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Familial Aggregation of Blood Pressure with Respect to Anthropometric Variables in a Business Community of Punjab, a North Indian State

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A B S T R A C T

This study aimed to examine the familial aggregation of blood pressure with respect to anthropometric variables in an upper-middle class business community in Punjab, a northern state of India. The results were evaluated in a sample of 75 families, constituting 305 individual from three generations such as offspring, parental and grandparental. The data were analyzed through familial correlations, multiple regressions, percent of variance and univariate analysis. The data indicate a strong familial aggregation of blood pressure in this population especially in offspring generations and show that such a familial influence on blood pressure can be detected from the different anthropometric variables, genetic factors, shared household environment and age. These effects were strong in SBP and moderate in DBP. SBP and DBP have showed higher genetic correlation with many anthropometric characters in offspring generation as compared to other generations. These correlations are negligible in male grandparental generation. The results suggest that almost all measured variables are significant multivariate correlates with blood pressure.

Key words: *familial aggregation, blood pressure, Bania population, India*

Introduction

It is well documented that blood pressure is a strong risk factor for cardiovascular diseases[1–4]. Many epidemiological studies[1,4–6] have suggested anthropometric indicators such as body mass index (BMI), waist-hip-ratio (WHR), waist circumference (WC) and thickness of skinfolds correlate significantly with blood pressures. However, familial concentration of blood pressure among genetically close relatives such as parent and offspring, brother and sister have suggested in many studies[7–9]. Hence, it appears that the degree of aggregation to be greater in first degree relatives than genetically distant relatives. The familial aggregation of blood pressures with respect to anthropometric measurements and other physiological traits have been well reported form western populations[10–13]. However, country like India undergoing rapid economic expansion have limited population based data and intervention program in this context. Keeping in mind that India with its high cardiovascular disease morbidity and mortality, the present homogeneous population is well suited for family studies aimed to investigate the familial aggregation of blood pressure and to evaluate association of some anthropometric measurements among the samples of families with three generations such as offspring, parental and grandparental. This study also reports familial correlations and the effects of cohabitation on these correlations. Despite of many recent studies[4,14–19], relatively few studies have reported the relative contribution of these anthropometric traits such as BMI, WHR and skinfold for aggregation of blood pressure in the families. Therefore, in the present study, we have attempted to quantify the contribution of large number of anthropometric characters for familial aggregation of blood pressure in three generations. This study would also help to identify the suitable anthropometric parameters for tracking the aggregation of blood pressure in the family as a greater risk for cardiovascular diseases.

In particular, family studies from India, where home environment and caste membership play an important role, are emerging as an important contributor for familial aggregation of blood pressure. Some distinguished factors have been found in Indian population as compared to western societies such as: (i) marriage within

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caste or consanguinity has been seen in most of the parts of the country, which may effect spouse resemblance and genetic similarities (increased homozygosity) (ii) the meals are consumed primarily at home with strictly under female's observation (mother, grand mother or at least older sister). Sharing common household in general may lead to increase similarity among family members which may affect familial aggregation of blood pressure[16,20].

Materials and Methods

The family study

Data were collected in Bania community located in the state of Punjab, India. This community is mostly engaged in business and trades, as compared with other parts of India, Punjab have larger sections of employment in agriculture and industrial sectors. All participant families are engaged in similar type of business. The education level and socio-economic status of all selected families are fairly high. Unemployed individuals are very rare in this community, whereas, mothers were often housewives. Therefore, it is assumed that high socio-economic status, sedentary life style, physical inactivity and rich diet are statistically related to cardiovascular disease but familial genetic factors probably are also play an important role. They are primarily vegetarians and non-alcoholic, however, many male members of the family prefer alcoholic drink time to time especially in social functions or gatherings. They are mostly living in single household and share both genes and environment. They are also living in patrilocal family system like other typical Indian populations where wives have migrated to their husband's residence. The core of the household consists of a group of brothers, their wives, unmarried sister, their parents and grandparents. Consanguineous marriages are very rare in this community.

Samples

The recruitment of the samples was done through surveys and subsequent visits of randomly selected households' inhabitants in this community. Table 1 presents a list of variables that are significant independent predictors of cardiovascular diseases and sample sizes for three generations. A total of 305 individuals, constituting 75 families were ascertained to study. The mean age of male offspring generation (N=53) is 16.87±5.0 (SD) years (range 10 to 27 years) and for female offspring generation (N=45) is 17.17±4.62 (SD) years (range 10 to 22 years). The mean age of male parental generation (N=72) is 42.55±8.25 (SD) years (range 28 to 55 years) and for female parental generation (N=74) is 39.81±8.13 (SD) years (range 23 to 53 years). The mean age of male grandparental generation (N=29) is 63.22±7.73 (SD) years (range 56 to 75 years) and for female grandparental generation (N=32) is 59.89±7.99 (SD) years (range 54 to 75 years).

TABLE 1
DISTRIBUTION OF SUBJECTS BY SEX, GENERATIONS AND DIFFERENT CATEGORICAL VARIABLES

Population/variables	Anthropometric	Physiometric
Variables	Height, Weight, Waist circumference, Hip circumference, BMI, WHR, Biceps skinfold, Triceps skinfold, Subscapular skinfold and Suprailiac skinfold	Systolic blood pressure (SBP), Distolic blood pressure (DBP), Mean Arterial blood pressure (MBP) and Pulse rate
Population	Sample size	Sample size
Male grand parents	29	29
Female grand parents	32	32
Male parents	72	72
Female parents	74	74
Male offspring	53	53
Female offspring	45	45
Total	305	305

