

SEX DIFFERENCES IN BLOOD PRESSURE LEVELS AND ITS ASSOCIATION WITH OBESITY INDICES: WHO IS AT GREATER RISK

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Objective: The aim of our study was to investigate blood pressure (BP) levels and their association with different indices of body fat in adult Baniyas.

Design and setting: A cross-sectional survey was carried out on an endogamous group of 577 adults (307 females and 270 males) aged 25–60 years in Delhi, India.

Methods: Data were collected for weight, height, waist circumference and blood pressure using standardized procedure. Body mass index (BMI), waist to hip ratio (WHR), waist to height ratio (WHtR) and grand mean thickness (GMT) were calculated to assess obesity. Also, the sex-specific prevalence estimates for various BP categories was calculated. Correlation was calculated between systolic and diastolic BP and various indices of obesity. Odds ratios for association of hypertension with obesity indices were obtained using multiple logistic regression.

Results: Prevalence of prehypertension and hypertension was higher among males and prevalence of obesity was higher in females. Correlations of BP with all indices of obesity were significant. Odds ratio of hypertension was higher in males than in females for all the indices of obesity at 95% CI.

Conclusion: Although obesity was found to be higher among females, males were found to be at higher risk of hypertension. High odds ratios of obesity indicate that the optimum cut-off should be calculated for screening those who are at-risk of becoming hypertensive and thus are at the greater risk of developing cardiovascular diseases. (*Ethn Dis.* 2010;20:370–375)

Key Words: Hypertension, Obesity, Sex Difference, Waist-height Ratio, Odds Ratio, Endogamous Group

INTRODUCTION

Hypertension is a disease of complex etiology, affecting 972 million people worldwide.¹ It is estimated that the worldwide prevalence of hypertension could increase from 26.4% in 2000 to 29.2% in 2025.¹ Hypertension is an important risk factor for cardiovascular disease (CVD) and has become a major global burden on public health.² Obesity and weight gain have been identified as the most important determinants of hypertension.^{3–6} The association between obesity and hypertension forms part of a broader relationship between body weight and blood pressure (BP).

Cardiovascular risk factors, including hypertension, have become major public health issues in urban areas in low and middle-income countries especially in sub-Saharan Africa as reported in many previous studies.^{7,8} Several studies have reported very high prevalence figures of hypertension in the rural areas as well.⁹

Body mass index (BMI), as an indicator of obesity, has been found to be consistently associated with an increased risk of hypertension,¹⁰ yet this measurement does not account for variation in body fat distribution and abdominal fat mass, which can differ greatly across populations and can vary substantially within a narrow range of BMI.¹¹ Excess intra-abdominal fat is associated with greater risk of obesity-related morbidity than is overall adiposity.¹² Thus, measurements of waist circumference and waist–hip ratio (WHR) have been viewed as alternatives to BMI, with both measures regularly used in the clinical and research settings. Waist circumference has been shown to be the best simple measure of both intra-abdominal fat mass and total fat.¹³ Several studies in adults have reported a stronger positive association between

cardiovascular risk factors such as hypertension, and lipid and glucose concentrations, with abdominal adiposity (measured by waist circumference or WHR) than with overall adiposity (as measured by BMI).¹⁴

Based on the current evidence, the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7)¹⁵ recommended a new classification for blood pressure in which normal blood pressure is defined as systolic blood pressure <120 mm Hg and diastolic blood pressure of <80 mm Hg, while persons with systolic blood pressure of 120 to 139 mm Hg and/or diastolic blood pressure of 80 to 89 mm Hg are classified as having prehypertension. This new classification places a large number of persons previously considered as normal in this higher risk category and emphasizes the need for monitoring and possible intervention in persons with blood pressures between the range of normal and hypertensive. Since the publication of JNC 7 a number of studies have reported associations between prehypertension and other risk factors for CVD.¹⁶

To date, only a few reports of national or large population prevalence estimates for prehypertension have been published, with prevalence estimates ranging from 30% to 48.9%.^{17–20} In most of these studies, prehypertension was more common than hypertension. The aim of our study was to investigate blood pressure (BP) levels and their association with different indices of body fat in adult Baniyas.

METHODOLOGY

Target Population

The study included 577 individuals, aged 25–60 years, 270 were males and

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307 were females from the Baniyas population.

