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Multivariate analysis of sexual dimorphism in two types of dermatoglyphic traits in five endogamous populations of West Bengal, India

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Summary

Five different endogamous populations who encompass the main social rank in the caste hierarchy of West Bengal were analysed for this report. The present approach is to compare the pattern of sex differences/similarities exhibited by two different sets of dermatoglyphic traits. Cluster and discriminant analysis and Mantel test of matrix correlations were performed. The nature of variation between sexes within population groups and two types of variable sets has a good similarity in all five populations. These results strongly suggest that the two categories of dermatoglyphic variables provide similar possibilities to discriminate between the sexes in populations.

Introduction

Since Galton 1892, dermatoglyphic traits have been extensively used to characterise human populations by establishing biological relationships among them (see, among others: Palti et al 1975, Froehlich & Giles 1981, Dow et al 1987, Crawford & Duggirala 1992, Reddy & Reddy 1992, 2001, Jantz et al 1993, Sanna & Floris 1995, Karmakar et al 2001). Assessment of these biological relationships on different sets of variables is mainly based on sex-relationship and bimanual relationship (including asymmetry). There is a hypothesis that females may be more canalized in their growth and development than males (Meier 1990, Sorenson 1990). Thus, females are less affected by environmental insult (Jantz 1977, Jantz & Weeb 1980; Bailey et al 1984). It is also known that maturation timing is associated with sex chromosomes as a factor in dermatoglyphic variation suggested by Barlow (1973), Netley & Rovet (1982) and Meier et al (1987). The presence of the Y-chromosome and an increase in the level of testosterone delays the timing of maturation (Sorenson 1990). As a consequence, in the case of males the dermatoglyphic traits are more influenced by intrauterine environment. However, agreement between the results of dermatoglyphics with respect to the measures of sex differences and population relationships is still contradictory to a certain degree. Therefore, it is interesting to study the sex relationship (differences or similarities) of different sets of traits among different ethnic groups.

In a study on Telugu populations Reddy & Reddy (2001), using Anova and multiple discriminant analysis on 22 dermatoglyphic traits, suggest that «there is a high degree of consistency in the pattern of population relationships between male and female samples, probably implying biological validity of the observed patterns». In our previous paper (Karmakar et al 2001) we reported the findings of sexual dimorphism among the same five populations based on 38 dermatoglyphic traits of diversity and asymmetry. We found that the pattern of dermatoglyphic variables both in males and females confirm the known ethnohistorical background. After a first analysis of 38 dermatoglyphic characteristics we proposed to compare the extent of variation of dermatoglyphic traits in a population between two different sets and between the sexes. This study will help in understanding how two different sets of variables influence sex dimorphism in different population groups. With this objective in mind, we considered two different sets of quantitative dermatoglyphic variables: (1) 22 commonly used traits and (2) 38 diversity and asymmetry traits (from Karmakar et al 2001).

Material and methods

The samples of five populations have been extracted from a large survey of several objectives, where variables of palmar and plantar dermatoglyphics, anthropometry and asymmetry have been included. These populations represent all strata of the Indian society from tribe to upper caste Brahmins; they also include the middle ranking agricultural castes and low ranking castes, ranging from shepherds to traditional labourer castes (table 1). Dermatoglyphic prints were collected using the ink and roller method following Cummins & Midlo 1961. Most of the variables used were scored after Cummins & Midlo 1961 and Holt 1968. Dermatoglyphic variables are set out in Appendix 1 and the formulae for calculating various indices in Appendix 2. Since the same samples from our previous publication (Karmakar et al 2001) were used, we performed statistical analysis as a continuation from the previous one. Here we have done discriminant and cluster analysis and Mantel test of correlation matrix, in addition to another set of 22 variables along with 38 variables. Mantel test has gained wide popularity for providing a useful analytical framework for matrix correlation analysis in several disciplines including anthropology (Smouse & Long 1992, Livshits et al 1991). The Mantel test statistic Z is monotonically related to the product moment correlations upon which clusterings were based in the present study, and thus introducing this important method is very appropriate.

Table 1: Sample description

Population	Abbreviation	No. of families	No. of individuals
Brahmin (Rarhi)	BR	100	449
Mahisya	MA	100	504
Padmaraj	PA	100	525
Muslim (Sunni)	MU	100	555
Lodha	LO	100	402
Total		500	2435

Cluster analysis

The phenotypic correlations between dermatoglyphic variables were determined in males and females separately. Obtained matrices of correlations were used to calculate the Euclidean distances between each pair of traits. These results were constructed by the complete linkage method and grouped into dendrograms, following Hartigan 1983.

Discriminant analysis

In the present study, the aim of analysis is to compare the capability of sorting individuals into male and female groups, by two categories of dermatoglyphic variables. The analysis was performed in two stages: (1) Selection of independent variables on the basis of their discriminating power according to Wilks' step-wise method in which the variable minimizes the overall Wilks' Lambda and maximizes the Mahalanobis distances; (2) a correct classification was arranged, based on comparisions between the sexes. The SPSS statistical software (Nie et al 1975) was used for discriminant analysis.

