ABSOLUTE AND FLUCTUATING ASYMMETRY OF DIGITAL RIDGE COUNTS AMONG HATKARS OF MAHARASHTRA

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Absolute (right-left) and fluctuating asymmetry (signed right left) is studied among 411 Hatkar males of Maharashtra utilizing two traits, total finger ridge coun (TFRC) and absolute finger ridge count (AFRC). The distributions of absolute asymmetry on each digit and total hand in respect of both TFRC and AFRC measures deviate significantly from normality. Compared to American Whites, British and Poles, the Hatkars are more symmetric, but are less symmetric compared to Japanese, Waskia of New Guinea and American Blacks.

INTRODUCTION

It is well established that homologous parts in the same individual often display differences. When such bilateral structures show non-directional differences in size it is termed developmental noise (Waddington, 1975), or fluctuating asymmetry (Van Valen, 1962). It is assumed that the genetic information for both sides is the same and, therefore, the observed 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 (Riesenfelt, 1973; Siegel *et al.*, 1977) bring about increases in the magnitude of fluctuating asymmetry.

Although the existence of bilateral asymmetry in several dermatoglyphic traits has long been established (Cummins and Midlo, 1943), systematic quantitative studies began since 1954. Holt (1954) first demonsrated in a British sample of 254 males and females that 63.39% of males and 66.67% of females had more ridges on their right hands.

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 differences 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 opposit 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 on a number of population groups from India (among others see, Singh, 1961; Mavalwala, 1963; Srivastava, 1965; Sen, 1968; Malhotra *et al.*, 1980) but none investigated directional and absolute bilateral asymmetry in ridge counts of individual digits, although Chakraborty and Malhotra (1981) and Chakraborty *et al.* (1982) using Jantz method studied asymmetry among 29 populations of Maharashtra state.

The purpose of this paper is threefold : (i) to report for the first time in India directional and absolute asymmetry in finger ridge counts among the Hatkar Dhangars of Maharashtra, India; (ii) to investigate both the measures of asymmetry using total as well as absolute finger ridge counts, and (iii) to compare the result of this study with the results reported by Jantz (1978, 1979), Harvey and Singh (1980) and Loesch and Martin (1982).

METHODS AND MATERIALS

Bilateral rolled inked finger prints of 411 apparently normal male Hatkar Dhangars were drawn, using a multistage stratified random sampling design, from 40 villages of 10 districts in the state of Maharashtra. The Hatkar Dhangars, a semi-nomadic endogamous caste of shepherds, number over five hundred thousand and are found widely distributed in the state of Maharashtra (Malhotra and Gadgil, 1981). The ridge counts of finger patterns were scored after Holt (1958). The characters investigated were total and absolute ridge counts on individual fingers. Based on these two measures of digital counts, directional (signed) and absolute (non-signed) right-left differences were calculated separately for each finger and for the whole hand.

RESULTS

1. *Proportion of symmetric and asymmetric individuals by digit*

Table 1 gives data in respect of proportion of individuals by digits having ridge counts greater on the right or left side, or equal on both sides. In respect of total ridge counts it is observed that the proportion of individuals, irrespective of the digit, having greater counts on the right side predominate; digit I having the highest number of such individuals (63.36%) while digit IV the least (44.04%). It is noteworthy that individuals having equal counts are highest (17.52%) on digit II, and lowest (9.98%) on digit I. The proportion of individuals with counts greater on the right or left side, or equal on both sides on different digits is significantly heterogeneous ($X^2_8 = 46.23$, $p < 0.001$).

TABLE 1. Proportion of symmetric and asymmetric (directional) individuals by digit among the 411 Hatkar males.