Measurements

All the measurements and information were taken by the second female author at home or work place of the subjects by face to face and therefore, inter-investigator error is ruled out and all measurements have been taken through same protocol. The anthropometric measurements were height, weight, waist circumference, hip circumference and four skinfolds (biceps, triceps, subscapular and suprailliac). The physiometric variables were systolic (SBP), diastolic (DBP) and mean arterial blood pressure (MBP) which is defined as the average blood pressure level during cardiac cycle and pulse rate. All anthropometric measurements were taken on each individuals using standard anthropometric techniques[21,22]. BMI was calculated as weight in kilograms divided by height in meters squared. WHR was calculated as waist circumference divided by hip circumference. Mean arterial blood pressure (MBP) was simply estimated[23] as DBP+(SBP-DBP)/3. Two consecutive readings were recorded for each of SBP and DBP and the average was used. The systolic (first phase) and diastolic (fifth phase) blood pressures were measured with mercury sphygmomanometer in a sitting position with the right forearm placed horizontal on the table. The recordings were taken as recommended by American Heart Association[24]. All procedure related assessments of the subjects were approved by the Ethical Committee of the Guru Nanak Dev University, Amritsar, Punjab in 2007 and all subjects gave written consent. The number of complete illiterate subjects is very negligible in the present samples.

Statistical analysis

Various pair-wise intra-familial correlations were estimated with blood pressure phenotypes. Simple product moment correlation coefficients for SBP, DBP and MBP were calculated for all measured variables among different generations. The multiple regressions and analysis of variances (univariate) of each variable were done to find out significant predictor of blood pressure in each generation. Two-tailed tests were used and probability levels >0.05 for statistical significance are reported. All data were analyzed by SPSS (SPPS Inc., Chicago, IL, USA, and Version 17).

Results

Descriptive statistics for systolic, diastolic and mean arterial blood pressure alongwith other anthrometric measurements such as height, weight, BMI, waist circumference, hip circumference, WHR, four skinfolds (biceps, triceps, subscapular and suprailiac), pulse rate and mean average age are presented in Table 2 among different generations. As shown in the table, the maximum mean values of anthropometric variables such as height, weight, BMI and three skinfolds (triceps, subscapular and supralic) are found in male parental generation. The mean values of waist and hip circumferences, WHR, biceps skinfold, SBP, DBP and MBP are found maximum in male grandparental generation whereas, maximum pulse rate is found only in male offspring generation. However, the same trend is found for height, weight, hip circumference, WHR, three skinfolds (triceps, subscapular and suprailiac), SBP, DBP, MBP and pulse rate among respective counter female generation.

The maximum population heterogeneity or variability for different measured variables are found in age, weight and three skinfolds (triceps, subscapular and suprailiac) for male parental generations, biceps, SBP and MBP for female parental generation, waist circumference, DBP and pulse rate for male parental generation; height for female offspring generation.

Ten intra-familial correlation coefficients and estimated sample size in pairs are presented in Table 3. The correlations between spouse, father-offspring (male and female), mother-offspring (male and female), grandfather-offspring (male and female) for blood pressure phenotypes are all about same magnitude and highly significant. The familial correlations for grandmother-offspring (male and female) are not significant with blood pressure. The sibling (brother-sister) correlation is higher as compared to others. For SBP, DBP and MBP, the magnitude of the correlation was maximum for brother-sister pairs (0.306, 0.325 and 0.332 respectively) and followed by grandfather-female offspring (0.226) for SBP, mother-male offspring (0.258) for DBP and grandfather-female offspring (0.254) for MBP. The least was found among grandmother-female offspring for SBP (0.029) and DBP (0.046). The overall pattern of contrasting correlations between different relative pairs showed genetic and environmental effects.

Estimates of Pearson product-moment correlation coefficients for blood pressure phenotypes with other metric variables along with their significance level are presented in Table 4 among different categories of generations. Almost all variables except WHR and pulse rate are found significantly correlated ($p<0.05$) with blood pressures among male offspring generation, whereas, only waist circumference has been found significantly correlated with SBP and MBP among female offspring generation. Weight, BMI, waist circumference and WHR

TABLE 2
DESCRIPTIVE STATISTICS FOR ALL VARIABLES BETWEEN DIFFERENT CATEGORIES OF GENERATIONS

Variables	MO	FO	MP	FP	MGP	FGP
Age (years)	16.87±5.06	17.17±4.62	42.55±8.25	39.81±8.13	63.32±7.73	59.89±7.99
Height (cm)	162.26±7.40	155.33±8.17	170.20±5.77	157.24±4.87	169.13±6.39	156.07±6.29
Weight (kg)	58.62±8.35	52.36±8.67	78.37±10.06	69.01±9.73	76.63±7.82	68.42±9.23
BMI	21.60±4.60	21.69±3.79	27.16±3.19	27.93±3.83	26.67±4.53	28.02±3.95
Waist Circumference (cm)	74.26±7.75	69.91±9.09	95.76±9.20	98.76±7.35	97.94±10.96	90.53±10.24
Hip Circumference (cm)	84.74±8.85	88.19±10.34	99.09±7.17	102.2±9.97	99.65±8.70	103.09±10.25
WHR	0.87±0.006	0.79±0.002	0.961±0.005	0.85±0.006	0.978±0.006	0.88±0.006
Biceps Skinfold (mm)	5.82±2.96	6.99±2.62	7.57±2.98	10.17±3.92	7.60±3.14	8.54±3.70
Triceps Skinfold (mm)	10.26±2..25	12.54±2..55	12.49±3.96	18.19±2.62	12.24±2.68	16.10±2.62
Subscapular Skinfold (mm)	14.20±2.35	17.54±2.10	24.58±3.35	24.67±2.46	21.57±2..21	22.63±3.01
Suprailiac Skinfold (mm)	14.84±2.70	16.59±2.26	23.16±3.62	24.18±2.16	21.92±2.80	23.30±2.39
SBP (mm Hg)	118.20±8.44	116.84±5.23	131.76±7.75	127.31±10.63	137.41±9.75	134.03±8.83
DBP (mm Hg)	78.03±6.63	76.84±5.01	89.19±8.85	84.95±8.79	92.75±9.31	91.09±7.89
MBP (mm Hg)	91.42±7.16	90.28±4.94	103.17±7.35	99.07±9.20	107.64±8.91	105.40±8.35
Pulse rate	75.90±5.25	75.66±5.90	73.81±5.24	73.48±4.99	74.13±6.36	74.68±6.05