Mantel test

The test statistic Z measures the degree of difference in the relationships between two matrices. It takes two symmetric similarity/dissimilarity matrices and plots one matrix against the other (see Mantel 1967, Sokal 1979). The quantity of Z is obtained from the procedure of the corresponding elements of the two half-matrices which are multiplied and summed up. The test criterion is $Z = \sum Xij\ Yij$, where Xij and Yij are the off-diagonal elements of matrix X and Y .

Significance tests were carried out by comparing the observed Z value with its permutational distribution. This distribution is obtained by comparing one matrix, say X, with all the possible matrices, in which the order of the variables in the other matrix Y, has been permuted. If the two matrices show similar relationships, then Z should be the large one. The Mxcom matrix comparision programme was used for this analysis. The data were processed at the Tel Aviv University Computer Center and at the Indian Statistical Institute.

Results

Cluster analysis

The cluster trees have been drawn based on the correlation matrices of 22 quantitative dermatoglyphic traits, and 38 dermatoglyphic traits of intra-individual diversity and asymmetry.

22 traits: The dendrograms based on 22 quantitative dermatoglyphic traits in males and females are presented in figures 1a and 1b for each population. Cluster trees represent clearly three main clusters for both the sexes in all populations. The first cluster is the broadest one out of the three, and comprises variables of the ridge counts of individual fingers; total and absolute ridge counts and PII. The PII

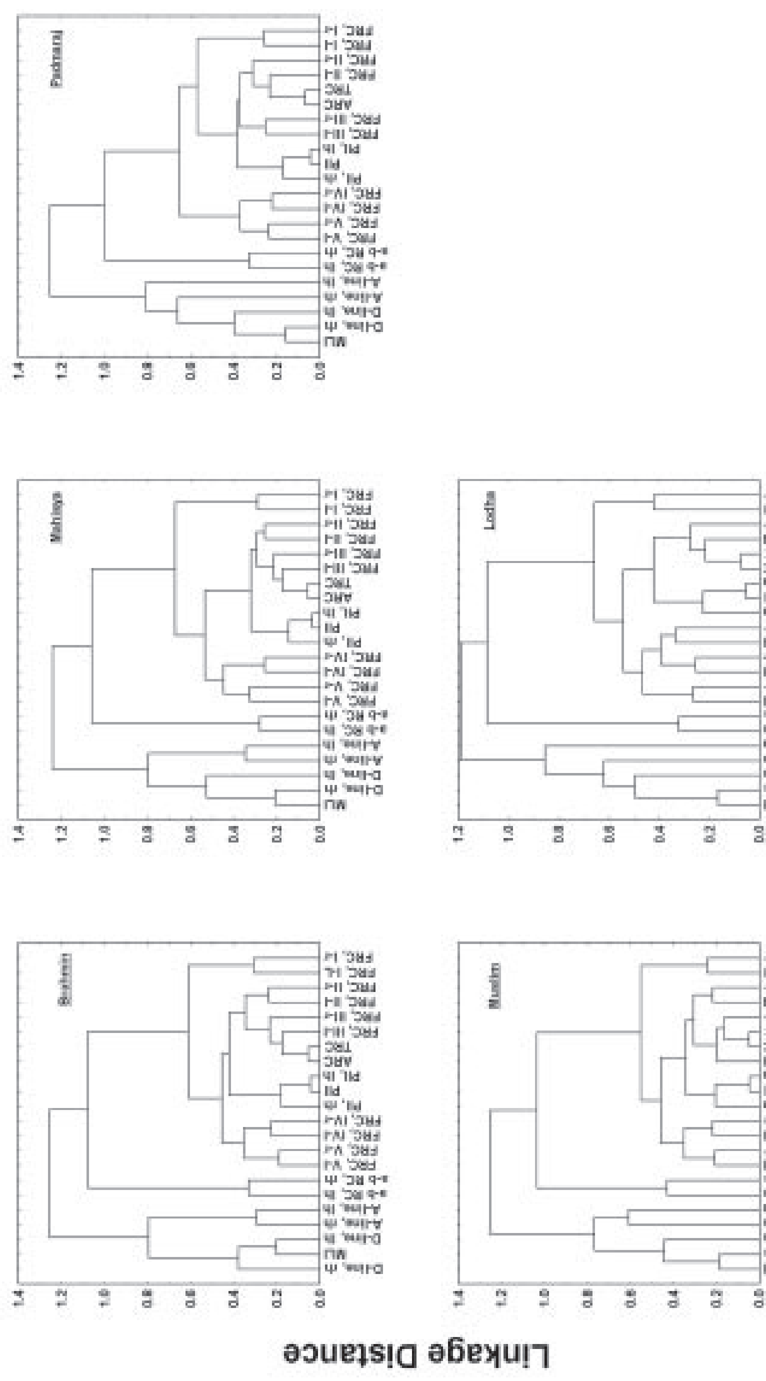

Fig. 1a: Tree diagram for 5 populations (males, 22 traits).

