

## Prevalence & risk factors of pre-hypertension & hypertension in an affluent north Indian population

S. Yadav, R. Boddula, G. Genitta, V. Bhatia, B. Bansal, S. Kongara, S. Julka, A. Kumar, H.K. Singh, V. Ramesh\* & E. Bhatia

*Departments of Endocrinology & \*Pathology, Sanjay Gandhi Postgraduate Institute of Medical Sciences Lucknow, India*

Received August 16, 2007

**Background & objectives:** Urban Indians have a high prevalence of insulin resistance, hypertension and cardiovascular disease. We studied the prevalence of pre-hypertension and hypertension, as well their association with cardiovascular risk factors, in a north Indian upper socio-economic population.

**Methods:** A total of 1746 adults (age  $\geq 30$  yr) residing in an urban colony of high-income group residents in the city of Lucknow, north India, were invited to be enrolled for the study. The response rate was 64 per cent (n=1112). Blood pressure, anthropometry, plasma glucose in response to oral glucose tolerance test and lipids were measured. The variables contributing significantly to pre-hypertension and hypertension were analyzed by multiple logistic regression analysis.

**Results:** The age and sex adjusted prevalence of hypertension was 32.2 per cent and pre-hypertension was 32.3 per cent. In contrast to hypertension, which was highest in the age group 60-69 yr (64%), pre-hypertension was highest (36%) in the group 30-39 yr. There was a high prevalence of cardiovascular risk factors in the general population [central obesity (86.7%), elevated LDL cholesterol (22.8%), abnormal glucose tolerance (41.6%) and smoking (20.3% of males)]. Two or more of the cardiovascular risk factors were present in a higher proportion of hypertensive [66%, odds ratio (OR) 3.0,  $P < 0.0001$ ] and pre-hypertensive, (56%, OR 2.0,  $P < 0.0001$ ) compared to normotensive subjects (39%). Subjects with pre-hypertension had body mass index, waist-hip ratio and frequency of glucose intolerance, which was intermediate between normotensive and hypertensive subjects. In multiple logistic regression analysis, increasing age, body mass index, waist hip ratio and impaired glucose tolerance/diabetes were independent risk factors for both hypertension and pre-hypertension.

**Interpretation & conclusions:** A high prevalence of pre-hypertension and hypertension were noted in affluent urban north Indians. Increasing age, body mass index, central obesity and impaired glucose tolerance/diabetes were significantly associated with both hypertension and pre-hypertension. Pre-hypertension was associated with an increased prevalence of cardiovascular risk factors.

**Key words** Body mass index - diabetes - hypertension - metabolic syndrome - pre-hypertension

Hypertension affects nearly 26 per cent of the adult population worldwide<sup>1</sup>. Hypertension is an important independent predictor of cardiovascular disease,

cerebrovascular accidents and death<sup>2-4</sup>. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood

Pressure (JNC7) defines hypertension as blood pressure  $\geq 140/90$  mmHg. Persons with blood pressure above optimal levels, but not clinical hypertension (systolic blood pressure of 120-139 mm Hg or diastolic blood pressure of 80-89 mm Hg), are defined as having "pre-hypertension"<sup>5</sup>. Persons with pre-hypertension have a greater risk of developing hypertension than do those with lower blood pressure levels<sup>6</sup>. In addition, pre-hypertension is associated with increased risk of major cardiovascular events, independent of other cardiovascular risk factors<sup>7</sup>.

The prevalence of cardiovascular diseases and hypertension is rapidly increasing in developing countries<sup>8</sup>. This increase, most marked in the urban population, is likely to be related to changing life-styles and to an increased longevity. Cardiovascular diseases are estimated to have led to 1.59 million deaths in India in the year 2000 and this figure is projected to increase to 2.03 million for the year 2010<sup>8,9</sup>. Hypertension has been reported to be responsible for 57 per cent of all stroke deaths and 24 per cent of all cardiovascular deaths in East Asians<sup>10</sup>. Earlier studies in the Indian urban population (albeit using older WHO guidelines *i.e.*, blood pressure  $\geq 160/95$  mmHg) reported the prevalence of hypertension as 1.2-4.0 per cent<sup>11</sup>. Subsequent studies report an increasing prevalence and current data suggest that hypertension affects nearly 25 per cent of urban Indians<sup>11-13</sup>. However, there are only a few studies on the prevalence and risk factors for pre-hypertension in Indians<sup>14,15</sup>. Shanthirani *et al* reported a 47 per cent prevalence of pre-hypertension among urban residents in Chennai who were  $>18$  yr<sup>16</sup>, while in a survey in an industrial population, Prabhakaran *et al*<sup>15</sup> reported pre-hypertension in 44 per cent<sup>15</sup>.

