastern Hill University, Shillong, India.

Anthropometric Measurements: Anthropometric measurements such as stature, weight, waist circumference (WC), hip circumference (HC) and mid-upper arm circumference (MUAC) were taken on each participant. Height was measured using an anthropometer rod and weight was measured using portable analog-based weighing machine. Circumferential measurements were taken using a non-expandable measuring tape. All the anthropometric measurements were taken using standard techniques (Weiner and Lourie, 1981; WHO, 2008).

Adiposity Indicators: A number of important adiposity indicators that include body mass index {BMI= Weight (kg) / Height (m^2)}, waist circumference (WC), waist-to-height ratio {WHtR = Waist (cm) / Height (cm)}, waist-to-hip ratio {WHR = Waist (cm) / Height (cm)} and mid-upper arm circumference (MUAC) were measured and/or calculated in the present study. BMI categories were classified using Asian criteria as follows- Underweight = $\leq$18.5 kg/m^2, Normal weight = 18.5-22.9 kg/m^2, Overweight = 23-24.9kg/m^2 and Obese = $\geq$25kg/m^2 (WHO, 2000). For WC, health risks were classified as follows- normal = <90 cm and <80 cm for males and females respectively; at risk = $\geq$90 cm and $\geq$80 cm for males and females respectively (WHO, 2000). WHtR was categorized as normal (<0.5) and at risk ($\geq$0.5) for both the sexes (Yoo, 2016). Health risks based on WHR were classified as follows- low risk = <0.95, moderate risk = 0.96-1.00 and high risk = >1 for males; low risk = <0.80, moderate risk = 0.81-0.85 and high risk = >0.85 for females (Singh *et al.,* 2018). Health risks based on MUAC was classified into two groups as- malnutrition = $\leq$23 cm and normal = >23 cm (Ferro-Luzzi and James, 1996).

Blood Pressure: Systolic (SBP) and diastolic blood pressures (DBP) were collected on each participant for the present study. Blood pressure was measured with the participant in sitting position using a mercury sphygmomanometer. Ample recovery time was given to the participants to relax from recent activities. Measurements were taken twice with a minimum of two minutes gap between the two readings and the average was taken.

Categories of BP were based on the classification given by the American Heart Association (*cf.* Ghosh *et al.*, 2016). In our analysis, hypotension and low normal categories were pooled as one group *i.e.,* Low Normal. Hence, four categories of blood pressure were classified as follows- low normal = <119/79 mmHg, normal = 120-130/80-84 mmHg, high normal = 131-140/85-90 mmHg, and hypertension = >141/90 mmHg.

Socio-economic Information: Data on socio-demographic and dietary pattern were collected using a pre-structured interview schedule. Occupation was grouped into three groups based on the demand of physical labor- Group I (cultivators and daily wagers), Group II (entrepreneurs, government and private sector employees) and Group III (homemakers, students and not working). Similarly, education status was grouped into three levels- Level I (illiterate and primary level), Level II (under-matric and post-matric) and Level III (graduate and above). Three income groups were categorized based on per-capita income as follows: Low-income group ($\leq$5,000 Rupees), Middle income group (5,001-10,000 Rupees) and High-income group (>10,000 Rupees). Income groups were classified as follows: Low- income group (below 50^{th} percentile), Middle income group (50^{th} – 75^{th} percentile) and High-income group (above 75^{th} percentile) (United Nations, 2011). Frequency of weekly meat intake was recorded. Further, data on alcohol and tobacco (chewing and smoking tobacco combined) consumption was collected and recorded as 'User' or 'Non-user'.

Statistical Analysis: All the statistical analyses were computed using IBM-SPSS software (version 20.0). Descriptive statistics in the form of mean and standard deviation were computed. Student's t-test (for continuous variables) and chi-square test (for categorical variables) were computed to assess sex differences in anthropo-physiological measurements and adiposity indicators. Multivariate multiple regression (MMR) analysis depicting both general model (GM) and most parsimonious model (MPM) was computed to assess the association of adiposity indicators, socio-demographic and dietary parameters with blood pressure in Mising adults.

