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Association of Body Mass Index, Body Fat Distribution and Fat Patterning with Blood Pressure in Two Populations of Andhra Pradesh

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INTRODUCTION

Physical anthropologists are concerned to a large extent to understand human variability within and between populations and their continuing goal of research is to understand the causes of human variation. Since anthropometric traits vary within and between populations and many studies have been attempted to identify the relative contribution of genetic and environmental factors.

During the last two decades, physical anthropologists were not only studying human variation but also eminently capable of conducting genetic epidemiological research (Majumder and Rao, 1991; Blangero and Blangero, 1993). Among the other epidemiological diseases, coronary heart disease (CHD) has attracted much attention over the last several years as it is one of the major killers in developed as well as in developing countries like India. Many risk factors are responsible for this disease. However, the major and significant risk factors for this CHD are hypertension, hypercholesterolemia, diabetes, obesity and sedentary lifestyle (Singh and Niaz, 1995).

Obesity is considered as a predisposing factor for several chronic diseases including cardiovascular disease (Lapidus et al., 1984; Larsson et al., 1984), hypertension (Williams et al., 1992), stroke (Larsson et al., 1984) and noninsulin-dependent diabetes mellitus (Lundgren et al., 1992; Ohlsson et al., 1985). The understanding of the underlying etiology of obesity can be useful in reducing morbidity and mortality. Several prospective studies have shown that both overall and abdominal obesity are related to cardiovascular disease, either through alterations in one or several of the risk factors or directly (Heitmann, 1992). The body mass index (BMI) refers to the overall fatness where as waist-to-hip ratio (WHR) and conicity index (CI) refers to abdominal adiposity. During the last ten years the abdominal obesity has emerged as an important risk factor for atherosclerosis and coronary heart disease (Paffenberger et al., 1993). However, in the recent years, the conicity index (CI) has been identified as the most important risk factor for cardiovascular disease than the WHR because CI has several advantages over the WHR (*see* Valdez et al., 1993). Both the waist-to-hip ratio and conicity index have got significant associations with most of the risk factors of CHD in seven European populations (Valdez et al, 1993). Kotchen et al. (1993) in their study on weight loss programme did find in females that both BMI had significant positive association with systolic (SBP) and diastolic pressures (DBP) but WHR shows correlation only with SBP. Both BMI and CI find insignificant negative associations with SBP and DBP. In the Pitt county (blacks) study both BMI and WHR showed statistically significant correlations with blood pressure (Croft et al, 1993). In the Micronesian Naurans (Hodge et al., 1993) WHR rather than BMI has shown significant relationship with blood pressure. Positive association of high WHR with elevated blood pressure was observed in bi-racial population (Folsom et al., 1989; Gillum, 1987; Svec et al., 1990). The WHR showed significant positive association with both the blood pressures but not with lipid variables in one of the rural Indian populations (Gupta and Majumdar, 1994). The BMI has associated with blood pressure variables in an Andhra population (Nirmala et al., 1993). In the present study an attempt has been made to examine the association of CI with blood pressure along with the other adiposity measures which were included in the earlier studies (Nirmala et al., 1993; Gupta and Majumdar, 1994).

MATERIALS AND METHODS

The data for the present study have been collected from Bangarupalem mandal of Chittoor district, Andhra Pradesh. Two populations: the Reddi and the Mala with contrasting socio economic and lifestyle backgrounds were selected. The Reddis are basically agriculturists whereas the Malas are agricultural labours. The sample comprises of 209 (Males-107, Females-102) adults of the Reddis and 204 (Males-102, Females-102) adults of the Malas. The age of the subjects ranges from 20-60 years.

