Parent-Offspring Correlations in Body Measurements, Physique and Physiological Variables among Santhals of West Bengal

Ghosh, Sudipta and Malik, S.L.
Department of Anthropology, University of Delhi, Delhi-110007

Abstract

Intrafamilial resemblances in different morpho-physiological variables were examined among Santhals, a tribal population from West Bengal. Data were collected on 400 families that included 400 fathers, 400 mothers, 292 sons and 170 daughters. The parent-offspring and mid-parent-offspring correlation coefficients reveal that the degree of resemblance varies considerably from one measurement to another. Relationship between the parental and the filial generation is stronger in the transverse and longitudinal measurements, followed by head and face measurements and the weakest in the circumferential and bulk measurements.

Key Words: Body Measurements, Somatotype, Santhals, Parent-Offspring Correlations, Familial Resemblance,Tribe

Introduction

Morpho-physiological features are the product of continuous and complex interaction of biological or indigenous and environmental or exogenous factors. Biological factors influencing these characteristics, among other, are heredity or genetics, age and sex of an individual. Exogenous factors, on the other hand, include both environmental and socio-cultural factors such as nutrition, altitude, climate, socio-economic status, religious practices, cultural activities and mode of subsistence.

It is now well established that both environmental and genetic factors contribute to the patterns of growth and development of different body measurements (*Devi and Reddi, 1983*). Therefore, all the anthropometric traits are the result of the influence of either genetic or environmental factors, or combinations of both (*Susanne, 1975*). The influence of genetic and environmental factors in anthropometric traits indicates varying degree of hereditary control over their phenotypic expression (*Singh, 1992*). In terms of phenotypic resemblances of relatives, correlations among parent-offspring probably provide the best estimates of the genetic resemblance of parent and children in human populations (*Mueller, 1976*). The parent–offspring and mid-parent–offspring correlation coefficients indicate that to what extent genetic determination varies from one measurement to another (*Susanne, 1975*). Correlations among first degree relatives, i.e. parent–offspring and sib–sib pairs with respect to body size are affected by assortative mating and common household environment (*Malik and Singh, 1996*). In a panmictic population, for polygenic traits, correlation coefficient for mid-parent–offspring and parent–offspring would occur 0.71 and 0.50 respectively, though the observed correlation coefficient are mostly lower than the expected values both for mid-parent– offspring and parent– offspring (*Susanne, 1975*).

Further, it is useful and imperative to study the familial resemblance of a trait under different environmental conditions and in different ethnic groups, as heritability and familial resemblance is a property not only of a trait but is also a function of the population (*Falconer, 1960*). Gene frequencies and environmental causes of variation may differ among populations and cause fluctuations in parent-offspring correlation of a particular trait.

The question of the genetic contribution to anthropometric measurements is frequently raised. Several investigators have reported that human variations in different anthropometric measurements are closely associated with the differences in their nutritional status. However, there are less number of studies examining the role of genetics and environment on anthropometric measurements in different regions, especially in Indian tribal populations. Internationally, there have been investigations on intrafamilial correlations involving parents and their children for morpho-physiological parameters in a variety of populations representing different genetic and environmental backgrounds (*Susanne, 1975; Rao et al., 1975; Mueller, 1976; Russell, 1976; Roberts et al., 1978; Bouchard et al., 1980; Sanchez-Andres and Mesa, 1994; Katzmarzyk et al., 2000; Rebato et al., 2000; Perusse et al., 2000; Burke et al., 2001; Safer et al., 2001; Koziel, 2001; Coady et al., 2002; Hunt et al., 2002; Skaric-Juric, 2003; Salces et al., 2003 and 2004*).

It is ideal to conduct Anthropological research on a homogenous population where hereditary aspects of a trait can be examined with less error and contamination. Like any tribal population, Santhals of West Bengal are close knit homogenous population, prerequisite for familial study, where tribe endogamy and clan exogamy are strictly followed during marriages. Keeping these objectives in mind, a study was carried out to investigate intrafamilial resemblance of consanguineal relatives, i.e. parent–offspring to study the relative effect of heredity and environment on various morpho-physiological traits among the Santhals of West Bengal. In order to meet the aim of the present study, a number of anthropometric measurements, somatotype components and physiological parameters have been taken into considerations.

Materials and Methods

The Sample: Cross-sectional sample of 400 Santhal families, consisting of 1262 individuals, were surveyed from 18 villages of Ranibandh block of Bankura district of West Bengal. The selection of the district, block and the villages was based on Multi-stage random cluster sampling. Unit of the study was a family having ever married women, her husband and at least one of their adult children. In the present study, an ever-married woman from each selected family has been henceforth referred as 'Mother', her husband as 'Father', their sons as 'Son' and their daughters as 'Daughter'. Parent-Offspring (PO) resemblances in morpho-physiological variables of Santhals were examined for four familial correlations [Father-Son (FS), Father-Daughter (FD), Mother-Son (MS) and Mother-Daughter (MD)]. Similarly, in Mid-Parent-Offspring (MPO), familial correlations for Mid-Parent-Son (MPS) and Mid-Parent-Daughter (MPD) were estimated simultaneously. If available, in a family data on both son and daughter, but not on two sons or two daughters were collected. In case of multiple adult children in a family simple random sampling was used to select: (i) one son, (ii) one daughter or (iii) one son and one daughter, as the case may be. The subjects comprised 400 Fathers, aged 40-87 years (mean age 57.5 years); 400 Mothers, aged 35-83 years (mean age 48.6 years); 292 Sons, aged 18-63 years (mean age 26.3 years) and 170 Daughters, aged 18-50 years (mean age 24.5 years).

Nearly 85 percent of such families that met the requirement were covered from these 18 villages. Anthropometric and physiological measurements were taken on each subject. Date of birth of subjects was recorded by asking them. In case of doubt it was verified by other sources. Decimal age of each subject was calculated by subtracting the date of birth of the subject from the date of data collection, using the decimal age calendar (*Tanner et al., 1969*). All the subjects between 25.500 and 26.500 years were classified in the age group 26 years, whereas those falling between 48.500 and 49.500 were included in the age group of 49 years and so on.

The Place: West Bengal, with an area of 88,752 km^2, is the most densely populated state in the country (904 persons living per km^2) having a total population of 80,221,171 (*Census, 2001*). Bankura district is one of the districts of the state of West Bengal with a total land area of 6,882 km^2. The district is situated at the latitude of $23^0 12^/$ and the longitude of $87^0 6^/$. Located in the western part of the state, Bankura is situated on the northern bank of the river Dhaleshwari (Dhalkisor). The district is bordered by Bardhaman in its north, Puruliya in its west, Hugli in its east and Midnapur in its south. Bankura is a district with high percentage of tribal population. Cultivation is the main source of income. The total population of Bankura is 31, 91,822, as per *2001 census*, constitute 4 percent of the state's population. The total number of Schedule tribe population is 3, 29,080 out of which 16, 5843 are males and 16, 3237 are females. Schedule caste (31.4%) and schedule tribe (10.3%) constitute 41.7 percent of the district population that is higher than the state's contribution (29.2%). The district has a population density of 464 persons per km^2, which is lower compared to 904 of the state. Percentage of the urban population is the lowest (7.37%) as compared to the other districts of the state. Sex ratio of 953 is the highest, as compared to the other districts of West Bengal and it is slightly higher than that of the state average of 951 as well as national figures (*Census, 2001*). According to 2001 census, literacy in Bankura is 77.21% among males and 49.80% among females.