RESULTS & DISCUSSION

Sex-wise distributions of anthropo-physiological measurements and adiposity indictors of the Mising adults are presented in Table 1. The results show that Mising males were significantly taller ($p<0.001$), heavier ($p<0.001$) and revealed greater circumferential values in WC ($p<0.001$) and MUAC ($p<0.001$) than their female counterparts. On the other hand, HC was slightly lower in males ($78.95 \pm 10.78_{Males}$ vs. $79.21 \pm 8.91_{Females}$), but the difference is not statistically significant ($p>0.05$). Significant ($p<0.001$) sex difference was noted in WHR where males showed higher ratio than the females ($1.00 \pm 0.21_{Males}$ vs. $0.92 \pm 0.05_{Females}$). Further, males exhibited significantly higher mean readings in both SBP ($p<0.001$) and DBP ($p<0.001$) than the females.

TABLE 1

Descriptive statistics of anthropo-physiological measurements and adiposity indices in Mising adults, by sex

Measurements	Males N=101	Females N=107	Total N=208	t-values
Stature (cm)	162.52 ± 5.64	152.14 ± 4.85	157.18 ± 7.38	14.240*
Weight (kg)	58.49 ± 8.19	50.34 ± 7.63	54.30 ± 8.88	7.425*
WC (cm)	77.92 ± 9.79	72.62 ± 6.94	75.19 ± 8.83	4.513*
HC (cm)	78.95 ± 10.78	79.21 ± 8.91	79.08 ± 9.84	0.193
MUAC (cm)	25.99 ± 2.38	24.58 ± 3.55	25.26 ± 3.11	3.322*
BMI (kg/m^2)	22.10 ± 2.55	21.71 ± 2.89	21.90 ± 2.73	1.023
WHtR	0.47 ± 0.05	0.47 ± 0.04	0.47 ± 0.05	0.232
WHR	1.00 ± 0.21	0.92 ± 0.05	0.96 ± 0.16	3.857*
SBP (mm/Hg)	129.98 ± 12.67	119.43 ± 13.60	124.55 ± 14.14	5.774*
DBP (mm/Hg)	91.61 ± 9.95	81.81 ± 10.82	86.57 ± 11.48	6.787*

*p<0.001

Notes: WC = Waist circumference, HC = Hip circumference, MUAC = Mid-upper arm circumference, BMI = Body mass index, WHtR = Waist-to-height ratio, WHR = Waist-to-hip ratio, SBP = Systolic blood pressure, DBP = Diastolic blood pressure

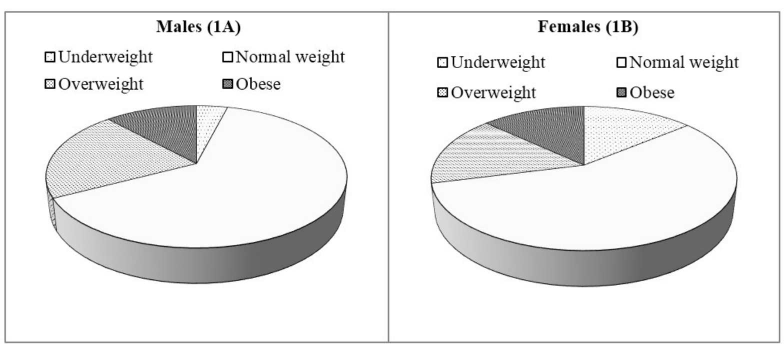

Figure 1: Nutritional status among Mising males (1A) and females (1B)

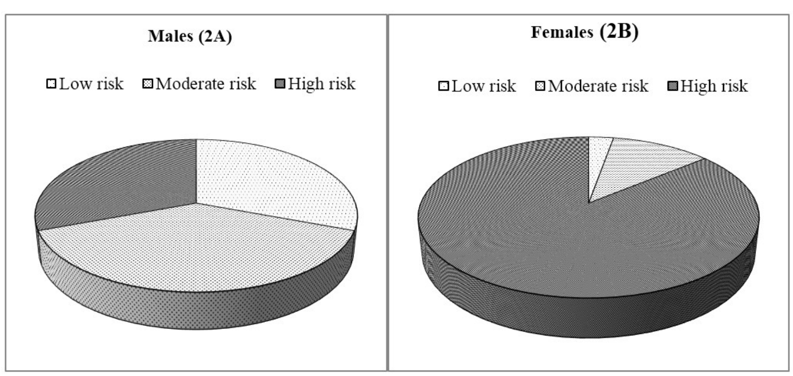

Figure 2: Waist-to-hip ratio health-risks among Mising males (2A) and females (2B)

