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Interethnic Comparisons of Three Endogamous Groups of West Bengal with Respect to Two Sets of Variables

The present paper focuses on the interethnic comparison among three endogamous groups (a higher caste, a tribe and a religious group) with different ethnohistorical background. A total of 700 individuals were studied from their anthropometric and dermatoglyphic traits along with their asymmetries. Statistical comparisons were carried out through the use of student's 't' test and Sanghvi's T^2 statistics. Heterogeneity for most of the anthropometric and some dermatoglyphic traits supports their different origins. Though dermatoglyphic asymmetry doesn't reveal significant discrimination, heterogeneity in anthropometric asymmetry corroborates with their different occupations. The anthropometric distances show greater values than the dermatoglyphic distances. This difference is probably due to the fact that anthropometry is not independent of environment and not a stable character like dermatoglyphic traits.

Keywords: Biological differences, Dermatoglyphics, Anthropometry, Asymmetry, Three endogamous groups, India.

Introduction

The people of India have been broken into a number of endogamous groups (Dobzhansky, 1951). There are about 5000 well-defined populations in India (Thangaraj et al., 1999), the members of which are forbidden to marry outsides by some social laws. This endogamous nature is not only for caste system but also for different languages, different religious believes and existence of different tribes. The history of the origin and the evolution of these groups are very difficult to trace, as most of these groups have been isolated for a hundred generations or more. But the endogamous nature of the people gives immense opportunity to study them from various aspects.

The classifications of any living organism including man are based on biological differences. In India, investigations on morphological traits for understanding these differences among human being were begun during the latter half of 19th century. The exclusive works were done by Risley (1915) and Guha (1931, 1937), both of whom stu-

died a large number of individuals including several groups of India and systematically classified them according to some morphological characters. But each of these groups is composed of several endogamous populations. The endogamous nature of these populations creates genetic distances amongst them. In the last century, many other attempts have been made to understand the differentiation among these endogamous populations using genetic markers like blood groups, serum proteins etc., and other biological traits (Banerjee and Banerjee, 1975; Malhotra et al., 1978; Vijaya Kumar M. 1988; Reddy, 1990; Murty et al., 1993; Ramana et al., 1996; Reddy and Chopra 1999; Reddy et al., 1987, 1988, 1995, 2000, 2001a,b). Still then a number of populations, especially in West Bengal, are remained to be study.

In advancing our knowledge, at present, the biological differences have been studied with the help of two sets of data like– ecosensitive anthropometric traits and relatively stable dermatoglyphic variables. The later one indicates that variations of these quantitative characters are to a large extent genetic in origin (Holt 1968; Meier, 1980). As such, they can be applied for tracing the origin of the populations and have been considered convenient for investigations of variability between populations (Loesch, 1979). However, the relationship between different sets of traits and interaction that forms between different loci through ontogenesis and evolution has been explained in different studies. In general, these studies support a hypothesis that, "every character for an organism is affected by all genes and every gene affects all characters "(Mayr, 1970). For this reason, dermatoglyphic and anthropometry have been considered in the present study to compare these two sets of traits with respect to population variation.

Most importantly dermatoglyphics, along with other morphological traits like anthropometry, show inequalities in structure between right and left sides of an individual. This particular feature is widely known as bilateral asymmetry. Fluctuating asymmetry (FA), a kind of asymmetry, is defined as the random deviation from perfect bilateral symmetry (Arrieta et. al., 1993). Statistically significant negative association between FA and heterozygosity was estimated by serological protein (Leary et al., 1983; Biemont, 1983; Kat, 1984) as well as by dermatoglyphics (Livshits & Kobyliansky, 1987). As the endogamous groups are expected to be more homozygous for different traits (Reddy and Reddy, 2001), the endogamous nature may reflect the asymmetry of different traits. The asymmetry is, therefore, studied by different authors (Salzano and Benevides, 1974; Jantz, 1975; Chakraborty et al., 1982; Ditmar, 1998; Karmakar et al., 2001; Kasuma et al., 2001) for comparing interpopulation differences, and also taken into consideration in the present study.

The sex difference in dermatoglyphic characters (Holt, 1968; Schauman and Altar, 1976; Loesch, 1983; Karmakar et al., 2002) as well as in dermatoglyphic asymmetries

(Micle and Kobiliansky, 1986, 1988; Karmakar et al., 2001) is well known. Different investigations have shown that the level of sexual dimorphism in dermatoglyphics in a given population is influenced by environmental stress and by environmental improvement (Stinson, 1985). As such the present paper includes the populations in both sexes separately.

At present, we have chosen three endogamous groups including a higher caste, a tribe and a religious group with contrasting enthnohistorical and cultural background in order to represent the main three types of ethnic composition of Indian society. The main aims of the study are to 1) ascertain the population differentiation with regard to anthropometric traits and dermatoglyphic characters along with their asymmetry in conformity to their background and 2) compare the biological differences among the three groups obtained by these two sets of data.

Materials and Methods

Sample

700 normal adult individuals (ranges from 30 – 70 years) belonging to three endogamous groups namely- Santal (Male 50, Female 50), Muslim (Male 100, Female 100) and Vaidya (Male 200, Female 200) were investigated from three districts of West Bengal (Figure 1), India. Care was taken to have random sampling so that the representative of the stocks may be obtained. Though the sample details are presented in Table 1, the ethnohistorical background of the groups is given here.

Santal: Santal is a tribal group found mostly in Chhotonagpur platue, North Orissa and West Bengal and classed on linguistic grounds as 'Kolarian'. From the physical characteristics, they may be regarded as a typical examples of the pure Dravidian stock (Chaudhuri, 1989). Most of them are engaged in agricultural work. Though their mother tongue is Santali, in West Bengal they use Bengali language.

