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Overall and Abdominal Adiposity on Blood Pressure: Consistency and Evaluation of their Association in an Adult Indian Population

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KEYWORDS Body Mass Index. Waist Hip Ratio. Abdominal Adiposity. Blood Pressure

ABSTRACT To assess the relationship and consistency of overall and abdominal obesity on blood pressure in adult Indian population using cross-sectional descriptive design collected height, weight, circumferences of waist and hip, systolic blood pressure (BP) and diastolic BP besides the information on demographic variables from 303 males + 357 females (untreated for hypertension) between 21-60 years. Men were found to have higher abdominal obesity (0.90±0.07) than women (0.84±0.08) ($p<0.05$) while there was no difference in body mass index (BMI). Average systolic blood pressure (SBP) and diastolic blood pressure (DBP) found to increase linearly over the whole variation range of BMI, waist hip ratio (WHR) and age groups. The correlation coefficients of SBP and DBP for age, varied from 0.153-0.275 ($p<0.05$) in men, 0.219-0.171 in women. In males, adiposity indicators (BMI, WHR) were positively associated with blood pressure, while in females, only BMI shown positive association. The prevalence of hypertension increased with age and BMI quartiles. Men with higher WHR are 2.988 times, and women with higher WHR are 1.177 times at risk to develop hypertension. The odds of hypertension were more than six-fold among the elderly in male sex (OR=6.213:95%CI;1.815,21.273), but in females it is only two-fold (OR= 2.423: 95%CI;0.801,7.334). The odds of hypertension rose steadily with increase in BMI reaching 7.579 (95CI;1.510,38.046) in males and 15.56 (95%CI;1.883,128.526) in females with BMI >25 kgm^{-2}. Adjustment for age, decreased the odds of hypertension in males and increased in females in the BMI category of >25 kgm^{-2}, while no change in the remaining quartiles. These findings suggest consistent linear relation of adiposity with BP, independent of age.

INTRODUCTION

The prevalence of obesity and its associated coronary heart disease (CHD) risk factors, mortality and morbidity due to non-communicable diseases, are increasing in developing countries (Doll et al. 2002; Singh et al. 1999; Engstrom et al. 2001; Reddy et al. 2002). Globally, about 58% of diabetes mellitus and 21% of ischemic heart diseases are attributable to BMI above 21 kg/m^2 (WHO 2002). Developing countries are increasingly faced with a double burden of hypertension and other cardiovascular diseases, along with infections and malnutrition (Murray and Lopez 1996; WHO 2003). An increasing number of developing nations are acquiring atherogenic lifestyles which include the adoption of atherogenic dietary habits similar to those seen in industrialized societies. This appears to be consistent with the economic development (Beaglehole 1992). Major coronary risk factors are smoking, hypertension, dislipidemia, diabetes and obesity. Other risk factors that are considered to be important are fat distribution, family history of premature CHD and life style risk factors (Wilson et al. 1998). In this regard, the World Health Organization has recommended the development of national programmes for the prevention and control of CHD through the simultaneous adoption of several strategies (WHO 2003).

Obesity and hypertension have been shown to increase in parallel across populations along with their degree of development and acculturation (Kaufman et al.1996; Cooper et al. 1997). Research results to date claim that, developing countries have a higher susceptibility of blood pressure (BP) to excessive adiposity than Western populations and will be more severely affected, particularly in terms of hypertension-driven cardiovascular morbidity and mortality, by the current global upward trend in obesity (Cooper and Rotimi 1997; Forrester et al. 1998; Wilks et al. 1998).

This assumption has to be tested against the

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background of existing knowledge about the hypertensive effect of obesity. Since long-term cohort studies are difficult to conduct and the magnitude of its effect in a given population is generally assessed by examining the cross-sectional association between measures of obesity and BP levels after adjustment for potential confounders. Usual anthropometric measures of adiposity are body mass index (BMI) and waist circumference (WC), reflecting total body fat and abdominal fat deposition, respectively. Additionally, the ratio of waist to hip circumference (WHR) is frequently used as an index for abdominal adiposity. All these adiposity parameters have been shown to correlate significantly with systolic blood pressure (SBP), diastolic blood pressure (DBP) and hypertension at an individual level over a broad spectrum of socio-economic conditions (Seidell et al. 1992; Reddy et al. 1997; Ledoux et al. 1997). Age has to be considered as a potential confounder because, both adiposity and BP are generally increasing over the course of life. The increase of BP with age was found to accelerate in populations from developing countries adopting modern lifestyles (Reddy et al. 1999; Reddy et al. 2008).