Table 2 presents the distribution of Mising males and females in different adiposity indicators and blood pressure categories. The prevalence of underweight was found to be relatively low (4.0%) in males when compared to the females (14.0%). However, a considerably high frequency of overweight (18.3%) and obese (12.5%) individuals were observed in both the sexes (Figure 1). Normal weight was found to be the dominant nutritional status in Mising adults. Regarding the WC, majority of the participants were normal (88.9%) and only a nominal frequency of the Mising were at risk (11.1%) in terms of health risks. It was also observed that higher numbers of females were at-risk concerning WC categories than the males. The frequency of occurrence of 'at-risk' in WHtR was higher in males than in the females ($35.6\%_{Males}$ vs. $23.4\%_{Females}$). Contrastingly, health risks based on WHR was found to be notably higher in females than their male counterparts (Figure 2). In the case of MUAC, relatively high frequencies of females (39.3%) were found under 'malnutrition', while in males, low frequencies of them (13.9%) were found under this category. Significant sex differences were found in almost all the adiposity indicators including WHtR ($p<0.005$), WHR ($p<0.001$) and MUAC ($p<0.001$).BMI and WC, on the other hand, showed no significant sex differences in this population ($p>0.05$).

TABLE 2

Percentage distribution of adiposity indicators and blood pressure in Mising adults

Parameters and its categories		Males N=101		Females N=107		Total N=208S		χ^2-values
		n	%	n	%	n	%	
BMI	Underweight	4	4.0	15	14.0	19	9.1	6.848
	Normal weight	64	63.4	61	57.0	125	60.1	
	Overweight	21	20.8	17	15.9	38	18.3	
	Obese	12	11.9	14	13.1	26	12.5	
WC	Normal	92	91.1	93	86.9	185	88.9	0.920
	At risk	9	8.9	14	13.1	23	11.1	
+WHtR	Normal	65	64.4	82	76.6	147	70.7	3.780*
	At risk	36	35.6	25	23.4	61	29.3	
WHR	Low risk	31	30.7	3	2.8	34	16.3	67.488**
	Moderate risk	39	38.6	12	11.2	51	24.5	
	High risk	31	30.7	92	86.0	123	59.1	
MUAC	Malnutrition	14	13.9	42	39.3	56	26.9	17.025**
	Normal	87	86.1	65	60.7	152	73.1	
SBP	Low normal	8	7.9	44	41.1	52	25.0	33.439**
	Normal	57	56.4	47	43.9	104	50.0	
	High normal	22	21.8	10	9.3	32	15.4	
	Hypertension	14	13.9	6	5.6	20	9.6	
DBP	Low normal	3	3.0	37	34.6	40	19.3	46.255**
	Normal	12	11.9	19	17.8	31	14.9	
	High normal	30	29.7	30	28.0	60	28.8	
	Hypertension	56	55.4	21	19.6	77	37.0	

*p<0.005, **p<0.001

Notes: BMI = Body mass index, WC = Waist circumference, WHtR = Waist-to-height ratio, WHR = Waist-to-hip ratio, MUAC = Mid-upper arm circumference, SBP = Systolic blood pressure, DBP = Diastolic blood pressure

Considering the blood pressure, results of the present study (Table 2) show that females exhibited a considerably higher frequency of occurrence in the low normal SBP category when compared to males ($41.1\%_{Females}$ vs. $7.9\%_{Males}$). Consequently, the prevalence of SBP hypertension was found to be significantly higher in males than their female counterparts ($13.9\%_{Males}$ vs. $5.6\%_{Females}$) (Figure 3). Similarly, the prevalence of DBP hypertension was considerably higher in males (55.4%) when compared to the females (19.6%) (Figure4). Hence, sex difference was found to be highly significant ($p<0.001$) in both SBP and DBP.