In contrast to developed economies, the risk of metabolic and cardiovascular diseases (CVD) is reported to be highest in affluent urban sections of the population in third world countries<sup>8,9</sup>. It has been reported that type 2 diabetes (T2DM) is higher in upper socio-economic strata compared with those in lower strata<sup>17</sup>. However, such data are not available for hypertension or pre-hypertension. Studies targeting high socio-economic groups would provide an estimate of the future magnitude of the problem and assist in developing strategies for control of hypertension and CVD. We therefore estimated the prevalence and risk factors for hypertension and pre-hypertension in affluent urban population in a north Indian city.

### Material & Methods

*Patients:* A study was conducted between July and December 2003 to determine the prevalence of

different components of the metabolic syndrome (including hypertension) in an affluent urban Indian population. A representative urban colony (Ashiana colony) of high-income group residents in the city of Lucknow, north India, was chosen for the study. High-income group was defined on the basis of occupation (businessmen, professionals, government class 1 officers and their family members), education (college) and self-ownership of a house in a high income group colony. Rapport with the community was built by public lectures and the local residents association was actively involved in the project. Assuming a prevalence of hypertension 20 per cent<sup>11</sup>, a sample size of 1082 was calculated to give the true prevalence with a precision of 2 per cent with 90 per cent of confidence level. All subjects aged  $\geq 30$  yr were invited to participate in the study. Pregnant women, disabled and acutely ill subjects were excluded from the study. Informed written consent was obtained from all subjects and the study was approved by the institutional ethics committee.

All eligible subjects ( $n=1746$ ) were called by an appointment to a local community center after an overnight fast. A total of 1112 subjects participated, giving a response rate of 64 per cent. Three attempts, including a personal visit by a social worker, were made to contact eligible subjects prior to labelling them as non-responders. The subjects who responded had a similar age ( $49.8 \pm 11.5$  yr, range 30-90 yr vs.  $47.0 \pm 11.6$  yr, range 30-85 yr), sex ratio (male/female = 1.0 vs. 0.96) and occupations as compared to non-responders. For each subject, a detailed history was taken followed by anthropometric measurements. Previous history of cardiovascular disease (angina, acute myocardial infarction) was based on the treating physician's notes or prescription details. Details of previous blood pressure measurements and treatment of hypertension were recorded. A random selection of subjects ( $n=473$ ) was done for assessment for physical activity, using a questionnaire previously validated in Indian subjects<sup>18</sup>.

Blood pressure (systolic and diastolic phase V of Korotkoff) was measured using a standard mercury sphygmomanometer in the right arm in a sitting posture, after at least 5 min of rest. It was repeated after 5 min and the second reading was used for analysis. Blood pressure was measured only by the physicians in the study and two identical sphygmomanometers (Diamond, Industrial Electronic and Allied Products, Pune) were utilized. Blood pressure variation was

between 2-4 mm of Hg. Height was measured using a Harpendon stadiometer (Holtain Ltd., Cambridge MD, UK), while weight was recorded using a weighing machine (Avery India Ltd. Haryana) with beam balance (sensitivity of scales is up to 100 g). Body mass index (BMI) was calculated using the formula: weight in kg/height in m<sup>2</sup>. Waist circumference was measured at the midpoint between lowermost point of the costal margin and highest point of iliac crest with the subject standing, at the end of normal expiration. Hip circumference was measured at the level of the greater trochanters with the subject wearing minimum clothes. The mean of two readings was taken in for calculating the waist-hip ratio (WHR). All subjects, except those known to have diabetes, underwent an oral glucose tolerance test in accordance with World Health Organization guidelines<sup>19</sup>. Fasting and 2 h postprandial plasma glucose were measured in subjects with previously diagnosed diabetes. Blood samples (10 ml) were collected with sterile technique using disposable syringes. Samples for plasma glucose were collected in fluoride vials, while samples for other analytes were collected without anticoagulant.

**Biochemical analysis:** Plasma for glucose measurement was separated within half an hour in the field itself. All samples were transported on ice to the laboratory in our institute (SGPGI) where biochemical analyses were performed. All analytes were measured in an autoanalyzer (Bayer RA-Xt, Tarrytown, NY, USA) using kits by the same company (Bayer Diagnostics, Tarrytown, NY, USA). Plasma glucose was measured by the glucose oxidase-peroxidase technique<sup>20</sup>. Serum total cholesterol and triglycerides were measured by cholesterol oxidase peroxidase and lipoprotein lipase peroxidase methods respectively<sup>21,22</sup>. Serum HDL cholesterol was measured after precipitation by magnesium chloride phosphotungstate<sup>23</sup>. LDL cholesterol was calculated using Friedewald's equation<sup>24</sup>.

**Definition and diagnostic criteria:** Hypertension was diagnosed according to JNC 7 criteria<sup>5</sup>. Normal blood pressure was defined as systolic blood pressure <120 mm Hg and diastolic blood pressure <80 mm Hg and pre-hypertension as systolic blood pressure between 120 to 139 mm Hg or diastolic blood pressure between 80 to 89 mm Hg. Hypertension was defined as systolic blood pressure  $\geq$  140 mm Hg or diastolic blood pressure  $\geq$  90 mm Hg. All subjects currently on anti-hypertensive medications, or having written prescriptions of anti-hypertensive drugs, were classified as "hypertensive", irrespective of their current blood

pressure reading. Overweight was defined as BMI  $\geq$  23 kg/m<sup>2</sup>, and obesity as BMI of  $\geq$  27.5 kg/m<sup>2</sup> while central obesity was defined as WHR >0.88 in male and >0.81 in female<sup>25,26</sup>. Metabolic syndrome was defined according to the Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) *i.e.*, NCEP-ATP III criteria<sup>27</sup>.

