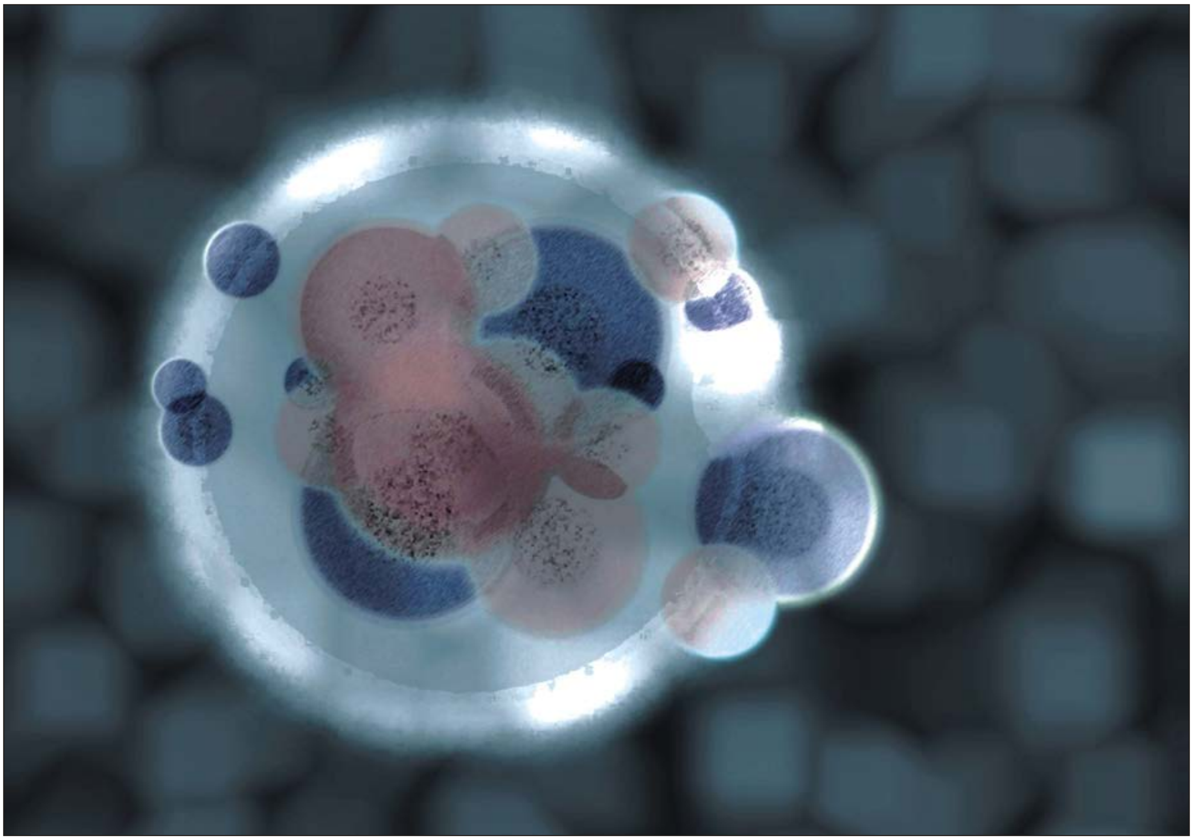

Journal of Biological Sciences

ISSN 1727-3048

Journal of Biological Sciences 12 (2): 74-82, 2012
ISSN 1727-3048 / DOI: 10.3923/jbs.2012.74.82

Heritability of Certain Anthropometric and Physiometric Phenotypes among Three Predominant Caste Population in Punjab, India

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Abstract: Genetic and environmental factors contribute a significant proportion of anthropometric and physiometric variance. However, very limited study have been done on the relative contributions of genetic and environmental components in the variability of anthropometric and physiometric traits in different regions and caste in India. The present study was carried out to examine the heritability patterns of different anthropometric and physiometric traits among three caste populations with two generation in Punjab. A total of 150 families were studied, 50 families each of the three caste such as Brahmin, Khatri and Bania populations which constituted a total of 517 individuals. The anthropometric measurements taken were height, weight, waist circumference, hip circumference, biceps skinfold, triceps skinfold, supra-iliac skinfold and subscapular skinfold. The physiometric variables included measurement of Systolic Blood Pressure (SBP), Diastolic Blood pressure (DBP) and pulse rate. The estimation of heritability has been calculated from the degree of resemblance between relatives. Almost all heritabilities of anthropometric and physiometric phenotypes were found significant with caste populations. Although heritabilities for some phenotypes (WHR, supra-iliac skinfold and pulse rate) were relatively low as compared to other studies in literature. Khatri population has showed greater variability for both generations whereas, Brahmin population for both generations have showed minimum heritability. Since, caste effects were significant for most of the phenotypes in comparison, therefore, it is suggested that inter-caste differences among these castes are more prominent. However, heritabilities are different in magnitudes across the caste groups. Thus, heritability pattern of anthropometric and physiometric phenotypes observed in the present study exhibited significant variations among Punjabi Brahmin, Khatri and Bania populations.