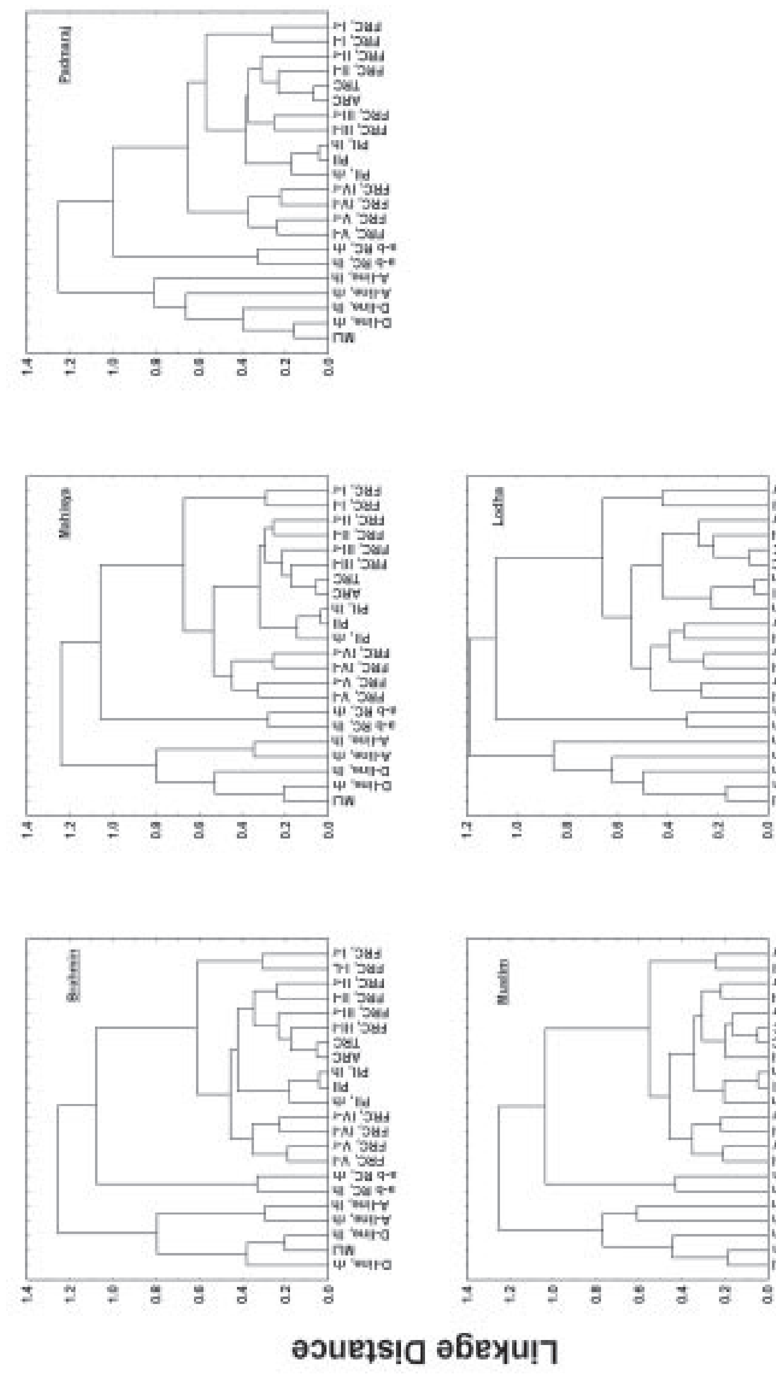

Fig. 1b: Tree diagram for 5 populations (females, 22 traits).