**Statistical analysis:** The age-adjusted prevalences of pre-hypertension and hypertension were calculated using the 2001 census data for Lucknow, obtained from Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India. Continuous variables are expressed as mean  $\pm$  standard deviation. The one-way analysis of variance or Student's t test was used for comparison of continuous variables while Bonferroni's correction was used to adjust for multiple comparisons. Hypertensives were excluded when analyzing pre-hypertensives, and vice versa. The z test was used to calculate the significance of proportions while the chi square test was employed for comparison of categorical variables. Trend was calculated by chi-square for trend or by ANOVA for linearity, as applicable. Risk factors for hypertension and pre-hypertension were separately tested in a univariate logistic regression analysis. Independent variables tested were age, gender, smoking (only for males), family history of hypertension, physical activity grade, BMI, WHR, and impaired glucose tolerance (IGT)/diabetes and lipids. Variables were age and sex adjusted while performing the univariate analysis. For the purpose of regression analysis variables were categorized into units as follows: age: 10 yr, BMI: 2 kg/m<sup>2</sup>, WHR: 0.05 units, serum total cholesterol, serum triglycerides and serum LDL cholesterol: 10 mg/dl and HDL cholesterol: 5 mg/dl. All variables which were significant in univariate analysis were then tested by forward multiple logistic regression analysis. A two-tailed P value <0.05 was considered significant. Statistical analyses were performed using SPSS Statistical Package (version 9.0; SPSS, Chicago, IL, USA).

## Results

In the study population, the prevalence of overweight and obese subjects was 47 and 32 per cent respectively. Central obesity was present in 96 per cent of males and 77 per cent of females surveyed. The prevalence of the metabolic syndrome according

to the NCEP-ATP III criteria was 67 per cent. Among the cardiovascular risk factors, serum LDL cholesterol was elevated in 23 per cent, 20 per cent of males were current or ex-smokers and 42 per cent had abnormal glucose tolerance (IGT 17%, diabetes mellitus 25%). The proportion of the population who were sedentary or performing light activity was 61 per cent while only 2 per cent were engaged in heavy activity (Table I).

The age and sex adjusted prevalence of hypertension was 32.2 per cent (Table II). Of these 72 per cent (307/429) were previously detected as hypertensives and were on treatment. Hypertension was higher in males (35.9%) when compared to females (28.1%;  $P<0.0001$ ). The overall prevalence of hypertension in the age group 30-39 yr was 13.7 per cent and increased to a peak of 64 per cent in the age group 60-69 yr (trend chi square  $P<0.0001$ ) (Fig. A).

A similar increasing trend was observed in both males and females.

The age and sex adjusted prevalence of pre-hypertension was 32.3 per cent; it was significantly higher in males (36%) compared to females (28.1%;  $P<0.0001$ ; Table II). The prevalence of pre-hypertension in the youngest age group was 36 per cent. Its prevalence either did not change (in females) or was lower with increasing age (in males,  $P<0.05$ ) (Fig. B). The age adjusted prevalence of hypertension and pre-hypertension combined was 63 per cent. In the age group 30-39 yr, 50 per cent of subjects were normotensive, while among those in the age groups 60-69 yr only 14 per cent had normal blood pressure. The proportion of subjects with hypertension compared to those with pre-hypertension increased from 0.4 in the age group 30-39 yr to 2.8 in subjects 60-69 yr of age.

**Table I.** Clinical characteristics of study population

Variables	Males (n=557)	Females (n=555)	Total (n=1112)
Age (yr) (mean $\pm$ SD)	51.2 $\pm$ 11.5	48.4 $\pm$ 11.4	49.8 $\pm$ 11.5
Family history of hypertension	277 (53.2)	312 (59.7) <sup>+</sup>	589 (56.4)
Overweight/obese (BMI >23 kg/m <sup>2</sup> )	414 (74.5)	466 (84.0) <sup>++</sup>	880 (79.3)
Central obesity (Waist hip ratio)*	536 (96.2)	426 (77.0) <sup>++</sup>	962 (86.7)
Diabetes mellitus	158 (28.4)	115 (20.7) <sup>+</sup>	273 (24.6)
Impaired glucose tolerance	89 (16.6)	101 (18.2)	190 (17.1)
Metabolic syndrome	423 (75.9)	324 (58.4) <sup>++</sup>	747 (67.2)
History of coronary artery disease	38 (6.8)	17 (3.1) <sup>+</sup>	55 (4.9)
Elevated triglycerides ( $\geq$ 150 mg/dl)	230 (41.3)	163 (29.4) <sup>++</sup>	393 (35.3)
Elevated LDL cholesterol ( $\geq$ 130 mg/dl)	95 (17.9)	159 (29.0) <sup>++</sup>	254 (22.8)
Low HDL cholesterol (<40 mg/dl)	310 (55.7)	295 (53.2)	605 (54.4)
Sedentary physical activity	128 (63.1)	158 (58.5)	286 (60.5)
Smoking	113 (20.3)	0	113 (10.2)