Ranibandh block is one of the 22 Community Development Blocks of district Bankura. The total land area of the block is 428 km^2 with a population density (244 per km^2), the lowest as compared to the other blocks. The total population of the block is 1,08,591. The sex ratio of Ranibandh (964 females per 1000 males) is the highest as compared to the other blocks and is also higher than that of the district, as well as the state average. The total number of tribal population of this block is 49,321 out of these 24,912 are males and 24,409 are females. 55,550 of the total population (including both tribal and non-tribal) are literates in this block, out of which 36,238 are males and 19,312 are females (*Census, 2001*). The tribal populations inhibiting in Ranibandh block are Santhal, Sardar, Munda and Bumij. Of these, Santhals are the highest in number. The area is undulating, relatively hard and is reddish lateritic in nature. Ranibandh is predominantly a Santhal region and some of the villages are exclusively occupied by them. The block has 208 villages that are governed by 8 Gram Panchayats, namely, 1) Puddi, 2) Ambikanagar, 3) Rajakata, 4) Rudra, 5) Haludkanali, 6) Ranibandh, 7) Barikul, and 8) Raotora.

The Population: Santhals are the third largest tribal community in India after the Gonds and the Bhils. The Santhal inhabit in a wide area of West Bengal, Bihar, and Orissa. Their main concentration is in Bihar, mainly in the Santhal Paragana. In West Bengal, they are mainly distributed in the district of Malda, Birbhum, Bankura, Midnapur and 24th Paragana.Their habitational places are generally covered with the forest and the hills. These are intercepted by numerous streams and springs. In some parts, there are ranges of low hills, while in others, the conical shaped hills rise abruptly from the undulating plains. Most part of the countryside is covered with the Sal forest that contributes to the well being of the dwellers. The area in the plain is characterized with the lateritic reddish soil having scanty water supply.

The Santhals belong to the Proto-Australoid, according to Guha (*Guha, 1944*), who considered that they arrived in India soon after the Negritos. Santhals are the largest tribe to retain an aboriginal language, known as *Santali,* belonging to Austro-Asiatic, sub-family of the Austric family. This language is closely related to Mundari as well as Ho, Korku, Savara and Gadaba languages spoken by nearby inhabiting smaller tribes (*Culshaw, 1949*). The Santhals have been living in southern and western part of the West Bengal for at least five hundred years. It has been found that few of the Santhal villages in Bankura district are over three hundred years old.

The primary occupation of the Santhals is agriculture, while food gathering and hunting are their important subsidiary occupations. In addition, animal husbandry also contributes marginally to their livelihood. Both men and women take part in agricultural activities, with a division of labor on the basis of gender. Women are tabooed from ploughing the field. Otherwise, both the genders take equal part in transplanting, deweeding, reaping, thrashing, winnowing, and husking. Santhals are expert hunters who hunt a variety of animals that are available in their surrounding forests. Fishing is additional economic activity of the Santhals. They fish in river, ponds and other water- logged areas with the help of nets, traps, bow and arrows. They also do fishing with the help of poisonous plants. Between the harvest and the spring festival, a period, which corresponds with the cold weather, most of the villagers of the Bankura district, migrate to the east, for work in the harvest fields of the Ganges delta.

The community life of the Santhals hovers around their village. The houses are built on either side of the village street, which is wide enough to cross two bullock carts at a time. This kind of settlement is known as linear type settlement pattern. Every house has its main door's opening on to the village street, but the entrance of each hut or room never faces the street, instead it faces the small courtyard of the house. The huts are generally two-sloped gable shaped, though four-sloped huts are also not very rare.

The staple food of the Santhals is boiled rice, locally known as *daka*. They usually take meals thrice a day. In the morning they take breakfast, known as *basiam*. It consists of a small quantity of cold rice or rice gruel, prepared with the evening meal of the previous day and is kept for the morning. In the morning they eat that with salt. For lunch and dinner they have hot boiled rice with vegetable curry (*utu*). When available their vegetable diet is supplemented with fish and meat.

Since Santhals live in a patrilineal society, every male of their society has to undergo an initiation rite through the *Cacho chhatiar* ceremony by which he becomes an effective member of the society and enjoys the rights, duties and privileges of a full-fledged member (*Mukherjee, 1962*). Marriage is not permissible for those who do not performs this rite, and those who die without observing this ceremony will be buried instead of cremated after their death. In a Santhal society a political unit, named *Panchayat*, maintain law and order in the society. It governs by a number of officials. The village headman or *Manjhi* is the man of greatest consequence in the community. The post of the village headman is hereditary; the eldest son of the headman becomes the next headman. There is often a deputy headman, the *Paranik*, who works as an adviser. Another important position in the political organization is the post of the *Jogmanjhi*, who is a kind of "censor of morals", according to *Culshaw* (*1948*). He is the guardian of the morals of the young men in the village, and his wife gives moral lessons to the young women. *Naeke*, the village priest, is entrusted with the duties of worshiping the village deities. The humblest of the village officials is the *Godet*, the messenger of the headman. When a child is born or a villager dies, it is the *Godet* who carries the news to all the houses.

The Santhals are divided into 12 exogamous totemic clans, locally known as *Paris*. These are: 1) *Hansda*, 2) *Marndi*, 3) *Soren*, 4) *Hembrom*, 5) *Tudu*, 6) *Kisku*, 7) *Murmu*, 8) *Baske*, 9) *Besra*, 10) *Pauria*, 11) *Chore* and 12) *Bedea* (*Datta-Majumdar, 1956*). *Pauria*, *Chore* and *Bedea* clans are on the verge of extinction and not even a single member of these three clans was found during the present study. The clans are strictly exogamous in nature and there are no intra-clan marriages. Generally members of a clan may marry person of another clan, with two exceptions. The first exception prohibits marriage between a *Marndi* and a *Kisku* and the second prohibits the marriage of a *Tudu* and a *Besra*, both because of the quarrel between these clans. In marriage system, monogamous marriage is the most prevalent one among Santhals, though polygynous marriage is also found in some cases. There are seven accepted forms of marriages or *Bapla* namely, *Kring Bahu Bapla*, *Ghardi Jawae Bapla*, *Itut Bapla*, *Sanga Bapla*, *Kiring Jawae Bapla, Tunki Dipil Bapla* and *Nirbolok Bapla*.

The supreme deity in Santhal religion is termed as *Maran Buru*, who is believed to be the giver of life, rain, crops and all other necessaries. *Maran Buru* is also referred to as *Thakur*. *Cando, Sin Cando, Cando Bonga and Sin Bonga*, all of which stands primarily for Sun God, often refer to as the synonyms of *Maran Buru*.

Measurements: Following anthropometric measurements were taken by using standard methods (*Martin and Saller, 1957; Tanner et al., 1969*). These measurements are; 1) Height vertex, 2) Sitting height vertex, 3) Total upper extremity length, 4) Total upper arm length, 5) Total fore arm length, 6) Hand length, 7) Total lower extremity length and 8) Head cum neck segment, 9) Body Weight, 10) Biacromial breadth, 11) Bicristal breadth, 12) Head circumference, 13) Mid upper arm circumference, 14) Mid calf circumference, 15) Head length, 16) Head breadth, 17) Nasal height, 18) Nasal breadth, 19) Bizygomatic breadth, 20) Bigonial breadth and 21) Total facial height.

In addition, physiological parameters like, I) Blood pressure (both Systolic and Diastolic), II) Heart rate, III) Pulse rate and IV) Handgrip strength were collected from each subject.

Further, somatotype was rated by using Heath and Carter's anthropometric method (*Carter, 1980*). Somatotype components were determined using the equations of Heath and Carter (*Heath and Carter, 1967*) as follows:

Endomorphy (relative fatness) was calculated from the sum of the triceps, subscapular and suprailiac skinfolds and was adjusted for stature.

$$Endomorphy = -0.7182 + 0.1415 (X) - 0.00068 (X)^2 + 0.0000014 (X)^3$$

Where, X is the sum of skinfolds at triceps, subscapular and suprailiac.