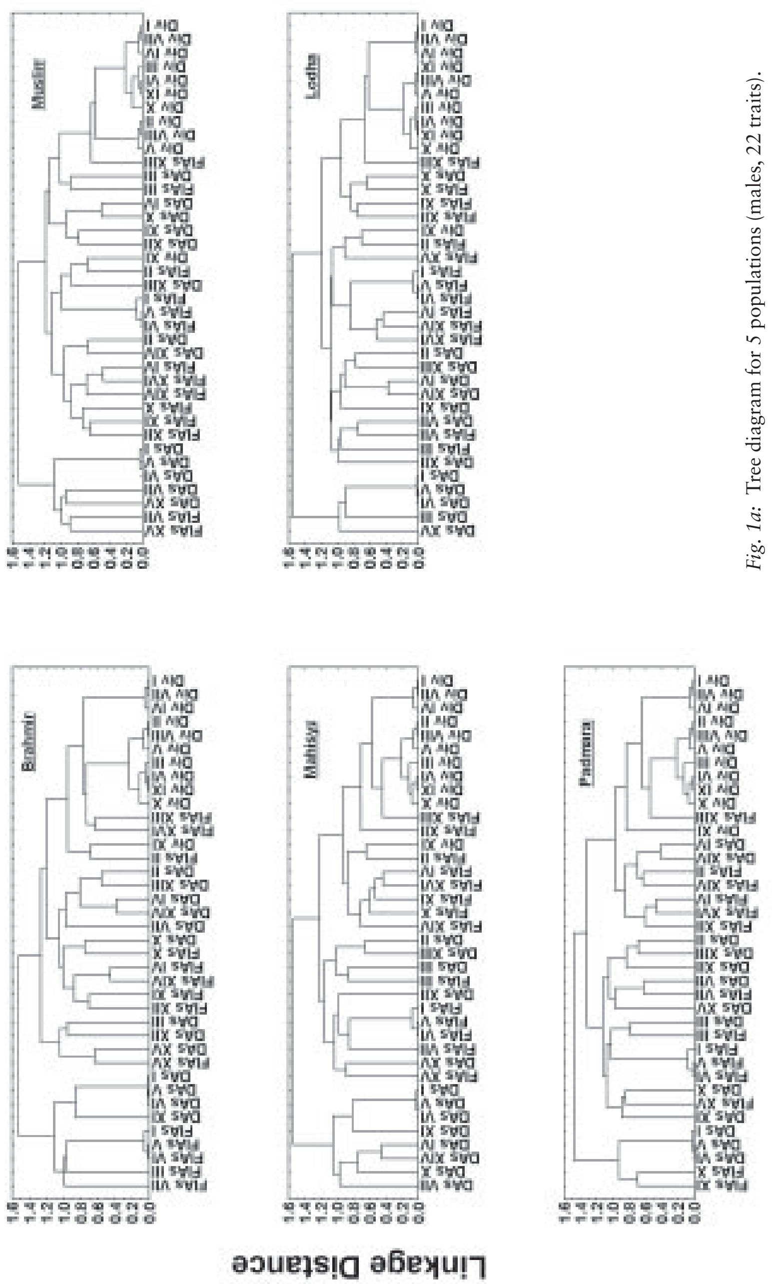

Fig. 1a: Tree diagram for 5 populations (males, 22 traits).