\*Central obesity – waist hip ratio (Indian criteria) >0.88 in men and >0.81 in women<sup>26</sup>

Metabolic syndrome by ATP III criteria<sup>27</sup>

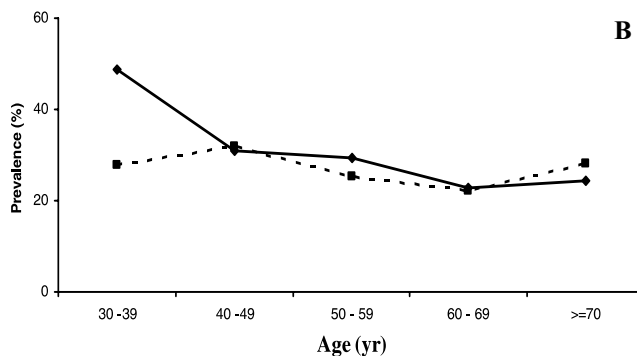
Physical activity scoring done in 473 individuals; family history of hypertension was not available in 68 individuals (36 males and 32 females); no female admitted to smoking. Figures in parentheses are percentages. BMI not available in 2 and WHR in 3 subjects

<sup>+</sup> $P<0.05$ , <sup>++</sup> $<0.001$  compared to males

**Table II.** Crude and age-adjusted prevalence of hypertension and pre-hypertension

Group	Hypertension			Pre-hypertension		
	n	Crude prevalence	Age adjusted prevalence	n	Crude prevalence	Age adjusted prevalence
Overall (n= 1112)	429	38.6 (35.7-41.4)	32.2 (29.5-34.9)	329	29.6 (26.8-32.1)	32.3 (29.6-35.0)
Males (n= 557)	239	42.9 (38.8-47.0)	35.9 (33.1-38.7)	174	31.2 (27.3-35.0)	36.0 (33.2-38.8)
Females (n=555)	190	34.2 (30.3-38.2)	28.1 (25.5-30.7)	155	27.9 (24.1-31.6)	28.1 (25.5-30.7)

Figures in parentheses are 95 per cent confidence intervals



A. Hypertension n (%)

Age group (yr)	30-39	40-49	50-59	60-69	≥70
Males	18/86 (20.9)	66/188 (35.1)	64/136 (47.1)	73/114 (64)	18/33 (54.5)
Females	11/126 (8.7)	48/194 (24.7)	62/126 (49.2)	49/77 (63.6)	20/32 (62.5)

B. Pre-hypertension n (%)

Age group (yr)	30-39	40-49	50-59	60-69	≥70
Males	42/86 (48.8)	58/188 (30.9)	40/136 (29.4)	26/114 (22.8)	8/33 (24.2)
Females	35/126 (27.8)	62/194 (32.0)	32/126 (25.4)	17/77 (22.1)	9/32 (28.1)

Fig. Prevalence of hypertension (A) and pre-hypertension (B) in different age groups in males and females

As a group, subjects with either pre-hypertension or hypertension had increased body mass index, waist-hip ratio and higher prevalence of IGT/diabetes compared to those with normal blood pressure (Table III). There was a significant increasing trend for various cardiovascular risk factors as the population moved from normotension to pre-hypertension and hypertension (BMI,  $P<0.0001$ , WHR,  $P<0.0001$ , LDL cholesterol,  $P=0.003$ , diabetes,  $P<0.0001$ , IGT,  $P<0.0001$ ). Of the four risk factors for

cardiovascular disease (central obesity, LDL cholesterol, IGT /diabetes and smoking), two or more were present in 49, 63 and 66 per cent of males ( $P<0.05$ ) and in 32, 47 and 66 per cent of females ( $P<0.0001$ ) with normal blood pressure, pre-hypertension and hypertension respectively. Known cardiovascular disease was significantly more frequent in hypertensive individuals compared to those with normal blood pressure (9.8% vs. 2.3%;  $P<0.0001$ ). There was no significant difference

Table III. Comparison of clinical and metabolic parameters in normotensive, pre-hypertensive and hypertensive subjects