In the next step, Endomorphy was corrected with Height, using the following equation:

Height corrected Endomorphy = Endomorphy * 170.18 / Height.

Mesomorphy (relative musculo-skeletal development) was derived from the humerus and femur breadths and from flexed arm and calf girths corrected for the corresponding skinfold thickness (triceps or medial calf).

Mesomorphy = (0.858* Bicondylar humerus + 0.601*Bicondylar femur + 0.188 *Corrected mid upper arm circumference + 0.161*Corrected mid calf circumference) – (Height * 0.131) + 4.50

Where,

Corrected Mid upper arm circumference = Mid upper arm circumference (cm) – Skinfold at triceps (mm) / 10 and

Corrected calf circumference = Calf circumference (cm) – Skinfold at calf (mm) / 10.

Ectomorphy (relative linearity) was based on a height-weight ratio.

$$HWR = \frac{Height}{\sqrt[3]{Weight}}$$

When, HWR > 40.75, then

Ectomorphy = HWR*0.732 – 28.58

When HWR < 40.75 > 38.25, then

Ectomorphy = HWR*0.463 – 17.63

When HWR ≤ 38.25, then

Ectomorphy = 0.1

Statistical Analysis

In statistical analysis, mean, standard error and coefficient of variation were estimated in Fathers (400), Mothers (400), Sons (292) and Daughters (170) for above mentioned anthropometric measurements, somatotype components and physiological variables by using computerized statistical softwares, viz. SPSS and MS Excel. Additionally, partial correlations were calculated for above-mentioned morpho-physiological variables in four familial pairs of parent and offspring, e.g., Father-Son (FS), Mother-Son (MS), Father-Daughter (FD) and Mother-Daughter (MD). Furthermore, mid-parent-offspring partial correlations were calculated for the same measurements. T-test was anticipated to examine the significance of four pairs of parent-offspring as well as mid-parent-offspring correlations for these measurements. Finally, Z-test was estimated to analyze the significance of the difference between mid-parent-son and mid-parent-daughter correlations for different morpho-physiological variables and somatotype components.

Results and Discussion

Results of present study of Parent-Offspring resemblances in morpho-physiological variables among Santhals of West Bengal are presented in three categories, viz. Body measurements, Body physique and Physiological variables.

Body Measurements: In Santhals, Son and Daughter are markedly taller and heavier with longer extremities, bigger bone widths and circumferences than Father and Mother respectively (Table 1). On the other hand, Father and Mother show higher mean values in most of the head and face measurements, like Head length, Nasal height, Nasal breadth, Bigonial breath and Total facial height, than Son and Daughter respectively. Among these four groups of Santhals, i.e. Father, Mother, Son and Daughter, Son have greater mean values in most of the body measurements, except for segmental measurements of upper extremity and head and face measurements, where Father show marginally higher values. Sex differences are evident in this population, as Father and Son have relatively higher mean values than Mother and Daughter in all the body measurements, except for Bicristal breadth, which is comparatively greater in Mother.

Table 1. Descriptive statistics of Body measurements of Father, Mother, Son and Daughter

Body Measurements	Father (400)			Mother (400)			Son (292)			Daughter (170)		
	Mean	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*
Height vertex, cm	159.84	3.94	0.32	148.94	3.82	0.29	162.88	3.87	0.37	150.79	3.96	0.46
Sitting height vertex, cm	79.29	4.86	0.19	73.71	4.82	0.18	81.10	4.61	0.22	74.51	4.31	0.25
Total upper extremity length, cm	74.39	5.12	0.01	67.17	4.88	0.16	74.37	5.30	0.23	67.58	9.78	0.50
Total upper arm length, cm	30.20	7.95	0.12	26.76	7.44	0.10	30.26	8.03	0.14	27.15	8.33	0.17
Total fore arm length, cm	26.16	6.28	0.08	23.92	6.66	0.08	26.11	6.58	0.10	24.13	8.59	0.16
Hand length, cm	18.03	9.77	0.09	16.49	9.02	0.07	18.00	8.05	0.09	16.29	11.84	0.15
Total lower extremity length, cm	91.70	4.69	0.22	88.16	4.16	0.18	92.29	5.24	0.28	88.32	4.78	0.32
Head cum neck segment, cm	28.72	9.04	0.13	27.67	8.72	0.12	30.32	7.65	0.14	28.22	10.96	0.24
Body weight, kg	47.15	14.29	0.34	41.38	16.05	0.33	51.94	12.01	0.37	42.86	13.65	0.45
Biacromial breadth, cm	37.96	6.42	0.12	35.14	6.69	0.12	39.45	6.43	0.15	35.87	6.08	0.17
Bicristal breadth, cm	27.09	6.96	0.09	29.97	7.25	0.10	27.55	7.04	0.11	26.49	6.37	0.13
Head circumference, cm	54.87	3.20	0.09	54.20	2.95	0.08	55.55	2.80	0.09	54.25	2.59	0.11
Mid upper arm circumference, cm	23.72	9.55	0.11	23.39	10.36	0.12	25.01	7.16	0.11	23.43	8.36	0.15
Mid calf circumference, cm	29.25	8.43	0.12	28.84	8.36	0.12	31.66	6.79	0.13	29.54	7.53	0.17
Head length, cm	19.26	4.44	0.04	18.46	3.77	0.04	19.20	4.14	0.05	18.37	3.68	0.05
Head breadth, cm	14.13	4.05	0.03	14.01	3.99	0.03	14.28	4.27	0.04	14.12	3.74	0.04
Nasal height, cm	4.79	9.20	0.02	4.38	9.87	0.02	4.65	9.99	0.03	4.27	7.61	0.03
Nasal breadth, cm	3.82	10.29	0.02	3.48	8.87	0.02	3.78	7.51	0.02	3.47	9.28	0.03
Bizygomatic breadth, cm	13.73	4.34	0.03	13.25	4.34	0.03	13.82	4.24	0.03	13.28	4.56	0.05
Bigonial breadth, cm	10.82	5.80	0.03	10.15	6.51	0.03	10.80	6.27	0.04	10.09	6.50	0.05
Total facial height, cm	11.30	5.82	0.03	10.39	6.74	0.04	11.03	6.30	0.04	10.32	6.36	0.05

Variability in body measurements, as evident from coefficient of variation, is the highest in Body weight as compared to other body measurements, more so in parental generation than in filial generation (Table 1). This is perhaps because of the fact that Body weight can be influenced by numerous environmental factors. It varies with changes in nutritional status, socio-economic status, occupation, etc. medium variability is observed in Hand length, Head cum neck segment and mid upper arm circumference. Nasal shape has high variability in this population, as both Nasal height and Nasal breadth have large coefficient of variations. Head shape, on the other hand, exhibits low variability in Santhal Father, Mother, Son and Daughter, as manifested from coefficient of variation of Head circumference, Head length and Head breadth. Similar low variability is observed in Stature.

Thus, both Son and Daughter have affinity with their Father and Mother. Sex differences are apparent in almost all the body measurements. For example, Santhal Father and Son are taller, heavier with broader shoulder, greater circumferences and bigger head and face in comparison with Mother and Daughter. As a consequence, Sons resemble their Father while Daughters resemble their Mother in terms of different body measurements. Considerably higher mean values of different body measurements among Son and Daughter, than their Father and Mother respectively indicate a positive secular trend. This observation of secular trend is further strengthened by the fact that the parents have not yet reached senescence, as mean ages of Father and Mother are 57.5 and 48.6 years respectively. These observations are in agreement with the study made by previous investigators who observed secular trend in filial generation in various body measurements (*Susanne, 1975 and 1977; Kaur and Singh, 1981; Malik and Singh, 1996; Roy and Singh, 1992; Ulijaszek, 2001; Ali et al., 2000; Krawczynski et al., 2003; Malina et al., 2004; Carrascosa et al., 2004; and Simsek, 2005*).