MO – Male Offspring, FO – Female Offspring, MP – Male Parent, FP – Female Parent, MGP – Male Grand Parent, FGP – Female Grand Parent

TABLE 3
ESTIMATES OF FAMILIAL CORRELATIONS WITH STANDARD ERRORS (SE) FOR BLOOD PRESSURE PHENOTYPES

Parameters	SBP	DBP	MBP	N (No. of Pairs)
Spouse	0.209±0.05	0.217±0.07	0.224±0.06	146
Father-male offspring	0.203±0.06	0.226±0.05	0.216±0.07	125
Father-female offspring	0.211±0.08	0.201±0.08	0.232±0.07	117
Mother-male offspring	0.211±0.06	0.258±0.06	0.236±0.07	127
Mother-female offspring	0.201±0.07	0.199±0.06	0.216±0.07	119
Brother-sister	0.306±0.07	0.325±0.06	0.332±0.08	98
Grandfather-male offspring	0.197±0.06	0.207±0.06	0.210±0.06	82
Grandfather-female offspring	0.226±0.06	0.245±0.07	0.254±0.07	74
Grandmother-male offspring	0.083±0.06*	0.092±0.05*	0.029±0.05*	85
Grandmother-female offspring	0.029±0.06*	0.046±0.05*	0.071±0.05*	77

*Correlation is not significant as based on SEs

are significant for SBP ($p<0.05$) among male parental generation. It is interesting to note that no variables have been found significantly correlated with DBP and MBP for male parental generation. Age, weight, BMI and four skinfolds (biceps, triceps, subscapular and supra-liac) have shown significant correlation ($p<0.05$) with blood pressures among female parental generation. It has also been seen that all observed variables except age and height for male grandparental generation and age for female grandparental generation are not significantly correlated with SBP, DBP and MBP. The overall patterns of correlations suggested that multiple regression model may provide a different kind of relationship between anthropometrics and blood pressures.

In multiple regressions models, the standardized regression coefficient with associated standard errors (SE) and the percent of variance accounted by the regressions (R^2) for SBP and DBP are given in the Tables 5 to 7 among different generations. All measured variables except pulse rate have significant effect ($p<0.05$) on SBP and DBP among male offspring generation (Table 5). Maximum percent of variances (R^2) are found for age (33% for SBP and 41% for DBP) and are followed by weight and waist circumference (29%, 28% for SBP and

TABLE 4
ESTIMATES OF CORRELATION COEFFICIENTS FOR BLOOD PRESSURE WITH OTHER METRIC VARIABLES AMONG DIFFERENT GENERATIONS

Variables	Male Offspring			Female Offspring			Male Parent			Female Parent			Male Grandparent			Female Grandparent		
	SBP	DBP	MBP	SBP	DBP	MBP	SBP	DBP	MBP	SBP	DBP	MBP	SBP	DBP	MBP	SBP	DBP	MBP
Age (yrs)	0.60**	0.65**	0.64**	0.14	0.21	0.20	0.19	0.21	0.20	0.37**	0.33**	0.35**	0.34*	0.37*	0.38*	0.63**	0.57**	0.60**
HT (cm)	0.45**	0.51**	0.49**	0.02	0.06	0.03	0.03	0.06	0.03	0.07	-0.05	-0.02	0.39*	0.56**	0.52**	–0.41	–0.01	–0.14
WT (kg)	0.56**	0.59**	0.59**	0.26	0.20	0.21	0.26*	0.20	0.21	0.36**	0.30**	0.33**	0.19	0.20	0.32	–0.15	–0.15	–0.15
BMI	0.48**	0.48**	0.48**	0.28	0.19	0.23	0.28**	0.19	0.23	0.36**	0.33**	0.34**	0.07	0.21	0.15	–0.15	–0.16	–0.16
WC (cm)	0.54**	0.55**	0.55**	0.49**	0.29	0.35*	0.41**	0.29	0.21	0.05	0.01	0.05	0.18	0.21	0.22	0.15	0.19	0.18
HC (cm)	0.45**	0.50**	0.48**	0.27	0.20	0.21	0.17	0.20	0.21	0.19	0.12	0.16	0.1	0.19	0.21	0.10	0.08	0.06
WHR	0.26	0.23	0.29	0.19	0.09	0.02	0.38**	0.09	0.02	0.06	0.04	0.04	0.20	–0.17	–0.03	0.19	0.18	0.22
BSF (mm)	0.36**	0.36**	0.36**	0.17	0.14	0.14	0.14	0.14	0.14	0.24*	0.26*	0.25*	0.10	0.10	0.03	–0.16	–0.15	–0.15
TSF (mm)	0.28*	0.33*	0.29*	0.06	0.03	0.06	0.23	0.03	0.06	0.23*	0.24*	0.22*	0.15	0.35	0.31	–0.08	–0.09	–0.09
SSF (mm)	0.46**	0.51**	0.49**	0.12	0.06	0.10	0.12	0.06	0.10	0.39**	0.33**	0.37**	0.03	0.14	0.11	–0.10	–0.09	–0.09
SISF (mm)	0.42**	0.45**	0.44**	0.17	0.13	0.16	0.17	0.13	0.16	0.27*	0.26*	0.24*	0.23	0.26	0.28	0.19	0.19	0.19
PR	–0.06	–0.02	–0.03	–0.24	–0.29	–0.27	–0.16	–0.29	–0.27	–0.15	–0.13	–0.14	0.11	0.10	0.02	–0.19	–0.20	–0.21