Key words: Heritability, Punjabi population, family study

INTRODUCTION

Heritability is the proportion of phenotypic variation in a population that is attributable to genetic variation among individuals. Heritability analyses estimate the relative contributions of differences in genetic and non genetic factors to the total phenotypic variance in a population. However, to study the genetic structure of human populations many quantitative phenotypes have been used (Blangero, 1990; Chakraborthy, 1990; Duggirala and Crawford, 1994; Arya *et al.*, 2002; Lykken, 2007; Pan *et al.*, 2007). Previous studies have suggested different degrees of genetic and environmental influences on the familial aggregation of systolic and diastolic blood pressures (Burns and Lauer, 1996; Fagard *et al.*, 2003; Taarnhoj *et al.*, 2006; Fermino *et al.*, 2009). It has also been suggested that higher heritability of SBP (41%) (range 25 to 82%) has been seen in offspring generation than parental one whereas heritability observed for DBP ranged from 64% (offspring) to 19% (parent) (Friedlander *et al.*, 1988; Knuiman *et al.*, 1996; Wang *et al.*, 2008). Therefore, it is important to understand the population structure to investigate the heritabilities and genetic variance components for different anthropometric and physiometric variables. Therefore, the variation that exists in a quantitative trait can be divided into genetic and non-genetic or environmental components and the genetic component can be further subdivided into additive, dominance and epistatic variances. In principle, one can include components of variance for gene-environment interactions and shared environmental (e.g., household) effects as well. In humans, estimation of the entirety of the epistatic and gene-environment components of variance

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of a trait is difficult, although contributions to some of these variance components (e.g., additive-additive epistasis), for individual pairs of loci, have been estimated from genotype data (Cloninger *et al*., 1998; Blangero *et al*., 2000; Abney *et al*., 2001).

The genetic diversity is comparatively high in Punjab. This diversity is largely attributable to the effects of evolutionary forces, particularly genetic admixture, through successive historic migrations. However, the Punjab has been considered the gateway of India from ages. All foreign invaders like Alexander, Aryans, Persians, Greeks, Scythians, Parthians, Huns, Turks, Mongols, Afghans and Mughals came to India through North-West Punjab. Most of the successive invaders inroad into the Punjab and settled here permanently and adjusted themselves to the new socio-cultural system and adopting the customs and traditions of the local land. Therefore, they merged into the indigenous population in process and became part of the culture of the Punjab. The present Punjabi population is the descendants of the various racial stocks which entered into it during the different stages of its history (Sekhon, 2000). Thus, Punjab has a great potential for the study of quantitative genetic variation within and between populations and it offers a unique opportunity to examine the genetic determinants of anthropometric phenotypes of caste groups and to understand the morphologic and/or genetic diversity among caste populations. However, the studies related with the examination of the structure of the caste populations using anthropometric data, in Indian populations are limited (Kaur and Singh, 1981; Byard *et al*., 1984; Poosha *et al*., 1984; Sharma *et al*., 1984; Byard *et al*., 1985a, b; Sharma, 1987; Rice *et al*., 1993; Reddy, 1998; Arya *et al*., 2002). Many studies have done to demonstrate association between obesity, hypertension and type 2 diabetes with anthropometric parameter (Afridi *et al*., 2003; Alhamdan, 2008; Latiffah and Hanachi, 2008; Latiffah *et al*., 2008; Mahajan *et al*., 2009; Afoakwah and Owusu, 2011; Kumar *et al*., 2011; Veghari, 2011). Therefore, in the present study, a variance component approach has been used to study the heritability patterns of different anthropometric (height, weight, waist circumference, hip circumference, biceps skinfold, triceps skinfold, subscapular skinfold and suprailiac skinfold) and physiometric (SBP, DBP and Pulse rate) variables among the three caste populations such as Brahmin, Khatri and Bania in Punjab using nuclear family data.

MATERIALS AND METHODS

Sample: The three caste populations in Punjab namely Brahmin, Hindu Khatri and Bania were undertaken in the present work to study the heritability of anthropometric and blood pressure phenotypes. A total of 150 families were studied, 50 families each of the three caste populations which constituted a total of 517 individuals. The families from Jalandhar and Kapurthala districts of Punjab were included between the time periods of July 2008 to January 2009. The samples were recruited on house to house basis with a preconsent from the individuals. The age range of all the individuals among offspring generation is between 13-30 years and that of parental generation is between 35-80 years. For data collection, personal interviews were held with each subject. General information regarding name, age, caste, religion, sex, address, educational qualification, occupation and monthly income was recorded on the proforma. The other information regarding any pre-existing disease or disorder, consumption of alcohol, smoking, type of diet like vegetarian or non- vegetarian, physical activities, stress, time spent on watching T.V. and duration of sleep was also noted down properly. The project was approved by the Ethical Committee of Guru Nanak Dev University, Amritsar, Punjab on November 20, 2008.

