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DIGITAL RIDGE COUNT ASYMMETRY AMONG FIVE ENDOGAMOUS GROUPS OF RAJASTHAN

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Abstract : The paper reports fluctuating and absolute asymmetry as well as the measure $\sqrt{A^2}$ in finger ridge counts among five endogamous populations of the Indian state of Rajasthan. The mean values of $\sqrt{A^2}$ and the total signed asymmetry variance show greater interfinger homogeneity and less asymmetry among the Indian populations compared to the European populations but more compared to the African populations. The limited data from India substantiates Jantz's (1979) hypothesis that the variation in asymmetry appears to be patterned along 'racial' lines.

INTRODUCTION

It is a well known fact that homologous parts in the same individual often display differences. When such bilateral structures show non-directional inequalities in size, it is termed developmental noise (Waddington 1957) or fluctuating asymmetry (Van Valen 1962) It is assumed that the genetic information for both sides is the same and, therefore, the observed bilateral inequality at birth is attributed to intrauterine environment (Adams and Niswander 1967). A number of studies in humans (Bailit *et al.* 1970, Doyle and Johnston 1977) and in rats and mice have demonstrated that stress, such as noise, cold (Siegel and Smookler 1973, Siegel and Doyle 1975). audiogenic and heat (Riesenfeld 1973, Siegel *et al.* 1977) bring about increase in the magnitude of fluctuating asymmetry.

Although the existence of bilateral asymmetry in several dermatoglyphic traits has long been established (Cummins and Midlo 1943), no systematic quantitative studies began only since 1954. Holt (1954) first demonstrated in a British sample of 254 males and females that 63.39 per cent of males and 66.67 per cent of females had more ridges on their right hands.

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More recently a number of indices have been advanced to examine bilateral asymmetry with respect to finger ridge counts. Holt (1954) used right-left difference as a measure of asymmetry. Another measure of asymmetry (A) is the summed absolute difference between finger ridge counts in homologous digits (Parsons 1964), Singh (1968, 1970) used the mean of the squared finger ridge count differences between homologous digits :

$$\sqrt{A^2} = \sqrt{\sum_{i=1}^{5}(R_i - L_i)^{2/5}}$$

Jantz (1975) defined a measure taking the square root of squared differences between homologous digits :

$$\sqrt{A^2} = \sqrt{\sum_{i=1}^{5}(R_i - L_i)^2}$$

Bilateral asymmetry can also be measured (a) taking into account signed right-left differences separately for each finger ; the mean of the differences provides a measure of directional asymmetry, and the variance of the difference evaluate the magnitude of fluctuating asymmetry (Jantz 1979) and (b) taking into account non-signed (absolute) difference which represent ambidirectional asymmetry (Loesch and Martin 1982).

Jantz (1978, 1979) studied fluctuating and directional asymmetry in finger ridge counts among American Whites, American Blacks, Japanese and Britishers, while Harvey and Singh (1980) studied the same among Waskia of Papua New Guinea. Loesch and Martin (1982) studied both directional and absolute asymmetry among 221 pairs of twins and 80 pairs of opposite sex siblings and concluded that both types of asymmetry were largely under environmental control, but with significant genetic component, particularly in males.

All the above mentioned studies, however, considered only total finger ridge count and not absolute finger ridge count.

Surveying literature it is also evident that although finger ridge counts have been reported for over a hundred population groups from different parts of India (among others see, Singh 1961 ; Mavalwala 1963, Srivastava 1965, Sen 1968, Malhbtra *et al.* 1980) only one study (Malhotra and Sengupta 1984) investigated directional and absolute bilateral asymmetry in ridge counts of individual digits among the Hatkars of Maharashtra. It may, however, be noted that Chakraborty and Malhotra (1981) and Chakraborty *et al* (1982) using Jantz's method ($\sqrt{A^2}$) studied asymmetry among 29 populations of Maharashtra state.

The intent of this paper is threefold : (i) to report directional and absolute asymmetry as well as $\sqrt{A^2}$ in finger ridge counts among five endogamus population groups of Rajasthan state in India ; (ii) to investigate all the three measures of asymmetry using total as well as absolute finger ridge counts, and (iii) to compare the results of this study with the findings by earlier investigators (Jantz 1978, 1979, Harvey and Singh 1980, Loesch and Martin 1982 and Malhotra and Sen Gupta 1984).