Muslim: Muslim belongs to a religious group. The early phase of historical development of the Muslim society of Islam was among the Arabs and the later phase Arabs came into contact with Iranians, Africans, Tibetans, Chinese, etc. There are two groups among Muslims in West Bengal (Shia and Sunni) each of that is endogamous. The Sunni group was selected for the present study for having largest sects in West Bengal. They are specialized in various activities mainly agriculture, architectural work, trading, tailoring garments, bookbinding, etc. In West Bengal, most of the Muslim people use Bengali language rather than Urdu.

Vaidya: Vaidyas are the caste groups generally representing higher social status in

Hindu religion. The exact time and origin of this caste as a separate caste group is under dispute among different scholars (Dutta, 1969). Some consider the Vaidya to be an offsboot of the Brahmins who are intermarried with the other castes like Vaishya, Sudra, etc., but there are also claims that they are direct descendents of Aryans who immigrated to Bengal. They are traditionally recognized as physician. Their mother tongue is Bengali.

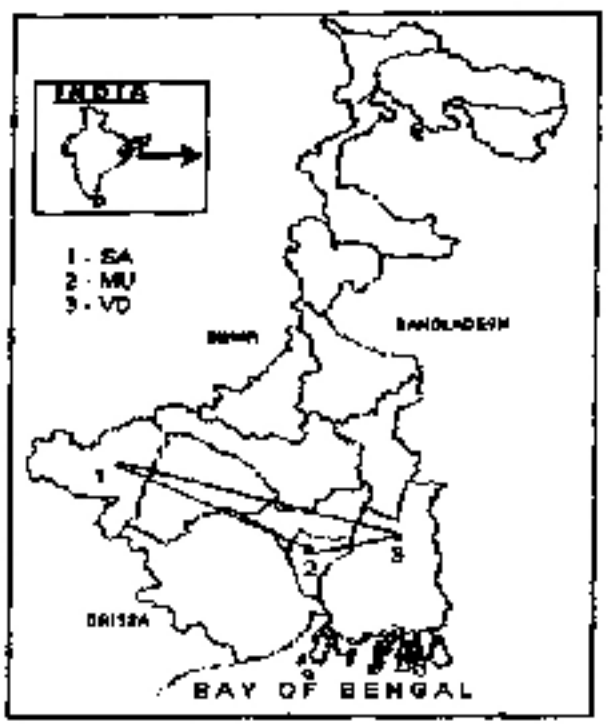

Figure 1. Map of West Bengal showing geographical location of studied populations.

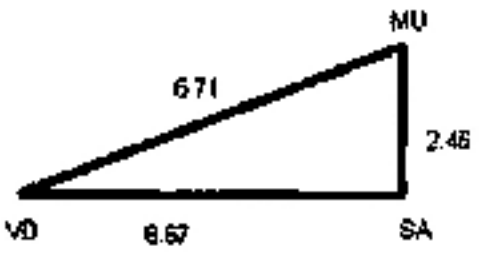

Figure 2a (Males)

Figure 2b (Females)

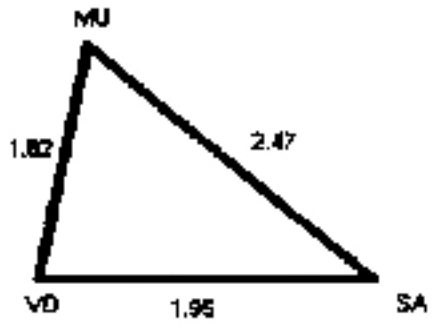

Figure 2c (Males)

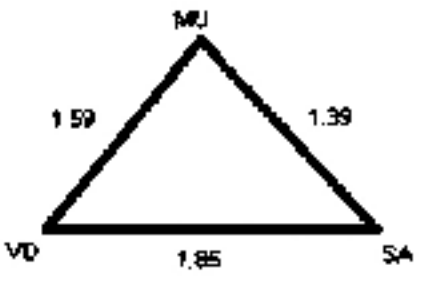

Figure 2d (Females)

Figure 2. Sanghvi's T^2 distance measure among the three endogamous groups based on: 2a and 2b –anthropometric traits, 2c and 2d –dermatoglyphic traits.

Table 1. Brief description of the three sample populations of West Bengal

Population	Abbreviation	Sex	Sample size	Pattern of the population	Traditional occupation	Sampling location
Santal	SA	M	50	Tribal group	Agriculturists	Purulia
		F	50			
Muslim	MU	M	100	Religious group	Diverse field	Howrah
		F	100			
Vaidya	VD	M	200	Caste group	Physicians	24-Parganas
		F	200			

Nature of data

Six anthropometric measurements were obtained from both sides of each individual following the method given in Martin and Saller (1957). In addition to the anthropometric measurements, finger and palm prints were collected by roller and ink method of Cummins and Midlo (1961). The standard classification of dermatoglyphic patterns was used following the method of Penrose (1968) and ridge count was estimated after Holt (1961). The two sets of data were collected from the same individuals. The variables with their abbreviations used in the present study are given in Table 2. Following the work of Jantz and Webb (1980), asymmetry (As) was measured from each individual trait (both dermatoglyphics and anthropometry) as the absolute value of difference between the right (R) and left (L) sides. As = (XiR-XiL), where XiR and XiL are individual values for the trait on the right and left side of the body, respectively.