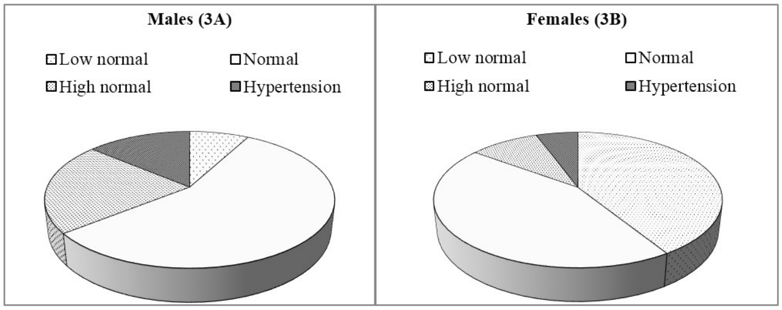

Figure 3: Systolic blood pressure among Mising males (3A) and females (3B)

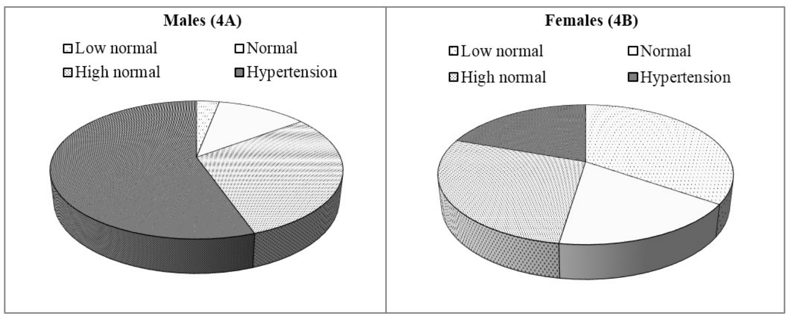

Figure 4: Diastolic blood pressure among Mising males (4A) and females (4B)

Sex-wise distribution of blood pressure according to different categories of adiposity indicators are displayed in Table 3. With regards to BMI, results of the present study suggests that blood pressure generally increases as the BMI increases baring DBP in males, in which, obese males showed marginally lower level of DBP than overweight males ($91.66 \pm 8.07_{\text{Obese}}$ vs. $94.85 \pm 8.36_{\text{Overweight}}$). Similarly, individuals falling under 'at-risk' category in WC and WHtR showed higher blood pressure readings than their counterparts in normal category, irrespective of sex. In the case of WHR, blood pressure readings found to be elevated as the health risk increases in both males and females, except DBP in females where individuals falling under the 'high risk' showed marginally lower level of SBP than the individuals falling under the 'moderate risk' category ($119.51 \pm 13.46_{\text{High risk}}$ vs. $120.00 \pm 10.66_{\text{Moderate risk}}$). In MUAC categories, irrespective of the gender, individuals classified under malnutrition showed lower levels of SBP and DBP when compared to their counterparts under normal category.

TABLE 3

Distribution of blood pressure according to the adiposity indicators in Mising males and females

Adiposity indicators and its categories	Males		Females	
	SBP(mm/Hg)	DBP(mm/Hg)	SBP(mm/Hg)	DBP(mm/Hg)
Body mass index				
Underweight	121.00 ± 2.00	86.25 ± 2.50	109.53 ± 8.21	75.13 ± 6.11
Normal weight	128.68 ± 12.80	90.87 ± 10.83	118.75 ± 12.14	80.39 ± 9.82
Overweight	133.23 ± 11.62	94.85 ± 8.36	123.41 ± 11.02	86.17 ± 11.52
Obese	134.16 ± 13.95	91.66 ± 8.07	128.21 ± 19.67	89.85 ± 12.25
Waist circumference				
Normal	129.81 ± 12.65	91.60 ± 10.19	117.92 ± 11.83	80.74 ± 10.02
At risk	131.66 ± 13.46	91.66 ± 7.50	129.50 ± 19.81	88.92 ± 13.47
Waist-to-height ratio				
Normal	127.84 ± 11.25	90.44 ± 9.36	116.79 ± 11.53	79.89 ± 9.54
At risk	133.83 ± 14.25	93.72 ± 10.74	128.12 ± 16.29	88.12 ± 12.48