Baniyas is an endogamous caste group that is divided into three groups based on language difference: (Hindi, Marwari and Punjabi). They are not, however, identified as Punjabi Baniyas, Marwari Baniyas or Hindi Baniyas but rather they are the trading community who mostly have a sedentary lifestyle. Their diet usually includes oily foods that predispose them to many cardiovascular health risks. The Baniyas are divided into 18 gotras (or clans) and generally practice caste monogamous endogamy and gotra exogamy.

Data Collection

Participants were interviewed through a structured protocol. We obtained anthropometric measurements including height, weight, skinfold thickness, waist and hip circumference and blood pressure measurements using standardized procedures and calculated various indices of obesity (eg, BMI, WHR, and waist to height ratio [WHtR]).

Definitions and Procedures

Body mass index was calculated as weight divided by height squared (kg/m^2), and categorized as normal (<25.0), overweight (≥ 25.0 and <30.0), and obese (≥ 30.0).¹¹ Abdominal obesity was defined as waist circumference ≥ 90 centimetres in men and ≥ 80 centimetres in women.²¹

Waist-to-hip ratio was calculated by dividing waist circumference by hip circumference. High waist hip ratio was defined as ≥ 0.9 in men and ≥ 0.85 in women.²²

Grand mean thickness (GMT) was calculated adding all skinfold thicknesses taken at different sites divided by number of skinfold sites.

Waist to height ratio was calculated as the ratio of waist circumference (in cm) to height (in cm). High WHtR was defined as $\geq .50$ for both males and females.

Table 1. Selected characteristics of participants by sex

Characteristics	Males		Females	
	Mean	SD	Mean	SD
Age (years)	43.4	5.3	38.7	4.9
Weight (kg)	72.8	13.1	68.1	11.5
Height (cm)	166.7	5.8	152.1	5.5
Waist circumference (cm)	98.3	11.8	92.0	10.5
Hip circumference (cm)	98.1	8.4	107.1	10.9
Body mass index (kg/m^2)	26.1	4.3	29.4	4.8
Waist to hip ratio	1.0	.1	.86	.1
Waist to height ratio	.59	.1	.6	.1
Grand mean thickness	22.9	7.8	32.0	6.9
Systolic blood pressure (mm Hg)	128.1	14.0	119.6	13.8
Diastolic blood pressure (mm Hg)	88.5	11.1	82.9	9.1

Blood pressure was measured using a manual (mercury) sphygmomanometer with the patient seated in a chair. Three readings were taken for both systolic and diastolic measures; the mean of the readings was used as the final measure.

Height was measured using an anthropometer rod and recorded to the closest 0.1 cm. Waist circumference and hip circumference were measured with a non-stretchable tape measure to the nearest 0.1 cm. Weight was measured with weighing balance to the nearest 0.1 kg.

All measurements were conducted by trained personnel and all instruments were calibrated once weekly. The protocol for the study was reviewed and approved by ethical committees in the Department of Anthropology, Faculty of Sciences of the University of Delhi, India.

Statistical Analysis

Data was analysed using Statistical Package for the Social Sciences (SPSS) version 15.0 for windows (SPSS Inc., Chicago, USA). The difference between various obesity indices and BP was compared by sex. Pearson correlation coefficients were calculated for blood pressure with BMI, waist circumference, GMT, WHR and WHtR, a $P < .05$ was considered statistically significant. Logistic regression was performed to estimate the odds ratio between systolic

and diastolic blood pressure with various obesity indices at 95% CI.

RESULTS

The general characteristics of the population are shown in Table 1. Males had higher weight and height than females and, although waist circumference was higher in males, hip circumference was higher in females. Waist to hip ratio was higher in males whereas WHtR was found to be higher in females. Body mass index and GMT were also higher in females. However, males had higher mean systolic and diastolic blood pressure. All the sex differences were found to be statistically significant at $P < .01$.

Based on BMI (Table 2), 71% of Baniya adults were found to be either overweight or obese, with a third (32%) falling into the obese category. Females were found to be more overweight than males; among females, 42% were overweight and 42.7% obese, compared to 35.6% and 20.7% of males, respectively. Significant sex differences were also observed in the WHR.