Measurements: Both the anthropometric and physiometric measurements were included in the present study. The anthropometric measurements taken were height (cm), weight (kg), waist circumference (cm), hip circumference (cm), biceps skinfold (mm), triceps skinfold (mm), supra-iliac skinfold (mm) and subscapular skinfold (mm). All the anthropometric measurements were taken on the left side of each individual using standard anthropometric techniques (Singh and Bhasin, 1968; Weiner and Lourie, 1981). The age of the individuals was determined directly from their reported date of birth. Height was measures the vertical distance from the point vertex to the base of the heels using an anthropometric rod. The reading was then, recorded to the nearest 0.1 cm. The weight of the subject was measured in kilograms on a weighing machine with minimal clothing and without shoes. It was recorded to the nearest 0.5 kg with an allowance deducted for clothing. Waist circumference was measured using a steel tape. The measurement was taken mid-way between the inferior margin of the last rib and the crest of the ilium in a horizontal plane. Hip circumference of the subject was taken with steel tape fitted around the pelvis at the point of maximal protrusion of buttocks or at their widest portion while the subject was standing with his/her feet close to each other. The subcutaneous skinfold thickness over the biceps, triceps, subscapular and suprailiac muscle were taken with the help of the Harpenden's caliper. Body mass index was calculated by dividing weight of the subject in kilograms by square of his/her height in meters. Waist to Hip ratio was calculated by dividing waist circumference by hip circumference.

The physiometric variables included measurement of Systolic Blood pressure (SBP), Diastolic Blood Pressure (DBP) and pulse rate. Two consecutive readings were recorded for each of SBP and DBP and the averages were used. The measurements were taken with the help of mercury sphygmomanometer in a sitting position with the right forearm placed horizontal on the table. The recordings were taken as recommended by the American Heart Association (AHA, 1981). An appropriate sized cuff was fitted on the arm of the subject and was inflated to about 20 mmHg above the point at which the radial pulse disappeared. The pressure within the cuff was then, released at a rate of approximately 2 mmHg/second while osculating with a stethoscope placed over the brachial artery. The onset of sound (Korotkoff- phase I) was taken as indicative of systolic blood pressure and the disappearance of sound (Korotkoff- phase V) was taken as indicative of diastolic blood pressure. Korotkoff phase was taken. All efforts were made to minimize the factors which might affect blood pressure like anxiety, fear, stress, laughing and recent activity (Badaruddoza and Afzal, 1999). The alternate expansion and recoil of elastic arteries after each systole of the left ventricle create a traveling pressure wave that is called the Pulse (Tortora and Grabowski, 1996). It is the strongest in the arteries closest to the heart. It becomes weaker in the arterioles and disappears altogether in the capillaries. The radial artery at the wrist is most commonly used to feel the pulse. It was counted over one minute.

The estimation of heritability has been done from the degree of resemblance between relatives. The regression of offspring on parents and correlation has been expressed in the terms of heritability. Therefore, the relationship between these two is as follows:

$$h^2 = b/r$$

where, r is the coefficient of the additive variance in the co-variance and b is the regression coefficient of offspring on parents.

Statistical analysis: All statistical analyses such as means, standard deviations, coefficients of variation and ANOVA were performed using SPSS software 19.0 version. The $p<0.05$ level was selected as the criterion of statistical significance. Heritability estimation was done from regression of offspring on parents.

RESULTS

Distributions of 150 nuclear families (50 families each of the population- Brahmin, Khatri and Bania) with 517 individuals (171 for Brahmins, 175 for Khatris and 171 for Banias) are given in Table 1. These families included 145 fathers (45 for Brahmins, 51 for Khatris and 49 for Banias), 176 mothers (62 for Brahmins, 58 for Khatris and 56 for Banias), 102 sons (32 for Brahmins, 33 for Khatris and 37 for Banias) and 94 daughters (32 for Brahmins, 33 for Khatris and 29 for Banias). In many families among the three caste populations, presence of grandfather and grandmother have been found, however, the data of grandfather and grandmother are not included in the present analysis due to small number which may lead to sample stratifications. The family structure with father, mother and one offspring has been found maximum among all the three caste populations such as 44% for Brahmin, 44% for Khatri and 52% for Bania population. The family structure with two offspring, father and mother has been found second highest among all the three populations such as 16% for Brahmin, 24% for Khatri and 28% for Bania. However, this structure is much less in Brahmin population (16%) as compared to the other two populations.