Waist-to-hip ratio				
Low risk	127.19 ± 10.86	89.22 ± 9.01	115.00 ± 30.00	78.33 ± 23.62
Moderate risk	129.82 ± 12.28	92.15 ± 9.10	120.00 ± 10.66	78.83 ± 10.91
High risk	132.96 ± 14.44	93.32 ± 11.59	119.51 ± 13.46	82.31 ± 10.38
Mid-upper arm circumference				
Malnutrition	124.92 ± 15.94	89.28 ± 13.56	115.38 ± 11.46	78.52 ± 8.96
Normal	130.79 ± 11.97	91.98 ± 9.29	122.06 ± 14.29	83.93 ± 11.43

Notes: SBP = Systolic blood pressure, DBP = Diastolic blood pressure

The results of multivariate multiple regression (MMR) analysis of blood pressure with adiposity indicators as the confounding variables is presented in Table 4. It is interesting to note that the variations in blood pressure which can be explained through these confounding variables were ≈ 24.3% in SBP and ≈ 36.5% in DBP, as evident from the general model (GM). Sex ($p<0.05$), BMI ($p<0.005$) and WC ($p<0.05$) were found to be the most crucial confounding factors which significantly influenced SBP in the adult Misings (Table 4). These three confounders alone can explain ≈ 23.6% of variation in SBP, as evident from the most parsimonious model (MPM), which depicts that an increase in BMI and WC can significantly elevate the level of SBP in Mising adults. Similarly, sex ($p<0.001$), BMI ($p<0.001$) and WHtR ($p<0.05$) were noted to be the most important confounders which significantly impacted the level of DBP. These three confounders alone can explain ≈ 36.3% of variation in DBP (Table 4). In both SBP and DBP, males showed higher levels of blood pressure than their female counterparts.

TABLE 4

Multivariate multiple regression (MMR) analysis of blood pressure categories and adiposity indicators in Mising adults

[General model including all tested variables and most parsimonious model including only statistically significant confounding factors (β-coefficient and p-values* for each variable with multiple R^2)]

Dependent Variable	Confounding variables	General Model (GM) β-coefficient	General Model (GM) p-values	Most Parsimonious Model (MPM) β-coefficient	Most Parsimonious Model (MPM) p-values
SBPcategories	Age	0.006	0.451		
	Sex Male vs Female	-0.372*	0.020*	0.359*	0.020*
	BMI	0.101*	0.004*	0.082*	0.005*
	WC	0.053*	0.026*	0.046*	0.038*
	WHtR	-7.396	0.059		
	WHR	-0.294	0.419		
	MUAC	-0.026	0.319		
Multiple R^2	24.3%	23.6%			
DBPcategories	Age	0.008	0.402		
	Sex Male vs Female	-0.776*	<0.001*	0.786*	<0.001*
	BMI	0.191*	<0.001*	0.190*	<0.001*
	WC	0.038	0.167		
	WHtR	-10.126*	0.027*	-9.692*	0.020*
	WHR	0.040	0.924		
	MUAC	0.003	0.928		
Multiple R^2	36.5%	36.3%			

*Indicate Significant p-values

Notes: SBP = Systolic blood pressure, DBP = Diastolic blood pressure, BMI = Body mass index, WC = Waist circumference, WHtR = Waist-to-height ratio, WHR = Waist-to-hip ratio, MUAC = Mid-upper arm circumference

Table 5 illustrates the main results of MMR analysis of blood pressure with selected bio-social factors as independent parameters. From GM, it is observed that the bio-social and dietary variables can explain ≈ 19.5% and ≈ 27.1% of variation in SBP and DBP respectively. Age ($p<0.05$), sex ($p<0.001$), education level ($p<0.05$) and alcohol consumption ($p<0.05$) were found to be important confounders of the level of SBP that can explain ≈ 17.7% of variation in SBP in Mising adults (Table 5). This result indicates that as age increases, Misings tend to become more hypertensive in SBP.