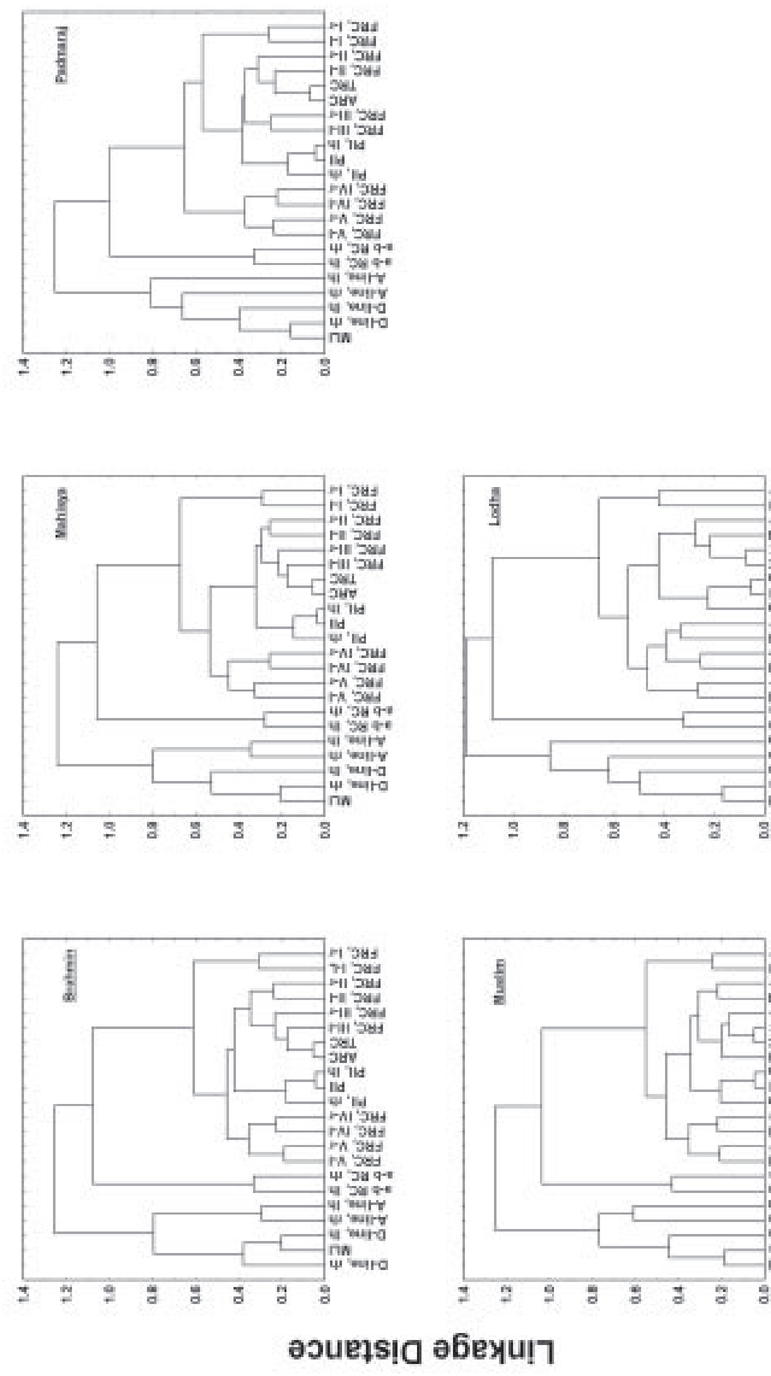

Fig. 1b: Tree diagram for 5 populations (females, 22 traits).

are aggregated at the end of the first cluster in the area connecting the second cluster and they appear in a separate component. The second cluster includes the a–b ridge counts. The third cluster comprises main line index (MLI) and its components. These results are very similar in both males and females in each population.

38 traits: The dendrograms based on 38 dermatoglyphic traits consists of intra-individual diversity, directional and fluctuating asymmetry, and are presented in figures 2a for males and 2b for females. The cluster tree can be classified into three main clusters: The first cluster comprises in both sexes (with very minor exception in LO and PA females) and in all populations 11 intraindividual diversity indices of the finger ridge counts, and they are joined by some other measures of FlAs indices. The second cluster is mainly aggregated by the indices of fluctuating asymmetry and also directional asymmetry. The third cluster contains the variables of directional and also some indices of fluctuating asymmetry. There is a higher concentration in DAs than FlAs. In general, the variables Div XI (Shannon index) and DAs/FlAs XVI (asymmetry index), XV (MLI), VII (<atd), III (a–b ridge counts), II (PII) are scattered in clusters 1 to 10. These variables form small sub-clusters of the broad clusters. Out of these variables, the Shannon index and PII together form one small cluster under a sub-cluster in all populations. A common association between a–b ridge counts and <atd; between MLI and <atd (small clusters) have also been observed. DAs and FlAs for some variables form small clusters, for example: MLI, a–b ridge count, <atd and asymmetry index (AI) always remain separate from the other variables in almost all populations. All the dendrograms between males and females are markedly similar in all 5 populations, just only a number of rearrangements have occurred.

Discriminant analysis

The variables manifesting a partial multivariate F-ratio which were selected, are those that are larger than 4 and are used in the discriminating procedure. In the first stage, such variables that have the best capability to discriminate between the two groups of dermatoglyphic variables are presented in tables 2 to 6. In the second stage, a sorting or a correct classification has been made which related every individual into a group as males and females based on the selected independent variables from the two groups of dermatoglyphic variables and are presented in tables 7 to 11.

22 traits: The discriminating power of the 22 variables in tables 2–6 ranks as follows: BR (6), MA (6), PA (8), MU (5), and LO (6). These values were selected, and they are rather similar. The correct classification by sex also depicts this pattern: BR (61.49%), MA (61.57%), PA (62.72%), MU (58.18%), and LO (66.01%). Similar observations are also found in Wilks' Lambda and minimum Dsq. values.

38 traits: Similarly for 38 traits, the selected number of variables by discriminating power are: BR (7), MA (8), PA (11), MU (5) and LO (7) that are observed. There is a large difference between PA and MU. However, from the correct classification by sex there appears almost similar results: BR (63.75%), MA (60.87%), PA (63.39%), MU (60.00%) and LO (61.01%). The difference between PA and MU is marginal. Similar results are also clear from Wilks' Lambda and Minimum Dsq. values.

Table 2: Discriminant analysis between males and females. The selected discriminant traits with F>4, and their Wilks lambda and minimum D squared values in Brahmin**.**

Variables	Wilks lambda	Minimum D squared
A. From 22 quantitative dermatoglyphic traits.		
Finger RC I-l	0.968	0.132
Finger RC II-l	0.962	0.159
Finger RC V-l	0.949	0.215
a–b, RC, rh	0.944	0.235
A-line exit,l	0.938	0.261
Main line index	0.931	0.297
B. From 38 dermatoglyphic traits including indices of intraindividual diversity and of Directional and fluctuating asymmetry.		
FlAs IV	0.983	0.070
DAs II	0.969	0.126
DAs V	0.957	0.178
FlAs VI	0.946	0.229
FlAs XIV	0.937	0.268
DAs XI	0.927	0.316
DAs XII	0.921	0.344

Table 3: Discriminant analysis between males and females. The selected discriminant traits with F>4, and their Wilks lambda and minimum D squared values in Mahisya.