The comparison of descriptive statistics including raw data means and standard deviations for each of 14 quantitative variables among parental and offspring generations within the three caste populations are presented in Table 2 and 3. Among male parent generation: weight, waist and hip circumferences, WHR, triceps, sub-scapular, SBP and DBP variables have been found with significant inter-caste differences (at least $p<0.05$). However, the maximum mean values of weight (76.00±11.09), BMI (26.44±3.77), hip circumference (105.50±8.33), biceps skinfold (24.89±7.02), sub scapular skinfold (30.61±7.90) and supra-iliac skinfold (29.29±8.81) have been found in Khatri population, whereas, the maximum mean values for age (50.12±4.24), height (169.77±6.09), waist circumference (105.62±10.33), WHR (1.02±0.06), triceps skinfold (31.74±7.56), SBP (148.33±18.44), DBP (95.71±11.61) and pulse rate (82.71±6.83) have been found in Bania population (Table 2). Among female parent generation: weight, BMI, waist and hip circumferences, sub-scapular, pulse rate, SBP and DBP variables have been found with significant inter-caste differences (at least $p<0.05$). The maximum mean values of age (46.02±8.08), SBP (141.59±16.49) and DBP (92.77±10.98) have been found in Brahmin population, whereas, the same have been found for biceps skinfold (29.38±6.01), triceps skinfold (36.73±6.47), supra-iliac skinfold (33.60±6.94) and pulse rate (86.02±10.22) in Khatri population and for height (155.32±5-69), weight (69.94±14.14), BMI (31.10±15.13), waist circumference (103.72±12.56), hip circumference (111.00±11.79), WHR (0.93±0.07) and sub scapular skinfold (33.50±6.03) in Bania population (Table 2).

As shown in Table 3 in male offspring generation, the means of SBP (139.06±10.73) and DBP (88.44±10.27) for Brahmin, pulse rate (83.46±11.38) for Khatri, age

Table 1: Distribution of nuclear family types of the three populations

	Brahmin population		Khatri population		Bania population	
Types	Family count	Individual count	Family count	Individual count	Family coun	Individual count
G_f G_m FMOO--	--	--	1 (2)	6	--	--
G_f G_m FMO	2(4)	10	1 (2)	5	--	--
G_m FMOO	--	--	1 (2)	5	--	--
G_f FMO	--	--	2 (4)	8	1 (2)	4
G_f G_m MO	--	--	1 (2)	4	--	--
G_m FMO	7 (14)	28	3 (6)	12	5 (10)	20
G_m MOO	2 (4)	8	--	--	--	--
G_f FO	--	--	--	--	1 (2)	3
G_m FO	1 (2)	4	1 (2)	3	--	--
G_f MO	1 (2)	3	--	--	--	--
G_m MO	3 (6)	9	--	--	2 (4)	6
FMOO	8 (16)	32	12 (24)	48	14 (28)	58
FMO	22 (44)	66	22 (44)	66	26 (52)	77
MOO	3 (6)	9	6 (12)	18	1 (2)	3
FO	1 (2)	2	--	--	--	--
Total	50 (100)	171	50 (100)	175	50 (100)	171

G_f: Grandfather; G_m: Grandmother; F: Father; M: Mother; O: Offspring, Values in parenthesis represents percentage.

Table 2: Comparison of means with standard deviations between parental generations among three caste populations