	Asymmetry					
	$R > L$		$R < L$		$R = L$	
Finger	*No.*	(%)	*No.*	(%)	*No.*	(%)
Total ridge count						
I	260	63.26	110	26.76	41	9.98
II	197	47.93	142	34.55	72	17.52
III	201	48.91	149	36.25	61	14.84
IV	181	44.04	175	42.58	55	13.38
V	193	46.96	169	41.12	49	11.92
Total	1032	50.22	745	36.25	278	13.53
Absolute ridge count						
I	272	66.18	115	27.98	24	5.84
II	207	50.37	143	34.79	61	14.84
III	162	39.42	200	48.66	49	11.92
IV	216	52.55	162	39.42	33	8.03
V	181	44.04	191	46.47	39	9.49
Total	1038	50.51	811	39.46	206	10.02

It is noteworthy that when absolute ridge counts are considered digits I, II and IV show preponderance of individuals with greater count on the right digit; digit III and V show greater counts on the left side. The pattern in respect of individuals having equal counts on both the sides is although similar to what has been observed in the case of total ridge count, the magnitude is reduced in all the digits. The proportion of individuals right>left, or right <left, or right = left on different digits, is however significantly heterogeneous ($X^2 = 83.60$, $p < 0.001$).

The proportion of individuals with right digit having a higher count than the left digit in decreasing order of magnitude for total and absolute ridge count are those for digit I, III, II, V and IV, and I, IV, II, V and III, respectively.

2. *Distribution of absolute asymmetry*

In Table 2 are set out values of measures of skewness and kurtosis for each digit and for whole hand and for both total and absolute ridge counts in respect of absolute asymmetry. The distributions in the form of histograms are shown in Figure 1 and 2. It is evident that the distributions of absolute right-left differences on all digits, irrespective of total or absolute counts, deviate significantly from normality, being positively skewed and mostly leptokurtic.

TABLE 2. Means, standard deviations and measures of skewness and kurtosis of absolute right-left differences among 411 Hatkar males.

Finger	*Range*	*Mean* ± *S. E.*	*S. D.*	β_1	β_2	W_1	W_2
Total ridge count							
I	0-17	[illegible].71 ± 0.18	3.18	0.99	4.86	8.30*	7.90*
II	0-20	3.09 ± 0.15	3.41	1·50	5.49	10.21*	10.56*
III	0-18	2.82 ± 0.14	2.85	2.09	8.32	12.05*	22.48*
IV	0-13	2.72 ± 0.13	2.46	0.71	5.79	7.03*	11.82*
V	0-13	2.84 ± 0.14	2.43	0.54	5.21	6.13*	9.38*
Total	0-32	7.27 ± 0.36	5.92	1.26	4.12	9.36*	4.78*
Absolute ridge count							
I	0-31	6.64 ± 0.33	6.01	1.45	4.01	10.04*	4.32*
II	0-25	5.25 ± 0.26	5.34	0.93	3.50	8.04*	2.17*
III	0-31	4.38 ± 0.22	4.69	2.83	6.96	14.03*	16.75*
IV	0-23	5.07 ± 0 25	4.71	1.62	4.47	10.61*	6.26*
V	0-18	4.07 ± 0.20	3.79	1.61	4.18	10.58*	5.04*
Total	0-60	13.73 ± 0.68	11.03	1.62	4.67	10.61*	7.10*

* Significant at 5% level

3. *Means and standard deviations—absolute asymmetry*

The means and standard deviations for each of the digit as well as whole hand in respect of absolute right-left difference in total and absolute ridge counts are given in Table 2. In the case of total ridgecount the range of absolute asymmetry is seen maximum on digit II (0 to 20 counts) while minimum (0 to 13 counts) on digit IV and V. When absolute ridge counts are considered the range substantially increases, and while the maximum is shared between digits I and III (0 to 31 counts) the minimum is found on digit V (0 to 18 counts). The range of the difference between the summed counts of the two hands for total and absolute ridge counts are 0 to 32 counts and 0 to 60 counts, respectively.