Table 2. Abbreviation of the Anthropometric and Dermatoglyhpic variables

SL. No.	Anthropometry	Abbreviation	Dermatoglyphics	Abbreviation
1.	ear length	EL	Total ridge count	TRC
2.	ear breadth	EB	Absolute ridge count	ARC
3.	Hand length	HL	Total radial ridge count	RRC
4.	Hand breadth	HB	Total ulnar ridge count	URC
5.	Foot length	FL	Finger pattern intensity	FPI
6.	Foot breadth	FB	a-b ridge count	AB

Statistical analysis

Both sets of data were analyzed for intergroup differences by the application of 't' test to compare the means of each two endogamous groups. From obtained 't' values Sanghvi's (1953) T^2 has been calculated. Although Snghvi's T^2 is valid measure of divergence, it violates the triangle law and as such this measure does not fulfill the requirements of a true distance function listed by Rao (1952) which considers that the distance between any two of three populations should not be greater than the sum of the two distances between each of these populations and the third. As the square roots of the T^2 measures don't violate the triangle law (Bhanu, 1974), it was chosen as distance function in the present study.

Results

Anthropometric traits

Descriptive analysis of anthropometric variables and their asymmetric traits are presented in Table 3. In both sexes, VD shows lower values (except ear length and hand length for male) than other two populations. Both SA males (except ear length and breadth) and females show the highest values for all anthropometric traits.

Among males, SA shows highest asymmetry for ear length (0.17±0.15), ear breadth (0.22±0.18) and hand length (0.25±0.17); while VD shows highest asymmetry for foot length (0.30±1.08) and foot breadth (0.27±0.97). On the other hand, among females, SA shows highest asymmetry for all traits except hand breadth, which is highest in MU (0.17±0.13).

These measurements are analyzed for intergroup differences by the application of 't' test and the results are presented in Table 4. Six measurements from both sides were analyzed, out of which SA and MU males significantly differ from each other only in FL and FB for both sides ($p < 0.01$) and in EL and EB for right sides only ($p < 0.05$). MU and VD differs in EL, EB, FL and FB for both sides, while SA significantly differs from VD in all characters except HL ($p > 0.05$). In case of female, SA groups exhibit heterogeneity with the MU groups in HL, HB, FL and FB for both sides in 1% level, while SA and VD differs in all traits except HL (L: $t = 1.03$; R: $t = 1.20$). On the other hand, MU females differs from VD females in EL, EB and FL for both sides and in HL only for left sides ($p < 0.01$).

When asymmetries of these traits were analyzed SA differs from VD males as many as 4 traits. In case of females, asymmetries of EL ($t = 2.55$), FB ($t = 2.01$) show statistically significant difference for SA × MU, EL ($t = 3.40$) and EB ($t = 2.07$) for SA × VD and only EB ($t = 2.75$) for MU × VD.

Table 3. Variation of some anthropometric trait among three groups

Variable		Male			Female		
		SA (n = 50)	MU (n =100)	VD (n = 200)	SA (n = 50)	MU (n = 100)	VD (n = 200)
		Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD
EL	L	6.04±0.50	6.13±0.40	6.71±0.50	5.71±0.45	5.68±0.35	6.23±0.40
	R	5.94±0.49	6.11±0.41	6.70±0.51	5.59±0.42	5.67±0.34	6.23±0.40
	As	0.17±0.15	0.13±0.09	0.12±0.09	0.20±0.16	0.14±0.11	0.12±0.09
EB	L	3.48±0.30	3.55±0.31	3.07±0.25	3.33±0.33	3.33±0.30	3.12±0.46
	R	3.42±0.27	3.53±0.29	3.02±0.28	3.33±0.36	3.30±0.30	3.09±0.35
	As	0.22±0.18	0.17±0.12	0.11±0.09	0.15±0.15	0.14±0.11	0.12±0.09
HL	L	17.94±0.82	17.70±0.90	17.83±0.82	16.74±0.80	16.36±0.77	16.61±0.80
	R	17.94±0.79	17.74±0.92	17.84±0.83	16.72±0.85	16.41±0.78	16.54±1.26
	As	0.25±0.17	0.19±0.14	0.24±0.96	0.24±0.21	0.20±0.14	0.19±0.13
HB	L	7.88±0.35	7.86±0.44	7.78±0.37	7.40±0.29	7.11±0.39	7.14±0.32
	R	7.97±0.35	7.89±0.43	7.86±0.38	7.45±0.28	7.21±0.38	7.28±0.74
	As	0.17±0.15	0.17±0.13	0.10±0.66	0.15±0.14	0.17±0.13	0.16±0.12
FL	L	24.92±1.06	24.46±1.18	24.13±1.21	23.29±0.93	22.61±1.17	22.32±1.12
	R	24.96±1.01	24.42±1.21	24.09±1.21	23.26±0.94	22.63±1.19	22.27±1.56
	As	0.11±0.05	0.20±0.16	0.30±1.08	0.25±0.25	0.19±0.14	0.21±0.15
FB	L	9.64±0.45	9.99±0.48	9.32±0.58	9.65±0.32	8.62±0.98	8.45±0.90
	R	9.76±0.46	9.52±0.63	9.37±0.55	9.54±0.47	8.67±0.94	8.57±1.14
	As	0.26±0.19	0.21±0.13	0.27±0.97	0.27±0.23	0.20±0.15	0.20±0.15

L = Left, R = Right, As = Asymmetry

Table 4. Values of 't' for inter-group differences for anthropometric characters

Variable		Male			Female		
		SA × MU	SA × VD	MU × VD	SA × MU	SA × VD	MU × VD
EL	L	1.11	8.10**	10.86**	0.41	7.47**	12.22**
	R	2.11*	9.73**	10.81**	1.17	9.73**	12.66**
	As	2.01*	2.26*	0.30	2.55**	3.40**	1.33
EB	L	1.33	8.92**	13.45**	0.00	3.69**	4.75**
	R	2.29*	9.51**	15.02**	0.51	4.24**	5.40**
	As	2.10*	4.15**	3.65**	0.51	2.07*	2.75**
HL	L	1.63	0.93	1.21	2.78**	1.03	2.62**
	R	1.38	0.79	0.92	2.16*	1.20	1.10
	As	2.54**	2.69**	0.09	1.46	0.06	0.61
HB	L	0.30	1.79*	1.56	5.12**	5.55**	0.64
	R	1.22	1.95*	0.59	4.37**	2.59**	1.08
	As	0.12	0.29	0.60	0.94	0.94	0.70
FL	L	2.41**	4.58**	2.26*	3.86**	6.32**	2.05*
	R	2.88**	5.23**	2.23*	3.53**	5.73**	2.22*
	As	4.83**	4.34**	0.90	1.47	0.64	1.41
FB	L	4.39**	17.43**	10.61**	4.25**	15.37**	1.45
	R	2.65**	5.15**	2.03*	7.56**	9.28**	0.81
	As	1.93	0.87	0.38	2.01*	0.01	1.02