	Brahmin		Khatri		Bania		Males		Females	
Variables	Male (n = 45)	Female (n =62)	Male (n = 51)	Female (n = 58)	Male (n = 49)	Female (n = 56)	F^*	p	F^*	p
Age (years)	48.11±6.82	46.02±8.08	49.25±7.69	45.52±7.18	50.12±4.24	45.83±4.33	1.150	0.319	0.083	0.921
Height (cm)	169.50±6.06	155.04±6.07	169.59±5.22	154.52±6.25	169.77±6.09	155.32±5.69	0.027	0.974	0.261	0.770
Weight (kg)	70.89±9.29	64.23±9.06	76.00±11.09	69.31±11.33	74.83±10.89	69.94±14.14	3.055	<0.050	4.369	<0.014
BMI (kg/m^2)	25.23±4.30	26.75±3.52	26.44±3.77	29.05±4.61	26.06±4.01	31.10±15.13	1.117	0.330	3.321	<0.038
Waist circumference (cm)	99.42±9.47	97.98±9.02	102.84±9.41	101.31±10.53	105.62±10.3	103.72±12.56	4.750	<0.010	4.263	<0.016
Hip circumference (cm)	101.19±6.22	105.96±8.09	105.50±8.33	110.02±10.67	103.55±8.17	111.00±11.79	3.766	<0.025	4.083	<0.019
WHR	0.98±0.08	0.92±0.05	0.98±0.06	0.92±0.06	1.02±0.06	0.93±0.07	5.809	<0.004	0.527	0.592
Biceps skinfold (mm)	22.75±5.72	27.47±5.79	24.89±7.02	29.38±6.01	24.41±7.15	29.11±7.0	61.322	0.270	1.629	0.199
Triceps skinfold (mm)	27.61±7.08	36.36±5.72	31.46±9.09	36.73±6.47	31.74±7.56	37.22±5.29	3.873	<0.023	0.319	0.727
Sub scapular skinfold (mm)	25.28±7.43	30.23±5.85	30.61±7.90	32.42±6.07	29.57±7.11	33.50±6.03	6.660	<0.002	4.620	<0.011
Supra-iliac skinfold (mm)	26.42±7.45	31.62±7.38	29.29±8.81	33.60±6.94	27.88±7.81	32.57±7.81	1.512	0.224	1.079	0.342
SBP (mmHg)	140.56±10.13	141.59±16.49	139.09±18.9	6131.98±13.75	148.33±18.4	137.15±21.58	4.434	<0.014	4.521	<0.012
DBP (mmHg)	91.67±9.71	92.77±10.98	89.66±12.08	83.23±10.54	95.71±11.61	90.65±14.55	3.737	<0.0261	0.12	<0.001
Pulse rate	80.61±8.71	77.49±6.92	82.14±12.08	86.02±10.22	82.71±6.83	81.65±8.06	0.605	0.5471	5.15	<0.001

F^*: one ways ANOVA

Table 3: Comparison of means with standard deviations between offspring generations among three caste populations

	Brahmin		Khatri		Bania		Males		Females	
Variables	Male (n = 32)	Female (n =32)	Male (n = 33)	Female (n = 33)	Male (n = 37)	Female (n = 29)	F^*	p	F^*	p
Age (years)	20.75±5.98	20.84±4.60	21.33±6.83	19.55±5.29	22.65±5.35	19.72±3.22	0.903	0.409	0.775	0.464
Height (cm)	168.91±8.43	156.87±5.35	168.15±9.82	155.42±5.88	171.03±8.76	155.76±4.93	0.968	0.383	0.629	0.536
Weight (kg)	63.19±16.54	52.59±8.46	62.15±14.62	50.33±9.44	72.29±17.45	50.59±7.46	4.150	<0.019	0.670	0.514
BMI (kg m^2)	21.96±4.58	21.24±3.32	21.79±4.28	20.76±3.37	24.71±5.71	20.86±2.98	3.905	<0.023	0.196	0.822
Waist circumference 9 (cm)	86.97±12.18	81.72±9.17	86.15±12.72	79.64±8.56	95.51±14.59	82.38±9.70	5.399	<0.006	0.776	0.463
Hip circumference (cm)	96.19±10.16	94.16±7.64	95.88±11.81	91.03±9.09	101.22±10.6	993.83±5.48	2.783	0.067	1.641	0.199
WHR	0.91±0.06	0.87±0.07	0.89±0.05	0.88±0.06	0.94±0.06	0.88±0.07	6.860	<0.002	0.238	0.789
Biceps skinfold (mm)	19.19±8.31	22.00±5.67	17.91±8.91	22.24±7.99	22.38±8.07	20.72±5.35	2.637	0.077	0.478	0.622
Triceps skinfold (mm)	25.75±9.81	28.59±6.04	22.03±9.68	27.76±8.36	27.76±9.00	28.00±5.09	3.244	<0.043	0.131	0.878
Sub scapular skinfold((mm)	20.69±9.75	24.19±6.81	19.94±8.44	22.18±7.44	26.00±8.43	21.14±5.17	4.913	<0.009	1.704	0.188
Supra-iliac skinfold (mm)	21.00±10.93	23.13±6.71	18.64±8.81	22.18±7.79	24.41±10.49	20.28±5.94	2.883	0.061	1.337	0.268
SBP (mmHg)	139.06±10.73	131.72±10.29	126.97±12.2	4120.15±6.31	138.65±14.3	126.72±9.19	9.865	<0.001	14.39	<0.001
DBP (mmHg)	88.44±10.27	85.63±5.50	80.30±9.68	77.42±7.92	88.24±7.93	83.28±6.02	8.361	<0.001	12.73	<0.001
Pulse rate	82±11.26	82.56±9.73	83.46±11.38	89.12±14.26	81.14±8.20	85.89±10.84	0.448	0.640	2.498	0.088