The anthropometric measurements such as: height (cm), weight (kg), waist (cm) and abdominal circumference (cm) and six skinfold thickness (SFT) measurements at triceps, biceps, subscapular, supra-iliac, abdominal and calf in mms were recorded according to Weiner and Lourie (1981). By using the above anthropometric measurements, seven adiposity measures were derived. They are, body mass index (BMI = weight(kg)/height(m)^2); four measures of body fat distribution: waist to-hip ratio (WHR = waist circumference/hip girth), conicity index (CI = abdominal girth/(0.109$\sqrt{W/H}$), the sum of the three trunk skinfolds (TSF3 = abdominal + subscapular + suprailiac), the sum of the six skinfolds (SF6 = abdominal + subscapular + suprailiac + calf + triceps + biceps) and two measures of fat patterning: the ratio of the sum of the trunk to the sum of the extremity skinfolds (TE ratio:TSF3/ [calf + triceps + biceps]) and relative fat pattern index (RFPI = subscapular/ [subscapular + suprailiac]). The BMI, TSF3, SF6, TE ratio and RFPI were calculated as described by Hasstedt et al. (1989), the waist to-hip circumference ratio was calculated as per Tanphaichitr et al. (1990) and the conicity index was calculated according to Valdez et al. (1993). The systolic and diastolic blood pressures were recorded with the help of mercury sphygmomanometer.

Statistical Analyses: SPSS was used for statistical analyses. Analyses include the calculation of descriptive statistics, t-test, Pearson's correlation coefficients and multiple linear regression analysis. The multiple linear regression was applied for with SBP and DBP as dependant variables with age and other adiposity measures as independent variables to evaluate the effect of adiposity measures on blood pressure. This was performed in two models. In model 1, all the seven adiposity measures were included as independent variables whereas in model 2, BMI, WHR and CI were included as independent variables.

RESULTS AND DISCUSSION

The descriptive statistics for different variables of males and females of the Reddi and the Mala populations were presented in table 1. The means of all the variables in both sexes were higher among the Reddis than in the Malas except for relative fat pattern index (RFPI). Among the Reddis, females had higher mean values for hip circumference, all the six skin folds, CI,TSF3 and SF6 where as, in the remaining variables males had higher mean values. In the Mala population also a similar pattern was observed for these measurements. However, in both populations no difference was found for relative fat pattern index (RFPI) between the genders. Significant to highly significant differences for all the variables except for age were observed between populations of the same sex.

The Pearson's correlation coefficients among age, BMI, WHR, CI,TSF3, SF6, TE ratio, RFPI, SBP and DBP for the Reddi and the Mala populations were presented in tables 2 and 3, respectively.

Reddis: Age was significantly and positively correlated with all the variables except TE ratio in males, where as in females, age had positive significant association with WHR, CI, SBP and DBP. Age in both the sexes was negatively correlated with TE ratio but this value was statistically insignificant. The BMI, WHR, TSF3 and SF6 were intercorrelated with each other in males and females. In addition to the above, the BMI in males was positively significantly correlated with CI. The TE ratio was negatively correlated with RFPI in both the sexes but the value was insignificant in females. The BMI, TSF3 and SF6 were positively associated with both the blood pressures in males but in females BMI and WHR had significant association with both the pressures. The WHR, CI and RFPI were positively associated with SBP in males. The SBP and DBP

Table 1: Means, standard deviations for different variables among the Reddi and the Mala populations