* $p < 0.05$; ** $p < 0.01$; L = Left, R = Right, As = Asymmetry

Dermatoglyphic traits

The mean values of dermatoglyphic traits were presented in Table 5, from which it has been seen that, SA males exhibit relatively higher mean values for all the traits except RRC (71.44±20.94 and 74.28±17.20 for left and right hands, respectively). In case of females, TRC is higher among SA (L = 69.24±19.09; R = 69.96±18.32) while ARC is higher among VD (L = 95.71±41.66; R = 97.60±39.78). In all other traits also, MU females show the intermediate value except URC, which is highest among them

Table 5. Variation of some dermatoglyphic trait among three endogamous groups

Variable		Male			Female		
		SA (n = 50) Mean± SD	MU (n =100) Mean± SD	VD (n = 200) Mean± SD	SA (n = 50) Mean± SD	MU (n = 100) Mean± SD	VD (n = 200) Mean± SD
TRC	L	75.20±22.59	64.34±21.21	69.56±20.69	69.24±19.09	60.95±23.94	62.68±21.68
	R	77.32±18.55	66.99±21.63	70.64±20.36	69.96±18.32	62.93±23.39	63.58±23.28
	As	9.56±9.44	6.56±5.64	6.23±4.38	5.04±4.19	6.48±5.26	5.83±4.22
ARC	L	113.52±51.32	99.21±40.71	106.09±47.39	89.92±37.35	84.10±42.25	95.71±41.66
	R	114.96±44.56	102.40±41.02	111.54±45.27	86.28±34.84	84.10±41.01	97.60±39.78
	As	18.40±11.94	16.25±11.08	15.26±12.10	11.48±14.86	12.95±11.45	13.82±12.40
RRC	L	71.44±20.94	64.12±17.29	74.99±22.06	60.84±18.22	62.25±20.97	67.83±22.34
	R	74.28±17.20	66.92±19.69	78.01±21.56	63.36±17.54	62.07±19.83	71.80±19.61
	As	9.48±5.81	8.97±8.10	8.84±7.01	6.36±6.91	8.39±5.08	9.24±6.84
URC	L	42.88±32.17	35.09±28.63	31.10±29.69	31.60±21.26	31.85±26.45	27.87±24.80
	R	40.20±29.62	35.48±27.21	33.52±28.27	27.20±19.00	32.03±26.82	25.80±24.52
	As	13.28±8.87	12.52±9.58	11.92±11.25	10.08±7.87	11.67±9.85	12.14±11.11
FPI	L	13.68±2.44	12.49±2.68	12.57±2.19	13.00±1.80	12.39±2.08	12.42±2.06
	R	13.48±2.28	12.68±2.57	12.78±2.06	12.28±1.68	12.41±2.19	12.42±2.05
	As	1.16±1.03	1.01±0.59	0.83±0.80	1.04±0.84	1.01±0.93	0.91±0.90
AB	L	40.20±6.00	40.58±5.93	40.06±5.45	39.32±6.36	38.54±5.69	38.39±5.56
	R	41.20±8.38	39.57±6.46	38.91±5.34	36.88±5.49	37.22±5.51	37.96±5.48
	As	5.32±3.03	4.25±2.97	3.60±2.93	3.36±3.28	3.28±2.93	3.73±2.85

L = Left, R = Right, As = Asymmetry

(L = 31.85±26.45; R = 32.03±26.82). But as a whole, in all three populations, males have larger ridge counts than females.

Anthropometric asymmetries are also higher in all cases for SA males. Unlike males, SA females exhibit higher asymmetries only for FPI (1.04±0.84) while asymmetries of other traits are higher among VD.

The 't' values comparing the means of the three groups (Table 6) indicate a slight heterogeneity among them with regard to these dermatoglyphic traits. SA males differ from MU males in a significant manner with reference to the TRC (t = 2.83 and 3.04 for L and R, respectively) and RRC (t = 2.13 and 2.35 for L and R, respectively) for both sides and FPI (t = 2.72) for left side only. SA and VD males differ significantly in the mean values of TRC for right, URC for left and FPI for both sides at 5% level, while MU and VD differ in TRC ($p < 0.05$) and RRC ($p < 0.01$) only. Females show week difference amongst them, specially between SA and MU followed by VD and MU.

The difference of asymmetry within the three males groups is negligible with only TRC and AB mean values differing between SA and each of other two groups. Females do not exhibit any significant difference of asymmetry amongst them except for RRC ($p < 0.01$) between SA and VD.

Distance analysis

The three endogamous groups are compared with each other using T^2 statistics and presented in Table 7 and Figure 2. When dermatoglyphic traits are used it is observed that among males, MU and VD appears to be closest ($T^2 = 1.82$) and SA and MU farthest ($T^2 = 2.47$); among females, SA -MU combination is closest ($T^2 = 1.39$) and SA-VD combination is farthest ($T^2 = 1.85$). On the other hand, in case of anthropometric traits the MU males appear to be the farthest from VD males ($T^2 = 6.71$) and closest with SA males ($T^2 = 2.45$), while VD females are farthest from SA females ($T^2 = 6.75$) and closest with MU females ($T^2 = 4.75$).