In the light of this background and existing literature, the present study is aimed at determining the relationship and consistency between adiposity (BMI and WHR) and blood pressure in populations where the prevalence of obesity is growing rapidly. Such information would thus be relevant to the prevention and control of hypertension in developing countries.

MATERIALS AND METHODS

The present study was conducted at Sri Venkateswara University, Tirupati, India. As a part of our University Silver Jubilee Celebrations, an Obesity Awareness Camp (OAC) was conducted by the Department of Anthropology, with an aim to create awareness about the adiposity among the staff and students of the University. Formal written requests were sent to the individual faculty and circulars to the student community to participate in the OAC. A total of 660 subjects (303 males + 357 females) responded positively and gave consent to participate in the programme. The study protocol was approved by our Institutional Ethical Committee.

The present study focusing on adiposity and BP, has a cross-sectional descriptive design, allowing internal comparisons among the major socio-demographic groups, such as sex, education, occupation etc. The age range in the present sample is 21–60 years. Pregnancy (in women), usage of antihypertensive medication and any gross physical abnormality were the exclusion criteria against the physical measurements.

Data were collected using a pretested questionnaire and the physical measurements like weight, height, circumferences of waist and hip and blood pressure were collected. The survey instrument, mainly the questionnaire, has been validated in a small pilot study among our Departmental Staff and Students. The physical assessment included height, weight, circumferences of waist and hip were measured as specified by Reddy et al .(1998). Weight and height were measured as the participants standing without footwear and wearing light clothing. Participants stood upright with the head in Frankfort plane for height measurement. Height was recorded to the nearest 0.5 cm and weight was recorded to the nearest 100g. Body mass index (BMI) was calculated as weight in kg/height in metre^2 (kgm^{-2}). Overweight was defined as BMI >23 and obesity was defined as BMI > 25 (Reddy et al.1998). Waist girth was measured at the level of umbilicus with person breathing silently and hip measured as standing inter-trochanteric girth according to the WHO guidelines. Waist hip ratio (WHR) was calculated from the circumferences of waist and hip. Abdominal adiposity was defined as WHR>0.90 for males and >0.85 for females (WHO 1995). Blood pressure was measured with a random zero muddler sphygmo-manometer at the study site in a sitting position after the participant rested for at least 5 min. Three consecutive measurements were taken with an interval of 3 min in between. Average systolic blood pressure and diastolic blood pressure were determined from the second and third measurements. Hypertension was diagnosed when the systolic blood pressure was > 140 mmHg or the diastolic blood pressure was > 90 mmHg, as per the guidelines prescribed by the Joint National Committee on detection, evaluation and treatment of high blood pressure (Chobanian et al. 2003).

Statistical analysis was carried out via SPSS – 15.0 and the alpha levels were set at $p < 0.05$. The prevalence rates were reported as percent. Continuous variables were reported as mean ±

SD and the differences between genders were tested by students 't' test and within the categories of age groups and BMI quartiles were tested by one way analysis of variance. The distribution of mean SBP and DBP across BMI quartiles and age groups were shown in graphical representation for male and females separately. Correlations between continuous variables were examined using correlation coefficients. Further, logistic regression analysis was carried out to determine the odds of hypertension across the age groups, BMI and WHR categories, education and occupation, while controlling for possible confounding.

RESULTS

Descriptions of the selected demographic and coronary risk factors were presented in table 1. The subjects are divided into 10 years age class intervals and the sample size in each age group was shown. 75 percent of males attained post - graduation and the rest were with graduation, wherein female gender is 50 percent each with graduation and post-graduation. 32 percent of the males and 42 percent of the females were employed. In both the sexes, around 20 percent of sample was overweight and 15 percent obese, and 13 percent of the males along with 18 percent of the female gender are categorized as under nutrition. At the same time 40 percent of the males and 36 percent of the females classified under abdominal adiposity. The prevalence of hypertension in the present sample was 15% in males and 10% in females.