**Correlation is significant at the 0.01 level (2 tailed), *Correlation is significant at the 0.05 level (2 tailed), HT –Height, WT – Weight, BMI –Body Mass Index, WC – Waist Circumference, HC – Hip Circumference, WHR –Waist-Hip Ratio, BSF – Biceps Skinfold, TSF –Triceps Skinfold, SSF – Subscapular Skinfold, SISF – Suprailiac Skinfold, PR – Pulse Rate

TABLE 5
STANDARDIZED REGRESSION COEFFICIENT AND STANDARD ERROR AND PERCENT OF VARIANCE (R^2) FOR DIFFERENT VARIABLES IN MULTIPLE REGRESSION MODEL FOR SBP AND DBP AMONG MALE (N=53) AND FEMALE (N=45) OFFSPRING GENERATIONS

Variables	Male Offspring				Female Offspring			
	SBP		DBP		SBP		DBP	
	Coefficients	R^2	Coefficients	R^2	Coefficients	R^2	Coefficients	R^2
Age (yrs)	0.99±0.29**	0.33	0.85±0.13**	0.41	0.16±0.17	0.01	0.23±0.16	0.02
HT (cm)	0.22±0.06**	0.19	0.19±0.04**	0.25	0.02±0.09	0.02	0.04±0.09	0.02
WT (kg)	0.26±0.10	0.29	0.19±0.07**	0.34	0.12±0.07	0.04	0.09±0.07	0.02
BMI	0.88±0.22**	0.22	0.69±0.16**	0.22	0.39±0.20	0.06	0.25±0.19	0.01
WC (cm)	0.33±0.07**	0.28	0.26±0.056**	0.29	0.23±0.08**	0.15	0.16±0.08*	0.06
HC (cm)	0.27±0.75**	0.19	0.26±0.07**	0.23	0.12±0.07	0.03	0.09±0.07	0.02
WHR	31.9±16.8*	0.05	19.27±2.5**	0.02	11.9±2.09*	0.02	5.49±2.01*	0.14
BSF (mm)	1.04±0.37**	0.11	0.89±0.29**	0.11	0.34±0.30	0.07	0.27±0.29	0.03
TSF (mm)	0.47±0.11**	0.06	0.41±0.17**	0.07	0.008±0.224	0.02	0.05±0.22	0.02
SSF (mm)	0.51±0.14**	0.20	0.46±0.10**	0.24	0.104±0.133	0.09	0.05±0.13	0.02
SISF (mm)	0.46±0.14**	0.16	0.38±0.10**	0.18	0.14±0.12	0.06	0.10±0.12	0.06
PR	–0.09±0.22	0.01	–0.03±0.17	0.02	–0.29±0.13	0.03	–0.25±0.12*	0.07

**Coefficient is significant at the 0.01 level (2 tailed), *Coefficient is significant at the 0.05 level (2 tailed). HT – Height, WT – Weight, BMI – Body Mass Index, WC – Waist Circumference, HC – Hip Circumference, WHR – Waist-Hip Ratio, BSF – Biceps Skinfold, TSF – Triceps Skinfold, SSF – Subscapular Skinfold, SISF – Suprailiac Skinfold, PR – Pulse Rate

34%, 29% for DBP respectively) in this generation. Among female offspring generation, the regression coefficients of waist circumference and WHR are significant ($p<0.05$) for SBP and DBP. The maximum percent of variances (R^2) for SBP and DBP were 15% and 14% (Table 5). Therefore, all measurements except pulse rate among male offspring and only waist circumference and WHR among female offspring have significant impact on SBP

TABLE 6
STANDARDIZED REGRESSION COEFFICIENT AND STANDARD ERROR AND PERCENT OF VARIANCE (R2) FOR DIFFERENT VARIABLES IN MULTIPLE REGRESSION MODEL FOR SBP AND DBP AMONG MALE PARENTAL (N=72) AND FEMALE PARENTAL (N=74) GENERATIONS

Variables	Male Parent				Female Parent			
	SBP		DBP		SBP		DBP	
	Coefficients	R^2	Coefficients	R^2	Coefficients	R^2	Coefficients	R^2
Age (yrs)	0.30±0.18	0.02	0.27±0.16	0.03	0.48±0.14**	0.13	0.35±0.12**	0.09
HT (cm)	–0.30±0.27	0.03	–0.21±0.23	0.02	0.01±0.26	0.01	–0.09±0.21	0.01
WT (kg)	0.34±0.15*	0.05	0.17±0.13	0.01	0.39±0.12**	0.12	0.27±0.10*	0.07
BMI	1.35±0.46**	0.09	0.72±0.41	0.08	0.98±0.31**	0.11	0.74±0.22**	0.09
WC (cm)	0.52±0.16**	0.12	0.26±0.14*	0.05	0.05±0.01	0.01	0.01±0.01	0.01
HC (cm)	0.31±0.22	0.02	–0.04±0.18	0.01	–0.21±0.12	0.02	0.10±0.10	0.01
WHR	84.5±24.9**	0.13	64.9±21.4**	0.10	9.7±1.16**	0.01	5.7±17.0	0.01
BSF (mm)	0.61±0.52	0.05	0.34±0.44	0.06	0.64 ±0.31*	0.04	0.41±0.26*	0.02
TSF (mm)	0.76±0.39*	0.04	0.65±0.33*	0.04	0.41±0.20*	0.040	0.27±0.17*	0.02
SSF (mm)	–0.02±0.09	0.01	–0.03±0.07	0.01	0.64±0.18**	0.14	0.45±0.15**	0.09
SISF (mm)	0.54±0.27	0.04	0.43±0.23	0.03	0.47±0.19*	0.06	0.29±0.16	0.03
PR	–0.40±0.29	0.01	–0.40± 0.25	0.20	–0.31±0.25	0.08	–0.21±0.20	0.02