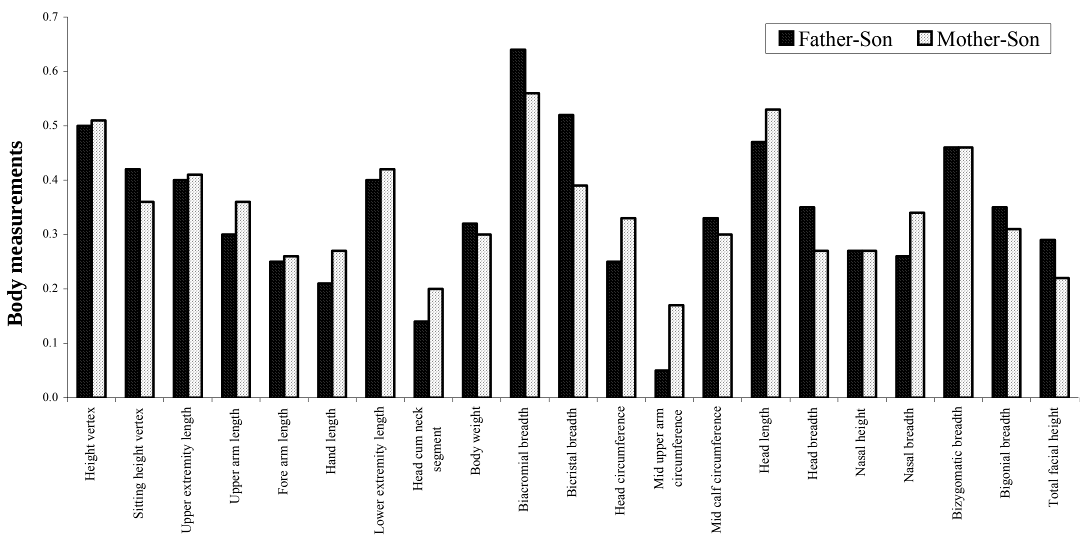

Figure 1. Parent-Son (PS) correlations in Body measurements

Examination of intra-familial correlations in body measurements suggests that both Son and Daughter have the highest correlation in Biacromial breadth with their parents, as compared to other body measurements. This is followed by Stature and Total upper extremity length (Table 2 and 3). On the other hand, the lowest correlation is observed in Mid upper arm circumference in Mother-Son (MS), Father-Son (FS) and Father-Daughter (FD) but not in Mother-Daughter (MD), where the lowest correlation is noticed in Body weight.

Table 2. Parent-Son (PS) correlation coefficient (r) for Body measurements

Body Measurements	Father–Son (FS)		Mother-Son (MS)	
	(r)	*T - test*	*(r)*	*T - test*
Height vertex, cm	.50	9.75*	.51	9.96*
Sitting height vertex, cm	.42	7.95*	.36	6.51*
Total upper extremity length, cm	.40	7.37*	.41	7.57*
Total upper arm length, cm	.30	5.32*	.36	6.47*
Total fore arm length, cm	.25	4.42*	.26	4.62*
Hand length, cm	.21	3.68*	.27	4.81*
Total lower extremity length, cm	.40	7.34*	.42	7.88*
Head cum neck segment, cm	.14	2.34*	.20	3.53*
Body weight, kg	.32	5.73*	.30	5.28*
Biacromial breadth, cm	.64	14.34*	.56	11.63*
Bicristal breadth, cm	.52	10.23*	.39	7.26*
Head circumference, cm	.25	4.32*	.33	5.99*
Mid upper arm circumference, cm	.05	0.78	.17	2.96*
Mid calf circumference, cm	.33	5.93*	.30	5.30*
Head length, cm	.47	9.02*	.53	10.50*
Head breadth, cm	.35	6.45*	.27	4.81*
Nasal height, cm	.27	4.72*	.27	4.78*
Nasal breadth, cm	.26	4.62*	.34	6.22*
Bizygomatic breadth, cm	.46	8.70*	.46	8.82*
Bigonial breadth, cm	.35	6.38*	.31	5.53*
Total facial height, cm	.29	5.20*	.22	3.79*

* Significant at 5% probability level, N = 292, d.f. = 290

In general, Body weight shows a trend of paternal influence, as both Son and Daughter have greater resemblance with Father in Body weight than with Mother (Figure 1 and 2). In transverse measurements, generally sons have relatively greater degree of paternal affinity, whereas Daughters have equivalent degree of resemblance with both Mother and Father.

Table 3. Parent-Daughter (PD) correlation coefficient (r) for Body measurements

Body Measurements	Father–Daughter (FD)		Mother-Daughter (MD)	
	(r)	*T - test*	*(r)*	*T - test*
Height vertex, cm	.48	7.00*	.48	7.15*
Sitting height vertex, cm	.32	4.41*	.37	5.08*
Total upper extremity length, cm	.49	7.31*	.47	6.96*
Total upper arm length, cm	.23	3.11*	.30	4.17*
Total fore arm length, cm	.35	4.81*	.21	2.80*
Hand length, cm	.31	4.29*	.31	4.24*
Total lower extremity length, cm	.33	4.56*	.35	4.89*
Head cum neck segment, cm	.18	2.37*	.27	3.66*
Body weight, kg	.21	2.81*	.08	1.08
Biacromial breadth, cm	.52	7.91*	.52	7.93*
Bicristal breadth, cm	.35	4.78*	.35	4.89*
Head circumference, cm	.43	6.17*	.20	2.67*
Mid upper arm circumference, cm	.07	0.88	.14	1.85
Mid calf circumference, cm	.11	1.42	.26	3.52*
Head length, cm	.49	7.23*	.39	5.52*
Head breadth, cm	.17	2.24*	.48	7.13*
Nasal height, cm	.26	3.42*	.30	4.12*
Nasal breadth, cm	.29	3.99*	.35	4.87*
Bizygomatic breadth, cm	.44	6.39*	.28	3.75*
Bigonial breadth, cm	.27	3.61*	.27	3.56*
Total facial height, cm	.23	3.05*	.34	4.75*

* Significant at 5% probability level, N = 170, d.f. = 168

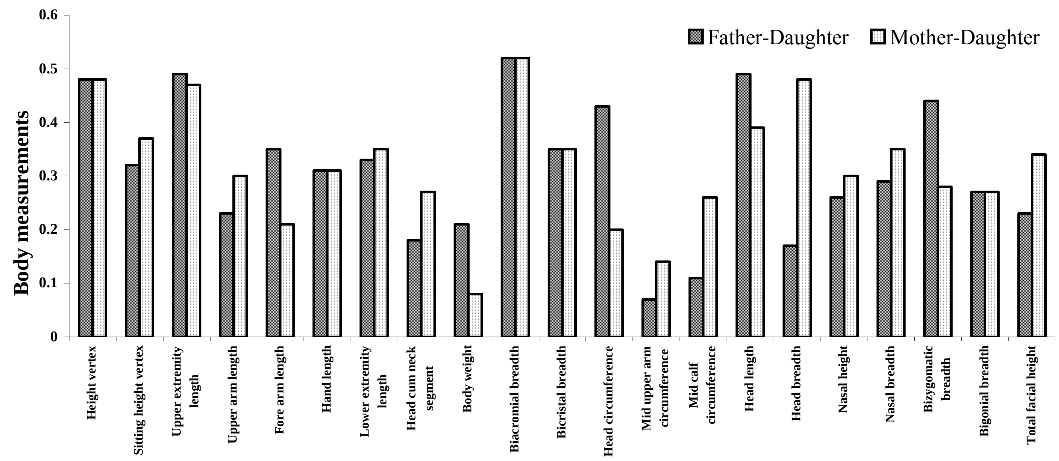

Figure 2. Parent-Daughter (PD) correlations in Body measurements

Overall, Parent–Offspring (PO) correlations are reasonably higher in transverse, longitudinal and segmental measurements, followed by head and face measurements and they are the least in circumferential and bulk measurements. In body measurements, both Son and Daughter exhibit greater correlations with Mother than Father. It suggests a strong pre-natal and post-natal resemblance between mothers and children, which continues even when they grow up, irrespective of the sex. However, both Son and Daughter have similar degree of resemblance with their parents in some body measurements. For example, with both Father and Mother,