Physical measurements were available for all the participants, for whom the BMI and WHR could be calculated (Table 2). The mean weight and height varied between male and female subjects. Men were taller and heavier than their female counterparts. However, the resulting mean BMI in men (22.19±3.09) didn´t vary with women (21.65±3.19). Male gender are found to have higher waist circumference than female gender (p<0.05), while no significant difference in hip circumference. Men are found to have higher abdominal adiposity (0.90±0.07) than women (0.84±0.08). Although males possess higher systolic and diastolic BP than females, significant difference observed only with systolic blood pressure (p<0.05).

Correlation coefficients for age, anthropometry and blood pressure are shown in table 3. The unadjusted pair wise correlations were higher in males than females. Age has shown a positive association with anthropometry and blood

Table 1: Description of the selected demographic and coronary risk factor characteristics

Variable	*Males (n=303)*	*Females (n=357)*
Age(in years)		
21-30	98 (32.34)	104 (29.13)
31-40	75 (24.75)	106 (29.69)
41-50	73 (24.09)	75 (21.01)
51-60	57 (18.81)	72 (20.17)
Physical Activity		
Sedentary	17 (05.61)	28 (07.84)
Mild	196 (64.69)	232 (64.99)
Moderate	84 (27.72)	90 (25.21)
Heavy	6 (01.98)	7 (01.96)
Education		
Graduation	72 (23.76)	183 (51.26)
Post graduation	231 (76.24)	174 (48.74)
Occupation		
Employee	95 (31.35)	153 (42.86)
Student	208 (68.65)	204 (57.14)
BMI Category		
<18.5	39 (12.87)	64 (17.93)
18.5 to 23.0	162 (53.46)	162 (45.38)
23.0-25	56 (18.48)	75 (21.00)
>25.0	46 (15.18)	56 (15.68)
WHR Category		
Men<0.90; Women<0.85	180 (59.41)	227 (63.58)
Men>0.90; Women>0.85	123 (40.59)	130 (36.41)
Blood Pressure		
Normotension	258 (85.15)	319 (89.36)
Hypertension	45 (14.85)	38 (10.64)

( ) = percentages

Table 2: Descriptive statistics for the anthropometry and blood pressure in the study population

Variable	*Males*	*(Mean±SD)*	*Females*	*(Mean±SD)*	*t-test*
Height in cm	167.23± 6.43	(151-186)	155.23± 6.24	(145-176)	19.82*
Weight in Kg	62.18± 9.95	(42-86)	52.21± 8.50	(35-79)	11.33*
Body mass Index	22.19± 3.09	(15.43-29.69)	21.65± 3.19	(15.34-28.95)	1.80*
Waist circumference in cm	82.11±11.43	(59-116)	75.59±10.39	(51-105)	6.26*
Hip circumference in cm	92.45± 8.08	(66-121)	90.56± 9.97	(54-121)	2.16*
WHR	0.89± 0.07	(0.63-1.09)	0.84± 0.08	(0.65-1.01)	6.81*
Systolic BP in mmHg	125.64±12.45	(91-152)	121.58±11.28	(86-153)	3.58*
Diastolic BP in mmHg	82.31±10.21	(50-108)	80.57± 8.58	(54-104)	1.94*

* p<0.05

Table 3: Correlation coefficients of age, anthropometry and blood pressure

Males *Females*	*Age*	*Ht*	*Wt*	*BMI*	*Wc*	*Hc*	*WHR*	*SBP*	*DBP*
Age	-	0.102	0.550*	0.577*	0.538*	0.381*	0.507*	0.153*	.275*
Ht	0.005	-	0.497*	0.020	0.267*	0.317*	0.123	0.043	-0.010
Wt	0.456*	0.413*	-	0.876*	0.829*	0.724*	0.646*	0.283*	.316*
BMI	0.498*	-0.090	0.866*	-	0.808*	0.654*	0.684*	0.302*	0.372*
Wc	0.484*	0.090	0.660*	0.674*	-	0.839*	0.813*	0.247*	0.304*
Hc	0.323*	0.137*	0.560*	0.546*	0.721*	-	0.370*	0.264*	0.223*
WHR	0.299*	-0.028	0.302*	0.337*	0.588*	-0.130*	-	0.139*	0.279*
SBP	0.219*	0.128*	0.407*	0.375*	0.257*	0.251*	0.090	-	0.745*
DBP	0.171*	0.033	0.419*	0.443*	0.306*	0.348*	0.053	0.720*	-