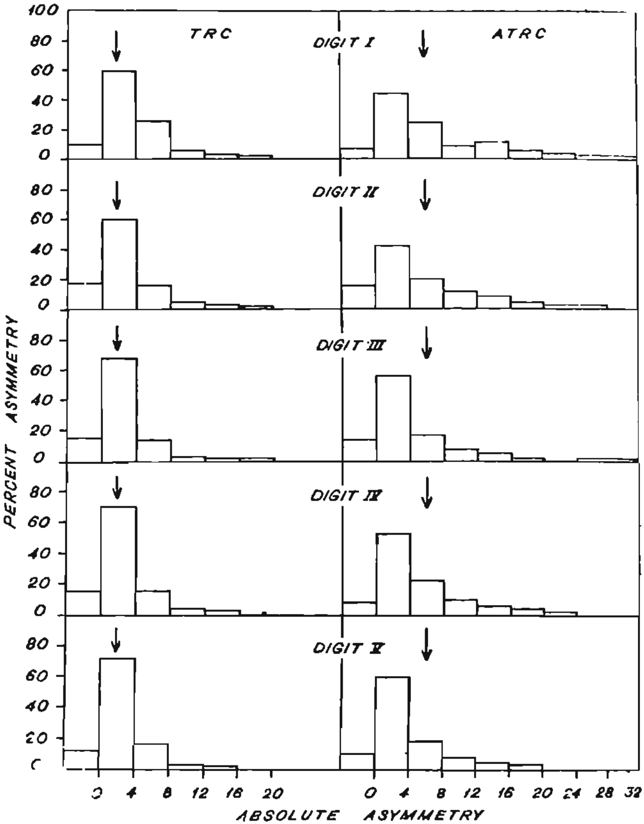

Figure 1. Distribution of absolute asymmetry for individual digits in respect of total finger ridge count and absolute finger ridge count; means of the distributions are shown by an arrow.

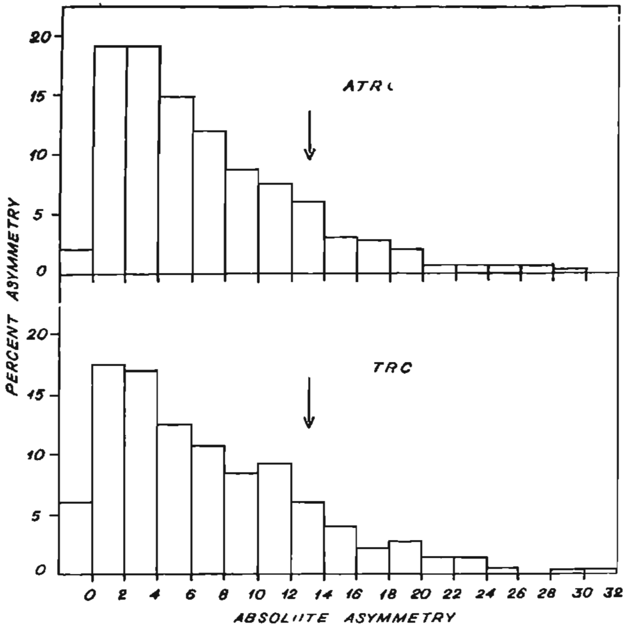

Figure 2. Distribution of absolute asymmetry for total hand count in respect of total finger ridge count and absolute finger ridge count; means of the distributions are shown by an arrow.

The highest mean absolute asymmetry, 3.71, in respect of total ridge count is for digit I, the lowest, 2.72, being for digit IV; in decreasing order of magnitude the mean asymmetry is for digits I, II, III, V and IV. The means of absolute asymmetry are significantly heterogeneous on different digits ($F = 7.87$, 4 and ∞ degree of freedom, $p < 0.01$; Table 4).

When absolute ridge counts are considered (Table 2) the highest mean absolute difference, 6.64, is for digit I, the lowest, 4.07 for digit V. In decreasing order of magnitude the mean asymmetry is for digits I, II, IV, III and V. The means on different digits are significantly heterogeneous ($F = 16.53$, 4 and ∞ degree of freedom, $p < 0.01$; Table 5).

An inspection of standard deviations in respect of total ridge count reveal that digit II is the most variable (S. D$=3.41\pm0.12$) while digit V is the least variable (S. D. $=2.43\pm0.08$). In decreasing order of magnitude the standard deviations are those for digits II, I, III, IV and V. The standard deviations of absolute asymmetry on different digits are significantly heterogeneous by Bartlett's test ($X^2_4 = 74.68$, $p < 0.001$).

When standard deviations in respect of absolute ridge counts are considered, it is observed that digit I is the most variable (S. D. $=6.01\pm0.21$) while digit V is the least variable (S.D. $=3.79 \pm0.13$). The magnitude of variance reveal an increasing trend from digit V through I. However, the standard deviations on different digits are significantly heterogeneous by Bartlett's test ($X^2_4 = 93.69$, $p < 0.001$).

