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ADIPOSITY INDICATORS IN BLOOD PRESSURE: A STUDY AMONG BHIL TRIBAL POPULATION OF INDIA

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ABSTRACT

The present study was aimed to assess the effects of various adiposity indicators i.e. body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) on the causation of blood pressure among Bhil tribal population of India. In this population based-cross sectional study, a total of 406 individuals aged between ≥25 to ≤65 years, both males and females, from Bhil tribal population tracing their origin to Rajasthan (India), were recruited. Blood pressure was measured using digital BP machine; whereas BMI, WHR and WHtR were calculated using the somatometric measurements (height, weight, waist circumference and hip circumference). SPSS vs. 20 was used for the statistical analysis. Male sex, higher age and alcohol consumption was found significantly higher in hypertensive group as compared to that of non-hypertensive group. Underweight was found to pose significantly reduced risk with hypertension. Estimate change analysis revealed that with a unit increase in WHtR there was a significant increase in SBP by +28.95 mm Hg (p = 0.00) and DBP by +16.41 mm Hg (p = 0.04), respectively. In Bhil tribal population WHtR seems to be the best predictor for hypertension.

Key words: Bhil, body mass index, hypertension, waist hip ratio, waist-to-height ratio

INTRODUCTION

Hypertension is a major public health concern in developing countries (Kearney *et al.*, 2005). It has been identified as one of the most potent antecedents of cardiovascular diseases (CVD) by Framingham study and is labeled as one of the conventional risk factors for its potency in the pathogenesis of coronary artery disease (CAD), heart and renal failure (Khot *et al.*, 2003; Scott *et al.*, 2016). The studies have revealed that generalized obesity and regional abdominal adiposity play major role in aggravating the risk of hypertension (Deshmukh *et al.*, 2006; Kotsis *et al.*, 2015). The gain in weight and blood pressure (BP) elevation may be the intermediate phenotypes of an underlying sympathetic over-activity in hypertension (Julius *et al.,* 2000). Due to rapid industrialization and globalization, hypertension is reported to be the most prevalent among urban and non-tribal populations in India (Anchala *et al.,* 2014). Though hypertension and other chronic metabolic diseases are believed to be less common in tribal populations, yet some studies have revealed a higher frequency of hypertension in some tribal groups of India (Kshatriya, 2014; Rizwan *et al.*, 2014; Kandpal *et al.*, 2016; Ningombam *et al.*, 2018). Such information on Bhil tribal population is very scarce (Deo *et al.*, 2018).

With improved medical management available, hypertension may not be a fatal phenotype. However, it affects the population through morbidity specifically in terms of social and financial stress. In developing countries like India where diversity is huge, understanding the population specific risk factors is important. The present study was aimed to evaluate the effects of various adiposity indicators like body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), etc. on the causation of BP among Bhil tribal of India. Bhils are one of the largest tribal populations of India with a population of 41,00,264 (Census, 2011). Further, Bhil tribal population in India in general and in Rajasthan in particular is mostly restricted to rural settings. However, there are some Bhil settlements close to the urban settings, be it a town or a city, which are likely to be influenced by the growing urbanization. The presently studied Bhils were from various villages close to the Udaipur city, Mount Abu town, Sirohi district and Delhi. Bhils have significant presence in many states of India such as Rajasthan, Gujarat, Western Madhya Pradesh and Southern Maharashtra; however, in the present study only the Bhils who trace their ancestors exclusively from Rajasthan were recruited in the present study.

MATERIALS AND METHODS

Participants and data collection

The present study was a population-based cross-sectional study. The villages inhabited by Bhils residing in and around the cities and townships were included. The recruitment of Bhil individuals in this study was done from nearby villages of Udaipur district (namely Dhinkli, Kanela, Boramagra, Debari, Raghunathpura, Kalimagri and Kuriyon ki Gawari), villages from Sirohi district (Shivaji Marg, Rajeev colony, Sitavan, Mali colony, Banda, Gorachapra, Tumana, Dilwara, Kalachapra, Lower Ambedkar colony, Ambedakar colony, Dhundiya, Back side of Global Hospital) and from Delhi (Bhil Basti and Baljeet Nagar). The present study was a part of a Government funded project (January, 2015 to December, 2018) which included pilot survey and data collection. The study was approved by Ethics Committee of the Department of Anthropology, University of Delhi, India vide their letter No. 2015/15 dated 19 January, 2015.