* p<0.05

pressure except in height. The correlation coefficients of SBP and DBP for age varied from 0.153- 0.275 (p<0.05) in men, from 0.219 - 0.171 in women. The indicators of adiposity (BMI, WHR) were positively associated with blood pressure in males, while in females only BMI shown a positive association with blood pressure.

Conventional BMI cutoff points were applied to classify the study populations into underweight (BMI<18.5 kg/m^2), normal (BMI: 18.5-22.99 kg/m^2), overweight (BMI:23.0-24.99 kg/m^2), obese (BMI>25 kg/m^2), and the mean values for SBP and DBP against the classification are shown in figure 1. Generally, both mean SBP and DBP increased along with increasing BMI quartiles. Mean SBP (f-value= 6.281:p<0.05 for males; 13.153: p<0.05 for females) and DBP (f-value=9.935: p<0.05 for males; 20.534: p<0.05 for females) shown a significant increase across the categories. A clear -cut examination of the results shows that the increase is more pronounced in obese category. Mean BMI, WHR, SBP and DBP across the age groups are shown in figures 2 and 3 respectively. The resulting distribution revealed a concomitant increase in mean SBP (f-value: males: 2.869; p<0.05, females: 6.136; p<0.05) and DBP (f-value: males: 7.836; p<0.05, females: 4.572;p<0.05) across the age groups in both sexes. Similarly, an elevation in mean BMI (f-value: males: 27.842; p<0.05, females: 41.811; p<0.05) and WHR (f-value: males: 32.469; p<0.05, females: 6.154; p<0.05) from 20-29 age group to 50-59 yrs age group is noticed in both the sexes.

The prevalence of hypertension increased with age and BMI quartiles (Table 4). However, the extent of this association varied between different age groups and BMI quintiles. The rise in the prevalence of hypertension was more drastic at age group 41-50 years in male sex and 51-60 in female sex. There is a steep increase in hypertension in second BMI quartile and with no difference to third quartile between sexes and sudden elevation in fourth quartile is noticed in male sex. The prevalence of hypertension is elevated in males and decreased in females with an increase in abdominal adiposity.

Table 4: Distribution of hypertension across the age groups and BMI categories.

Variable	*Males (n=303)*	*Females (n=357)*
Age (in years)		
21-30	6 (01.98)	9 (02.52)
31-40	6 (01.98)	12 (03.36)
41-50	16 (05.28)	3 (00.84)
51-60	17 (05.61)	14 (03.92)
Total	45 (14.85)	38 (10.64)
BMI Category		
<18.5	3 (0.99)	2 (0.56)
18.5 to 23.0	12 (3.96)	9 (2.52)
23.0-25	12 (3.96)	12 (3.36)
>25.0	18 (5.94)	15 (4.20)
WHR Category		
Men <0.90; Women<0.85	16 (5.28)	22 (6.16)
Men >0.90; Women>0.85	29 (9.57)	16 (4.48)

( ) = percentages

Selected socio-demographic and adiposity characteristics that are considered as possible determinants of hypertension were subjected to a logistic regression analysis. The analysis was conducted separately for each sex and the resulting OR and 95% CI are presented in table 5. The BMI along with WHR and age were found to be significant determinants of hypertension in the study population. The odds of hypertension were more than six -fold among the elderly in male sex (OR=6.213: 95%CI 1.815, 21.273), but in females the same is only two fold (OR= 2.423: 95% CI 0.801, 7.334). The odds of hypertension rose steadily with increase in BMI reaching 7.579 (95CI; 1.510, 38.046) in males and 15.56 (95%CI; 1.883, 128.526) in females with BMI >25 kgm^{-2}. When age is adjusted in the model, the odds of hypertension sharply declined in male sex (OR=4.339, 95%CI; .698, 26.966) and an

Table 5: Determinants of high blood pressure in the study population (logistic regression)