MATERIAL AND METHOD

The finger ball prints analysed here were collected as part of an ongoing Joint Indo-Soviet anthropological project during 1978-79 from Udaipur district in Rajasthan state. Among other biologic and cultural data, bilateral inked finger and palmar prints were also collected from 5 endogamous populations — four caste Hindus (Palival Brahmin, Rajput, Oswal and Meghwal) and a tribal group, the Bhil. Prints of 500 males, 100 from each group aged 10 to 55 years, were obtained ; prints of 20 individuals, however, could not be utilized owing to imperfect printing. The ridge counts of digital patterns were scored after Holt (1958). For each digit both total (TRC) and absolute ridge counts (ARC) were determined. Based on these two measures of digital counts, directional (signed) and absolute (non-signed) right-left differences as well as Jantz's $\sqrt{A^2}$ measure were calculated separately for each finger and for the whole hand. The names of the five groups studied and the sample sizes are given in Table 1.

RESULTS

I. Proportion of symmetric and asymmetric individuals by digit

In Table 2, proportion of individuals by digit having ridge counts greater on the right or left side or equal on both sides, separately for each group, are presented.

In respect of TRC it is noted that the proportion of individuals with higher counts on the right side predominate in all the groups on digits I, II and V (except among Bhils). Digit III (left) in all the groups (except among Meghwals) and digit IV (left) among Rajputs and Oswals show preponderance of individuals with higher counts.

It is, thus, evident that the trend observed among the five groups is the preponderance of individuals with greater counts on right hand digits I, II and V and higher counts on left hand digits III and IV. The distribution of individuals with counts higher on the right or left side or equal on both sides on different digits is significantly heterogeneous in all the five groups, except for Meghwal and Bhil (see Chisquare values in Table 2).

In respect of ARC it is observed that all right hand digits, except digit III, show preponderance of individuals with greater counts. Like TRC the distribution of individuals with counts greater on the right or left or equal on both sides on different digits is significantly heterogeneous among all the five groups, except Oswals and Bhils (see Chi-square values in Table 2).

The proportion of individuals with right hand digits having a higher count than the left hand digits in decreasing order of magnitude for TRC and ARC are those for digits I, II, IV III and V and I, II, IV, V and III, respectively.

II. Means and standard deviations of absolute asymmetry

The means and standard deviations for each digit as well as whole hand, separately for each group, in respect of absolute (unsigned) asymmetry for TRC and ARC are presented in Table 3. The highest mean asymmetry in respect of TRC is seen on digits II (in three groups) and I (in two groups), while the lowest is observed on digits V (in three groups), IV and III. The mean asymmetry in decreasing order of magnitude on different digits depicts heterogeneous pattern in the groups. The means of absolute asymmetry are, however, significantly heterogeneous on different digits in all the groups (see F-values in Table 7).

When ARC is considered the highest mean difference is observed for digit I and the lowest for digit V : this is true in all the five groups. The mean asymmetry, in decreasing order of magnitude, on different digits does not reveal any uniform pattern : the most prevalent sequence observed, however, is I > II > IV > III > V. The means on different digits, as in the case of TRC, are significantly heterogeneous among all the groups (see F-values in Table 7).

An examination of standard deviations in respect of TRC show that digits II (in three groups) and III (in two groups) are most variable, while digit V in all groups (except among Bhils) is the least variable. The digits, in different groups, do not depict a consistent decreasing or increasing orders : however, there is a tendency among the group to confirm the following decreasing order : II > I > IV > III > V. The standard deviations of absolute asymmetry on different digits among all the groups, except Oswals ($\chi^2_4 = 7.78$, $p < 0.25 < 0.100$), are significantly heterogeneous (as Table 6).