Pre-informed written consent was obtained from the recruited subjects prior to the data collection. The individuals were selected on the basis of selection criteria used for genetic study i.e. recruited samples were unrelated up to first cousin. The present study was a part of government funded project in which genetic analysis was also proposed to be done, therefore participants only unrelated upto first cousin were recruited through house to house survey. Data collection was done using pretested and modified interview schedules. Detailed information on name, age, sex, education, occupation, income and lifestyle (smoking and alcohol consumption) were collected. The study included only adult individuals of age between ≥25 to ≤65 years of both sexes (males and females) from Bhil tribal population specifically those tracing their ancestry to Rajasthan. On the other hand, individuals suffering with chronic infectious disease were excluded from the study.

The sample size was calculated on the basis of pooled estimate for mean prevalence of hypertension which worked out to be 16.1% among adult tribal populations of India. With confidence interval of 96% and permissible error of 4%, the sample size was calculated to be 357. Considering 20% drop out, a total of 428 sample collection was done. However, 22 individuals were excluded due to some technical reasons and data on 406 individuals only were used in the present study.

Somatometric measurements and sample classification

For weight measurement, the subjects were instructed to wear minimum clothing at the time of weighing, and weighing was done using standard weighing machine (Seca Clara, model No. 803). The measurement of height vertex or stature was taken as the vertical distance from vertex to floor where vertex was the highest point and head was in eye-ear plane and was accomplished by anthropometric rod. Waist circumference (WC) measurement was taken by using a non-stretchable tape, using as reference the narrowest part of the trunk between ribs and illiac crest (Taylor *et al.,* 2000). Hip circumference measurement was taken at maximum protuberance of buttocks. The above somatometric measurements were used for calculating the indices and ratios in present study and categorized according to standardized cut offs. Generalized obesity i.e. body mass index (BMI) was calculated as weight/height^2 (kg m^{-2}). Individuals with BMI as < 18.5 kg m^{-2} were considered as underweight; ≥ 18.5 kg m^{-2} but < 23 kg m^{-2} were considered as normal; ≥ 23 kg m^{-2} but < 27.5 kg m^{-2} as overweight; ≥ 27.5 kg m^{-2} as obese (WHO, 2000). Waist-to-hip ratio (WHR) was calculated as waist circumference/hip circumference and men and women with WHR ≥ 0.90 and ≥ 0.80, respectively, were considered to have high WHR (WHO, 2011). Waist-to-height ratio (WHtR) was calculated as waist circumference/height. The cut-off used was 0.5 for both sexes (Ashwell and Gibson, 2009). High waist circumference was categorized as ≥ 90 cm for men and ≥ 80 cm for women (WHO, 2011).

Physiological measurements and sample classification

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) measurements were taken on the left arm of subject in their sitting position using digital blood pressure machine (Omron-7080). A total of three measurements were taken to nullify the error, if any. For present study, SBP ≥ 130 and/or DBP ≥ 80 mm Hg were considered as hypertensive cases (i.e. with hypertension) as per JNCVII revised criteria (Whelton *et al.,* 2017); whereas those with SBP < 130 and/or DBP < 80 mm Hg were considered hypertension-free (Whelton *et al.,* 2017). The individuals having established hypertension or those on medication were also considered under hypertension category.

Statistical analysis

The data was statistically analyzed using SPSS v.20 (SPSS, 1998). χ^2 analysis was done to observe differences in the distribution of general characteristics of individuals within blood pressure categories. Student's 't' test was employed to see the difference between the groups with respect to age. Binary logistic regression was used to observe the risk of adiposity indicators (BMI, WC, WHR and WHtR) on hypertension after adjusting for confounders (age and alcohol). Linear regression analysis was performed to evaluate the association between adiposity indicators and SBP and DBP. A p-value of ≤ 0.05 (2-tailed) was considered as significant for all the tests.

RESULTS AND DISCUSSION

As per the distribution of several characteristics among hypertension cases and normal controls, higher age, male sex and alcohol were found to be significantly higher in hypertensive group (Table 1). Hypertension was significantly higher in males than females. Individuals with higher mean age and consuming alcohol were significantly higher in hypertensive group as compared to the control group. There are many confounding factors for hypertension (Fortmann *et al.,* 1983; Gillman *et al.,* 1995) but in present study only age, male sex and alcohol consumption were considered as confounders.