	Males		Females	
	OR	*95% CI*	*OR*	*95% CI*
Age (in years)				
21-30	1.00		1.00	
31-40	1.326	0.315, 5.585	1.333	0.437, 4.065
41-50	4.414	1.313, 14.862	0.437	0.085, 2.264
51-60	6.213	1.815, 21.273	2.423	0.801, 7.334
BMI Category				
<18.5	1.00		1.00	
18.5 to 23.0	0.960	0.191, 4.814	2.471	0.289, 21.152
23.0-25	3.310	0.641, 17.085	8.000	0.968, 66.089
>25.0	7.579	1.510, 38.046	15.56	1.883, 128.526
WHR Category				
Men <0.90; Women<0.85	1.00		1.00	
Men >0.90; Women>0.85	2.988	1.336, 6.683	1.177	0.504, 2.748
Education				
Graduation	1.00		1.00	
Post graduation	0.833	0.345, 2.015	0.967	0.422, 2.217
Occupation				
Student	1.00		1.00	
Employee	5.025	2.218, 11.383	1.262	0.550, 2.894

increase in female sex (OR=22.019, 95%CI; 2.343, 206.939) in the BMI category of >25 kgm^{-2}, while no change in the remaining categories. On the other hand, WHR and age when independent and are together adjusted in the model, no significant deviations taken place in the odds of hypertension among BMI categories of males, while in female sex the odds of hypertension increased in BMI >25 kgm^{-2}. Men with higher WHR are 2.988 times at risk to develop hypertension than with lower WHR. Similarly women with higher WHR are 1.177 times at risk to develop hypertension when compared to lower WHR. Age and BMI when independent and are together adjusted to see the changes in odds of hypertension in WHR categories, a decline in the odds ratio is evident in both males and females. The odds of hypertension among the male employees (OR= 5.025, 95% CI 2.218, 11.383) is grater than female employees (OR= 1.262, 95% CI 0.550, 2.894) in developing hypertension.

DISCUSSION

In this study, we examined the consistency and the relationship of hypertension with overall and abdominal adiposity in a population from developing country, and the results show an unpretentious, but significant linear association of BMI and WHR with blood pressure in males only, independent of age, while in females WHR failed to show association with blood pressure. However, BMI greater than 25 kgm^{-2} is equally associated with an increased risk of hypertension in the presence of higher abdominal obesity. These findings are in good agreement with other studies, supporting a stable relationship between body mass and abdominal adiposity with blood pressure (Kaufman et al. 1996; Reddy et al. 1997). The presence of insignificant differences in the relationship of BP with adiposity in female gender provides substantial argument against a lower hypertensive effect of obesity than male gender.

The above evidence presented supports a common general physiopathological mechanism linking the excessive fat deposition to elevated BP independently of genetic and environmental background. The mechanism of obesity-associated hypertension appears to be an inadequate vasodilatation in the face of the increased blood volume and cardiac output, which are the natural consequences of an increased body mass. This defect in control of vascular resistance has been attributed to increased activity of the sympathetic nervous system, abnormal renin-angiotensin-aldosterone relations, and insulin resistance (Dustan 1990). Obesity seems to accentuate the development of a cluster of metabolic disorders (including hypertension and dyslipidemia) among the subjects presenting the syndrome X, referred to as the insulin resistance syndrome (Schmidt et al. 1996; Srinivas et al. 2000).

Correlation coefficients for each of the adiposity and blood pressure markers indicates