Variables	Wilks lambda	Minimum D squared
A. From 22 quantitative dermatoglyphic traits.		
Finger RC I-r	0.978	0.091
a–b RC, lh	0.965	0.143
D-line exit, l	0.956	0.182
Finger RC III-r	0.950	0.208
TRC	0.939	0.257
Finger RC II-l	0.929	0.303
B. From 38 dermatoglyphic traits including indices of intraindividual diversity and of Directional and fluctuating asymmetry.		
DIV VIII	0.984	0.065
DAs II	0.974	0.108
DAs VII	0.965	0.143
DAs XII	0.957	0.179
FlAs II	0.950	0.210
DAs XI	0.945	0.232
DIV II	0.940	0.254
FlAs XI	0.935	0.276

Table 4: Discriminant analysis between males and females. The selected discriminant traits with F>4, and their Wilks lambda and minimum D squared values in Padmaraj.

Variables	Wilks lambda	Minimum D squared
A. From 22 quantitative dermatoglyphic traits.		
Finger RC I-r	0.953	0.198
Finger RC II-r	0.940	0.254
TRC	0.927	0.313
PII, lh	0.922	0.337
PII, rh	0.918	0.356
Finger RC IV-r	0.914	0.376
D-line exit, r	0.910	0.394
A-line exit, l	0.907	0.412
B. From 38 dermatoglyphic traits including indices of intraindividual diversity and of Directional and fluctuating asymmetry.		
Das XIII	0.982	0.073
FlAs X	0.967	0.136
FlAs XV	0.957	0.180
DAs II	0.946	0.228
DAs III	0.937	0.271
FlAs XIV	0.927	0.315
DAs VII	0.919	0.352
DAs XI	0.912	0.386
DAs XIV	0.903	0.430
Div VIII	0.896	0.465
FlAs XI	0.891	0.489

Table 5: Discriminant analysis between males and females. The selected discriminant traits with F>4, and their Wilks lambda and minimum D squared values in Muslim.

Variables	Wilks lambda	Minimum D squared
A. From 22 quantitative dermatoglyphic traits.		
Finger RC I-r	0.976	0.100
Finger RC II-r	0.963	0.156
D-line exit, r	0.955	0.188
D-line exit, l	0.951	0.207
a–b RC, lh	0.947	0.223
B. From 38 dermatoglyphic traits including indices of intraindividual diversity and of Directional and fluctuating asymmetry.		
DAs VII	0.984	0.064
DAs XII	0.973	0.109
FlAs I	0.962	0.158
DAs II	0.954	0.194
FlAs II	0.946	0.227

Table 6: Discriminant analysis between males and females. The selected discriminant traits with F>4, and their Wilks lambda and minimum D squared values in Lodha.

Variables	Wilks lambda	Minimum D squared
A. From 22 quantitative dermatoglyphic traits.		
Finger RC, I-r	0.931	0.296
Finger RC, IV-r	0.917	0.358
Finger RC, V-l	0.906	0.415
PII, lh	0.898	0.450
AbsRC	0.888	0.502
Finger RC, I-l	0.882	0.532
B. From 38 dermatoglyphic traits including indices of intraindividual diversity and of Directional and fluctuating asymmetry.		
Div V	0.963	0.153
FlAs X	0.943	0.239
FlAs VI	0.930	0.301
FlAs XIV	0.922	0.338
DAs II	0.914	0.375
FlAs XII	0.906	0.412
FlAs II	0.900	0.443

Table 7: Results of discriminant analysis between males and females in Brahmin.

A. By 22 quantitative dermatoglyphic traits.

Real group	No. of cases	Predicted group	
		Males	Females
Males	229	139 (60.7%)	90 (39.3%)
Females	215	81 (37.7%)	134 (62.3%)

Percent of correctly classified cases = 61.49%

B. By 38 dermatoglyphic traits including indices of intraindividual diversity and of directional and fluctuating asymmetry.

Real group	No. of cases	Predicted group	
		Males	Females
Males	213	137 (64.3%)	76 (35.7%)
Females	198	73 (36.9%)	125 (63.75%)

Percent of correctly classified cases = 63.75%

Table 8: Results of discriminant analysis between males and females in Mahisya.

A. By 22 quantitative dermatoglyphic traits.

Real group	No. of cases	Predicted group	
		Males	Females
Males	260	158 (60.8%)	102 (39.2%)
Females	237	89 (37.6%)	148 (62.4%)

Percent of correctly classified cases = 61.57%

B. By 38 dermatoglyphic traits including indices of intraindividual diversity and of directional and fluctuating asymmetry.

Real group	No. of cases	Predicted group	
		Males	Females
Males	256	163 (63.7%)	93 (36.3%)
Females	227	96 (42.3%)	131 (57.7%)

Percent of correctly classified cases = 60.87%

Table 9: Results of discriminant analysis between males and females in Padmaraj.

A. By 22 quantitative dermatoglyphic traits.

Real group	No. of cases	Predicted group	
		Males	Females
Males	279	173 (62.0%)	106 (38.0%)
Females	244	89 (36.5%)	155 (63.5)

Percent of correctly classified cases = 62.72%

B. By 38 dermatoglyphic traits including indices of intraindividual diversity and of directional and fluctuating asymmetry.