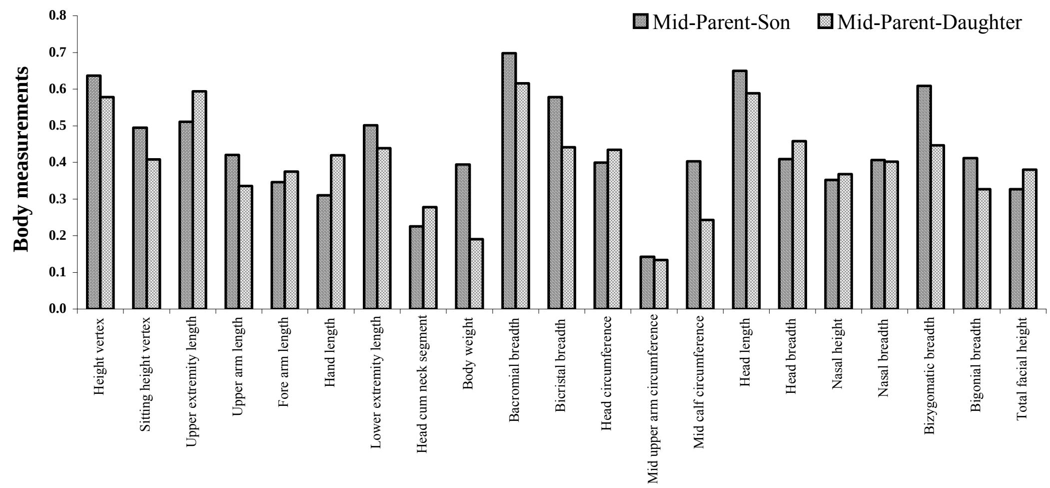

Figure 3. Mid-Parent-Offspring (MPO) correlations in Body measurements

Daughter have similar degree of affinity in Stature, Biacromial breadth, Bicristal breadth, Hand length and Bigonial breadth; while Son have similar degree of resemblance in Nasal height and Bizygomatic breadth. Comparison between the like-sex (FS and MD) and unlike-sex (MS and FD) pairs reveals that the differences are only marginal. This observation is similar to the one observed by *Mueller* (*1976*). Son have statistically significant correlations in all the body measurements with both Father and Mother, except for the correlation in mid upper arm circumference with Father. Daughter, on the other hand, have statistically significant correlations with both Father and Mother in all body measurements, except Mid upper arm circumference with both the parents and Body weight with Mother.

Mid-Parent-Offspring (MPO) correlations in body measurements of Santhals are represented in the Table 4 along with graphical illustration (Figure 3). MPO correlations have the same direction and variability as the PO correlations, but they are consistently higher.

Like PO correlation, both Mid-Parent-Son (MPS) and Mid-Parent-Daughter (MPD) show the highest correlation in Biacromial breadth, followed by Stature, Total upper extremity length, Bicristal breadth and Total lower extremity length. On the other hand, the lowest correlation is observed in Mid upper arm circumference in both MPS and MPD. As a consequence, in line with the observations recorded in Single-Parent-Offspring, higher Mid-Parent-Offspring correlation is observed in transverse measurement, followed by longitudinal, segmental and head and face measurements; the least is in soft tissue related measurements like circumferential and bulk measurements. Even in head and face measurements, measurements like Head length and Bizygomatic breadth precede other head and face measurements in both MPS and MPD. Correlations in both MPS and MPD are statistically significant in all the body measurements, except for Mid upper arm circumference in MPD. As compared to Daughter, Son exhibit greater degree of resemblance with their parents in most of the body measurements (Figure 3). However, the differences between the MPS and MPD correlations, as estimated from Z-test, are statistically non-significant in all the body measurements, except Body weight and Bizygomatic breadth (Table 4).

Table 4. Mid-Parent-Offspring (MPO) correlation coefficient (r) for Body measurements

Body Measurements	Mid-Parent–Son (MPS) [N_1]		Mid-parent–Daughter (MPD) [N_2]		*Z - test*
	(r_1)	*T - test*	*(r_2)*	*T - test*	
Height vertex, cm	.64	14.07*	.58	9.18*	0.96
Sitting height vertex, cm	.49	9.68*	.41	5.79*	1.11
Total upper extremity length, cm	.51	10.12*	.59	9.57*	1.23
Total upper arm length, cm	.42	7.88*	.34	4.61*	1.02
Total fore arm length, cm	.34	6.28*	.38	5.24*	0.34
Hand length, cm	.31	5.55*	.42	5.98*	1.30
Total lower extremity length, cm	.50	9.86*	.44	6.32*	0.83
Head cum neck segment, cm	.23	3.93*	.28	3.75*	0.58
Body weight, kg	.39	7.30*	.19	2.51*	2.31*
Biacromial breadth, cm	.70	16.60*	.62	10.13*	1.49
Bicristal breadth, cm	.58	12.06*	.44	6.37*	1.91
Head circumference, cm	.40	7.41*	.43	6.24*	0.44
Mid upper arm circumference, cm	.14	2.44*	.13	1.75	0.08
Mid calf circumference, cm	.40	7.50*	.24	3.24*	1.84
Head length, cm	.65	14.57*	.59	9.45*	1.02
Head breadth, cm	.41	7.63*	.46	6.68*	0.62
Nasal height, cm	.35	6.40*	.37	5.13*	0.19
Nasal breadth, cm	.41	7.57*	.40	5.69*	0.05
Bizygomatic breadth, cm	.61	13.08*	.45	6.46*	2.34*
Bigonial breadth, cm	.41	7.68*	.33	4.49*	1.00
Total facial height, cm	.33	5.89*	.38	5.33*	0.62

*Significant at 5% probability level, N_1 = 292, N_2 = 170

Thus, both Son and Daughter have similar degree of resemblance with mid-parent. In body measurements, both PO and MPO correlations exhibit values as high as the theoretical values, as proposed by *Susanne* (*1975*), especially in transverse and longitudinal measurements, more so in Son. He suggested that the observed correlation coefficients are mostly lower than the expected values, both for MPO and PO.

Body Physique: Among the three somatotype components of body physique, Mesomorphic component is dominant among Santhal Father, Mother, Son and Daughter (Table 5). Maternal effect is apparent in Mesomorphy, as both Son and Daughter resemble more with their Mother than their Father. In Endomorphy and Ectomorphy, sex differences are clearly evident. For example, in females (Mother and Daughter) these two components are co-dominant, whereas in males (Father and Son) Ectomorphy dominates over Endomorphy.