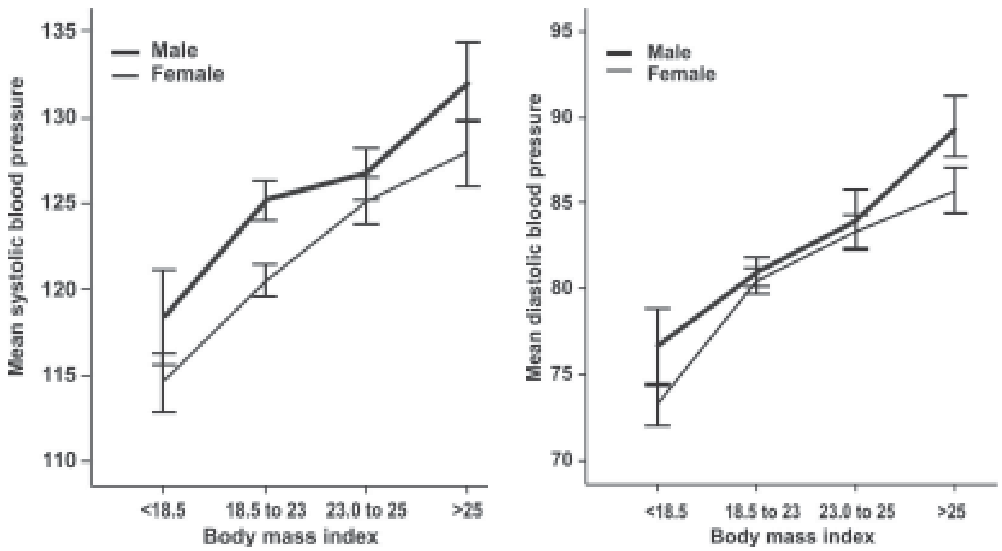

Fig. 1. Mean values of blood pressure against the BMI quartiles in males and females

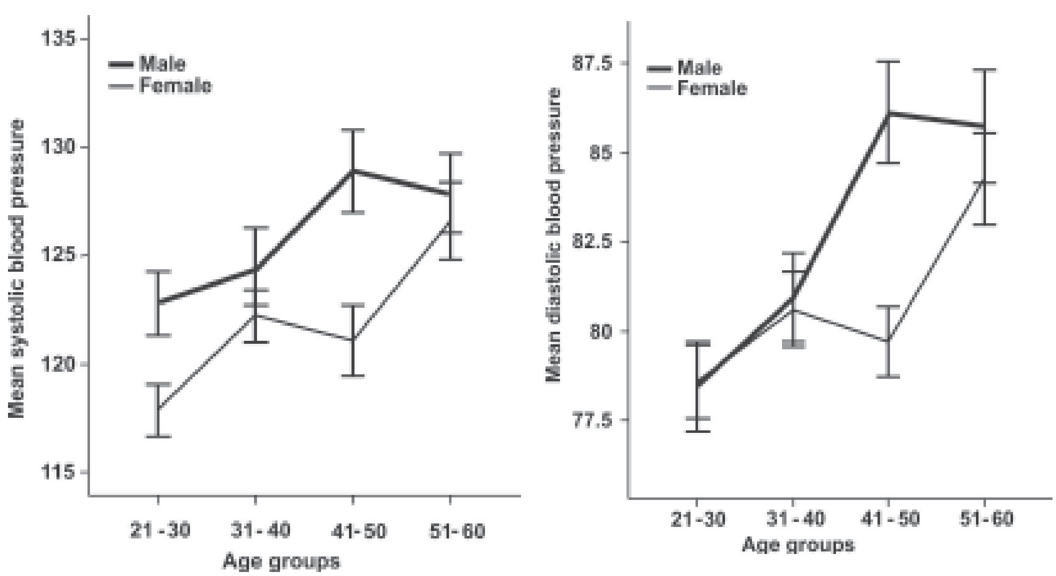

Fig. 2. Mean values of blood pressure against different age groups in males and females

that males dominate females (except for BMI in relation to SBP and DBP), suggesting a greater male responsiveness of BP to gain in overall weight. Significant correlation of BMI to SBP and DBP, in men and women, was reported by studies in Tanzania and Nigeria (Kadiri et al. 1999; Njelekela et al. 2001). Lower correlations between adiposity and blood pressure are documented in female subjects of Ethiopia origin (Tesfaye et al. 2007).

The relationship of BP to cardiovascular mortality has been found to be similar among different countries, continuous and linear, even at the lower range of BP, i.e., below the cut-off points (140/90 or 160/95 mmHg) generally used to define hypertension (Van den Hoogen et al.