When standard deviations of ARC are examined, it is observed that digit I is most variable (in all the groups) and digit V (except among Meghwals) is the least variable. There appears to be a tendency in the magnitude of variance to increase from digit V to I; in decreasing order of magnitude the most preferred sequence appears to be I > II > IV > III > V. In all the groups the standard deviations on different digits are significantly heterogeneous by Bartlett's test (see Table 6).

III. Means and standard deviations of directional asymmetry

In Table 4 are presented the means and standard deviations for each digit as well as whole hand, separately for each group, in respect of directional (signed) right-left differences for both TRC and ARC.

The highest mean directional asymmetry in the case of TRC is observed for digit I (the only exception being Palival Brahmins) and the lowest for digit III (the only exception being Meghwals). Except for Meghwals, the means on different digits are significantly heterogeneous in all the groups (see P-values in Table 8). An inspection of standard deviations reveals that digits II (in three groups) and III (in two groups) are most asymmetric while digit V is the least (the only exception being the Bhils). In all the groups, except Oswals the variances of asymmetry on different digits are significantly heterogeneous by Bartlett's test (see Table 6). There appears to be a gradient of increasing asymmetry from digit V to II.

With reference to TRC the highest mean asymmetry in all the groups is observed on digit I and the lowest on digit III (with the exception of Meghwals where it is digit II). Except for the Oswals the means on different digits are significantly heterogeneous in all the groups (see P-values in Table 8). In all the groups, except Meghwals, digit I is most asymmetric and digit V the least. The variances of asymmetry on different digits in all the groups, except Meghwals, are heterogeneous by Bartlett's test (see Table 6).

IV. Means and standard deviations of the measure $\sqrt{A_2}$

In Table 5 are given means and standard diviations of TRC. ARC and $\sqrt{A^2}$, separately for each group. The means of $\sqrt{A^2}$ in respect of TRC do not depict much variation among the five groups, the minimum value of 7.34 is observed among the Rajputs and the maximum (8.02) among Palival Brahmins. Like TRC, the means of $\sqrt{A^2}$ in respect of ARC also do not show much variation among the five groups: the observed range is between 13.54 among Meghwal and 15.42 among Rajputs. The standard deviations of $\sqrt{A^2}$ in respect of both TRC and ARC also do not depict much variation between the groups.

COMPARISON AND DISCUSSION

The rank order of mean absolute asymmetry on different digits in respect of both TRC and ARC observed in the present study do not fully agree with the results of Loesch and Martin (1982), and Malhotra and Sen Gupta (1984), thus, suggesting the existence of ethnic differences.

The inter-digit variability in absolute asymmetry, as measured by variances, in respect of both TRC and ARC also show departures from the earlier results of Loesch Martin (1982) and Malhotra and Sen Gupta (1984).

The present results that the greatest signed difference is for digit I and that on other digits the differences are usually low and ocassionally negative are in full agreement with the results of Jantz (1979), Loesch and Martin (1982) and Malhotra and Sen Gupta (1984). Jantz's (1979) observation that digit V displays least asymmetry and digit II the most is not fully corroborated by the present results. In general, the present results support the finding of Jantz (1978, 1979) that there is a gradient of increasing asymmetry from digit V to II.

The means of the measure $\sqrt{A^2}$ in respect of TRC and ARC found in the present study agree well with the results reported by Chakravarti and Malhotra (1981) and Chakraborty *et al.* (1982) among 29 populations of the Indian state of Maharashtra. Compared to the means of $\sqrt{A^2}$ (TRC) reported by Jantz (1975) for Eastern Island (8.17), English (9.20) and American Whites (8.98), the values obtained in the present study are relatively smaller (maximum value being 8.02). This indicates greater inter-finger homogoneity and less asymmetry among the Indian populations compared to the ones mentioned above. However, compared to the African populations reported by Jantz (1975) the Indian populations depict slightly larger values. Thus the Indian populations are less asymmetric than the European and Eastern Island populations but more asymmetric compared to the African populations.

In order to understand the magnitude of fluctuating asymmetary, Jantz (1979) computed an overall expression of the asymmetry by summing the variances of the individual digits. Jantz examined the total asymmetry variance among 15 samples of different ethnic origins and concluded that the asymmetry was patterned along racial lines : Europeans and West Asians are characterized by high asymmetry and African populations by low asymmetry ; East Asia and probably Oceania tend to occupy intermediate values.