Table 6.Values of 't' for inter-group differences for dermatoglyphic variables

Variable		Male			Female		
		SA × MU	SA × VD	MU × VD	SA × MU	SA × VD	MU × VD
TRC	L	2.83**	1.61	2.03*	2.30*	2.11*	0.61
	R	3.04**	2.23*	1.40	2.01*	2.08*	0.23
	As	2.07**	2.43*	0.51	1.82	1.19	1.07
ARC	L	1.72	0.93	1.30	0.86	0.96	2.25*
	R	1.67	0.48	1.77	0.34	2.00*	2.71**
	As	1.06	1.66	0.71	0.61	1.03	0.60
RRC	L	2.13*	1.06	4.67**	0.50	2.31*	2.23*
	R	2.35*	1.30	4.45**	0.41	2.97**	4.02**
	As	0.44	0.67	0.14	1.84	2.64**	1.21
URC	L	1.45	2.35*	1.12	0.06	1.07	1.25
	R	0.94	1.44	0.58	1.27	0.44	1.95
	As	0.48	0.92	0.48	1.07	1.51	0.37
FPI	L	2.72**	2.93**	0.26	1.85	1.98*	0.12
	R	1.94	1.98*	0.34	0.40	0.50	0.04
	As	0.95	2.11*	2.20*	0.20	0.96	0.89
AB	L	0.38	0.16	0.75	0.73	0.95	0.22
	R	1.22	1.84	0.88	0.36	1.24	1.10
	As	2.05*	3.61**	1.79	0.15	0.73	1.27

* $p < 0.05$; ** $p < 0.01$; L = Left, R = Right, As = Asymmetry

Table 7. Sanghvi's T2 values for the comparison of SA, MU and VD groups

Variable		Male			Female		
		SA × MU	SA × VD	MU × VD	SA × MU	SA × VD	MU × VD
Anthropometry	T^2	6.02	44.54	45.06	24.13	45.22	22.53
	Distance*	2.45	6.67	6.71	4.91	6.72	4.75
Dermatoglyphics	T^2	6.09	3.82	3.33	1.92	3.42	2.53
	Distance	2.47	1.95	1.82	1.39	1.85	1.59

*$\sqrt{T^2}$

Discussion

Anthropometric traits

In the present study it has been observed that the majority of the variables, as judges from means and standard deviations, depicts some discrimination among the three groups of West Bengal. SA males, who are agriculturists and engaged in hard work, show highest values for most anthropometric traits; while VD groups, who are physician and don't usually engaged in hard physical work, exhibit least values for most anthropometric traits. MU people, who are engaged in diverse field, show the intermediate value for most of the traits.

When 't' test was used, each of three populations shows significant departures from themselves in different anthropometric traits. The result is consistent with the expectation, as none of these three populations has same ethnohistorical background, similar occupation, social hierarchy or cultural norms. On the other hand, all of these groups are strictly endogamous in nature. As such neither there is possibility of admixture among them nor any gene flow from other populations, which generally play a role in the evolution of genetic structure of a population.

Asymmetry in anthropometry also shows significant difference for most of the traits among them. It is known that, different bone lengths and the size of muscle attachment of human body may well be acquired through preferential use and disuse (Schultz, 1937) and the asymmetry is also influenced by it. Heterogeneity in asymmetry is, therefore, not inconsistent among these three populations with distinct occupations.

Dermatoglyphic traits

When three groups are compared, SA male shows relatively higher mean values for all the traits except RRC. SA female also exhibits higher ridge counts for most of the traits than other two populations. This may be due the presence of whorl in higher frequency among SA. This is in agreement with Sarkar (1971) who observed that, in Hindu castes and Muslims in West Bengal there is a clear preponderance of loops over whorls, while the tribes are characterized by the preponderance of whorls over loops. The percentages of pattern frequency calculated by Biswas, 1956 (for Santal), Sarkar, 1969 (for Muslim) and Banerjee, 1970 (for Vaidya) also support the above hypothesis.

Karmakar et al. (2001) studied five endogamous groups in West Bengal and observed that tribal populations are less asymmetric compared to castes (though not statistically significant) which they explained as due to small population with strict endogamy

leading to have a common genetic background. But in the present study though females of the tribe Santal exhibits lower asymmetry than the higher caste Vaidya for some traits, all dermatoglyphic asymmetries are higher among SA males. As ethnographical details suggest that Vaidyas are the result of admixture between Brahmins and other castes like Vaishya, Sudra etc., they may be more heterozygous for different traits and thus exhibits less asymmetry than Santal. However, the present female groups corroborates with Jantz (1975) also who pointed out that the absolute asymmetry is greater in populations which have intermediate values of TRC than those which have high or low means. Though present males do not follow the hypothesis, probably due to the fact that asymmetry indices were used as absolute asymmetry in Jantz's study.

The interpopulation difference in dermatoglyphic asymmetry, for most of the cases, cannot reach to the significant level in both sexes. Since dermatoglyphic fluctuating asymmetry is regarded as the result of incapacity of the buffering mechanisms to resist the developmental noise factors (Waddington, 1957), our results lead to the conclusion that these groups do not differ significantly in their sensitivity to these factors.

Distance analysis

Another interesting observation emerging from these results is that males and females do not display the similar interpopulation variation. Sex difference in the pattern of interpopulation distances in dermatoglyphic traits is also observed in some earlier studies (Rudan, 1978; Lin et. al., 1984; Reddy et. al., 1988; Karmakar et al., 1989, 2003). In the present study, for anthropometric traits, MU and VD males show highest distance while SA and VD females exhibit highest distance among them. On the other hand, in dermatoglyphic traits, the distance between MU and SA males are highest but among females the highest distance is observed between SA and VD. Thus both sets of data indicates higher distance between SA and VD females.