Bivariate correlation analysis revealed that waist circumference and waist-to-height ratio were significantly and positively correlated with systolic and diastolic blood pressure (p value = 0.00, 0.004; p value = 0.006, 0.033, respectively) [Table 2]. On the other hand, no such significant correlation was observed for SBP and DBP with respect to BMI and WHR. Binary logistic regression was done to understand the risk of adiposity indicators (BMI, WC, WHR and WHtR) for hypertension. None of the indicators revealed any risk of hypertension even after adjusting for the selected confounders (age, sex and alcohol) [Table 3]. Except underweight which posed significant decrease in risk for hypertension (Dua *et al.,* 2014), no other variable posed hypertension risk. However, in contrast to other studies (Krauss *et al.,* 1998; Sorof and Daniels, 2002), none of the

Table 1: Distribution of general characteristics based on blood pressure categories among Bhil tribal population of India

General characteristics		Without hypertension N (%)	With hypertension N (%)	χ^2 P value
Age (years)	(mean ± SD)	229 (41.67±11.87)	177 (46.31±11.96)	<0.001*
Height (cm)	(mean ± SD)	154.02±8.34	155.64±9.36	0.07
Sex	Male	61 (45.19)	74 (54.81)	<0.001
	Female	168 (61.99)	103 (38.01)	
Education	Illiterate	159 (59.11)	110 (40.89)	0.12
	Literate	70 (51.09)	67 (48.91)	
Occupation	Housewife	80 (63.49)	46 (36.51)	0.23
	Labourers	101 (55.80)	87 (44.20)	
	Job	35 (51.47)	33 (48.53)	
	Retired/Dependent	13 (54.17)	11 (45.83)	
Per capita annual income (₹)	<45000	208 (57.78)	152 (42.22)	0.12
	≥45000	21 (45.65)	25 (54.35)	
Alcohol consumption	No	196 (61.63)	122 (38.37)	<0.001
	Yes	33 (37.50)	55 (62.50)	
Smoking status	No	169 (58.89)	118 (41.11)	0.12
	Yes	60 (50.42)	59 (49.58)	

*p-value significant at ≤ 0.05; N: number of individuals; The values in brackets show percentage; Test of significance: Student's t test - for mean ± standard deviation (mean ± SD); χ^2 - for distribution χ^2

obesity variables posed any risk for hypertension in the studied population (Table 3). The linear regression analysis after adjusting for age, sex and alcohol consumption revealed that with increase in a single unit of BMI, WC and WHtR, there was a significant increase in both systolic and diastolic blood pressure (Table 4). However, the increases in SBP and DBP due to BMI and WC were very low (< 1 mm Hg) but a single unit of waist height ratio caused a significant increase in SBP by +28.95 mm Hg (P = 0.00) and in DBP by +16.41 mm Hg (0.04). WHtR can be considered one of the most contributing factors to blood pressure in the studied population (Table 3).

Of the three types of analysis done to understand the association between adiposity and hypertension, the correlation and estimate change analysis indicated positive and significant association between some of the adiposity indicators (mainly WC and WHtR) with hypertension. Of these two variables, the contribution of WHtR to blood pressure seemed higher and significant. In support of this, recent studies (InterAct Consortium, 2012**;** Krzesinski *et al.*, 2016) have highlighted the importance of waist circumference in the causation of chronic health risk such as type 2 diabetes mellitus and cardiovascular risk among hypertensives. Many studies have been done seeking the risk of short stature (independently) in causation of coronary heart disease (Sichieri *et al.*, 2000; Paajanen and Oksala *et al.*, 2010) where short stature has been found to be significant risk

Table 2: Correlation between blood pressure with adiposity indicators

Parameters		Systolic blood pressure (mm Hg)	Diastolic blood pressure (mm Hg)
BMI (kg m^{-2})	Pearson correlation	0.096	0.096
	Sig. (2-tailed)	0.053	0.054
WHtR	Pearson correlation	0.136**	0.106*
	Sig. (2-tailed)	0.006	0.033
WC (cm)	Pearson correlation	0.173**	0.143**
	Sig. (2-tailed)	0.000	0.004
WHR	Pearson correlation	-0.043	0.012
	Sig. (2-tailed)	0.393	0.813

** = Correlation is significant at 0.01 level (2-tailed)

Table 3: Association analysis of adiposity indicators with hypertension among Bhil tribal population (India)