In Table 9 are set out the available data on total signed asymmetry variance among different populations. Altogether, including the present 5 samples, such data are now available on 24 populations.

It is noteworthy that considerable heterogeneity is noticed among the 8 populations from India ; the observed range is between 61.94 among the Bhils to 93.75 among the Parsis. While some populations like Parsis, Hatkar, P. Brahmin and Rajput approach European populations, others like Bhil are closer to the African populations. In view of the ethnic diversity of the Indian populations such a result is not altogether surprising. It is well known that Parsis in India are immigrants from Iran and came to India in the 7th century A. D. Several of the caste Hindus also depict ethnic affinities with west Asia. The tribal Bhils represent an earlier autochthonous ethnic element. The limited data from India, thus, further substantiates Jantz's hypothesis that the variation in asymmetry was patterned along racial lines.

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Table 1. Dermatoglyphic data by endogamous groups.

Sl. no	Population	No. of prints collected	No. of Prints utilized
1	Palival Brahmin	100	98
2	Rajput	100	98
3	Oswal	100	97
4	Meghwal	100	90
5	Bhil	100	97
Total		500	480

Table 2. Proportion of symmetric and asymmetric (directional) individuals by digit among populations of Rajasthan.

Finger	Asymmetry					
	R > L		R < L		R = L	
	No.	(%)	No.	(%)	No.	(%)
Palival Brahmin (males)						
Total ridge count[1]						
I	60	61.22	27	27.55	11	11.23
II	58	59.18	27	27.55	13	13.27
III	33	33.67	54	55.10	11	11.23
IV	50	51.02	37	37.75	11	11.23
V	48	48.99	36	36.73	14	14 28
Total	62	63.27	32	32.65	04	4.08

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Absolute ridge count[2]

I	62	63.27	26	26.53	10	10.20
II	59	60.20	30	30.61	09	9.19
III	38	38.78	50	51.02	10	10.20
VI	59	60.20	28	28.57	11	11.23
V	52	53.06	36	36.74	10	10.20
Total	71	72.45	26	26.53	01	1.02

1. χ^2_8 = 23.28, significant at 1% level 2. χ^2_8 = 18.18, significant at 5% level

Rajput (males)

Total ridge count[1]

I	61	62.25	27	27.55	10	10.20
II	55	56.12	25	25.51	18	18.37
III	38	38.78	46	46.93	14	14.29
IV	37	37.76	46	46.93	15	15.31
V	44	44.89	41	41.84	13	13.27
Total	58	59.18	38	38.78	02	2.04

Absolute ridge count[2]

I	65	66.33	26	26.53	07	7.14
II	52	53.06	30	30.61	16	16.33
III	38	38.78	53	54.08	07	7.14
IV	50	51.02	38	38.78	10	10.20
V	48	48.98	35	35.71	15	15.31
Total	58	59.18	40	40.82	00	0.00

1. χ^2_8 = 23.39, significant at 1% level 2. χ^2_8 = 25.91, significant at 1% level

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Oswal (males)

Total ridge count[1]

I	64	65.98	26	26.80	7	7.22
II	54	55.67	31	31.96	12	12.37
III	37	38.14	49	50.52	11	11.34
IV	40	41.24	41	42.27	16	16.49
V	44	45.36	35	36.08	18	18.56
Total	56	57.73	37	38.14	04	4.13

Absolute ridge count[2]

I	64	65.98	26	26.80	7	7.22
II	56	57.73	32	32.99	9	9.28
III	42	43.30	47	48.45	8	8.25
IV	49	50.51	41	42.27	7	7.22
V	48	49.48	38	39.18	11	11.34
Total	67	69.07	27	27.84	3	3.09

1. $\chi^2_8 = 23.50$, significant at 1% level 2. $\chi^2_8 = 12.31$, significant at 5% level

Meghwal (males)

Total ridge count[1]

I	56	62.22	24	26.67	10	11.11
II	41	45.55	35	38.89	14	15.56
III	41	45.55	32	35.56	17	18.89
IV	45	50.00	36	40.00	09	10.00
V	47	52.22	28	31.11	15	16.67
Total	59	65.56	30	33.33	01	1.11