Considering the values of distance from the highest to lowest, the ranking of the population pairs may be as follows:

Anthropometric traits:
Male: MU – VD > SA – VD > SA – MU; Female: SA – VD > SA – MU > MU – VD.

Dermatoglyphic traits:
Male: SA – MU > SA – VD > MU – VD; Female: SA – VD > MU – VD > SA – MU.

The trend of both anthropometric and dermatoglyphic distances of females, are more or less agreement with their geographic distances (see Figure 1). The higher correlation between dermatoglyphic and geographic distances among female than males has been observed in several earlier studies. Enciso (1983) noted a better relationship between dermatolgyphics and geography for Tlaxcaltecan females. Lin et al., (1984) found the same trend and suggested that males are more mobile, and the poorer fit of genetics and geography reflect differential rates of migration between the sexes. Crawford and Duggirala (1992) also found that only females show a moderate association between dermatoglyphic and geographical distances.

Comparison between anthropometric and dermatoglyphic traits

Whether or not the population differentiation obtained from dermatoglyphic data corroborates with those obtained from other sets of data like anthropometry, is still being debated. A majority of the investigators (Nel et. al., 1974; Friedlaender, 1975; Rudan, 1978; Rothhammer et al., 1979; Jantz and Chopra, 1983; Karmakar, 1984; Reddy et. al., 1987) found that dermatoglyphics seem to reveal relationships less clearly and produce a set of relationships differing from other sets of data. Though quite a few others did find close congruence between dermatoglyphics and other biological data (Rothhammer et al., 1977; Malhotra, 1978; Jantzs et al., 1982; Crawford and Duggirala, 1992). On the other hand some earlier studies suggested that dermatoglyphic traits are more advantageous polygenic marker for tracing the affinities between groups (Rife, 1954; Froehlich and Giles, 1981; Micle and Kobyliansky, 1986) and provides greater agreement with the ethnic histories as well as geographic background (Reddy and Reddy, 1992; Sanna and Floris, 1995; Floris et al., 1998) of different groups than serological or anthropometric traits.

In the present study, when 't' values are considered, the dermatoglyphic traits of these groups don't show heterogeneity as much as they differ from each other with regard to anrhropometric traits. When Sanghvi's method is applied, the same trend is observed i.e. for dermatoglyphic traits, the distances are also much smaller than those for anthropometric traits (Figure 2). The picture is true for both the sexes. The larger T^2 values obtained for the population comparison point out that the anthropometric data is a powerful tool for the distinction among three separate racial stocks.

However, this difference between two sets of traits may be due to the fact that dermatoglyphics is independent of the environmental and evolutionary forces, as no chan-

ge seems to appear either in the detailed structure or in the arrangement of the ridges through the individual's life after birth (Loesch, 1983). But anthropometric traits are influenced by environment and use of the related organ. Though there are few exceptions (Babler, 1978, Loesch and Martin, 1984; Loesch and Wolanski, 1985), it is generally believed that dermatoglyphic characters are selectively neutral (Van Valen, 1963; Holt, 1975; Sengupta and Karmakar, 2003) and phylogenetically more stable than other biological variables (Sachs and Bat-Miriams, 1957) and may, therefore, reflect population structures.

Conclusion

On the basis of the present findings in the light of earlier studies the following conclusions have been emerged: I) With respect to both sets of data these three populations exhibits discrimination, which is good agreement with their different ethnohistorical background, II) Much heterogeneity in asymmetry is observed in anthropometric traits than dermatoglyphics, probably as a result of different occupations and use of different organs in different ways, III) Sex difference in interpopulation variation is observed which corroborates with several earlier studies, IV) The distances obtained from dermatoglyphic traits are much smaller than those from anthropometric traits, probably due to the fact that dermatoglyphics is more stable character and independent of environment.

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References

Arricta MI, Criado B, martinez B, Lobato MN. 1993. Fluctuating dermatoglyphic asymmetry: genetic and parental influences. Ann Hum Biol 20: 557-563.

Babler WJ. 1978. Prenatal selection and dermatoglyphic patterns. Am J Phys Anthropol 48: 21-28.

Banerjee DK. 1970. Finger dermatoglyphics of some Bengalee castes. Man in India 50: 161-176.

Banerjee AR, Banerjee DK. 1975. Inter-caste distance in dermatoglyphics in some Bengalee caste groups. Ind J Phys Anthrop Hum Genet 1: 29-39.

Bhanu BV. 1974. Population distances: biological, cultural and geographical – a study on the Eshavas, Pulayas and Parayas of Kerala. Ph. D. Theses, India: University of Poona.

Biemont C. 1983. Homeostasis, enzymatic heterozygosity and inbreeding depression in natural populations of Drosophila melanogaster. Genetica 61:179-189.

Biswas PC. 1956. Santals of the Santal Parganas. Delhi: Bhartiya Adamjati Sewak Sangh.

Chakraborty R, Malhotra KC, Tateno Y. 1982. Variations on dermal ridges in nine population groups of Maharastra, India. III. Asymmetry and interdigital diversity. Am J Phys Anthropol 58: 53- 57.

Choudhuri A,1989. Biological variation amongst five endogamous groups of Giridih, Bihar. Tech. Report, ISI. no. Anthrop./1/89.

Crawford MH, Duggirala R. 1992. Digital dermatoglyphic patterns of Eskimo and American populations: relationships between geographic, dermatoglyphic, genetic and linguistic distances. Hum Biol 64(5): 683- 704.

Cummins H, Midlo C. 1961. Fingerprints, palms, and soles. MA: Research Publishers, South Berlin.