The prevalence of systolic prehypertension was 49.4% and 46.0% among males and females, respectively whereas percentage of systolic hypertensive males and females was 21.8% and 7.4%, respectively (Table 3). Among those in the obese category (BMI ≥ 30),

Table 2. Prevalence of BMI weight categories by sex

Categories	Male		Female	
	n	%	n	%
Underweight	7	2.6	3	1.0
Normal	111	41.1	44	14.3
Overweight	96	35.6	129	42.0
Obese	56	20.7	131	42.7
Total	270	100.0	307	100.0

the prevalence of hypertension was more common in males (49.1%) than in females (13.2%). 84.8% of hypertensive males had a BMI >25 (overweight) whereas all the hypertensive females were found to be overweight (data not shown).

Correlations between the measures of obesity and blood pressure were higher for males in all categories. (Table 4) For females, all the indices showed significant correlation except WHR; whereas with males, all indices of obesity showed significant correlation with blood pressure. The highest correlation was found with BMI in both males and females.

In logistic regression analysis (Tables 5 and 6), the odds of hypertension (systolic blood pressure) were found to be higher in males than females for all the indices of obesity except for BMI ≥ 30 . For males, the odds of being hypertensive was found to be highest among those with WHR >0.95 whereas in females it was found to be highest for BMI ≥ 30 .

DISCUSSION

The results of our study indicate that prehypertension affects almost half of

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the Baniya population. The prevalence of obesity was higher among females; however, prevalence of hypertension was higher among males. Prehypertension was associated with several other risk factors for CVD with significantly higher prevalence of overweight, obesity, and increased waist circumference when compared to persons with normal blood pressure.

We found the prevalence of prehypertension to be 47.6%, which is higher than that found in other studies: 28.5% in the Uruguay, 20.0% in Australia, 31% in the United States, and 34% in Taiwan.

The higher prevalence of hypertension among men compared to women is noteworthy. This finding of higher blood pressure among men compared to women has been previously reported in the Jamaican population.⁴ In that

study, prehypertension occurred at lower rates than found in our study: 35% of males and 25% of females. Similarly, the prevalence of systolic hypertension in our study was 21.8% and 7.4% in males and females, respectively, compared to 30% and 29%²³ as well as 13% and 18%²⁴ in Tanzanian males and females, respectively. The higher prevalence of hypertension among the Baniya population may be attributable to differences in dietary habits, socio-economic status, sedentary lifestyle, and rates of obesity. However, we also observed lower odds of hypertension among women compared to men, despite significantly higher rates of obesity. The lower rates of hypertension among women may be attributable to a protective effect of estrogen²⁵ and smoking, since most of the women were pre-menopausal, and non-smokers compared to studies conducted in Tanzania.^{23,24} The lower rate of hypertension among females may also be attributed to the compounding effect of essential fats.

In our study, women had significantly increased prevalence of obesity, but a reduced risk of hypertension. It is possible that increases in body fat may have different effects in women than in men, and that a greater degree of adiposity and a lipid risk profile similar to the male lipid risk profile must be achieved in women to obtain a significant rise in blood pressure.²⁶ Nevertheless, overall findings suggest that obesity is an important risk factor for hypertension and severe hypertension, therefore CVD prevention efforts should target reductions in excess body

Table 3. Prevalence of systolic and diastolic BP levels among Baniya males and females

	Systolic				Diastolic			
	Males		Females		Males		Females	
	n	%	n	%	n	%	n	%
Normal	78	28.8	143	46.6	46	17.0	112	36.5
Prehypertension	133	49.4	141	46.0	114	42.2	122	39.7
Hypertension	59	21.8	23	7.4	110	40.8	73	23.8
Total	270	100.0	307	100.0	270	100.0	307	100.0

Table 4. Correlation between blood pressure and obesity indices among Baniya males and females

Variables	Male		Female	
	Systolic	Diastolic	Systolic	Diastolic
Body mass index	.438**	.442**	.334**	.344**
Waist circumference	.361**	.393**	.140*	.115*
Grand mean thickness	.392**	.361**	.165*	.173**
Waist to hip ratio	.272**	.312**	.066	.116*
Waist to height ratio	.353**	.365**	.237**	.226**

** correlation significant at .01 level.
* correlation significant at .05 level.

weight, through weight reduction/maintenance strategies.