F^*:one ways ANOVA

(22.65±5.35), height (171.03±8.76), weight (72.29±17.45), BMI (24.71±5.71), WHR (0.94±0.06), biceps skinfold (22.38±8.07), triceps skinfold (27.76±9.00), sub scapular skinfold (26.00±8.43), supra- iliac skinfold (24.41±10.49), waist circumference (95.51±14.59) and hip circumference (101.22±10.69) for Bania were found slightly higher as compared to others. However, weight, BMI, waist circumference, WHR, triceps and sub-scapular skinfolds, SBP and DBP variables have been found with significant inter-caste differences (at least $p<0.05$). Among female

Table 4: Comparisons of coefficients of variance (CV %) of measured variables among three caste populations

	Brahmin				Khatri				Bania			
	Parental		Offspring		Parental		Offspring		Parental		Offspring	
Variables	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Age (years)	14.17	17.55	28.81	22.07	15.61	15.77	32.02	27.05	8.45	9.44	23.62	16.32
Height (cm)	3.57	3.91	4.99	3.41	3.07	4.04	5.84	3.78	3.58	3.66	5.12	3.16
Weight (kg)	13.10	14.10	26.17	16.08	14.59	16.34	23.52	18.75	14.55	20.21	24.13	14.74
BMI (kg/m^2)	17.04	13.15	20.85	15.63	14.25	15.86	19.64	16.23	15.38	48.64	23.10	14.28
Waist circumference (cm)	9.52	9.20	14.00	11.22	9.15	10.39	14.76	10.74	9.78	12.10	15.27	11.77
Hip circumference (cm)	6.14	7.63	10.56	8.11	7.89	9.69	12.31	9.98	7.88	10.62	10.56	5.84
WHR	8.16	5.43	6.59	8.04	6.12	6.52	5.61	6.81	5.88	7.52	6.38	7.95
Biceps skinfold (mm)	25.14	21.07	43.30	25.77	28.20	20.45	49.74	35.92	29.29	24.25	36.05	25.82
Triceps skinfold (mm)	25.64	15.73	38.09	21.12	28.89	17.61	43.94	30.11	23.80	14.21	32.42	18.17
Sub scapular skinfold (mm)	29.39	19.35	47.12	28.15	25.80	18.72	42.32	33.54	24.04	18.00	32.42	24.45
Supra-iliac skinfold (mm)	28.19	23.33	52.04	29.00	30.07	20.65	47.26	35.12	28.01	23.97	42.97	29.28
SBP (mmHg)	7.20	11.64	7.71	7.81	13.63	10.41	9.64	5.25	12.43	15.73	10.36	7.25
DBP (mmHg)	10.59	11.83	11.61	6.42	13.47	12.66	12.05	10.22	12.13	16.05	8.98	7.22
Pulse rate	10.80	8.93	13.73	11.78	14.70	11.88	13.63	16.00	8.25	9.87	10.10	12.62

Table 5: Estimates of familial correlation and level of significance for SBP, DBP and Pulse rate of three caste populations

	Brahmin			Khatri			Bania		
Relation	SBP	DBP	Pulse rate	SBP	DBP	Pulse rate	SBP	DBP	Pulse rate
Male parent-female parent	-0.06	0.16	-0.10	-0.04	-0.13	0.02	0.40**	-0.02	0.17
Male parent-male offspring	0.15	0.25*	0.04	-0.07	0.01	0.16	0.21	-0.14	-0.18
Male parent-female offspring	0.03	0.20	*-0.19	0.19*	0.23*-	0.20*	0.90**	0.11	-0.10
Female parent-male offspring	0.03	0.15	-0.40**	0.09	-0.08	-0.11	-0.03	0.05	-0.08
Female parent-female offspring	0.11	-0.06	0.05	0.11	0.04	0.29*	0.06	0.15	0.27*
Male offspring-female offspring	-0.15	-0.07	0.05	0.23	-0.17	0.05-	0.12	0.13	0.21

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

offspring generation, the means of age (20.84±4.60), height (156.87±5.35), weight (52.59±8.46), BMI (21.24±3.32), hip circumference (94.16±7.64), triceps skinfold (28.59±6.04), sub scapular skinfold (24.19±6.81), supra- iliac skinfold (23.13±6.71), SBP (131.72±10.29) and DBP (85.63±5.50) for Brahmin, WHR (0.88±0.06), biceps skinfold (22.24±7.99) and pulse rate (89.12±14.26) for Khatri and waist circumference (82.38±9.70) and WHR (0.88±0.07) for Bania were also found slightly higher as compared to others. However, in female offspring generation, only SBP and DBP variables have been found with significant inter-caste differences ($p<0.001$) (Table 3). The comparisons of coefficient of variance (CV) for all measured characters among all the generations have been presented in Table 4. Among male parent generation, almost all measured characters except sub scapular and biceps skinfolds have pronounced maximum variability in Khatri population. Whereas, among female parent generation, Bania population has indicated maximum variability for almost all characters. Khatri population exhibited maximum variability for all measured characters among male and female offspring generations as compared to Brahmin and Bania populations. As shown in all generations among the three caste populations, the blood pressure (SBP and DBP) phenotypes showed less variation as compared to anthropometric variables.