TABLE 5

Multivariate multiple regression (MMR) analysis of blood pressure categories and socio-economic, demographic and dietary parameters in Mising adults

[General model including all tested variables and most parsimonious model including only statistically significant confounding variables (β-coefficient and p-values* for each variable with multiple R^2)]

Dependent Variables	Confounding variables	General Model (GM) β-coefficient	General Model (GM) p-values	Most Parsimonious Model (MPM) β-coefficient	Most Parsimonious Model (MPM) p-values
SBP categories	Age	0.020*	0.018*	0.022*	0.010*
	Sex $_{\text{Male vs. Female}}$	-0.564*	<0.001*	0.628*	<0.001*
	Occupation	-0.060	0.497		
	Educational status	0.211*	0.023*	0.204*	0.020*
	Income group	0.046	0.491		
	Tobacco consumption (User vs. Non-user)	0.247	0.057		
	Alcohol consumption(User vs. Non-user)	0.362*	0.013*	0.365*	0.012*
	Meat intake per week	0.034	.691		
Multiple R^2	19.5%	17.7%			
DBP categories	Age	0.018	0.077		
	Sex $_{\text{Male vs Female}}$	-0.938*	<0.001*	0.968*	<0.001*
	Occupation	0.016	0.883		
	Educational status	0.358*	<0.001*	0.363*	<0.001*
	Income group	0.011	0.889		
	Tobacco consumption (User vs. Non-user)	0.155	0.325		
	Alcohol consumption(User vs. Non-user)	0.019	0.913		
	Meat intake per week	0.073	0.478		
Multiple R^2	27.1%	26.5%			

*Indicate Significant p-values

Notes: SBP = Systolic blood pressure, DBP = Diastolic blood pressure

Further, higher level of education and alcohol consumption were found to have positive association with SBP, as evident from the positive β-coefficient values in both the models. On the other hand, results from MPM depicts that sex (p<0.001) and education level (p<0.001) are crucial confounders, which can explain ≈ 26.5% of variation in DBP among the Mising adults. This result indicates that males and individuals with higher level of education are more prone to become hypertensive in DBP than their counterparts (Table 5).

Increasing secular trend of non-communicable diseases (NCDs) related risk factors like obesity and hypertension is not an unusual scenario even in developing countries like India. It is therefore important to understand the bio-cultural dynamics of cardiovascular risks and its correlates in human population. The major objective of this research was to assess sex difference and association of adiposity markers with blood pressure in Mising adults. In addition, this study attempts to examine the effects of bio-social and dietary parameters on blood pressure.

Our findings revealed significant sex differences in all the anthropo-physiologic measurements, baring HC. Mising males were taller, heavier and showed greater adiposity with higher blood pressure as compared to their female counterparts. These findings with regards to sex differences in adiposity and blood pressure are in terms with recent studies from other populations (Ghosh *et al.*, 2016; Gogoi and Saraswathy, 2020).In most of the ethnic groups, males tend to have higher SBP and DBP than females, and as a consequence, the prevalence of hypertension is generally higher among the males than the females (Everett and Zajacova, 2015). Similarly, the present study noted significantly higher prevalence of hypertension in both SBP and DBP in Mising males than the females. Pooling both the sexes together, the prevalence of hypertension was significantly higher in DBP (37.0%) than in SBP (9.6%).

It is perhaps intriguing to observe a notably high prevalence of overweight (18.3%) and obesity (12.5%) among the adult Mising, which commensurate with a previous study reported by Lohe and Ghosh (2021) on the same population. High adiposity in both sexes could be because of their high consumption of pork fat and protein-rich diet. Among the indigenous communities of Assam, Misings are known for their prodigious consumption of pork meat. Hence, despite putting a lot of physical labor in primitive technology-based agricultural activities, they tend to become overweight or obese. Even Lohe and Ghosh (2021) have reported a similar impact of regular pork meat and pork fat consumption on the nutritional status of Misings. Furthermore, studies in the past one decade reports a similar trend of high prevalence of over-nourished nutritional status and high blood pressure even among the neighbouring populations of North-East India viz., Hmars of Manipur (Lalnuneng and Khongsdier, 2017), Ao Nagas of Nagaland (Maken and Varte, 2013), Zo mothers of Manipur (Khual and Limbu, 2019), Padman males of Arunachal Pradesh (Limbu and Khual, 2020) and Rongmei Nagas of Manipur (Riamei and Ghosh, 2019).