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Absolute ridge count[2]

I	62	68.89	22	24.44	06	6.67
II	42	46.67	36	40.00	12	13.33
III	41	45.56	36	40.00	13	14.44
IV	42	46.67	41	45.56	07	7.77
V	50	55.56	29	32.22	11	12.22
Total	58	64.45	29	32.22	03	3.33

1. χ^2_8 = 10.06, non-significant at 5% level 2. χ^2_8 = 17.36, significant at 5% level

Bhil (males)

Total ridge count[1]

I	54	55.67	31	31.96	12	12.37
II	48	49.48	38	39.10	11	11.34
III	40	41.24	46	47.42	11	11.34
IV	46	47.42	42	43.30	09	9.28
V	37	38.14	44	45.36	16	16.50
Total	54	55.67	40	41.24	03	3.09

Absolute ridgecount[2]

I	55	56.70	34	35.05	08	8.25
II	52	53.61	39	40.20	06	6.19
III	39	40.20	50	51.55	00	8.25
IV	52	53.61	40	41.24	05	5.15
V	43	44.33	42	43.30	12	12.37
Total	63	64.95	33	34.02	01	1.03

1. χ^2_8 = 9.79, non-significant at 5% level 2. χ^2_8 = 10.91, non-significant at 5% level

Table 3. Means and standard deviations of absolute asymmetry among five groups from Rajasthan.

Population	P. Brahmin		Rajput		Oswal		Meghwal		Bhil	
Finger	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S D.	Mean	S.D.
TRC										
I	3.20	2.51	3.22	2.47	3.53	2.52	3.01	2.40	3.05	2.52
II	3.79	3.27	3.12	3.09	2.90	2.68	3.11	2.88	3.29	2.70
III	2.55	2.30	2.26	2.27	2.98	2 72	2.46	2.59	3.10	2.92
IV	2.53	2.33	2.31	2.73	2.63	2.46	2.91	2.38	2.35	1.95
V	2.68	2.11	2.01	1.65	2.34	2.07	2.11	1.79	2 37	2.29
Total	8.15	7.00	7.63	5.23	6.91	5.42	6.89	5.80	6.53	4.58
ARC										
I	6.95	6.44	6.09	6.68	5.60	6.75	5.96	4.96	5.64	5.75
II	6.22	5.31	6.21	5.91	5.09	4.62	5.46	4.79	5.15	4.17
III	3.61	3.42	4.41	4.61	5.03	4.97	4.08	4.17	5.15	4.92
IV	5.53	4.84	5.13	5.54	4.66	3.86	4.50	4.49	4.53	4.18
V	3.98	3.25	3.57	3.75	4 09	3.65	3.67	5.28	3.60	3.51
Total	14.79	11.29	16.40	12.60	13.43	10.81	13.58	11.16	13.03	9.86

Table 4. Means and standard deviations of directional asymmetry among five groups from Rajasthan.

Population / Finger	P brahmin		Rajput		Oswal		Meghwal		Bhil	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
TRC										
I	1.84	3.63	1.53	3.76	1.92	3.89	1.39	3.59	1.30	3.74
II	2.01	4.38	0.86	4.31	0.69	3.89	0.07	4.24	0.46	4.23
III	−0.41	3.41	−0.01	3.20	−0.03	4.03	0.68	3.50	0.07	4.26
IV	0.53	3.40	−0.45	3.55	0.44	3.57	0.18	3.76	0.17	3.05
V	0.60	3.36	−0.15	2.60	−0.05	3.12	0.36	2.75	−0.83	3.19
Total	4.95	9.54	1.59	9.12	2.74	8.34	2.13	8.75	1.25	7.87
ARC										
I	4.72	8.21	3.36	8.40	3.45	8.06	2.93	7.18	2.90	7.51
II	2.41	7.82	1.89	8.36	2.08	6.55	0.14	7.26	1.30	6.50
III	−0.08	4.97	−0.57	6.35	−0.04	7.07	0.19	5.83	−0.27	7.12
IV	2.84	6.78	0.60	7.53	1.24	5.92	−0.17	6.35	1.62	5.95
V	1.59	4.89	0.90	5.10	0.59	5.45	0.87	5.55	−0.42	5.01
Total	9.97	15.66	6.15	19.74	8.59	14.95	3.89	17.14	5.28	1[illegible].47