Estimates of familial correlation among household members for SBP, DBP, pulse rate, age, WHR and BMI are presented in Table 5 and 6 among the three caste populations. As shown in Table 5, the familial correlations between male parent-female parent among Bania population, male parent-female offspring among Bania and Khatri population have been found significant ($p<0.01$) for SBP. The familial correlations between male parent- male offspring among Brahmin population, male parent-female offspring among Brahmin and Khatri population have been found significant ($p<0.05$) for DBP. Similarly, the familial correlations between female parent –male offspring among Brahmin, male parent-female offspring among Khatri population, female parent-female offspring among Khatri and Bania population have been found significant ($p<0.05$) for pulse rate. As shown in Table 6, the familial correlations between male parent- female parent have been found significant ($p<0.05$) for BMI in Brahmin population and age in Bania population. The familial correlations between male parent- male offspring have been found significant ($p<0.05$) for BMI in Brahmin and Khatri population and that between male parent-female offspring have been found significant ($p<0.05$) for WHR in Brahmin and Bania population and BMI in Khatri population. Similarly, the familial correlations between female parent-male offspring have been found significant

Table 6: Estimates of Familial correlation and level of significance for Age, WHR and BMI of three caste populations

	Brahmin			Khatri			Bania		
Relation	Age	WHR	BMI	Age	WHR	BMI	Age	WHR	BMI
Male parent-female parent	-0.02	0.05	-0.20*	0.05	-0.16	0.14	0.24*	-0.09	0.01
Male parent-male offspring	-0.09	0.18	0.20*	-0.09	-0.06	-0.28*	0.01	-0.11	-0.11
Male parent-female offspring	-0.12	-0.23*	0.13	0.12	0.01	0.35**	-0.15	0.20*	-0.02
Female parent-male offspring	0.09	-0.28*	-0.28*	0.05	0.19	0.08	-0.07	0.03	-0.05
Female parent-female offspring	0.10	-0.05	-0.47**	0.21*	-0.25*	-0.02	-0.11	0.14	-0.18
Male offspring-female offspring	0.12	0.16	0.03	0.26*	-0.01	-0.23*	0.15	0.23*	-0.07

**Correlation is significant at the 0.01 level (2-tailed) *Correlation is significant at the 0.05 level (2-tailed)

Table 7: Estimates of heritability and genetic components of variance for different variables among three caste populations

	Brahmin		Khatri		Bania	
Variables	Heritability	Genetic component of Variance	Heritability	Genetic component of Variance	Heritability	Genetic component of Variance
Age (years)	0.413	0.165	0.535	0.294	0.425	0.182
Height (cm)	0.321	1.785	0.390	1.841	0.230	1.446
Weight (kg)	0.495	2.143	0.312	1.312	0.450	1.627
BMI (kg m^{-2})	0.774	0.984	0.834	0.714	0.388	0.138
Waist circumference (cm)	0.112	1.112	0.129	1.081	0.199	1.485
Hip circumference (cm)	0.188	1.272	0.225	1.031	0.822	0.700
WHR	0.068	1.402	0.870	0.784	0.582	0.350
Biceps skinfold (mm)	0.650	0.953	0.600	1.586	0.750	0.888
Triceps skinfold (mm)	0.338	1.132	0.400	2.021	0.350	1.369
Sub scapular skinfold (mm)	0.286	1.700	0.181	1.407	0.225	0.966
Suprailiac skinfold (mm)	0.163	1.383	0.188	1.446	0.075	1.167
SBP (mmHg)	0.612	0.377	0.677	0.485	0.674	0.463
DBP (mmHg)	0.736	0.551	0.822	0.673	0.541	0.299
Pulse rate	0.237	1.578	0.129	1.294	0.088	1.185