Table 5. Descriptive statistics of Somatotype components of Father, Mother, Son and Daughter

Somatotype Components	Father (400)			Mother (400)			Son (292)			Daughter (170)		
	Mean	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*
Endomorphy	1.98	49.22	0.05	3.16	48.73	0.08	2.04	43.47	0.05	3.18	40.41	0.10
Mesomorphy	4.81	25.86	0.06	5.43	24.26	0.07	5.33	19.59	0.06	5.31	22.77	0.09
Ectomorphy	3.98	34.42	0.08	3.17	49.50	0.08	3.50	33.91	0.07	3.15	45.32	0.11

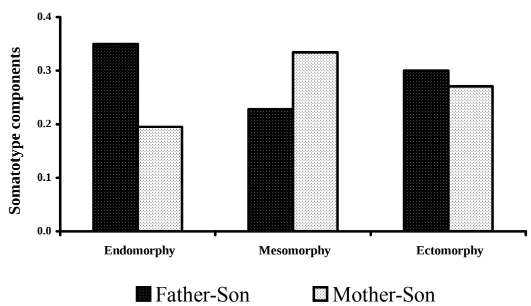

Figure 4. Parent – Son (PS) correlations in Somatotype components

Among somatotype components, Mesomorphic component shows greater homogeneity in this population, as evident from coefficient of variation, more so in filial generation than in parental generation. Among Santhals, gender has a role to play in the variations of Endomorphic and Ectomorphic components. For example, in males (Father and Son) comparatively greater dispersion is observed in Endomorphic component than in Ectomorphic component, whereas, in females (Mother and Daughter) similar magnitude of heterogeneity is noticed in both Endomorphic and Ectomorphic components.

Table 6. Parent-Son (PS) correlation coefficient (r) for Somatotype components

Somatotype Components	**Father–Son (FS)** *(r)*	*T- test*	**Mother-Son (MS)** *(r)*	*T- test*
Endomorphy	.35	6.36*	.20	3.39*
Mesomorphy	.23	3.99*	.33	6.03*
Ectomorphy	.30	5.36*	.27	4.79*

* Significant at 5% probability level, N = 292, d.f. = 290

In body physique, Son and Daughter have the highest correlation with Father in Endomorphic and Ectomorphic components respectively. The lowest correlation coefficient, on the other hand, is observed with Mother in Endomorphic component for both Son and Daughter. Both MS and MD pairs, have the highest correlation coefficient in Mesomorphic component as compared to other somatotype components

(Table 6 and 7). In somatotype, a hint of paternal influence is evident, as both Son and Daughter have greater degree of resemblance with Father than with Mother in all the three components, except for Mesomorphic component in Son (Figure 4 and 5).

Table 7. Parent-Daughter (PD) correlation coefficient (r) for Somatotype components

Somatotype Components	Father–Daughter (FD)		Mother-Daughter (MD)	
	(r)	*T- test*	*(r)*	*T- test*
Endomorphy	.28	3.74*	.06	.83
Mesomorphy	.28	3.74*	.26	3.52*
Ectomorphy	.30	4.14*	.24	3.16*

* Significant at 5% probability level, N = 170, d.f. = 168

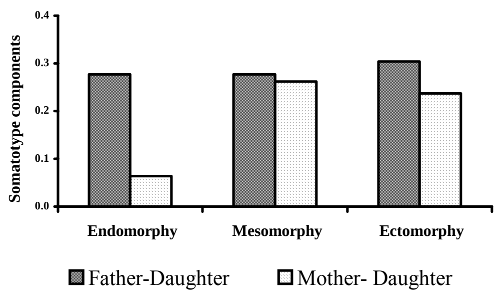

Figure 5. Parent – Daughter (PD) correlations in Somatotype components

Both Son and Daughter have statistically significant correlation coefficients with Father and Mother in all the three somatotype components, with the exception of the correlation between Mother and Daughter in Endomorphy.

MPO correlations in body physique of the Santhals are presented in Table 8 and Figure 6. The highest correlation coefficient is observed in MPS in Ectomorphic component, whereas the lowest correlation is noted in MPD in Endomorphic component. Both Son and Daughter have relatively greater resemblance in Ectomorphic and Mesomorphic components, followed by Endomorphic component with their Parent.

Table 8. Mid-Parent-Offspring (MPO) correlation coefficient (r) for Somatotype components

Somatotype Components	Mid-parent–Son (MPS) [N_1]		Mid-parent–Daughter (MPD) [N_2]		*Z - test*
	(r_1)	*T- test*	*(r_2)*	*T- test*	
Endomorphy	.33	5.85*	.18	2.40*	1.58
Mesomorphy	.37	6.87*	.34	4.67*	0.41
Ectomorphy	.38	6.95*	.34	4.66*	0.47

* Significant at 5% probability level, N_1 = 292, N_2 = 170

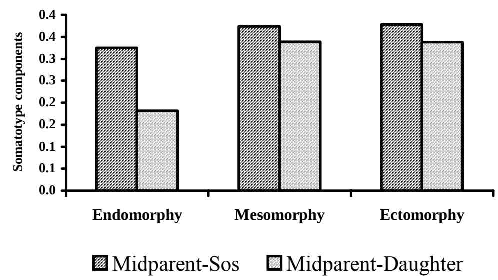

Figure 6. Mid-Parent –Offspring (MPO) correlations in Somatotype components

Among Santhals, both Son and Daughter have statistically significant correlation coefficients with Mid-Parent in all the three somatotype components. In general, Son reflect higher degree of resemblance with Mid-Parent as compared to Daughter in body physique (Figure 6), but, the difference is statistically non-significant at 5% probability level (Table 8).

Physiological Variables: Descriptive statistics of physiological variables of Santhal Father, Mother, Son and Daughter are represented in Table 9. Muscular strength, as estimated from Handgrip strength, is greater in Son and Daughter than Father and Mother respectively. On the other hand, Blood pressures, both Systolic and Diastolic, are relatively higher in Father and Mother as compared to Son and Daughter respectively.

Table 9. Descriptive statistics of Physiological variables of Father, Mother, Son and Daughter

Physiological Variables	Father (400)			Mother (400)			Son (292)			Daughter (170)		
	Mean	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*	*Mean*	*C.V.*	*S.E.*
Grip strength, kg	28.2	25.6	7.2	21.5	24.6	5.3	38.6	15.2	5.9	25.7	20.1	5.2
Systolic blood pressure, mm Hg	126.0	10.4	0.7	122.8	9.7	0.6	124.5	6.9	0.5	120.6	7.7	0.7
Diastolic blood pressure, mm Hg	82.1	10.9	0.5	81.6	11.1	0.5	81.1	11.1	0.5	78.8	10.6	0.6
Heart rate, per min	77.2	14.8	0.6	79.7	12.9	0.5	74.8	15.6	0.7	82.1	12.6	0.8
Pulse rate, per min	77.1	15.0	0.6	79.3	12.4	0.5	75.6	15.0	0.7	82.2	13.0	0.8

Sex differences are evident in Heart rate and Pulse rate, as Mother and Daughter have greater Heart rate and Pulse rate than the rates in Father and Son. The dispersion in Handgrip strength, as evident from coefficient of variation, is the highest amongst physiological variables. This heterogeneity in Handgrip strength is more apparent in parental generation than in filial generation. Systolic blood pressure, on the other hand, shows the minimum variation in Father, Mother, Son and Daughter. Gender differences are evident in Heart and Pulse rates, as these variables show greater dispersion in males (Father and Son) than in females (Mother and Daughter).