**Coefficient is significant at the 0.01 level (2 tailed), *Coefficient is significant at the 0.05 level (2 tailed). HT – Height, WT – Weight, BMI – Body Mass Index, WC – Waist Circumference, HC – Hip Circumference, WHR – Waist-Hip Ratio, BSF – Biceps Skinfold, TSF – Triceps Skinfold, SSF – Subscapular Skinfold, SISF – Suprailiac Skinfold, PR – Pulse Rate

TABLE 7
STANDARDIZED REGRESSION COEFFICIENT AND STANDARD ERROR AND PERCENT OF VARIANCE (R^2) FOR DIFFERENT VARIABLES IN MULTIPLE REGRESSION MODEL FOR SBP AND DBP AMONG MALE GRAND PARENTAL (N=29) AND FEMALE GRAND PARENTAL (N=32) GENERATIONS

Variables	Male GrandParent				Female GrandParent			
	SBP		DBP		SBP		DBP	
	Coefficients	R^2	Coefficients	R^2	Coefficients	R^2	Coefficients	R^2
Age (yrs)	0.52±0.27	0.08	–0.09±0.23	0.03	0.96±0.21**	0.38	0.88±0.22**	0.31
HT (cm)	0.54±0.33	0.05	0.80±0.23**	0.28	–0.07±0.35	0.03	–0.01±0.35	0.03
WT (kg)	0.04±0.16	0.03	0.27±0.11*	0.14	–0.17±0.20	0.09	–0.17±0.20	0.09
BMI	–0.18±0.49	0.03	0.43±0.38	0.08	–0.45±0.55	0.01	–0.51±0.55	0.05
WC (cm)	0.190±0.203	0.05	0.17±0.16	0.06	0.17±0.21	0.01	0.22±0.21	0.05
HC (cm)	0.13 ±0.26	0.03	0.44 ±0.18*	0.14	0.11 ±0.21	0.02	0.02±0.21	0.03
WHR	34.8±5.35**	0.03	–23.7±5.3**	0.09	35.6±2.9*	0.05	66.3±31.4*	0.09
BSF (mm)	–0.36±0.72	0.07	0.29±0.56	0.07	–0.50±0.59	0.09	–0.51±0.59	0.08
TSF (mm)	0.38 ± 0.48	0.03	0.69±0.35	0.09	–0.18 ± 0.39	0.02	–0.21±0.39	0.03
SSF (mm)	0.08 ±0.36	0.04	0.23±0.28	0.01	–0.236±0.42	0.02	–0.22±0.42	0.04
SISF (mm)	0.40±0.32	0.02	0.35±0.25	0.03	0.36±0.34	0.04	0.36±0.34	0.04
PR	–20±0.35	0.024	0.15±0.28	0.03	0.77±0.33	0.12	–0.61±0.35	0.06

**Coefficient is significant at the 0.01 level (2 tailed), *Coefficient is significant at the 0.05 level (2 tailed). HT – Height, WT – Weight, BMI – Body Mass Index, WC – Waist Circumference, HC – Hip Circumference, WHR – Waist-Hip Ratio, BSF – Biceps Skinfold, TSF – Triceps Skinfold, SSF – Subscapular Skinfold, SISF – Suprailiac Skinfold, PR – Pulse Rate

and DBP. Hence, 33% and 28% of SBP, 41% and 29% of DBP aggregation or elevation could be explained by age and waist circumference in male offspring, whereas 15% of SBP and 14% of DBP aggregation could be explained by waist circumference and WHR in female offspring respectively. The regression coefficients of waist circumference, WHR and triceps skinfold for SBP and DBP are significant ($p<0.05$) among male parental generation (Table 6). Among female parental generation, the significant ($p<0.5$) regression coefficients are found in age, weight, BMI, and four skinfolds (biceps, triceps, subscapular and suprailiac) for SBP and DBP (Table 6). However, the per-

TABLE 8
ANALYSIS OF VARIANCE (UNIVARIATE) WITH LEVEL OF SIGNIFICANCE OF SBP AND DBP WITH RESPECT TO OTHER VARIABLES AMONG MALE (N=53) AND FEMALE (N= 45) OFFSPRING GENERATIONS

Variables	Male Offspring				Female Offspring			
	SBP		DBP		SBP		DBP	
	F	P	F	P	F	P	F	P
Age (yrs)	14.11	0.000	38.50	0.000	0.949	0.335	1.98	0.167
HT (cm)	13.49	0.001	18.35	0.000	0.033	0.856	0.153	0.698
WT (kg)	11.97	0.000	27.92	0.000	3.13	0.084	1.70	0.198
BMI	15.36	0.000	15.64	0.000	3.87	0.06	1.65	0.206
WC (cm)	21.22	0.000	22.30	0.000	8.64	0.005	3.97	0.053
HC (cm)	13.34	0.001	17.13	0.000	2.56	0.117	1.82	0.185
WHR	3.85	0.55	2.19	0.144	1.67	0.203	0.373	0.545
BSF (mm)	7.80	0.007	7.67	0.008	1.30	0.260	0.864	0.358
TSF (mm)	4.40	0.41	5.15	0.027	0.130	0.720	0.049	0.825
SSF (mm)	14.19	0.000	18.03	0.000	0.608	0.440	0.151	0.699
SISF (mm)	11.10	0.002	13.11	0.001	1.26	0.267	0.744	0.393
PR	0.199	0.668	0.027	0.870	2.50	0.121	4.05	0.05

HT – Height, WT – Weight, BMI – Body Mass Index, WC – Waist Circumference, HC – Hip Circumference, WHR – Waist-Hip Ratio, BSF – Biceps Skinfold, TSF – Triceps Skinfold, SSF – Subscapular Skinfold, SISF – Suprailiac Skinfold, PR – Pulse Rate cent of variance (R^2) found minimum for almost all anthropometric measurements among both male and female generations. Therefore, the most important anthropometric traits in relation to aggregation or elevation of SBP and DBP are waist circumference, WHR and triceps skinfold for male parents and age, weight, BMI and skinfolds for female parents. Among male grandparental generation, the regression coefficients of WHR for SBP and height, weight, hip circumference and WHR for DBP are found significant ($p<0.05$, Table 7). Among female grandparental generations, the regression coefficients of age and WHR for both SBP and DBP are found significant ($p<0.05$, Table 7). However the percent of variances (R^2) are negligible for all measurements among both the generations. It is found that age and WHR are the important traits in relation of the elevation of blood pressure among grandparental generations.