The public health implication of this increased burden of at-risk people in our population is worthy of serious evaluation. It has been estimated that a 5 mm Hg reduction in systolic blood pressure in the population will produce a 14% reduction in the risk of stroke and a 9% reduction in the risk of coronary heart disease.¹⁵ If we apply a population approach to disease prevention we could therefore expect that a small reduction in mean population blood pressure will result in a relatively large reduction in overall CVD risk.

Genetic factors, metabolic and endocrine abnormalities and environmental and psychosocial determinants, including calorie intake, unbalanced diets and decreased physical activity, appear

to be involved in the pathogenesis of obesity.^{27,28} Many obese and/or hypertensive subjects present genetically determined resistance to leptin and higher plasma levels of leptin than lean subjects; this hormone opposes fat accumulation, perhaps by increasing thermogenesis and appetite by an action on the central nervous system and as well as through a direct effect on brown adipose tissue.²⁹

One hypothesis on the pathogenesis of hypertension in obese patients proposes that the development of hypertension in genetically predisposed obese individuals may be triggered by an adaptive response to excess carbohydrate and fat intake which conveys a positive energy balance and an increase in plasma insulin. The latter change would elevate the activity of the central

sympathetic nervous system, and thus increase cardiac activity and result in an increase in BP.^{30,31}

In our study, we found the highest correlation of measures between BP and BMI, which is in contrast to findings in the Australian population where the highest correlation was found between BP and WHR.⁵ We found the likelihood of having hypertension to be most closely associated with BMI in females; however, in males, it was most closely associated with WHR, which suggests that strategies should focus on a healthy diet, increased physical activity, and weight reduction and maintenance. Interventions to reduce weight gain are particularly warranted among women, and should address social, cultural, and sex-specific aspects of weight gain. The WHO and International Society of Hypertension risk prediction charts for assessment of cardiovascular risk factors for prevention and control of cardiovascular disease in low- and middle-income countries should be used for this population.³²

Our study has several limitations. First, the cross-sectional sampling design does not allow inferences to be drawn with respect to the causal relationships among variables. Second, the study sample is only representative of adult Baniyas residing in Delhi, and findings may not be generalizable to other populations. Due to a limited sample size of 577, we cannot rule out that there may be additional sex-related differences that we did not have sufficient statistical power to detect. Despite these limitations, this study provides important data regarding the prevalence and correlates of sex-specific CVD risk factors among adults in an urban Delhi setting.

CONCLUSION

This study adds strong evidence for the high prevalence of CVD risk factors in Baniyas, particularly among women. To date, no intervention addressing

Table 5. Result of logistic regression analysis: odd ratios of diastolic hypertension for different indices of obesity

Indices of obesity	Female		Male	
	OR	95% CI	OR	95% CI
Body mass index				
Overweight	2.407	1.17–4.97	4.831	1.82–12.82
Obese	5.662	2.66–12.06	5.989	1.68–21.39
Waist circumference				
≥80 cm for female, ≥90 for male	1.195	.53–2.70	1.686	.13–3.50
Waist to hip ratio				
≥.80 for female, ≥.95 for male	.917	.54–1.55	1.744	.82–3.71
Waist to height ratio				
≥.50	7.855	2.57–24.02	2.031	.89–4.66

Table 6. Result of logistic regression analysis: odd ratios of systolic hypertension for different indices of obesity

Indices of obesity	Female		Male	
	OR	95% CI	OR	95% CI
Body mass index				
Overweight	3.164	1.50–6.69	4.356	2.10–9.02
Obese	4.333	2.04–9.22	3.230	1.41–7.40
Waist circumference				
≥80 cm for female, ≥90 for male	.668	.30–1.49	3.497	1.88–6.50
Waist to hip ratio				
≥.80 for female, ≥.95 for male	.823	.50–1.37	5.257	2.75–10.04
Waist to height ratio				
≥.50	.259	.09–0.77	4.001	1.87–8.55

CVD prevention has been implemented, and the rates of obesity and hypertension are rising steadily. Health promotion, primary prevention, and health screening strategies are needed to target hypertension, metabolic syndrome, diabetes, and obesity, and reduce the burden of CVD in Baniyas.

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AUTHOR CONTRIBUTIONS

Design concept of study: Gupta, Kapoor
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Data analysis and interpretation: Gupta, Kapoor
Manuscript draft: Gupta, Kapoor
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Administrative, technical, or material assistance: Kapoor
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