Table 10. Parent-Son (PS) correlation coefficient (r) for Physiological variables

Physiological Variables	Father–Son (FS)		Mother-Son (MS)	
	(r)	*T- test*	*(r)*	*T- test*
Grip strength, kg	.15	2.57*	.32	5.81*
Systolic blood pressure, mm Hg	.07	1.23	.08	1.37
Diastolic blood pressure, mm Hg	.15	2.50*	.11	1.90
Heart rate/ mint.	.12	2.13*	.23	4.02*
Pulse rate/ mint.	.13	2.18*	.23	4.10*

* Significant at 5% probability level, N = 292, d.f. = 290

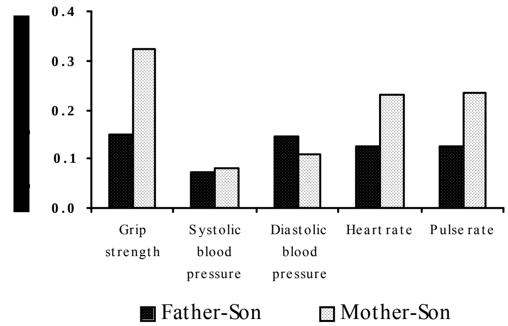

Figure 7. Parent – Son (PS) correlations in Physiological variables

Table 11. Parent-Daughter (PD) correlation coefficient (r) for Physiological variables

Physiological Variables	Father–Daughter (FD)		Mother-Daughter (MD)	
	(r)	*T- test*	*(r)*	T- test
Grip strength, kg	.29	3.85*	.34	4.72*
Systolic blood pressure, mm Hg	.16	2.05*	.27	3.68*
Diastolic blood pressure, mm Hg	.17	2.24*	.27	3.61*
Heart rate/ mint.	.25	3.40*	.09	1.20
Pulse rate/ mint.	.28	3.72*	.18	2.33*

* Significant at 5% probability level, N = 170, d.f. = 168

In physiological variables, Handgrip strength has the highest correlation coefficient in all the four familial correlations, i.e. FS, MS, FD and MD (Table 10 and 11). The lowest correlation, on the other hand, is observed in Systolic blood pressure in FS, MS and

FD, whereas it is noted in Heart rate in MD. Overall, maternal influence is apparent in physiological variables of Santhals, as both Son and Daughter have greater degree of resemblance with Mother as compared to their affinity with Father (Figure 7 and 8).

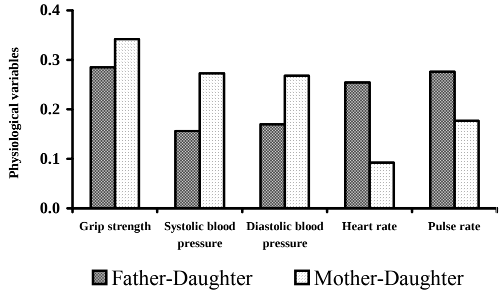

Figure 8. Parent – Daughter (PD) correlations in Physiological variables

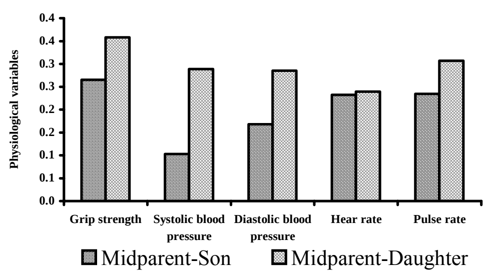

Figure 9. Mid-Parent – Offspring (MPO) correlations in Physiological variables

In general as compared to Son, Daughter has greater association with both Father and Mother in physiological parameters. Sons have statistically significant correlations with Father and Mother in all physiological variables, except Systolic blood pressure with Father and both Systolic and Diastolic blood pressure with Mother (Table 10). Daughter, on the other hand, have statistically significant correlations in all physiological parameters with both Father and Mother, except for Heart rate with Mother (Table 11).

Table 12. Mid-Parent-Offspring (MPO) correlation coefficient (r) for Physiological variables

Physiological Variables	Mid-parent–Son (MPS) [N_1]		Mid-parent–Daughter (MPD) [N_2]		*Z - test*
	(r_1)	*T- test*	*(r_2)*	*T- test*	
Grip strength, kg	.27	4.68*	.36	4.98*	1.06
Systolic BP, mm Hg	.10	1.76	.29	3.91*	2.00*
Diastolic BP, mm Hg	.17	2.90*	.29	3.85*	1.27
Heart rate/ mint.	.23	4.06*	.24	3.19*	0.08
Pulse rate/ mint.	.23	4.10*	.31	4.18*	0.81

* Significant at 5% probability level, $N_1 = 292$, $N_2 = 170$

MPO correlations of the Santhals in physiological variables are shown in Table 12 and Figure 9. Similar to the finding in PO correlations, the highest correlation is observed in Handgrip strength in both MPS and MPD. The lowest correlation, on the other hand, is noticed in Systolic blood pressure for MPS and in Heart rate for MPD (Table 12). Daughter have statistically significant correlations with Mid-Parent in all physiological variables, whereas, Son show statistically significant correlation in physiological variables, except Systolic blood pressure. As compared to Son, Daughter resembles more with their parents in all physiological parameters (Figure 9). However the difference, between the correlations of MPS and MPD is statistically non-significant, except systolic blood pressure.

From the above results it is clear that both PO and MPO correlations differ in various anthropological measurements. Correlations are generally the highest for transverse, longitudinal and other skeletal measurements, followed by head and face measurements and soft tissue related measurements like circumferential and bulk measurements. Calf girth shows higher PO correlation than arm girth. This finding is in agreement with earlier observations made on growing children (*Mueller, 1976*) and adults (*Susanne, 1975; Kaur and Singh, 1981; Malik and Singh, 1996; Devi and Reddi, 1983; Roy and Singh, 1992 and Sanchez-Andres, 1994*). Overall, both Father and Mother have nearly equivalent and important contributions in building up the morphological structure of the children. However, a trend of maternal effect is observed among Santhals, where, Mother have greater resemblance with Son and Daughter, as also noticed by Susanne and his co-authors (*Susanne et al., 2003*). Intrafamilial resemblance in somatotype components, especially in MPO correlations is statistically significant at 5% probability level. Son resemble more with their Mother than their Father in Mesomorphy. This observation is in accordance with the study made by *Sanchez-Andres* (*1995*). Father reflect greater resemblance in Endomorphy with their Son and in Ectomorphy with their Daughter. Therefore, by and large the results are in consistent with the notion that genes have influencing effect on human physique (*Katzmarzyk, 2000*). Significant intrafamilial resemblance is also observed in various physiological functions. However, familial resemblance of Systolic and Diastolic blood pressures differs. The degree of resemblance is higher in Diastolic blood pressure than Systolic blood pressure, which suggests that the Diastolic blood pressure has more pronounced genetic component as compared to Systolic blood pressure. This is in agreement with earlier investigations (*Skaric-Juric, 2003; Andre et al., 1986 and Hutchinson, 1987*). Grip strength has a maternal effect in its correlation, as both Son and Daughter resemble more with their Mother than their Father in Handgrip strength. Heart and Pulse rates suggest that gender does not play any role in genetic determination of these two variables, as Son resemble more with Mother than Father, while Daughter have greater degree of affinity with Father. In general, both Son and Daughter resemble their parents in all the morphological and physiological measurements. Even measurements with a large contribution of common family environment or residual environmental effects, like Blood pressure, have significant intrafamilial resemblance in this population. Hence, Santhals of West Bengal are a close knit and homogenous population with discernible positive secular trend and apparent familial affinity in morpho-physiological parameters.

Acknowledgement: We gratefully acknowledge the financial assistance rendered by the Ministry of Tribal Affairs, Govt. of India, for this investigation.

References

Ali, M.A., Uetake, T. and Ohtsuki, F. 2000. Secular changes in relative leg length in post-war Japan. *Am J Hum Biol,* **12 (3)**: 405-416.

Andre, J.L., Deschamps, J.P. and Gueguen, R. 1986. Familial resemblance of blood pressure and body weight. *Clin Exp Hypertens. A,* **8(4-5)**: 661-667.

Bouchard, C., Demirjian, A. and Malina, R.M. 1980. Heritability estimates of somatotype components based upon familial data. *Hum Hered,* **30(2)**: 112-118.