The aggregation and significant relationship of the blood pressure phenotypes with other metric variables were analyzed by the test of ANOVA (Analysis of Variance, Univariate analysis) among different generations (Tables 8 to 10). It is found that age, height, weight, BMI, waist and hip circumferences and three skinfolds (biceps, subscapular and suprailiac) have shown strong predictors and significant aggregation ($p<0.05$) for SBP and DBP among male offspring generation, whereas only waist circumference among female offspring generation is found significant ($p<0.05$, Table 8). It is again observed that BMI, waist circumference, WHR and triceps skinfold among male parental generation and age, BMI, subscapular and suprailiac skinfolds among female parental generations are found significant interactions with blood pressures ($p<0.05$, Table 9). Further, it has been observed that no anthropometric predictor has been significantly associated with both blood pressure phenotypes among male grandparental generation and also in female grandparental generations except age and pulse rate (Table 10). Furthermore, the results of analysis of variances using central blood pressure status and other anthropometric characters as categorical variables further demonstrated significant anthropometric predictors on elevation of blood pressures.

Discussion

The main purposes of this study were: (i) to explain the anthropometric factors to influence the familial aggregation of blood pressure between generations; (ii) to establish relationship between blood pressure phenotypes and anthropometric risk factors. The present results indicate a strong familial aggregation of blood pressure and it can also be explained the aggregation of different anthropometric variables. Almost all measured variables such as age, height, weight, BMI, skinfolds and pulse rate were strongly correlated with blood pressure phenotypes for male offspring generation and moderately correlated with other generations. However, when blood pressure were regressed on all sets of variables among all generations by using stepwise multiple regression, infact, almost all variables except pulse rate in male offspring groups; only three variables (BMI, waist circumference and WHR) for SBP and three variables (waist circumference, WHR and pulse rate) for DBP in female offspring groups; five variable (weight, BMI, waist circumference WHR and triceps skinfold) for SBP and three variables (waist circumference, WHR and triceps skin-

TABLE 9
ANALYSIS OF VARIANCE (UNIVARIATE) WITH LEVEL OF SIGNIFICANCE OF SBP AND DBP WITH RESPECT TO OTHER VARIABLES AMONG MALE PARENTAL (N=72) AND FEMALE PARENTAL (N= 74) GENERATIONS

Variables	Male Parent				Female Parent			
	SBP		DBP		SBP		DBP	
	F	P	F	P	F	P	F	P
Age (yrs)	2.59	0.112	2.85	0.096	11.56	0.001	8.64	0.004
HT (cm)	1.24	0.270	0.86	0.355	0.003	0.954	0.18	0.676
WT (kg)	5.05	0.028	1.78	0.187	10.52	0.002	7.05	0.10
BMI	8.43	0.005	4.08	0.030	10.39	0.002	8.52	0.005
WC (cm)	10.40	0.002	4.57	0.053	0.17	0.682	0.01	0.920
HC (cm)	2.09	0.153	0.00	0.998	2.77	0.101	1.06	0.307
WHR	11.49	0.001	9.18	0.003	0.22	0.640	0.11	0.740
BSF (mm)	1.34	0.250	0.583	0.448	4.23	0.043	2.53	0.116
TSF (mm)	3.80	0.055	3.91	0.052	4.02	0.049	2.58	0.112
SSF (mm)	0.03	0.870	0.00	0.966	13.00	0.001	8.87	0.004
SISF (mm)	3.89	0.053	3.53	0.064	5.77	0.019	4.19	0.038
PR	1.84	0.179	2.48	0.12	1.60	0.209	1.13	0.290

HT – Height, WT – Weight, BMI – Body Mass Index, WC – Waist Circumference, HC – Hip Circumference, WHR – Waist-Hip Ratio, BSF – Biceps Skinfold, TSF – Triceps Skinfold, SSF – Subscapular Skinfold, SISF – Suprailiac Skinfold, PR – Pulse Rate

TABLE 10
AnALYSIS OF VARIANCE (UNIVARIATE) WITH LEVEL OF SIGNIFICANCE OF SBP AND DBP WITH RESPECT TO OTHER VARIABLES AMONG MALE GRAND PARENTAL (N=29) AND FEMALE GRAND PARENTAL (N= 32) GENERATIONS

Variables	Male Grand- Parent				Female Grand- Parent			
	SBP		DBP		SBP		DBP	
	F	P	F	P	F	P	F	P
Age (yrs)	3.60	0.068	0.00	0.967	20.07	0.000	14.95	0.001
HT (cm)	2.58	0.120	12.04	0.002	0.05	0.824	0.00	0.997
WT (kg)	0.08	0.782	5.60	0.025	0.71	0.406	0.71	0.406
BMI	0.13	0.719	1.23	0.277	0.67	0.421	0.84	0.365
WC (cm)	0.87	0.359	1.18	0.287	0.68	0.415	1.14	0.294
HC (cm)	0.27	0.608	5.57	0.026	0.29	0.590	0.01	0.924
WHR	1.09	0.306	0.75	0.393	1.17	0.288	4.39	0.045
BSF (mm)	0.25	0.620	0.28	0.603	0.74	0.398	0.75	0.393
TSF (mm)	0.63	0.434	3.79	0.062	0.21	0.650	0.29	0.592
SSF (mm)	0.02	0.896	0.50	0.484	0.31	0.581	0.27	0.607
SISF (mm)	1.56	0.222	1.93	0.176	1.11	0.300	1.14	0.294
PR	0.342	0.564	0.28	0.599	5.26	0.029	3.01	0.053