	Normal blood pressure (n=354)	Pre-hypertension (n=329)	Hypertension (n=429)	Corrected <i>P</i> value
Sex (male)	114 (40.7)	174 (52.9) <sup>+++</sup>	239 (55.7) <sup>++</sup>	<0.01
Age (yr)	45.0 ± 10.0	48.3 ± 11.1 <sup>+++</sup>	54.9 ± 11.0 <sup>**</sup>	<0.01
Family history of hypertension	169 (49.7)	149 (48.4)	271 (68.4) <sup>**</sup>	<0.01
BMI (kg/m <sup>2</sup> )	24.9 ± 3.7	26.2 ± 4.01 <sup>+++</sup>	27.1 ± 4.4 <sup>+++*</sup>	<0.01
Waist-hip ratio	0.90 ± 0.09	0.94 ± 0.09 <sup>+++</sup>	0.96 ± 0.09 <sup>+++,*</sup>	<0.01
Diabetes mellitus	46 (13.0)	68 (20.7) <sup>++</sup>	159 (37.1) <sup>**</sup>	<0.01
Impaired glucose tolerance	50 (14.1)	63 (19.1) <sup>+</sup>	77 (17.9) <sup>+++</sup>	0.02
Serum triglycerides (mg/dl)	132.2 ± 82.6	154.8 ± 108.7 <sup>++</sup>	159.3 ± 109.5 <sup>+++</sup>	0.01
Serum LDL cholesterol (mg/dl)	104.6 ± 28.3	106.4 ± 31.4	111.2 ± 31.9	0.08
Serum HDL cholesterol (mg/dl)	38.5 ± 5.7	38.8 ± 5.7	39.3 ± 6.1	0.182
Smoking	31 (21.5)	43 (24.7)	39 (16.3)	0.102
Cardiovascular disease	8 (2.3)	5 (1.5)	42 (9.8) <sup>**</sup>	<0.01

Values are shown as mean ± SD; Figures in parentheses are percentages

Smoking only for males; no female admitted to smoking

“*P*” value calculated using ANOVA and corrected for multiple comparisons by multiplying by 11

<sup>+</sup> $P\leq 0.05$ , <sup>++</sup> $P<0.01$ , <sup>+++</sup> $P<0.001$  compared to normotension

<sup>\*</sup> $P<0.01$  compared to pre-hypertension; <sup>\*\*</sup> $P<0.001$  compared to normotension and pre-hypertension; <sup>\*\*</sup> $P<0.05$  compared to pre-hypertension

**Table IV.** Risk of hypertension or pre-hypertension in relation to modifiable risk factors

	Hypertension			Pre-hypertension		
	n (%)	Odds ratio (95% CI)	P	n (%)	Odds ratio (95% CI)	P
<i>Overweight/obese:</i>						
Yes (n=880)	361 (41.0)			265 (30.1)		
No (n=230)	66 (28.7)	2.2 (1.5-3.1)	<0.001	64 (27.8)	1.6 (1.1-2.3)	0.007
<i>Central obesity:</i>						
Yes (n=962)	400 (41.6)			287 (29.8)		
No (n=147)	28 (19.0)	4.1 (2.6-6.4)	<0.001	41 (27.9)	2.0 (1.3-3.0)	0.001
<i>Normal BMI with central obesity*:</i>						
Yes (n=173)	56 (32.4)			52 (30.1)		
No (n=55)	9 (16.4)	3.4 (1.5-7.6)	0.003	11 (20.0)	2.6 (1.2-5.5)	0.015
<i>Activity:</i>						
Sedentary (n=286)	109 (38.1)			93 (32.5)		
Active (n=187)	62 (33.2)	1.6 (1.0-2.5)	0.04	49 (26.2)	1.7 (1.1-2.7)	0.02
<i>Smoking:</i>						
Yes (n=113)	39 (34.5)			43 (38.1)		
No (n=444)	200 (45.0)	0.7 (0.4-1.2)	0.20	131 (29.5)	1.2 (0.7-2.0)	0.5

To calculate odds ratio, hypertensives were excluded when analyzing pre-hypertensives, and vice versa. Overweight/obese: BMI  $\geq 23$  kg/m<sup>2</sup>; central obesity: waist-hip ratio  $>0.88$  in men and  $>0.81$  in women. Smoking analyzed only in males (n= 557). Physical activity analyzed only in 473 individuals  
\*Individuals with BMI  $>23$  kg/m<sup>2</sup> were excluded from analysis; CI, confidence interval

between the groups in the prevalence of smoking, sedentary physical activity or occupation (data not shown).

Overweight/obese subjects had a high prevalence of both hypertension (41%) as well as pre-hypertension (30%; Table IV). As compared to normotensive subjects, being overweight/obese increased odds of hypertension (OR 2.2,  $P<0.001$ ) and pre-hypertension (OR 1.6,  $P=0.007$ ). Similarly, central obesity was associated with increased odds of having pre-hypertension (OR 2.0,  $P=0.001$ ) and hypertension (OR 4.1,  $P<0.001$ ). Thirty per cent of subjects with normal BMI but with central obesity were pre-hypertensive while 32 per cent were hypertensive. Sedentary/light physical activity was associated with a small increase in risk of both pre-hypertension and hypertension.