Real group	No. of cases	Predicted group	
		Males	Females
Males	258	171 (66.3%)	87 (33.7%)
Females	220	88 (40.0%)	132 (60.0)

Percent of correctly classified cases = 63.39%

Table 10: Results of discriminant analysis between males and females in Muslim.

A. By 22 quantitative dermatoglyphic traits.

Real group	No. of cases	Predicted group	
		Males	Females
Males	289	173 (59.9%)	116 (40.1%)
Females	261	114 (43.7%)	147 (56.3%)

Percent of correctly classified cases = 58.18%

B. By 38 dermatoglyphic traits including indices of intraindividual diversity and of directional and fluctuating asymmetry.

Real group	No. of cases	Predicted group	
		Males	Females
Males	280	180 (64.3%)	100 (35.7%)
Females	255	114 (44.7%)	141 (55.3%)

Percent of correctly classified cases = 60.00%

Table 11: Results of discriminant analysis between males and females in Lodha.

A. By 22 quantitative dermatoglyphic traits.

Real group	No. of cases	Predicted group	
		Males	Females
Males	201	131 (65.2%)	70 (34.8%)
Females	199	66 (33.2%)	133 (66.8%)

Percent of correctly classified cases = 66.00%

B. By 38 dermatoglyphic traits including indices of intraindividual diversity and of directional and fluctuating asymmetry.

Real group	No. of cases	Predicted group	
		Males	Females
Males	199	119 (59.8%)	80 (40.2%)
Females	196	74 (37.8%)	122 (62.2%)

Percent of correctly classified cases = 61.01%

Table 12: Matrix correlation r (= normalized Mantel statistic Z), Males vs females within population in 22 and 38 dermatoglyphic traits.

Populations	**22 traits**	**38 traits**
Brahmin	0.973	0.873
Mahisya	0.986	0.907
Padmaraj	0.982	0.908
Muslim	0.987	0.911
Lodha	0.976	0.899

- Level of similarity: $0.9 \leq r$ (very good similarity) and
- $0.8 < r \leq 0.9$ (good similarity).

Between 22 and 38 traits: From tables 2–6, the discriminating power between two groups, namely 22 and 38 variables, the selected number of variables are: BR (6 and 7), MA (6 and 8), PA (8 and 11), MU (5 and 5) and LO (6 and 7). These results clearly show very marginal variations within populations between two groups of variables. Variables from tables 7–11 for correct classification by sex are: BR (61.49% and 63.75%), MA (61.57% and 60.87%), PA (62.72% and 63.39%), MU (58.18% and 60.00%), and LO (66.01% and 61.01%), and they also show the same pattern. Wilks' Lambda and minimum D square values appear very similar between two groups of variables in all populations. These results indicate that sex dimorphism is similar in two categories of variables.

Mantel test of matrix correlations

Since our objective is to examine sex dimorphism between two categories of variables, we did not consider population comparisions among 5 populations that was the objective of our earlier paper. With the aim of comparing two categories of variables with respect to males *vs* females, we performed the Mantel test of matrix correlations for significance tests within population groups. The above discriminant power of the two groups of variables that proved to be similar between males and females are confirmed by the similarity/correspondance test of the Mantel statistic Z, and are presented in table 12. All the values of Z are within the level of non-significant i.e., very good similarities in 22 and 38 traits in each population group.

Discussion

Cluster analysis

The similarities between the two groups of the dermatoglyphic variables in males and females are well reflected by the cluster analysis in all populations (see figures1a, 1b, 2a and 2b). Earlier studies on the same are not available and thus the results cannot be compared with the Indian sample. With the same objective, the dendrograms obtained by Micle & Kobyliansky 1991 in Jewish populations are based on the same variables, and thus our results can be compared with this study. They concluded that «the cluster analysis shows very similar results in the two sexes». Therefore, our present results are corroborated by these results.

Discriminant analysis

It appears from this analysis that the two categories of dermatoglyphic variables: 22 quantitative traits and 38 indices of asymmetry and diversity provided similar possibilities of discrimination between sexes. These findings, too, are in agreement with the earlier findings in Jewish populations. Here the authors concluded «the two categories of dermatoglyphic variables, separately used in the discriminant analysis by sex, give similar results in sex discrimination».

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Appendix 1: List of the utilized traits and indices.