Variable	*Males*			*Females*		
	Reddis (n = 107)	*Malas (n = 102)*	*t-values*	*Reddis (n = 102)*	*Malas (n = 102)*	*t-values*
Age (yrs)	39.12 ± 14.79	36.85 ± 13.03	1.18*	37.30 ± 13.23	35.13 ± 11.54	1.25*
Height (cm)	168.09 ± 6.22	162.27 ± 6.01	6.92	156.09 ± 5.78	150.19 ± 5.37	7.66
Weight (kg)	60.92 ± 10.97	49.98 ± 7.27	8.54	52.25 ± 11.27	41.40 ± 7.41	8.44
Waist circumferenc (cm)	78.37 ± 8.92	68.89 ± 6.83	8.69	70.61 ± 8.33	63.02 ± 7.15	7.09
Abdominal circumference (cm)	83.48 ± 9.90	73.37 ± 7.93	8.28	81.04 ± 10.75	66.52 ± 8.25	10.75
Hip circumference (cm)	90.78 ± 7.05	81.62 ± 5.16	10.77	91.69 ± 8.18	82.04 ± 7.64	8.77
Triceps skinfold (mm)	11.55 ± 4.13	7.24 ± 3.45	8.28	14.75 ± 3.12	10.81 ± 4.15	7.88
Biceps Skinfold (mm)	6 .96 ± 3.08	3.50 ± 1.85	10.17	9.82 ± 2.94	5.60 ± 2.83	10.55
Subscapular skinfold (mm)	15.92 ± 5.55	9.60 ± 4.56	9.15	18.32 ± 4.13	13.13 ± 5.96	7.30
Suprailiac skinfold (mm)	17.64 ± 6.00	10.44 ± 5.49	9.11	20.93 ± 4.53	13.61 ± 6.25	9.76
Abdominal skinfold (mm)	17.66 ± 5.92	10.89 ± 5.57	8.56	18.28 ± 4.00	13.88 ± 6.16	6.12
Calf skinfold (mm)	12.70 ± 3.38	9.12 ± 3.34	7.95	14.70 ± 3.66	10.86 ± 3.15	8.17
Body mass index (kg/m^2)	21.55 ± 3.70	18.97 ± 2.48	6.14	21.44 ± 4.42	18.34 ± 3.08	5.96
Waist hip-ratio	0.86 ± 0.06	0.84 ± 0.05	3.34	0.77 ± 0.05	0.77 ± 0.05	0.00*
Conicity index	1.28 ± 0.07	1.21 ± 0.08	7.78	1.29 ± 0.10	1.16 ± 0.08	13.00
Sum of three trunk folds (mm)	51.22 ± 16.46	30.93 ± 14.88	9.39	57.54 ± 11.50	40.62 ± 17.93	8.05
Sum of six skin folds (mm)	82.44 ± 25.08	50.78 ± 20.93	9.95	96.80 ± 18.79	67.89 ± 25.96	9.11
TE ratio	1.65 ± 0.26	1.55 ± 0.42	2.50	1.49 ± 0.22	1.47 ± 0.36	0.67*
Relative fat pattern index	0.47 ± 0.05	0.49 ± 0.06	-3.34	0.47 ± 0.04	0.49 ± 0.04	5.00
Systolic blood pressure (mm/Hg)	127.67 ± 18.50	113.00 ± 8.78	7.40	118.91 ± 17.87	109.39 ± 10.49	4.67
Diastolic blood pressure (mm/Hg)	83.59 ± 8.81	76.00 ± 6.96	7.02	79.85 ± 7.85	73.12 ± 7.88	6.11

* insignificant; Abbreviations:TE ratio=The ratio of the sum of the trunk to the sum of the extremity skin folds

Table 2: Pearson's correlation coefficients among age, different adiposity measures and blood pressure in the Reddis

Variable	*Age*	*BMI*	*WHR*	*CI*	*TSF3*	*SF6*	*TE ratio*	*RFPI*	*SBP*	*DBP*
Age		0.159	0.422**	0.634**	0.260	0.074	-0.166	0.046	0.536**	0.233**
BMI	0.424**		0.355**	0.123	0.595**	0.603**	0.032	0.149	0.231*	0.344**
WHR	0.569**	0.513**		0.426**	0.119	0.155	-0.074	-0.012	0.373**	0.223*
CI	0.662**	0.381**	0.543**		0.077	0.144	-0.020*	0.083	0.386**	0.120
TSF3	0.297**	0.785**	0.460**	0.394**		0.950**	0.263**	-0.011	0.082	0.255**
SF6	0.340**	0.793**	0.460**	0.407**	0.986**		-0.045	0.020	0.061	0.203*
TE ratio	-0.147	0.159	0.112	0.030	0.333*	0.178		-0.099	0.078	0.183
RFPI	0.210*	0.126	0.042	0.198*	0.019	0.078	-0.347*		0.048	0.010
SBP	0.424**	0.407**	0.303*	0.363**	0.335**	0.360**	-0.033	0.222*		0.529**
DBP	0.282**	0.314**	0.053	0.169	0.241*	0.277**	-0.125	0.149	0.572**	

Two-tailed significance *p<0.05; **p<0.01

Note: Males=below diagonal; Females=above diagonal

Table 3: Pearson's correlation coefficients among age, different adiposity measures and blood pressure in the Malas