Adiposity indicators		N	With hypertension v/s Unadjusted		Without hypertension v/s Adjusted	
			OR (95% CI*)	P value	OR (95% CI*)	P value
BMI (kg m^{-2})	≥18.5 - <23.0	160	Reference		Reference	
	<18.5	89	0.62 (0.36-1.07)	0.08	0.54 (0.30-0.96)	0.04
BMI (kg m^{-2})	≥18.5 <23.0	160	Reference		Reference	
	≥23	157	1.12 (0.72-1.74)	0.62	1.07 (0.67-1.69)	0.78
WC (cm)	M <90; F <80	230	Reference		Reference	
	M ≥90; F ≥80	176	1.10 (0.74-1.63)	0.65	1.10 (0.71-1.70)	0.67
WHR	M <0.90; F <0.80	93	Reference		Reference	
	M ≥0.90; F ≥0.80	313	0.87 (0.55-1.39)	0.56	0.78 (0.47-1.31)	0.35
WHtR	<0.5	172	Reference		Reference	
	≥0.5	234	1.04 (0.70-1.55)	0.84	0.10 (0.65-1.52)	0.99

*= p-value at ≤0.05 significant; N: Number of individuals studied; Variables are adjusted for age, sex and alcohol. OR = Odd ratio; CI = Confidence interval at 95% level; M = Males; F = Females; BMI = Body mass index; WC = Waist circumference; WHR = Waist-to-hip ratio; WHtR = Waist-to-height-ratio

factor for hypertension (Marmot *et al.,* 1997; Paajanen and Oksala *et al.,* 2010). Although contrasting results have also been reported (Samaras *et al.,* 2013).

The present Bhil population is reported to have short stature (Bhargava and Kher, 1961). The average height of males (162.42±8.74 cm) and females (150.87±8.82 cm) of presently studied Bhil individuals was found to fall in a lower medium category as per Martin (Singh and Bhasin, 2004) which in nutshell can be counted as short stature. Such short stature is identified as adaptive strategy among hunting and gathering communities, for which Bhils have a long practicing history (Holmes, 1993) before their recent settlement as the agricultural labours.

The stature and waist circumference are contributed by genes and environment, respectively (Brandhagen *et al.,* 2012; Kondoh *et al.,* 2014). Stature is more influenced by genes (Mondal *et al.,* 2016) while central obesity on contrary is more contributed by the environment (Silventoinen *et al.,* 2000; Pilia *et al.,* 2006; Silventoinen *et al.,* 2008).

Genes do not change fast but the environment does (Hill and Peters, 1998). The short stature of Bhil population seemed common in both cases and control groups. In developing countries globalization has affected the livelihood, lifestyle and environment of people which has added to the central obesity. The present study supports the suggestion that one should keep their waist circumference less than half of their height (Savva *et al.,* 2000; Shimajiri *et al*., 2008; Kuriyan *et al.,* 2011) so as to be safe and sound from the risk of hypertension. Despite similar BMI in a short and tall persons short person is likely to be at a higher risk for cardiovascular adversities.

Table 4: Estimated change in blood pressure in relation to adiposity indicators among Bhil tribal population (India) (adjusted for age, sex and alcohol)

Somatometric variables (n = 406)	Systolic blood pressure (mm Hg)		Diastolic blood pressure (mm Hg)	
	Unstandardized coefficient B (SE)	P value ≤0.05	Unstandardized coefficient B (SE)	P value ≤0.05
BMI (kg m^{-2})	+ 0.46 (0.19)	0.02	+ 0.28 (0.13)	0.03
WC (cm)	+ 0.18 (0.08)	0.02	+ 0.11 (0.05)	0.04
WHR	- 8.71 (13.77)	0.53	+ 4.29 (9.20)	0.64
WHtR	+ 28.95 (11.86)	0.02	+ 16.41 (7.94)	0.04

Significant P value ≤ 0.05; Variables adjusted for age, sex and alcohol; BMI: body mass index; WC: waist circumference; WHR: waist-to- hip ratio; WHtR: waist-to-height

Conclusion: The present study revealed that in Bhil community slight changes in their food habits and physical activity has rendered them prone to increased blood pressure. Hypothetically slight changes in environment may not be harmful in populations which are generally tall. The present study revealed community specific risk factors for blood pressure specifically in terms of adiposity indicators. However, the results need to be validated in different population groups (using larger sample size) inhabiting different eco-cultural zones of India to help health planners to develop population specific strategies to combat hypertension risk.

Ethical statement: The study was approved by the Departmental Ethics Committee of the Department of Anthropology, University of Delhi, Delhi (India) vide their letter No.: /2015/15 dated 19 Jan., 2015.

Conflict of interest: The authors declare that they have no competing interests.

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Contributors: Divya Mishra (DM), Kallur Nava Saraswathy (KNS) analyzed the data and drafted the manuscript. P.C. Joshi (PCJ) and KNS designed the study and guided the implementation and data collection. DM collected the data and KNS provided necessary logistical support. Naorem Kiranmala and Shivani Chandel edited the manuscript for intellectual content and provided critical comments on the manuscript.

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