($p<0.05$) for WHR and BMI in Brahmin population and that between female parent-female offspring have been found significant ($p<0.05$) for BMI in Brahmin population and age and WHR in Khatri population. Whereas, the familial correlations between male offspring-female offspring have been found significant ($p<0.05$) for age and BMI in Khatri population and WHR in Bania population. Table 7 presents the heritability estimates (h^2) and genetic component of variance for all measured characters of the main data set among the three caste populations. The range of heritability was found highest in BMI (77%) to lowest in WHR (6%) for Brahmin population, 87% (WHR) to 13% (pulse rate and waist circumference) for Khatri population and 82% (hip circumference) to 7.5% (supra-iliac skinfold) for Bania population. The same observations of genetic component of variances are 2.14 (weight) to 0.165 (age) for Brahmin population, 2.021 (triceps skinfold) to 0.294 (age) for Khatri population and 1.627 (weight) to 0.138 (BMI) for Bania population. The following observations of heritability estimates have been found for different subsets of the data among the three caste populations. The maximum heritability estimates for weight (49%), sub scapular skinfold (29%) and pulse rate (24%) have been found in Brahmin population whereas, the estimates for age (53%), height (39%), BMI (83%), WHR (87%), triceps skinfold (40%), supra-iliac (19%), SBP (68%) and DBP (82%) have been found maximum in Khatri population. The estimates for waist circumference (19%), hip circumference (82%) and biceps skinfold (75%) have been found maximum among Bania population. Therefore, as a whole Khatri population have showed maximum heritability for almost all measured traits as compared to other populations. The lower estimates of heritability such as WHR (7%) in Brahmin population, sub scapular skinfold (18%) in Khatri population and pulse rate (9%) and supra-iliac (7%) in Bania population have been found. Similarly, Khatri population have showed maximum genetic component of variance for almost all the characters such as age (0.294), height (1.841), biceps skinfold (1.586), triceps skinfold (2.021), supra-iliac skinfold (1.446), SBP (0.485) and DBP (0.673).

DISCUSSION

The major purpose of the present research was to study the heritability patterns of different anthropometric and physiometric traits among three caste populations. The objective was examined in the three caste populations such as Brahmin, Khatri and Bania in Punjab. The study of anthropometric and physiometric characteristics have immense importance to quantify the heritable portion of phenotypic variability due to the fact genetic and environmental factors or their interactions including dietary and physical differences across the different caste groups affect the variations in these phenotypes. Therefore, the present study has a great potential for the study of quantitative genetic variation within and between the caste populations among different generations. In the present study, as expected, age, generation and caste differences were significant for the majority of the traits indicating heterogeneity of the populations.

Estimation of heritabilities through variance component approached and produced a wide range of heritabilities (7-87%) for anthropometric and physiometric phenotypes between two generations such as parent and offspring among the three caste populations that are Brahmin, Khatri and Bania. Overall, most of these phenotypes exhibited moderate to high heritabilities while some of these heritability estimates were relatively low such as WHR (7%) for Brahmin population and supra-iliac skinfold (8%) and pulse rate (9%) for Bania population. The results of the present study have also been supported by many other studies in literature (Devi and Reddy, 1983; Byard *et al*., 1984; Poosha *et al*., 1984; Yu *et al*., 1990; Fagard *et al*., 1995; Rice *et al*., 2000; Arya *et al*., 2002; Fava *et al*., 2005; Kupper *et al*., 2005; Owiredu *et al*., 2008; Odenigbo *et al*., 2011). In total sample, it is evident from statistical analysis that descriptive statistics, coefficient of variance, ANOVA and heritability estimation with genetic component of variance have shown significant caste effects for almost all phenotypes. However, it is interesting to note that Khatri population showed higher heritability with significant genetic component of variance for almost all of the characters including soft tissues and blood pressures as compared to other two caste populations. However, the general trend in heritability patterns observed in this present study is the agreement with the findings of different studies (Devor *et al*., 1986a; Devor *et al*., 1986b; Rice *et al*., 2000; Arya *et al*., 2002; Badaruddoza and Kumar, 2009). In the present study, it is to be noted from the analysis of coefficient of variance (CV) accounted for mean and standard deviations among the three caste populations with two generations, that Khatri male parents, male offspring and female offspring have shown maximum variance for almost all measured characters whereas, female parents among Bania population have showed maximum variance for measured variables. Therefore, it may be assumed from the present study that Khatri population for both generations except female parent has maximum heterogeneity as well as admixture for almost all characters as compared to Brahmin and Bania populations. These analyses also explain that Brahmin population for all generations have showed minimum variations or heterogeneity for almost all characters except few as compared to other populations. This hypothesis is further confirmed from the analyses of familial correlation matrix. Maximum significant familial correlations in between male parent- male offspring, male parent-female offspring, female parent- male offspring, male parent-female parent and female parent- female offspring for the characters such as SBP, DBP, pulse rate, BMI and WHR among Brahmin population have been observed. Therefore, this analysis might explain that strong familial aggregation of anthropometric and physiometric characters have been observed among Brahmin population as compared to other populations. These observations have also been supported from the previous studies (Bochud *et al*., 2005; Badaruddoza and Sawhney, 2009; Badaruddoza *et al*., 2009, 2011; Ghose *et al*., 2010; Tassaduqe *et al*., 2004).

ACKNOWLEDGMENT

This study was supported by Punjab Council for Sciences and Technology vide letter no. PSCST/AD /POS/80/1253-1273 dated 5-3-2009.

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