The results of univariate logistic regression analysis, using either hypertension or pre-hypertension as the dependent variable, are shown in Table VA. BMI, WHR, IGT/diabetes mellitus, serum triglyceride and sedentary/light activity were associated with both hypertension and pre-hypertension. A family history of hypertension was associated with hypertension but not pre-hypertension. All variables significant in the above analysis were tested in a forward multiple logistic regression analysis (Table VB). Increasing age, BMI,

WHR, IGT/diabetes, serum triglycerides and family history of hypertension were significant contributors to hypertension. In the case of pre-hypertension, all these variables were associated, except for family history of hypertension and serum triglycerides.

### Discussion

Our study documents the high prevalence of both hypertension and pre-hypertension, and their association with other metabolic and cardiovascular risk factors, in a north Indian urban high socio-economic population. The high frequency of pre-hypertension and hypertension are likely to be important contributors to the epidemic of cardiovascular disease in affluent Indian subjects.

The prevalence of hypertension has been increasing in India, both in rural and urban regions. The prevalence of hypertension in urban areas of India ranged from 2.6-5.2 per cent between 1960-1980<sup>28-30</sup> and it has increased to 20-33 per cent in last decade<sup>12,13,16</sup>. The high prevalence of hypertension in the current study (32.2%), confirms this increasing trend. In addition, there was a high prevalence of pre-hypertension in our study (31%). This was similar to that reported from industrialized economies<sup>1,31,32</sup>. In Indians, among urban residents  $>18$  yr living in Chennai, the prevalence of pre-hypertension was reported as 47 per cent<sup>16</sup>. In another study on 2122 men working in an industry

**Table V.** Univariate and multivariate logistic regression analysis of risk factors associated with hypertension and pre-hypertension

	Hypertension		Pre-hypertension	
	OR (95% CI)	P	OR (95% CI)	P
<i>A Univariate:</i>				
Age	2.39 (2.05-2.80)	<0.0001	1.32 (1.25-1.54)	0.0001
Sex	1.83 (1.37-2.44)	<0.0001	1.64 (1.21-2.22)	0.001
Family history of hypertension	2.19 (1.62-2.96)	<0.0001	0.95 (0.70-1.29)	0.74
BMI (kg/m <sup>2</sup> )	1.52 (1.37-1.67)	<0.0001	1.28 (1.17-1.40)	<0.0001
Waist-hip ratio	1.56 (1.37-1.79)	<0.0001	1.31 (1.16-1.48)	<0.0001
Diabetes/IGT	2.68 (1.93-3.73)	<0.0001	1.69 (1.22-2.34)	0.0017
Serum triglycerides	1.04 (1.02-1.06)	0.0001	1.02 (1.01-1.04)	0.008
Serum LDL cholesterol	1.05 (0.99-1.10)	0.11	1.02 (0.97-1.07)	0.51
Serum HDL cholesterol	1.12 (0.98-1.28)	0.09	1.06 (0.93-1.21)	0.39
Sedentary activity	1.59 (1.02-2.47)	0.039	1.72 (1.08-2.73)	0.023
Smoking	0.71 (0.42-1.20)	0.20	1.20 (0.71-2.02)	0.50
<i>B. Multivariate</i>				
Age	2.53 (2.09-3.07)	<0.0001	1.34 (1.14-1.57)	0.0004
BMI	1.37 (1.24-1.52)	<0.0001	1.21 (1.10-1.32)	<0.0001
Waist-hip ratio	1.26 (1.13-1.40)	<0.0001	1.17 (1.07-1.28)	0.0008
Diabetes mellitus/IGT	2.23 (1.52-3.28)	<0.0001	1.67 (1.17-2.38)	0.005
Serum triglyceride	1.04 (1.01-1.06)	0.013	1.01 (1.00-1.04)	0.24
Family history of hypertension	2.74 (1.86-4.03)	<0.0001	1.09 (0.78-1.52)	0.64

BMI, body mass index; IGT, impaired glucose tolerance. Smoking only analyzed in males (n=557).

Physical activity scoring done in 473 individuals. When physical activity score was included in multivariate analysis (n=476) then for hypertension age, BMI, WHR, family history and diabetes/IGT were significant predictors; for pre-hypertension age, sex, BMI and diabetes/IGT were significant. For purpose of analysis, age was in units of 10 yr, BMI in units of 2 kg/m<sup>2</sup>, and WHR in units of 0.05, triglycerides and LDL cholesterol in units of 10 mg/dl and HDL cholesterol in units of 5 mg/dl.

in north India, pre-hypertension was present in 44 per cent<sup>15</sup>. Even in the rural population in Assam, 54 per cent of subjects had pre-hypertension and one-third had hypertension<sup>33</sup>.

In the current study, the prevalence of hypertension increased significantly from age group 30-39 to 60-69 yr. In contrast, pre-hypertension was highest in the age group 30-39 yr (36%). The ratio of hypertensive to pre-hypertensive individuals increased from 0.4 in the age group 30-39 yr to 2.8 in the age group 60-69 yr. It is likely that this trend is a result of progression of subjects with pre-hypertension to hypertension. Analysis of the NHANES III data set has provided similar results<sup>31</sup>. The prevalence of hypertension and pre-hypertension was significantly higher in males compared with females, possibly due to the increased prevalence of metabolic risk factors for hypertension and pre-hypertension in males.