Variable	*Age*	*BMI*	*WHR*	*CI*	*TSF3*	*SF6*	*TE ratio*	*RFPI*	*SBP*	*DBP*
Age		0.003	-0.099	0.131	0.059	0.103	-0.096	0.058	0.304**	0.294**
BMI	0.128		0.270	0.299**	0.844**	0.852**	0.439**	0.043	0.294**	0.239*
WHR	0.225*	0.458**		0.502**	0.166	0.128	0.185*	0.066	0.067	0.027
CI	0.396**	0.347**	0.620**		0.309**	0.299**	0.175	-0.123	0.229*	0.185
TSF3	0.224*	0.779**	0.430**	0.583**		0.982**	0.643**	-0.052**	0.216*	0.186
SF6	0.206*	0.793**	0.386**	0.558**	0.980**		0.496**	-0.030**	0.233*	0.193
TE ratio	0.188*	0.347**	0.403**	0.423**	0.634**	0.476**		-0.131	0.043	0.045
RFPI	-0.236*	-0.153	-0.223*	-0.304**	-0.312**	-0.291**	-0.307**		0.175	0.078
SBP	0.295**	0.289**	-0.019	0.151	0.286**	0.263**	0.252*	0.100*		0.530**
DBP	-0.027	0.232*	-0.007	0.053	0.203*	0.220*	0.026	0.075	0.507*	

Two-tailed significance *p<0.05; **p<0.01

Note: Males=below diagonal;Females=above diagonal were intercorrelated with each other in both the sexes.

Malas: Age was significantly and positively associated with all the variables except BMI and DBP in males where as in females age was significantly correlated with SBP and DBP only. The body mass index and all the body fat distribution measures were associated significantly and positively with each other in males but in females this trend was not observed. The TE ratio was negatively related with RFPI in both the sexes but this value was significant only in males. The BMI, TSF3, SF6 were significantly associated with both the pressures in males but in females BMI was significantly related with both the pressures and CI, TSF3 and SF6 were positively related with only with SBP. In the Malas also, SBP and DBP were intercorrelated with each other.

The results of the multiple linear regression analysis with SBP and DBP as dependent variables were presented in table 4 (model 1). There was a significant positive relationship of age with SBP in females of both populations and SBP for males and DBP of females of the Malas. The BMI had a positive and significant relationship with DBP in females of Reddis and SBP with both sexes in Malas. The WHR was negatively related with DBP in males of Reddis and SBP in males of Malas. Based on the coefficient of relationship (r^2) values it has been observed that all adiposity measures contributed 27% and 20% to the variability of SBP and DBP, respectively in the Reddi males where as in the Reddi females, it was 36% for SBP and 20% for DBP. In the Mala males, 28% and 9% of variability of SBP and DBP, respectively was due these measures. In the Mala females, 23% variability of SBP and 19% of DBP was due to these measures. By keeping BMI, WHR and CI (model 2), the multiple regression analysis was performed to evaluate the influence of these three adiposity measures on blood pressure and the results were shown in table 5. The BMI was the only adiposity measure which had significant positive association with both the pressures in both the populations of both the sexes excepting SBP in the Reddi females. The conicity index had significant positive association only

Table 4: Multiple linear regression analysis with SBPand DBP as dependant variables

Variable	*Reddis*				*Malas*			
	Males		*Females*		*Males*		*Females*	
	SBP Stand.b	*DBP Stand.b*	*SBP Stand. b*	*DBP Stand.b*	*SBP Stand.b*	*DBP Stand.b*	*SBP Stand.b*	*DBP Stand.b*
Age	0.230	0.259	0.451***	0.217	0.305**	-0.041	0.286**	0.309**
BMI	0.208	0.257	0.156	0.266*	0.394*	0.183	0.416*	0.364
WHR	-0.023	-0.268*	0.118	0.067	-0.301*	-0.137	-0.113	-0.131
CI	0.086	-0.009	0.074	-0.040	0.111	0.050	0.190	0.131
TSF3	-1.324	-1.209	0.074	0.272	-1.198	0.580	0.997	2.802
SF6	1.351	1.287	0.364	-0.231	0.943	-0.353	-1.059	-2.638
TE ratio	0.212	0.085	0.312	0.125	0.523	-0.163	-0.219	-0.569
RFPI	0.124	0.026	0.017	-0.016	0.260	0.106	0.163	0.061
r2	0.269	0.197	0.360	0.197	0.278	0.091	0.233	0.189