Results of the present study indicate that there is a significant increase of SBP and DBP as adiposity rises. Higher BMI and WC were each found to be positively associated with higher blood pressure. Association of high BMI and WC with elevated blood pressure was also seen among young American adults (Brummett *et al.*, 2011), Chinese adults (Zhou *et al.*, 2009) and the Meghwal community of Rajasthan in India (Gogoi and Saraswathy, 2020). However, not all the adiposity markers were found to have equal and pronounced effect on blood pressure. Numerous researches have also shown that the association of adiposity markers with blood pressure is not uniform and that some anthropometric indices can better predict hypertension than others (Brummett *et al.*, 2011; Dzudie *et al.*, 2021; Maken and Varte, 2013; Nakamura *et al.*, 2011).

In line with the broader literature (Ghosh, 2011; Ghosh *et al.*, 2016; Gogoi and Saraswathy, 2020; Kaczmarek *et al.*, 2015), our findings showed significantly positive association of age with blood pressure. Thus, as age increases, individuals of the Mising community are more susceptible to develop hypertension. High incidences of hypertension in this community can be attributed to the greater adiposity found in this population, which can further be ascribed to the voracious consumption of pork fat and *apong* by this community. *Apong* is a locally brewed alcoholic beverage, which is an integral part of the daily socio-religious life of the Mising people, and therefore, it was observed during the fieldwork that their regular diet comprises of *apong* drink as an appetizer. Regular consumption of this locally prepared alcohol beverage may have accelerated the resting level of blood pressure in this community, even though none of the participants were under the influence of alcohol at the time of examination. Our claim is further confirmed as the MMR model showed significantly positive association between alcohol consumption and SBP. A similar finding on the effect of alcohol consumption on blood pressure was also observed among the Chuvash population of Israel (Ghosh *et al.*, 2016) and young American adults (Brummett *et al.*, 2011).

Educational status can have significant impact on overall health of a population. In developed countries, cardiovascular health including hypertension is worst in low education levels, for instance, among the Spanish (Graciani *et al.*, 2013) and Danish (Olsen *et al.*, 2014) populations. The case is however reversed in the present study which noted significantly higher prevalence of hypertension in higher educational levels. This is perhaps in accordance with the theoretical notion that people with higher education are more likely to have white-collar jobs which involves less physical activity, thereby, becoming more vulnerable to sedentary lifestyle related diseases like obesity, hypertension and other related cardiovascular diseases (CVDs).

Traditional tribes and lower caste groups of India are believed to have lower blood pressure than other higher ethnic groups (Kusuma *et al.*, 2002). Even in North-East India, high prevalence of undernutrition among tribal community was reported in previous literatures (Khongsdier, 2001; 2002). This is basically because many tribal populations from this region belong to low socio-economic group with agriculture as their main occupation, just like tribal populations from other parts of India. Besides, they practice traditional knowledge-based agriculture and have not developed or adopted modern machineries that is generally needed in agriculture. Nonetheless, looking at the present trend of rising adiposity and hypertension in the present study and different tribal groups of North-East India (in general), our study suggests that perhaps an alarming impact of rapid urbanization on the cardiovascular health amongst the indigenous populations in this region of the country is the reason behind such trend.

CONCLUSION

Overall, the prevalence of hypertension was found to be high amongst the Mising adults. Our analyses reported non-uniform association of adiposity markers with blood pressure. More specifically, out of the five adiposity indices taken into account, only BMI and WC were found to have a positive association with elevated blood pressure. In addition, age, alcohol consumption and educational status were found to be crucial factors that positively impacted blood pressure in Mising. In the past few years, incidences of high adiposity and cardiovascular risk factors have seen a dramatic rise due to the change in lifestyle along with the traditional calorie-rich diet, as a consequence of urbanization. Hence, our findings highlight the need to address the growing prevalence of adiposity related diseases like obesity and hypertension through early detection and health awareness programs starting at the remote-community levels.

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