4. *Means and standard deviations--Directional asymmetry*

In Table 3 are set out the means and standard deviations for each of the digits as well as for whole hand in respect of directional (signed) right-left differences.

TABLE 3. Means and standard deviations of directional asymmetry.

Finger	*Mean ± S. E.*	*S. D. ± S. E.*
Total ridge count		
I	1.97 ± 0.10	4.47 ± 0.16
II	0.79 ± 0.04	4.53 ± 0.16
III	-0.24 ± 0.01	4.00 ± 0.14
IV	-0.13 ± 0.01	3.66 ± 0.13
V	-0.45 ± 0.02	3.71 ± 0.13
Total	1.94 ± 0.10	9 17 ± 0.32
Absolute ridge count		
I	3.43 ± 0.17	8.27 ± 0.29
II	1.03 ± 0.05	7.42 ± 0.26
III	-0.50 ± 0.02	6.40 ± 0.22
IV	1.26 ± 0.06	6.80 ± 0.24
V	0.08 ± 0.00	5 56 ± 0.19
Total	5.30 ± 0.26	16 80 ± 0.59

The highest mean directional difference, 1.97±0.10, in case of total ridge count is for digit I, the lowest, –0.13±0.01, for digit IV; the means on different digits are significantly heterogeneous ($F=24.68$, 4 and ∞ degree of freedom, $p<0.01$, Table 6). An inspection of standard deviations reveal that digit II is the most asymmetric and digit IV is the least; the variances of asymmetry on different digits, however, are significantly heterogeneous by Bartlett's test ($X^2_4=33.25$, $p<0.001$). Broadly speaking, there is a gradient of increasing asymmetry from digit V to II.

When absolute ridge counts are considered the highest mean directional asymmetry, 3.43±0.17 is for digit I and the lowest, 0.08±0.003 is for digit V. The means on different digits are significantly heterogeneous ($F=29.05$, 4 and ∞ degree of freedom, $p<0.01$, Table 7). Digit V is the least asymmetric while digit I is the most. The variances of asymmetry on different digits are significantly heterogeneous by Bartlett's test ($X^2_4=72.83$, $p<0.001$).

COMPARISONS AND DISCUSSION

Our results that the distributions of absolute asymmetry in respect of total ridge count for each digit as well as total hand are significantly positively skewed are in complete agreement with the only available previous findings by Loesch and Martin (1982).

It is noteworthy that the distributions in respect of absolute ridge count also depict significant positive skewness; due to lack of data these results, however, cannot be confirmed.

The rank order of mean absolute asymmetry on different digits in respect of total ridge count in the present study (I > II > V > III > IV) differs from Loesch and Martin's (1982) results in a Polish sample (II > I > III > IV > V) indicating the existence of ethnic differences. Interestingly, the rank order noted above remains the same for absolute ridge count also, except that digits IV and V inter change their positions.

In respect of inter-digit variability, as measured by variances, the results of the present study corroborate the findings of Loesch and Martin (1982); in both the studiesthe variances, in decreasing order of magnitude, are those for digits II, I, III, IV and V. However, this order changes in the case of absolute ridge counts–I, II, IV, III and V. This was expected since it is a well-known fact that strong bilateral differences exist in the occurence of whorls on digit I and IV.

TABLE 4. Analysis of variance; F-test for means of absolute right-left differences on different digits for TRC.

Sources of variation	*d f.*	*Sum of squares*	*Mean sum of squares*	*F ratio*
Between fingers	4	263.912	65.978	7.87
Within fingers	2050	17184.526	8.383	($p<0.001$)
Total	2054	17448 438		

TABLE 5. Analysis of variance; F-test for means of absolute right-left differences on different digits for ATRC.

Sources of variation	*d. f.*	*Sum of squares*	*Mean sum of squares*	*F ratio*
Between fingers	4	1656.034	414.008	24.68
Within fingers	2050	34384.877	16.773	($p<0.001$)
Total	2054	36040.011		

TABLE 6. Analysis of variance; F-test for means of directional right-left differences on different digits for TRC.