*p<0.05; **p<0.01; ***P>0.001 Abbreviations: Stand. b = Standardised b

Table 5: Multiple linear regression analysis with SBPand DBP as dependant variables

Variable	*Reddis*				*Malas*			
	Males		*Females*		*Males*		*Females*	
	SBP Stand.b	*DBP Stand.b*	*SBP Stand. b*	*DBP Stand.b*	*SBP Stand.b*	*DBP Stand.b*	*SBP Stand.b*	*DBP Stand.b*
BMI	0.310***	0.370***	0.122	0.304**	0.340**	0.293**	0.261*	0.218*
WHR	0.012	-0.218	0.210	0.098	-0.255	-0.181	-0:107	-0.123
CI	0.239*	0.148	0.282**	0.041	0.191	0.064	0.205	0.182
r2	0.127	0.130	0.125	0.131	0.122	0.073	0.117	0.082

*p<0.05; **p<0.01; ***P> 0.001 Abbreviations: Stand.b = Standardised b with SBP in both sexes of the Reddis. No significant association was found with WHR in both the populations. The values of r^2 showed that 13% of variability of each was explained by BMI, WHR and CI in both the sexes of the Reddis on both the pressures. The variability due to these measures was lower in the Mala males (12% and 7%) for SBP and DBP, respectively. However, the variability was 11% and 8% in females on SBP and DBP, respectively.

Overweight and obesity may lead to many disease conditions like diabetes, hypertension, coronary and vascular disease. However, in recent years, the truncal obesity has emerged as an important factor in genesis of atherosclerosis and coronary heart disease (Paffenberger et al., 1993). Vague has observed in 1956 itself that excess body fat around the abdomen was related to diabetes and atherosclerosis in both males and females.

In the present report, though the two populations were significantly differing in all the adiposity measures, most of the adiposity measures had shown significant correlation with blood pressure. But in regression analysis, BMI was the only variable which had significant association with blood pressure (model 2) and the same was observed in one other population from Andhra Pradesh (Nirmala et al., 1993). The WHR of rural males of Rajasthan showed positive correlation with SBP and DBP but not with lipid levels (Gupta and Majumdar, 1994). The Naurans (Micronesian population) though having high prevalence of obesity and higher values of WHR, the WHR alone was significant for both systolic and diastolic blood pressure in both the sexes and BMI showed significant association only with DBP in females (Hodge et al., 1993). Our study failed to show such significant influence of WHR with blood pressure. This may be possibly because of lower values of WHR in the present populations compared to Naurans (Hodge et al., 1993) and Rajasthanese (Gupta and Majumdar, 1994). The results of multiple linear regression analysis (model 2) showed that the body mass index has greater influence on blood pressure than the other adiposity measures. And the conicity index was significant in the case of SBP of both the sexes of the Reddis only. It might be due to the fact that the abdominal adiposity and subcutaneous adipose tissue were lower in the Malas compared to the Reddis. The reasons might also be attributed to ethnic as well as socio-economic disparities between these two populations. The Reddis were better-off section over the Malas and as such Reddis were better in their nutrition and more sedentary than the Malas. In terms of physical activity, the Malas were involved in more physical activity than the Reddis. The higher frequencies of smokers and tobacco chewing were also observed in the Malas.

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KEY WORDS Adiposity Measures. Blood Pressure. Correlaton. Regression Analysis. Andhra Populations.

ABSTRACT The association of systolic and diastolic blood pressures with body mass index, waist-hip ratio, conicity index, the sum of the three trunk skinfolds, the sum of the six skinfolds, the ratio of the sum of the trunk to the sum of the extremity skinfolds and relative fat pattern index and the correlations between each of these were examined among 209 and 204 adults of the Reddi and the Mala populations, respectively of Andhra Pradesh, India. The correlation coefficients of the adiposity measures and blood pressure are intercorrelated with each other with a few exceptions in both the populations. The multiple linear regression of age, BMI, WHR, CI, TSF3, SF6, TE ratio and RFPI with blood pressure did not show consistent relationship. But regression on blood pressure by BMI, WHR and CI after excluding other adiposity measures shows that the BMI is the best indicator to influence blood pressure in both the populations and CI is influencing SBP only in the Reddis.

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