HT – Height, WI – Weight, BMI – Body Mass Index, WC – Waist Circumference, HC – Hip Circumference, WHR – Waist-Hip Ratio, BSF – Biceps Skinfold, TSF – Triceps Skinfold, SSF – Subscapular Skinfold, SISF – Suprailiac Skinfold, PR – Pulse Rate

fold) for DBP in male parental groups; eight variables (age, weight, BMI, WHR and four skinfolds) for SBP and seven variables (age, weight, BMI and four skinfolds) for DBP in female parental groups; one variable (WHR) for SBP and four variables (height, weight, WHR and hip circumference) for DBP in male grandparental groups; three variables (age, WHR and pulse rate) for SBP and two variables (age and WHR) for DBP in female grandparental groups remained significance at 5% level. This suggests that almost all of these variables are significant multivariate correlates with blood pressures. Hence, it appears from previous studies[4,18,25,26] that many anthropometric traits can be used as basic predictors for tracking the elevation of the blood pressure in families.

In the present study, the higher correlations for almost all set of variables have been found among offspring generations as compared with other generations. The observation suggests that genetically closeness and same family environmental factors determine the variations of blood pressure phenotypes. The similar observations have been found in many previous studies[27–30]. The influence of household environment on the pattern of familial aggregation of blood pressures may be understood through the study of multi-generation data. However, the effects of cohabitation in the present study are not so significant except male offspring generation with higher estimates of correlation. The possible reason for this result is that the environment is relatively more cordial for male children in the Indian society. The other possible reason is the presence of dominance deviation, which tends to increase the correlation for offspring. However, present study does not support this hypothesis because female offspring does not show significant correlation for most of the variables. Otherwise, any significant genetic effect for familial aggregation of blood pressure is to be more important to parent than offspring generation.

The present study does not find gender differences in familial correlation of blood pressure. The father-offspring (male and female) are more or less similarly correlated with blood pressure and consistent with other studies[7]. The present results also have showed significant blood pressure correlations among parent-offspring, sib-sib, spouse, and grandfather-offspring. Therefore, the study is also strengthen the hypothesis that a substantial fraction of the variation in human blood pressure is determined genetically derives from family studies of familial aggregation[16,31,32]. The finding of a strong familial aggregation of blood pressure especially in offspring generation in the present population indicates the need for further investigation into genetic determinants of blood pressure through epidemiologic family studies. The consistently higher sib-sib association compared with the spouses, parent-offspring association suggests that shared environment is also important for familial aggregation of blood pressure. The magnitude of the familial effect for SBP is more consistent than DBP in every generation. However, familial estimates of SBP reported here were less than those in the most of the previous studies[33,34].

Significant genetic effects on blood pressure have been established in many studies[9,10,16,27,35.] These reports suggested the possibility of major gene effects on blood pressures. However, they have used linear statistical methods like co-variation components and path analysis models to study the mode of inheritance of blood pressure. Schork et al.[36] have showed significant additive genetic factors for both SBP and DBP due to variance components. However, in the present study it has been shown significant additive effect for SBP, whereas it is negligible for DBP. But, in multiple regression analysis it has found significant genetic correlation across the different generations for both SBP and DBP. Majumdar et al.[37] tested various hypothesis of blood pressure transmission adjusted for anthropometric variables and showed that there was no residual genetic heritability of adjusted SBP or DBP. Therefore, our major observations can be summarized as: (i) anthropometric traits such as BMI, WHR, skinfolds, shared household environment, genetic factors and age have significant impact on the variation and aggregation of SBP and DBP in offspring generation; (ii) SBP and DBP have showed significant phenotypic correlation with BMI, WHR, skinfolds, age and other anthropometric traits, which showed substantial genetic component but not equal in every generation. Offspring generation showed strongest genetic correlation as compared to other generations, likewise many studies[38–40] have observed significant correlations between blood pressure and various anthropometric measurements but the magnitude of their covariation is different due to the selection of the particular anthropometric measure in the specific population.