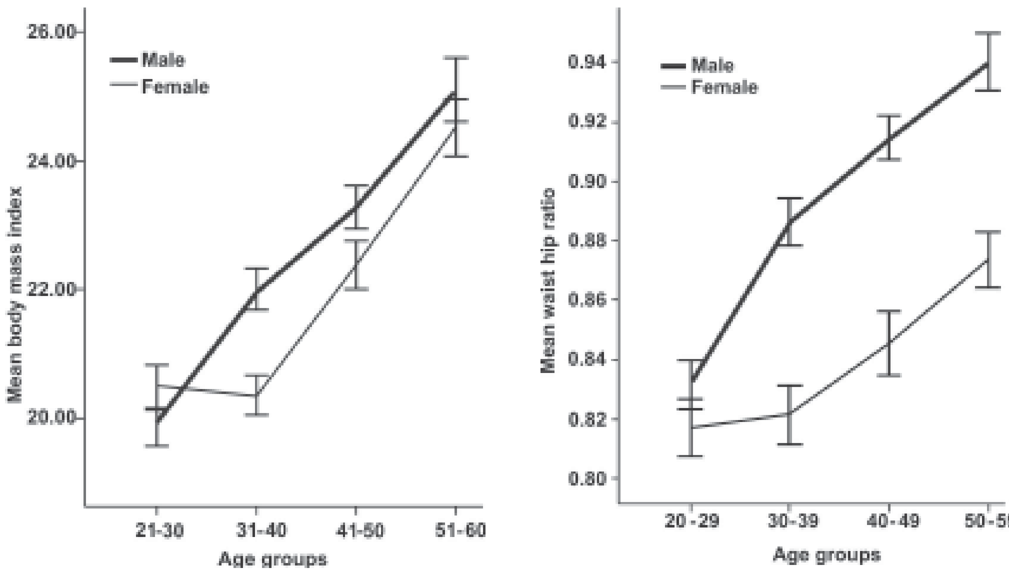

Fig. 3. Mean values for body mass index and waist hip ratio against different age groups in males and females

2000). Therefore, the changes in BP corresponding to define gains in adiposity, which can directly be converted into their effect on the relative risk of death from cardiovascular diseases. Measuring the relation of the adiposity parameters (BMI, WC and WHR) to BP by considering the prevalence of hypertension would underestimate their real impact on mortality.

In the present sample, a constant increase in mean SBP, DBP and adiposity is observed with age in both sexes. Thus, when BP increased with age, the BMI and WHR also increased with age. A significant correlation between blood pressure and age was also reported in an Indian population (Singh et al. 1997). The age-specific prevalence of hypertension increased consistently with increasing age (group), in both genders except in 41-50 yrs age group of female sex, with a steep increase at the age group 51-60 years. A similar pattern has been reported in other studies (Bovet et al. 2002; Mufunda et al. 2006). The prevalence of hypertension at different BMI quartiles revealed a steep rise at fourth quartile in both males and females. Significant associations between BMI and BP have also been documented in various populations (Hu et al. 2000).

In the present study, logistic regression analysis identified obesity, abdominal obesity and age as significant determinants of hypertension in both the genders (males and females). Similar findings have also been reported in other studies (Singh et al. 1997). Relationship between adiposity and BP in this study might be potentially confounded by dietary salt intake and physical activity levels, both of which are not available for the present sample. The study demonstrated that adiposity is closely associated with BP in countries at different stages of socioeconomic and epidemiologic transition. Mean BP levels are increasing consistently with the categories of BMI and WHR. The risk of hypertension is higher with overall and abdominal obesity. Together with data from other studies (Stamler et al. 1978), there is an overall convergence of evidence towards a steeper rise in BP with the advance of age in developing countries when compared to developed countries. In the present study, this mechanism proved to be an independent of body mass and abdominal adiposity while some experts think that body mass is the dominant causal factor (Gyarfas 1996). Further, research is needed to determine the etiopathology of this mechanism.

In conclusion, the results demonstrates that the observed steady and age-independent linear association between BP and adiposity, though weak, favors the population approaches attempting to shift the whole distribution of BP in a more favorable direction by improving the population adiposity profile as measured by anthropometric parameters (BMI and WHR). The present study supports the recommendations of WHO (2003), for developing countries to put emphasis on primary prevention community programs promoting physical activity and healthy dietary habits, including the reduction of alcohol consuming and the intake of salt which are probably involved in the increase of BP with the advance of age. Their benefits are likely to be extended to the control of other disorders such as dyslipidemia, as it was found by a similar study (Reddy et al. 1997).

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