Sources of variation	*d. f.*	*Sum of squares*	*Mean sum of squares*	*F ratio*
Between fingers	4	1632.772	408.193	16.53
Within fingers	2050	50626.980	24.696	($p<0.001$)
Total	2054	52259.752		

TABLE 7. Analysis of variance; F-test for means of directional right-left differences on different digits for ATRC.

Sources of variation	*d. f.*	*Sum of squares*	*Mean sum of squares*	*F ratio*
Between fingers	4	5626.724	1406.681	29.04
Within fingers	2050	99282.353	48.430	($p < 0.001$)
Total	2054	104909.077		

In Table 8 are given comparative available data on directional and fluctuating asymmetry among males of 6 populations. In all these studies, including the present one, the greatest signed difference is for digit I. On other digits the differences are usually rather low and in some cases even negative, and, therefore, are unimportant. It is noteworthy that in all the previous studies digit V was found to be least asymmetric but in the present study it is the digit IV which is least asymmetric. In all the populations studied so far, except the Waskia of New Guinea (Harvey and Singh, 1980), digit II displays maximum asymmetry. Earlier, Jantz (1978, 1979) observed a gradient of increasing asymmetry from digit V through II among British, American Whites, American Blacks and Japanese. Loesch and Martin (1982) confirmed these results of Jantz in a Polish sample. However, among the Waskia and the Hatkars some departures from this gradient have been observed.

Although comparative data on directional asymmetry in respect of absolute ridge counts are not available it is interesting to note that the pattern of variation on different digits remains the same as in the case of total ridge count.

It is noteworthy that the Hatkars are less asymmetric compared to American Whites, British and Poles but are more asymmetric compared to Japanese, Waskia and American Blacks. The available data reveal that the Poles are the most asymmetric (S.D. = 10.63) and Waskia the least (S.D. = 8.25).

TABLE 8. Comparative data on directional asymmetry (signed differences).

Population / Finger	American Whites ($N=185$)[1]		American Blacks ($N=102$)[1]		Britishers ($N=359$)[4]		Japanese ($N=242$)[1]		Polish ($N=324$)[3]		Waskia ($N=286$)	
	$\bar{X}$	S.D.	X	S.D.	$\bar{X}$.	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D	X	S.D.
I	3.04	4.42	1.64	3.69	2.72	4.27	2.98	4.29	2.32	4.03	4.06	4.49
II	-0.01	5.28	1.19	4.26	0.44	5.13	0.29	4.47	0.43	5.72	0.71	3.61
III	0.09	4.53	0.26	3.13	-0.42	4.45	-0.25	3.70	-1.22	4.20	-0.19	3.32
IV	0.16	3.77	0.37	2.99	0.23	4.07	-0.22	3.09	-0.34	3.61	0.7	3 69
V	0.10	3.38	0.20	2.54	0.22	3.47	0.16	2.99	-0.09	3.12	0.84	3.19
Total	3.38	9.68	3.66	7.55	3.19	9.64	2.96	8.40	1.10	10.63	6.21	8.25

1. after Jantz (1979)
2. after Jantz (1978)
3. after Loesch and Martin (1982)
4. after Harvey and Singh (1980)

The total asymmetry variance (sum of values of individual digits) was reported as 71.66 by Jantz (1979) for an Indian sample obtained in South Africa. Among the Hatkars, however, the value is considerably higher being 84.09.

Jantz (1979) also reported total asymmetry variance for 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. Subsequent studies by Harvey and Singh (1980), Loesch and Martin (1982) and the present study support Jantz's conclusions.

Jantz further suggested that fluctuating asymmetry apparently means more than environmentally induced developmental noise and that the evidence suggests a genetic component. He also stressed that the intergroup differences in respect of fluctuating asymmetry appear to be related to adaptational differences. The results of Loesch and Martin (1982) that both types of asymmetry are largely under environmental control but with significant genetic component, particularly in males, however, do not fully support Jantz's observations.

India with its diverse ethnic groups and varied ecosystems provides the most ideal situation to examine various aspects of absolute and fluctuating asymmetry in general and the relative role of genetics and environment in determining asymmetry in particular.

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