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REFERENCES

1. SAADAT N, SALEHI P, EMAMI H, AZIZI F, Int J Endocrinol Metab, 1 (2005) 37. — 2. MESSNER T, LUNDBERG V, STEGMAYR B, Scand J Public Health, 31 (2003) 359. — 3. FORD ES, MOKDAD AH, AJANI UA, Pediatrics, 114 (2004) 1534. — 4. BANIK SD, Coll Antropol, 31 (2007) 717. — 5. SILVENTOINEN K, JOUSILAHTI P, VARTIAINEN E, TUOMILEHTO J, Scand J Public Health, 31 (2003) 283. — 6. BOSE K, GHOSE A, ROY S, GANOPADHYAY S, Anthrop Anz, 63 (2005) 205. — 7. KNUIMAN MW, DIVITINI ML, BARTHOLOMEW HC, WELBORN TA, Am J Epidemiol, 143 (1996) 48. — 8. FENG Y, ZANG T, XU X, XU X, Obesity, 16 (2008) 125. — 9. ŠKARIĆ-JURIĆ T, Coll Antropol, 27 (2003) 229. — 10. LIVSHITS G, GINGSBURG E, KOBYLIASKY E, Hum Biol, 71 (1999) 685. — 11. CHARTURVEDEI N, Heart, 89 (2003) 681. — 12. KOZIEL S, Int J Anthropol, 18 (2003) 153. — 13. WADA K, TAMAKOSHI K, YATSUYA H, OTSUKA R, MURATA C, ZHANG H, TAKEFUJI S, MATSUSHITAK, SUGIURA K, TOYOSHIMA, Prev Med, 42 (2006) 358. — 14. BADARUDDOZA, Coll Antropol, 28 (2004) 311. — 15. TAKSANDE A, CHATURVEDI P, VILHEKAR K, JAIN M, Ann Pediat Cardiol, 1 (2008) 101. — 16. LIVSHITS G, GERBER LM, Hypertension, 37 (2001) 928. — 17. KHAN A, HAQ FU, PERVEZ MB, SAIEHEEN D, FROSSARD PM, ISHAQ M, HAKEEM A, SHEIKH HT, AHMAD U, Int J Cardiol, 124 (2008) 259. — 18. JAFAR TH, ISLAM M, POULTER N, HATCHER J, SCHMID CH, LEVEY AS, CHATURVEDI N, Circulation, 111 (2005) 1291. — 19. YALCIN BM, SAHIN EM, YALCIN E, Family Practice, 22 (2005) 541. — 20. RICE T, NIRMALA A, REDDY PC, RAMANA PV, KRISHNA KS, RAO DC, Hum Biol, 64 (1992) 869. — 21. SINGH IP, BHASIN MK, Anthropometry (Kamla Raj Enterprises, Delhi, 1968). — 22. WEINER JS, LOURIE JA, Practical Human Biology (Academic Press, London, 1981). — 23. PERUSSE L, RICE T, BOUCHARD C, VOLGER GP, RAO DC, Am J Hum Genet, 45 (1989) 240. — 24. AMERICAN HEART ASSOCIATION, Circulation, 64 (1981) 510A. — 25. BADARUDDOZA, KUMAR R, Anthrop Anz, 67 (2009) in press. — 26. BADARUDDOZA, AFZAL M, Ind J Physiol Pharmacol, 44 (2000) 304. — 27. CUI J, HOPPER JL, HARRAP SB, Hypertension, 40 (2002) 7. — 28. VIZCAINO VM, AGUILAR FS, GUTIERREZ RF, CRESPO YJ, NAVALON PG, ROJAS VD, Prev Med, 28 (1999) 131. — 29. CHEN W, SRINIVASAN SR, BAO W, BERENSON GS, Ann Epidemiol, 11 (2001) 522. — 30. HARRAP SB, STEBBING M, HOPPER JL, HOANG HN, GILES GG, Am J Epidemiol, 15 (2000) 152. — 31. RICE T, RAO R, PERUSSE L, BOUCHARD C, RAO DC, Hum Biol, 72 (2000) 415. — 32. BYARD PJ, MUKHERJEE BN, BHATTACHARYA SK, RUSSELL JM, RAO DC, Am J Phy Anthropol, 79 (1989) 305. — 33.RICE T, PERUSSE R, BOUCHARD C, RAO DC, Hum Biol, 72 (2000) 415. — 34. GU C, BORECKI IB, GAGNON J, BOUCHARD C, LEON AS, SKINNER JS, WILMORE JH, RAO DC, Hum Biol, 70 (1998) 77. — 35. RICE T, BOUCHARD C, BORECKI I, RAO DC, Am J Hum Genet, 46 (1990) 37. — 36. SCHORK NJ, WEDER AB, TREVISAN M, LAURENZI M, Am J Hum Genet, 54 (1994) 361. — 37. MAJUMDER PP, DAS RN, NAYAK S, BHATTACHARYA SK, MUKHERJEE BN, Hum Biol, 67 (1995) 827. — 38. LIVSHITS G, YAKOVENKO K, GINSBURG E, KOBYLIANSKY E, Ann Hum Biol, 25 (1998) 221. — 39. HERNELAHTI M, LEVALAHTI E, SIMONEN RL, KAPRIO J, KUJALA UM, UUSITALO-KOSKINEN ALT, BATTIE MC, VIDEMAN T, J Appl Physiol, 97 (2004) 1046. — 40. KEAVNEY B, Int J Epidemiol, 31 (2002) 730.

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NASLJEDNOST VRIJEDNOSTI KRVNOG TLAKA S OBZIROM NA ANTROPOMETRIJSKE VRIJEDNOSTI RADNE ZAJEDNICE IZ PUNJABA, SJEVERNOINDIJSKE DRŽAVE

S A Ž E T A K

Cilj ove studije bilo je proučiti nasljednost vrijednosti krvnog tlaka s obzirom na antropometrijske vrijednosti više srednje klase radne zajednice iz Punjaba u sjevernoistočnoj Indiji. Rezultati su dobiveni na uzorku od 75 obitelji, odnosno 305 pojedinaca iz tri generacije. Podaci su analizirani putem obiteljske korelacije, multiple regresije, postotka varijance te univarijatne analize. Dobiveni rezultati upućuju na snažnu nasljednu komponentu vrijednosti krvnog tlaka u ovoj populaciji, posebno u najmlađoj generaciji te potvrđuju da je do tih zaključaka moguće doći na temelju antropometrijskih varijabli, genetskih faktora, zajedničkog životnog prostora te dobi. Ove varijable su imale snažan utjecaj na sistolički krvni tlak (SBP) i umjeren utjecaj na dijastolički krvni tlak (DBP). Obje vrste krvnog tlaka su pokazale visoku razinu genetičke korelacije sa mnogim antropometrijskim karakteristikama u najmlađoj generaciji, u usporedbi sa starijim generacijama. Navedene korelacije su zanemarive kod muških pripadnika najstarije generacije. Općenito, rezultati upućuju na činjenicu da su sve mjerene varijable značajno povezane s krvnim tlakom.