Dittmar M. 1998. Finger ridge-count asymmetry and diversity in Andean Indians and interpopulation comparisons. Am J Phys Anthropol 105(3): 377-393.

Dutta NK. 1969. Origin and growth of caste in India. Vol. II. Calcutta: Firma K. L. Mukhopadhyay.

Dobzhansky TH. 1951. Genetics and the origin of species. New York: Columbia University Press.

Ensico VB. 1983. Estimates of genetic distances and population structure from blood and dermatoglyphic data. MA. thesis. Lawrence: University of Kansas.

Floris G, Franceschi MG, Paoli G, Sanna E, Taglioli L. 1998. Population structure in Sardinia on the basis of quantitative palmar dermatoglyphic traits. Int J Anthropol 13: 57- 64.

Friedlaender JS. 1975. Patterns of human variation. Cambridge: Harvard University Press. 1-24.

Froehlich JW, Giles E. 1981. A multivariate approach to finger prints variation in Papua New Guinea. Am J Phys Anthropol 54: 93- 106.

Guha BS. 1931. Racial affinities of the people of India. Census of India, Part III. New Delhi: Manager of publications.

Guha BS. 1937. An outline of the racial ethnology of India. Calcutta: Indian Science Congress Association.

Holt SB. 1961. Inheritance of dermal ridge-patterns. In: Penrose LS. (ed.): Recent advances in Human Genetics. 101- 109.

Holt SB. 1968. The genetics of dermal ridges. C.C. Thomas, Springfield, Illinois.

Holt SB. 1975. Dermatoglyphic pattern. In: Roberts DF (ed.): Human variation and natural selection. London: Taylor and Francis Ltd., 175-176.

Jantz RL. 1975. Population variation in asymmetry and diversity from finger to finger for digital ridge count. Am J Phys Anthropol 42: 215- 244.

Jantz RL, Webb S. 1980. Dermatoglyphic asymmetry as a measure of canalization. Ann Hum Biol 7(5): 489-493.

Jantz RL, Chopra VP. 1983. A comparison of dermatoglyphic methodologies in population studies. Am J Phys Anthropol 60: 61- 67.

Kat PW. 1984. The relationship between heterozygosity for enzyme loci and developmental homeostasis in peripheral populations of aquatic bivalves. Am Nature 119: 824-832.

Karmakar B. 1984. Palmer dermatoglyphic differentiation among the Dhagar caste-cluster of Maharashtra, India. Ph.D. Thesis, India: University of Calcutta.

Karmakar B, Malhotra KC, Narain P. 1989. Palmar dermatoglyphic distance analysis among 20 Dhangar castes of Maharashtra, India. Anthropologie, 27: 13- 28.

Karmakar B, Yakovenko K, Kobiliansky E. 2001. Sexual dimorphism: asymmetry and diversity of 38 dermatoglyphic traits in five endogamous populations of West Bengal, India. Coll Anthropol 25(1): 167- 187.

Karmakar B, Yakovenko K, Kobiliansky E. 2002. Dermatoglyphic sexual dimorphism: Finger and palmar quantitative characteristics in five endogamous populations of West Bengal, India. Anthropol Anz 60(3): 273- 292.

Karmakar B, Yakovenko K, Kobiliansky E. 2003. Multivariate analysis of sexual dimorphism in two types of dermatoglyphic traits in five endogamous populations of West Bengal, India. Homo 53(3): 263- 278.

Kasuma YS, Babu BV, Naidu JM. 2001. Asymmetry of finger ridge counts among four tribal populations of Andhra Pradesh, India. Homo, 52(2): 110- 116.

Leary RF, Allendrof FW, Knudson RL. 1983. Developmental stability and enzyme heterozygosity in rainbow trout. Nature 301: 71-72.

Lin PM, Bach-Enciso V, Craford MH, Hutchinson J, Sank D, Firschein BS. 1984. Quantitative analysis of the dermatoglyphic pattern of the Blach Carib populations of Central America. In: Crawford MH (ed.): Current developments in anthropological genetics. Vol 3. New York: Plenum Press. 241- 268.

Livshits G, Kobyliansky E. 1987. Dermatoglyphic traits as possible markers of developmental processes in humans. Am J Med Genet 26: 111-122.

Loesch D. 1979. Dermatoglyphic distances- selected topics. Birth Defects 15: 225- 248.

Loesch D. 1983. Quantitative dermatoglyphics: classification, genetics and pathology. Oxford University Press.

Loesch D, Martin NG. 1984. Finger ridge pattern and tactile sensitivity. Ann Hum Biol 11: 113-124.

Loesch D.Z, Wolanski N. 1985. Dermal ridge pattern and fertility in a Polish rural sample. Ann Hum Biol 12: 463- 477.

Malhotra KC. 1978. Micro-evolutionary dynamics among the Gavdas of Goa. In: Meier RJ (ed.): Evolutionary models and studies in Human diversity. 279- 314.

Malhotra KC, Chakraborty R, Chakraborty A. 1978. Gene differentiation among the Dhangar caste-cluster of Maharastra, India. Hum Hered 28: 26-36.

Martin R, Saller K. 1982. Lehrbuch der Anthropologie. Stuttgart: Gustav Fisher.

Mayr E. 1970. Popualtion, Species and Evolution. Harvard University Press.

Meier RJ. 1980. Anthropological dermatoglyphics: a review. Yearbook of Phys Anthropol 23: 147-178.

Micle S, Kobyliansky E. 1986. Dermatoglyphic sexual dimorphism in Israilis: Principal components and discriminant analyses applied to quantitative traits. Hum Biol 58: 485- 498.

Micle S, Kobyliansky E. 1988. Sex differences in the intraindividual diversity of finger dermatoglyphics: patterns types and ridge counts. Hum Biol 60: 123-134.