Table 5. Means and standard deviations of TRC, ARC and $\sqrt{A^2}$

Population	Means				Standard deviations			
	TRC	$\sqrt{A^2}$	ARC	$\sqrt{A^2}$	TRC	$\sqrt{A^2}$	ARC	$\sqrt{A^2}$
P. Brahmin	139.54	8.02	185.91	14.71	40.41	3.43	78.27	6.05
Rajput	147.95	7.34	206.64	15.42	40.68	3.368	85.19	7.07
Oswal	143.15	7.99	193.32	14.07	38.87	3.58	80.76	6.86
Meghwal	137.78	7.52	183.60	13.54	41.61	3.29	79.89	6.09
Bhil	143.54	7.82	190.61	13.59	39.93	3.32	79.79	6.25

Table 6. Obtained values of χ^2 Bartlett's test of homogeneity of variances.

Population	Directional Asymmetry		Absolute asymmetry	
	TRC	ARC	TRC	ARC
P. Brahmin	14.68**	44.93**	24.11**	64.50**
Rajput	26.65**	31.97**	39.65**	37.26**
Oswal	7.78	18.17**	8.62	49.05**
Meghwal	16.86**	10.50*	20.56**	5.88
Bhil	18.28**	18.74**	18.05**	27.52**

* Significant at 5% level ** Significant at 1% level

Table 7. Analysis of Variance : F-test for means of absolute right left differences on different digits for TRC and ARC among 5 groups of Rajasthan.

Population	F—Ratio	
	TRC	ARC
Palival Brahmin	4.41**	8.63**
Rajput	4.75**	4.20**
Oswal	2.99*	4.01**
Meghwal	2.69*	3.93**
Bhil	2.98*	2.84*

* Significant at 5% level ** Significant at 1% level

Table 8. Analysis of Variance : F-test for means of directional right-left differences on different digits for TRC and ARC among 5 groups of Rajasthan.

Population	F—Ratio	
	TRC	ARC
Palival Brahmin	7.15**	6.71**
Rajput	5.20**	4.01**
Oswal	4.51**	1.25
Meghwal	1.92	3.35**
Bhil	4.04**	4.57**

** Significant at 1% level

Table 9. Total directional asymmetry variance for different populations (males)

Population	No.	Asymmetry variance		Source
		TRC	ARC	
Europe or European Extraction				
American white	185	93.65		Jantz 1979
German	400	90.10		Jantz 1979
English (1)	825	85.99		Jantz 1979
English (2)	359	92.93		Jantz 1978
Polish	324	113.00		Loesch & Martin 1982
Africa or African Extraction				
Quioco	89	58.60		Jantz 1979
American Black	102	56.96		Jantz 1979
Yoruba (Nigeria)	127	59.25		Jantz 1979
Hehe (Tanzania)	107	59.89		Jantz 1979
Dogon	169	76.94		Jantz 1979
Efe Pygmy	152	63.95		Jantz 1979
Ginga	94	61.00		Jantz 1979
East Asia				
Japanese	242	70.59		Jantz 1979
Oceania				
Easter island	142	78.12		Jantz 1979
Bougainville	675	87.83		Jantz 1979
Waskia	286	68.06		Harvey & Singh 1980

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India				
Parsi	200	93.75		Jantz 1979
Indians (S. Africa)	97	71.66		Jantz 1979
Hatkar (Maharashtra)	411	84.09	282.24	Malhotra & Sengupta 1984
P. Brahmin (Rajasthan)	98	91 01	245.23	Present study
Rajput (Rajasthan)	98	83.17	389.67	—do—
Oswal (Rajasthan)	97	69.56	223.50	—do—
Maghwal (Rajasthan)	90	76.56	293.78	—do—
Bhil (Rajasthan)	97	61.94	239.32	—do—

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