A) 22 quantitative traits	B) 42 traits, representing indices of intraindividual diversity and asymmetry			
Finger RC, Ir	Div I	= max–min fRC (lh)	DAs XII	= fRC, IIIr–IIIl
Finger RC, IIr	Div II	= max–min fRC (rh)	DAs XIII	= fRC, IIr–IIl
Finger RC, IIIr	Div III	= max–min fRC (both h)	DAs XIV	= fRC, Ir–Il
Finger RC, IVr	Div IV	= S2 for lh, (or S^2L)	DAs XV	= MLI, rh–lh
Finger RC, Vr	Div V	= S2 for rh, (or S^2R)	FlAs I	= [Div I–Div II]
Finger RC, Il	Div VI	= S2 (both h)	FlAs II	= PII, [rh–lh]
Finger RC, II1	Div VII	= IIDL (for hl)	FlAs III	= a–b, RC, [rh–lh]
Finger RC, III1	Div VIII	= IIDR (for rh)	FlAs IV	= hRC, [rh–lh]
Finger RC, IV1	Div IX	= $S\sqrt{10}$, (both h)	FlAs V	= [Div V–Div IV]
Finger RC, V1	Div X	= $S\sqrt{5}$, (both h)	FlAs VI	= [Div VIII–Div VII]
Total RC (TRC)	Div XI	= Shannon's index	FlAs VII	= atd angle, [r–l]
AbsRC	DAs I	= Div II–Div I	FlAs VIII	= a–b dist, [r–l]
PII, hl	DAs II	= PII, rh–lh	FlAs IX	= ridge breadth [r-l]
PII, rh	DAs III	= a–b RC, r–l	FlAs X	= fRC, [Vr–Vl]
PII, both h	DAs IV	= hRC, rh–lh	FlAs XI	= fRC, [IVr–IVl]
a–b RC, rh	DAs V	= S^2, rh–lh	FlAs XII	= fRC, [IIIr–IIIl]
a–b RC, lh	DAs VI	= Div VIII–Div VII	FlAs XIII	= fRC, [IIr–IIl]
A-line exit, l	DAs VII	= atd angle, r–l	FlAs XIV	= fRC , [Ir–Il]
A-line exit, r	DAs VIII	= a–b dist., r–l	FlAs XV	= MLI, [rh–lh]
D-line exit, l	DAs IX	= ridge breadth, r–l	FlAs XVI	= A1, asymmetry index
D-line exit, r	DAs X	= fRC , Vr–Vl		**DAs VIII–IX and FlAs VIII–IX, based on a–b dist. a–b ridge breadth were excluded from the analysis. Numbering of the traits remain as in our other publications, for simplification of comparison with our previous data.**
MLI	DAs XI	= fRC , IVr–Ivl		

Abbreviations:
RC = ridge count; r = right; l = left; h = hand; PII–Pattern Intensity Index; MLI = main lineindex; Div I to Div XI = indices of intraindividual diversity of finger ridge counts; DAs I to Das XV = indices of directional asymmetry; FlAs I to FlAs XVI = indices of fluctuating asymmetry.

Appendix 2: Formulae for some indices of dermatoglyphic diversity and asymmetry.

Computation of the directional asymmetry (DA) was effected by the following equation:

$DAs_{ij} = (X_{iR} - X_{iL})/[0.5 \times (X_{iR} + X_{iL})]$.

Computation of the fluctuating asymmetry (FA) was done by using the absolute differences between the bilateral measurements. In order to avoid additional influences (scaling effects) like size of the trait or directional asymmetry, the distribution of the non-absolute differences for each individual were corrected (Livshits et al., 1988) so as to yield the following equation for computing FA:

$$FlAs_{ij} = 100 \left|(X_{iR} - X_{iL})/0.5\,(X_{iR} + X_{iL}) - 1/n \sum_{i=1}^{n} \left[(X_{iR} - X_{iL})/0.5\,(X_{iR} + X_{iL})\right]\right|$$

Where x_i = trait (x) of individual (i); R, L = right and left, n = size of the sample and FA_{ij} is the value of FA of trait (j) in the i-th individual.
Div I, Div II, Div III. Maximal minus minimal finger ridge counts in the five left (Div I), five right (Div II), or in all the ten finger ridge counts (Div III). Div IV, Div V = $\sum_{i=1}^{5} q_i^2 - Q^2/5$, for the left (Div IV, S^2L) or right fingers (Div V, S^2R); Div VI, $S^2 = \sum_{i=1}^{10} q_i^2 - Q^2/10$; Div VII, Div VIII = $\sqrt{\sum_{i=1}^{5} q_i^2 - Q^2/5}$, for the left (Div VII, IIDL), or right finger (Div VIII, IIDR); Div IX, $S\sqrt{10} = \sqrt{\sum_{i=1}^{10} q_i^2 - Q^2/10)/10}$; Div X, $S\sqrt{5} = \sqrt{\sum_{i=1}^{10} k_i^2 - Q^2/5)/5}$;

In these formulae, q_i is the ridge count for the i^{th} finger, Q is the sum of the five finger ridge counts of a hand (Div IV,V,VII,VIII) or of all the ten fingers (Div VI,IX,X), and k is the sum of ridge counts of the i^{th} pairs of homologous right and left fingers. Div.XI. Shannon's index, $D = -\sum_{i=1}^{4} P_i \log P_i$ where P_i is the frequency of each of the four basic finger pattern types on the ten fingers; Abs XVI, AI = $\sqrt{\sum_{i=1}^{5} (R_i - L_i)^2}$, where R_i and L_i are the ridge counts for the i^{th} finger of the right and left hand.