Pre-hypertensive subjects had greater obesity, central abdominal obesity and had an increased prevalence of diabetes/IGT compared to normotensive subjects. The same risk factors were further increased

in subjects with hypertension. This finding was in concordance with studies on pre-hypertension from developed market economies. Greenlund *et al*<sup>6</sup> reported that subjects with pre-hypertension were 1.65 times as likely to have at least 1 other adverse cardiovascular risk factor than those who were normotensive and to have 1.8 times increased risk of cardiovascular events.

Obesity and sedentary lifestyle are important modifiable risk factors for hypertension<sup>16,34</sup>. In the current study, being overweight or obese increased the odds of having hypertension and pre-hypertension by 2.2 and 1.6 times respectively. Among subjects who were centrally obese, nearly 40 per cent were hypertensive and 30 per cent were pre-hypertensive. Central obesity increased the odds of hypertension and pre-hypertension even among subjects who had a normal BMI. Previous studies have emphasized the propensity of Indians to develop central obesity and insulin resistance<sup>35,36</sup>. We also found an increased risk of hypertension and pre-hypertension among subjects with sedentary lifestyle, though this was not confirmed on multivariate analysis. Similar results have been shown in different ethnic groups<sup>37,38</sup>, including Indians<sup>13,14,39</sup>.

On multivariate analysis, increasing age, BMI, waist-hip ratio and the presence of diabetes or IGT independently contributed to both pre-hypertension and hypertension. In addition, a family history of hypertension was also an important contributor to hypertension but not pre-hypertension. The reason for this dichotomy is not clear. In previous studies, a family history has been shown to be important in predisposing to pre-hypertension<sup>14</sup> and hypertension<sup>40,41</sup>.

Our study had certain limitations. Subjects for the study were chosen from a single locality and thus may not be representative of affluent subjects throughout India. However, we took care to choose a colony which had a representative mix of subjects with all different professions, age groups and religions. Blood pressure measurements were taken on a single day and were not repeated again for practical reasons. Hence, we may have over-diagnosed both pre-hypertension and hypertension.

In conclusion, there was a high prevalence of pre-hypertension and hypertension in an affluent north Indian community. Both entities were associated with metabolic risk factors which are likely to further increase the risk of cardiovascular disease in these subjects.

### Acknowledgment

Authors thank Shriyut Intsar Ahmed and K. Jayaraj for technical assistance and acknowledge USV India Ltd. for providing partial financial assistance for the study.

### References

- Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. *Lancet* 2005; 365 : 217-23.
- World Hypertension League Year Book 2000-2001: Fighting hypertension into next millennium*. Toledo, OH: World Hypertension League; 2001. p. 3-6.
- Murray CJ, Lopez AD. Global mortality, disability, and the contribution of risk factors: Global burden of Disease Study. *Lancet* 1997; 349 : 1436-42.
- World Health Report. Mental Health: New Understanding, New Hope*. Geneva, Switzerland: WHO, 2001. p. 144-9.
- Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, *et al*. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 Report. *JAMA* 2003; 289 : 2560-72.
- Greenlund KJ, Croft JB, Mensah GA. Prevalence of heart disease and stroke risk factors in persons with pre-hypertension in the United States, 1999-2000. *Arch Intern Med* 2004; 164 : 2113-8.
- Liszka HA, Mainous AG 3rd, King DE, Everett CJ, Egan BM. Pre-hypertension and cardiovascular morbidity. *Ann Fam Med* 2005; 3 : 294-9.
- The World Health Report 1999: The double burden: emerging epidemics and persistent problems. Geneva: WHO; 1999. Available from: <http://www.who.org/>, accessed on June 2, 2007.
- Ghaffar A, Reddy KS, Singhi M. Burden of noncommunicable diseases in South Asia. *BMJ* 2004; 328 : 807-10.
- Rodgers A, Lawes C, MacMahon S. Reducing the global burden of blood pressure related cardiovascular disease. *J Hypertens* 2000; 18 (Suppl 1):S3-6.
- Gupta R. Trends in hypertension epidemiology in India. *J Hum Hypertens* 2004; 18 : 73-8.
- Gupta R, Gupta S, Gupta VP, Prakash H. Prevalence and determinants of hypertension in the urban population of Jaipur in western India. *J Hypertens* 1995; 13 : 1193-200.
- Anand MP. Prevalence of hypertension amongst Mumbai executives. *J Assoc Physicians India* 2000; 48 : 1200-1.
- Chockalingam A, Ganesan N, Venkatesan S, Gnanavelu G, Subramaniam T, Jaganathan V, *et al*. Patterns and predictors of pre-hypertension among "healthy" urban adults in India. *Angiology* 2005; 56 : 557-63.
- Prabhakaran D, Shah P, Chaturvedi V, Ramakrishnan L, Manhapra A, Reddy KS. Cardiovascular risk factor prevalence among men in a large industry of northern India. *Natl Med J India* 2005; 18 : 59-65.
- Shanthirani CS, Pradeepa R, Deepa R, Premalatha G, Saroja R, Mohan V. Prevalence and risk factors of hypertension in a selected South Indian population - the Chennai Urban Population Study. *J Assoc Physicians India* 2003; 51 : 20-7.
- Ramachandran A, Snehalatha C, Kapur A, Vijay V, Mohan V, Das AK, *et al*. Diabetes Epidemiology Study Group in India (DESI). High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey. *Diabetologia* 2001; 44 : 1094-101.
- Bharathi AV, Sandhya N, Vaz M. The development and characteristics of a physical activity questionnaire for epidemiological studies in urban middle class Indians. *Indian J Med Res* 2000; 11 : 95-102.
- Definition, diagnosis and classification of diabetes mellitus and its complications*. Report of a WHO Consultation, Part 1: *Diagnosis and classification of diabetes mellitus*. World Health Organization Department of Noncommunicable Disease Surveillance, Geneva: World Health Organization; 1999.
- Trinder P. Determination of blood glucose using an oxidase-peroxidase system with an non-carcinogenic chromogen. *J Clin Pathol* 1969; 22 : 158-61.
- Allain CC, Poon LS, Chan CS, Richmond W, Fu PC. Enzymatic determination of total serum cholesterol. *Clin Chem* 1974; 20 : 470-5.
- Fossati P, Prencipe L. Serum triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. *Clin Chem* 1982; 28 : 2077-80.
- Lopes-Virella MF, Stone P, Ellis S, Colwell JA. Cholesterol determination in high-density lipoproteins separated by three different methods. *Clin Chem* 1977; 23 : 882-4.
- Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in