Burke, V., Beilin, L.J. and Dunbar, D. 2001. Family lifestyle and parental body mass index as predictors of body mass index in Australian children: a longitudinal study. *Int J Obes Relat Metab Disord,* **25(2)**: 147-157.

Carrascosa, A., Yeste, D., Copil, A. and Gussinye, M. 2004. Secular growth changes. Weight, height and body mass index values in infant, children, adolescent and young adults from Barcelona population. *Med Clin (Barc),* **123(12)**:445-51.

Carter, J.E.L. 1980. *The Heath and Carter Somatotype Method.* 3rd edition. San Diego State University Syllabus Service, San Diego.

Census of India. 2001. West Bengal. www. censusindia.com.

Coady, S.A., Jaquish, C.E., Fabsitz, R.R., Larson, M.G., Cupples, A. and Meyers, R.H. 2002. Genetic variability of adult body mass index: a longitudinal assessment in Framingham families. *Obesity Research,* **10**: 675-681.

Culshaw, W.J. 1949. *Tribal Heritage: A study of the Santhals.* Lutterworth Press, London.

Datta-Majumdar, N. 1956. *The santal: Study in culture change.* Govt, of India press.

Devi, M.R. and Reddi, G.G. 1983. Heritability of body measurements among the Jalari population in Visakhapatnam. *Ann Hum Biol,* **10(5)**: 483-485.

Falconer, D.F. 1960. *Introduction to Quantitative Genetics.* Ronald Press. New York.

Guha, B.S. 1944. *Racial elements in the populations.* Oxford University Press, Oxford.

Heath, B.H. and Carter, J.E.L. 1967. A modified somatotype method. *Am J Phys Anthropol,* **27:** 57-74.

Hunt, M.S., Katzmarzyk, P.T., Perusse, L., Rice, T., Rao, D.C. and Bouchard, C. 2002. Familial resemblance of 7-year changes in body mass and adiposity. *Obes Res,* **10(6)**: 507-517.

Hutchinson, J. and Byard, P.J. 1987. Family resemblance for anthropometric and blood pressure measurements in Black Caribs and Creoles from St. Vincent Island. *Am J Phys Anthropol,* **73(1)**: 33-39.

Katzmarzyk, P.T., Malina, R.M., Perusse, L., Rice, T., Province, M.A., Rao, D.C. and Bouchard, C. 2000. Familial resemblance for physique: heritabilities for somatotype components. *Ann Hum Biol,* **27(5)**: 467-477.

Kaur, D.P. and Singh, R. 1981. Parent-adult offspring correlations and heritability of body measurements in a rural Indian population. *Ann Hum Biol,* **8(4)**: 333-339.

Koziel. S. 2001. Relationships among tempo of maturation, Midparent height and growth in height of adolescent boys and girls. *Am J Hum Biol,* **13**(1): 15-22.

Krawczynski, M., Walkowiak, J. and Krzyzaniak. A. 2003. Secular changes in body height and weight in children and adolescents in Poznan, Poland, between 1880 and 2000. *Acta Paediatr,* **92(3)**: 277-282.

Malik, P. and Singh, R. 1996. Filial transmission of body measurements. *Hum Biol,* 83-84.

Malina, R.M., Pena Reyes, M.E., Tan, S.K., Buschang, P.H., Little, B.B. and Koziel, S. 2004. Secular change in height, sitting height and leg length in rural Oaxaca, southern Mexico: 1968-2000. *Ann Hum Biol,* **31(6)**:615-33.

Martin, R. And Saller, K. 1957. *Lehrbuch der Anthropooigie*. Gustav Fischer Verlag, Stuttgart.

Mueller, W.H. 1976. Parent-child correlations for stature and weight among school aged children: a review of 24 studies. *Hum Biol,* **48(2)**: 379-397.

Mukherjee, C.L. 1962. *The Santhals.* Calcutta: A. Mukherjee and Co. Pvt. Ltd.

Narain, P. 1988. Quantitative inheritance. In: *Statistical methods in human population genetics*. Ed: Malhotra, K.C. Indian Institute of Bio-social Research and Development. Indian Statistical Institute. Indian Society of Human genetics. 311-332.

Perusse, L., Rice, T., Province, M.A., Gagnon, J., Leon, A.S., Skinner, J.S., Wilmore, J.H., Rao, D.C. and Bouchard, C. 2000. Familial aggregation of amount and distribution of subcutaneous fat and their responses to exercise training in the HERITAGE family study. *Obesity Research***, 8**: 140-150.

Rao, D.C., Maclean, C.J., Morton, N.E. and Yee, S. 1975. Analysis of family resemblance. 5. Height and weight in Northeastern Brazil. *Am J Hum Genet,* **27**: 509-520.

Rebato, E., Salces, I., Rosique, J., San Martin, L. and Susanne, C. 2000. Analysis of sibling resemblance in anthropometric somatotype components. *Ann Hum Biol,* **27(2)**: 149-161.

Roberts, D.F., Billewicz, W.Z. and McGregor, I.A. 1978. Heritability of stature in a West African population. *Ann Hum Genet,* **42(1)**:15-24.

Roy, G. and Singh, R. 1992. Parent-adult offspring correlations of anthropometric measurements in an urban Indian population. *J Hum Ecol,* **3**(2): 125-132.

Russell, M. 1976. Parent-child and sibling-sibling correlations of height and weight in a rural Guatemalan population of preschool children. *Hum Biol,* **48 (3)**:501-515.

Safer, D.L., Agras, W.S., Bryson, S. and Hammer, L.D. 2001. Early body mass index and other anthropometric relationship between parents and children. *Int J Obes Relat Metab Disord,* **25(10)**: 1532-1536.

Salces, I., Rebato, E. and Susanne, C. 2004. Genetic and environmental sources on familial transmission in Biscayan families. III. The dynamometric strength. *Homo,* **54(3)**: 275-288.

Salces, I., Rebato, E., Slachmuylder, J.L., Vercauteren, M., Rosique, J. and Susanne, C. 2003. genetic and environmental sources on familial transmission in Basque families. II. Stature, weight and body mass index. *Ann Hum Biol,* **30(2)**: 176-190.

Sanchez-Andres, A. and Mesa, M.S. 1994. Heritabilities of morphological and body composition characteristics in a Spanish population. *Anthropol Anz,* **52**: 341-349.

Sanchez-Andres, A. 1995. Genetic and environmental influences on somatotype components: Family study in a Spanish population. *Hum Biol,* **67**: 727-738.

Simsek, F., Ulukol, B. and Gulnar, S.B. 2005. The secular trends in height and weight of Turkish school children during 1993-2003. *Child Care Health Dev,* **31(4)**:441-447.

Skaric-Juric, T. 2003. Path analysis of familial resemblance in blood pressure in Middle Dalmatia, Croatia. *Coll Anthropol,* **27(1)**: 229-237.

Susanne, C., Salces, I., Rebato, E., Slachmuylder, J.L., Vercauteren, M. And Rosique, J. 2003. Genetic and environmental sources on familial transmission in Basque families. II. Stature, weight and body mass index. *Ann Hum Biol,* **30 (2)**: 176-190.

Susanne, C. 1975. Genetic and environmental influences on morphological characteristics. *Ann Hum Biol,* **2(3)**: 279-287.

Susanne, C. 1977. Individuals age changes of the morphological characteristics. *Journal of Human Evolution,* **6**:181-189.

Tanner, J.M., Hiernaux, J. And Jarnan, S. 1969. Growth and physique studies. In: *Human Biology- A guide to field Methods. IBP Hand book no, 9.* Ed. J.S.Weiner and J.A.Lourie. Blackwell Scientific Publication, Oxford. 315-340.

Ulijaszek, S.J. 2001. Socio-economic status, body size and physical activity of adults on Rarotonga, the Cook Island. *Ann Hum Biol,* **28**: 554-563.