Murty JS, Muralidhar B, Goud JD. 1993. Hierarchial gene diversity and genetic structure of tribal population of Andhra Pradesh, India. Am J Phys Anthropol 90: 169- 183.

Neel JV, Rothhammer FH, Linggoes JC. 1974. The genetic structure of a tribal population, the Yanomama Indians: X. Agreement between the representatives of village distances based on different sets of characteristics. Am J Hum Genet 26: 281- 303.

Penrose LS. 1968. Memorandum on dermatoglyphic nomenclature. Birth defects 4: 1-13.

Ramana GV, Naidu JM, Murty JS. 1996. Genetic structure of the Manne Dora, a tribal population of Andhra Pradesh. Hum Biol 68: 63-74.

Rao CR. 1952. Advanced statistical methods in biometric research. New York: John Willey.

Reddy BM, Chopra VP, Mukherjee DP. 1987. Biological affinities among the three endogamous groups of marine fishermen of Puri, Orissa, India. Am J Phys Anthropol 74: 407-415.

Reddy BM, Chopra VP, Karmakar B, Malhotra KC. 1988. Quantitative palmer dermatoglyphics and the assessment of population affinities: Data from marine fishermen of Puri, India. Anthropol Anz 46: 335-244.

Reddy BM. 1990. Quantitative dermatoglyphic affinities among the three endogamous groups of fisherman. Anthropologie, 74: 407- 415.

Reddy BM, Reddy PC. 1992. Dermatoglyphic affinities among the Telegu populations with contrasting Ethnohistorical backgrounds. Am J Hum Biol 4: 669- 682.

Reddy BM, Chopra VP, Rodewaldt A. 1995. Genetic affinities between migrant and parental populations of fishermen on the East Coast of India. Am J Hum Biol 7: 51-63.

Reddy BM, Chopra VP. 1999. Biological affinities between migrant and parental populations of fishermen on the East Coast of India. Hum Biol 71: 803-822.

Reddy BM, Chopra VP, Karmakar B. 2000. Quantitative dermatoglyphics and population structure in Northwest India. Am J Hum Biol 12: 315- 326.

Reddy BM, Reddy PC. 2001. Population structure and the patterns of dermatoglyphic variation in Andhra Pradesh, India. Int J Hum Genet 1: 203- 209.

Reddy BM., Sun G, Luis JR, Malhotra KC, Muller H. 2001a. Genetic diversity a thirteen short tandem repeat loci in a substructured caste population, Golla, of Southern Andhra Pradesh, India. Hum Biol 73: 175- 190.

Reddy BM, Pfeffer A, Crawford MH, Langstieh BT. 2001b. Population substructure and patterns of quantitative variation among the Gollas of Southern Andhra Pradesh, India. Hum Biol 73: 291-306.

Rife DC. 1954. Dermatoglyphics as ethnic criteria. Am J Hum Genet 6: 319- 327.

Risley H. 1915. People of India. Calcutta: Thaker Spink and Co.

Rothhmmer F, Chakraborty R, Llop E. 1977. A colletion of marker gene and dermatoglyphic diversity at various levels of population differentiation. Am J Phys Anthropol 46: 51- 60.

Rothhmmer F, Chakraborty R, Llop E. 1979. Dermatoglyphic variation among South American tribal populations and its association with marker gene, linguistic and geographic distances. In: Wertelecki W, Plato CC. (eds.): Dermatoglyphics fifty years later. 269- 276.

Rudan P. 1978. Biological structure of the Istrian population study of distances by anthropometric traits, dermatoglyphic properties, and blood group frequencies. Coll Anthropol 2: 53-58.

Sachs L, Bat-Miriam. M. 1957. The genetics of Jewish populations in Israel. Am J Hum Genet 9: 117-126.

Salzano FM, Benevides FF. de Sa F. 1974. Fingerprint quantitative variation and asymmetry in Brazilian Whites and Blacks. Am J Phys Anthropol 40: 325- 328.

Sanghvi LD. 1953. Comparison of genetical and morphological methods for a study of biological differences. Am J Phys Anthropol 11: 385- 404.

Sanna E, Floris G. 1995. Polymorphism of palmar main line terminations as an indicator of relationships among Sardinian linguistic groups of males. Int J Anthropol 13: 65- 80.

Sarkar D. 1969. A study of finger ball dermatoglyphics in West Bengal. Man in India 49: 378- 387.

Sarkar D. 1971. Dermatoglyphic study of some castes and tribes of Jalpaiguri district, West Bengal. Anthropologist 18: 49- 56.

Sauman B, Alter M. 1976. Dermatoglyphics in medical disorders. New York: Springer Verlag.

Schultz AH. 1937. Proportions variability and asymmetries of the long bones of the limbs and the clavicles in man and apes. Hum Biol 9: 281-328.

Sengupta M, Karmakar B. 2003. Intergenerational trend of some dermatoglyphic traits in Vaidyas of West Bengal, India. Coll. Antropol. 27(2):515-521.

Stinson S. 1985. Sex differences in environmental sensitivity during growth and development. Yearbook of Phys Anthropol 28: 123-147 (Supplement 6 to Am J Phys Anthropol). New York: AR. Liss.

Thangaraj K, Ramana GV, Singh L. 1999. Y chromosome and mitochondrial DNA polymorphisms in Indian populations. Electrophoresis 20: 1743- 1747.

Van Valen. 1963. Selection in natural population: human finger prints. Nature 200: 1237-1238.

Vijaya Kumar M. 1988. Biological composition of the three isolates of Siddis of Karnataka: a hybrid African- Indian population. Ph. D. Theses, India: University of Calcutta.

Waddington CH. 1957. The strategy of the genes. London: Allen and Unwin.

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