- plasma, without use of the preparative ultracentrifuge. *Clin Chem* 1972; 18 : 499-502.
25. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies; WHO expert consultation. *Lancet* 2004; 363 : 157-63.
  26. Snehalatha C, Viswanathan V, Ramachandran. Cutoff values for normal anthropometric variables in Asian Indian adults. *Diabetes Care* 2003; 26 : 1380-4.
  27. Expert panel on detection, evaluation, and treatment of high blood cholesterol in adults. Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). *JAMA* 2001; 285 : 2486-97.
  28. Mathur K, Wahi PN, Gahlaut D. Blood pressure studies in the adult population of Agra, India. *Am J Cardiol* 1963; 11 : 61-5.
  29. Malhotra SL. Dietary factors causing hypertension in India. *Am J Clin Nutr* 1970; 23 : 1353-63.
  30. Wasir HS, Ramachandran P, Nath LM. Prevalence of hypertension in a closed urban community. *Indian Heart J* 1984; 36 : 250-3.
  31. Wang Y, Wang QJ. The prevalence of pre-hypertension and hypertension among US adults according to the new joint national committee guidelines: new challenges of the old problem. *Arch Intern Med* 2004; 164 : 2126-34.
  32. Wolf-Maier K, Cooper RS, Banegas JR, Giampaoli S, Hense HW, Joffres M, et al. Hypertension prevalence and blood pressure levels in 6 European countries, Canada, and the United States. *JAMA* 2003; 289 : 2363-9.
  33. Hazarika NC, Narain K, Biswas D, Kalita HC, Mahanta J. Hypertension in the native rural population of Assam. *Natl Med J India* 2004; 17 : 300-4.
  34. Zachariah MG, Thankappan KR, Alex SC, Sarma PS, Vasan RS. Prevalence, correlates, awareness, treatment, and control of hypertension in a middle-aged urban population in Kerala. *Indian Heart J* 2003; 55 : 245-51.
  35. Chandalia M, Abate N, Garg A. Relationship between generalized and upper body obesity to insulin resistance in Asian Indian men. *J Clin Endocrinol Metab* 1999; 84 : 2329-35.
  36. McKeigue PM, Shah B, Marmot MG. Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. *Lancet* 1991; 337 : 382-6.
  37. Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. *Ann Intern Med* 2002; 136 : 493-503.
  38. Bassett DR Jr, Fitzhugh EC, Crespo CJ, King GA, McLaughlin JE. Physical activity and ethnic differences in hypertension prevalence in the United States. *Prev Med* 2002; 34 : 179-86.
  39. Zachariah MG, Thankappan KR, Alex SC, Sarma PS, Vasan RS. Prevalence, correlates, awareness, treatment, and control of hypertension in a middle-aged urban population in Kerala. *Indian Heart J* 2003; 55 : 245-51.
  40. Goldstein IB, Shapiro D, Guthrie D. Ambulatory blood pressure and family history of hypertension in healthy men and women. *Am J Hypertens* 2006; 19 : 486-91.
  41. Carretero OA, Oparil S. Essential hypertension. Part I: definition and etiology. *Circulation* 2000; 101 : 329-35.

*Reprint requests:* Dr Eesh Bhatia, Department of Endocrinology, Sanjay Gandhi Postgraduate Institute of Medical Sciences  
Lucknow 226 014, India  
e-mail: eebhatia@sgpgi.ac.in