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Total Fluctuating Asymmetry Variance of Digital Ridge Counts in Man

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ABSTRACT

The interpopulation variation in total fluctuating asymmetry variance (V_F) for digital ridge counts has been analysed among 69 population samples (49 male and 20 female). It is shown that neither genetic nor stress related environmental factors satisfactorily explain the observed interpopulation or bisexual variation in V_F.

Introduction

Recently Jantz[1] emphasized the usefulness of fluctuating asymmetry in digital ridge counts in understanding intraindividual as well as interpopulation variation. Asymmetry is considered to be fluctuating if no one side tends to be significantly enhanced over the other and the population distribution of signed differences between sides for the bilatereral phenotype (L-R or R-L) is approximately normally distributed with a mean of zero.[2] Fluctuating asymmetry is commonly considered to result from failure of genetic homeostatic mechanisms to overcome perturbations or stress during developmental process.[3] The observed inequalities between the sides at birth are attributed to intrauterine environment.[4] Several studies in humans[4,5,6] and other organisms[7,8,9] show an increase in fluctuating asymmetry due to exogenous environmental stress. A few studies have also shown that endogenous factors like inbreeding and chromosomal aberrations such as Down's Syndrome can result in increased fluctuating asymmetry.[10,11]

Based on 15 population samples of different ethnic backgrounds — 3 European, 2 West Asian, 7 sub-Saharan African, 1 East Asian, and 2 Oceanian — Jantz[1] showed that the total fluctuating asymmetry variance (sum of values of variance of individual digits) was patterned along racial lines: Europeans and West Asians were characterized by high asymmetry and African populations by low asymmetry. Jantz[1] further stressed that the evidence so far suggests a genetic component, and it would appear that the intergroup differences are related to adaptational differences.

Subsequent to Jantz's[1] study, a number of studies have reported asymmetric variance in different populations. Thus, such data are now available for 49 male and 20 female samples.

The object of this paper is threefold: (i) to collate the available information on asymmetric variance, (ii) to examine the nature and extent of interpopulation variation in Indian populations, and (iii) to examine the observations of Jantz mentioned above in the light of fresh data from India and elsewhere.

Materials and methods

Altogether data on total asymmetry variance are available for 32 male and 6

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female samples from India: 20 male and one female sample from Maharashtra,[11,12,13] 7 male and 5 female samples from Orissa,[14,15] and 5 male samples from Rajasthan.[16] The names of the populations, sex, number of individuals studied, the values of total fluctuating asymmetric variance (V_F) for both total finger ridge count (TFRC) and absolute total finger ridge count (ATFRC) and the source are given in Table 1. The approximate geographical location of

TABLE 1

TOTAL FLUCTUATING ASYMMETRY VARIANCE FOR DIFFERENT INDIAN POPULATIONS

Sl. no.	Population		N	Asymmetry variance		Source
				TFRC	ATFRC	
MAHARASHTRA						
1	Hatkar	(M)	411	83.66	241.56	12
2	Ahir	(M)	263	99.38	314.47	13
3	Dange	(M)	165	80.66	248.16	13
4	G-Dhengar	(M)	96	84.36	256.81	13
5	G-Nikhar	(M)	89	99.35	296.45	13
6	Hande	(M)	73	91.98	340.13	13
7	Kannade	(M)	82	79.40	222.84	13
8	Khatik	(M)	127	83.90	272 12	13
9	Khutekar	(M)	435	79.66	269.39	13
10	Ladshe	(M)	69	94.26	312.54	13
11	Mendhe	(M)	156	68.97	254.94	13
12	Sangar	(M)	57	92.22	380.98	13
13	Shegar	(M)	80	102.56	269.11	13
14	Telangi	(M)	77	97.96	298.59	13
15	Thellari	(M)	101	80.69	269.87	13
16	Unnikankan	(M)	52	73.42	254.16	13
17	Varhade	(M)	64	96.09	272.00	13
18	Zende	(M)	120	101.79	329.08	13
19	Kurmar	(M)	60	75.62	301.46	13
20	Parsis	(M)	200	93.75	—	1
	Parsis	(F)	200	89.85	—	1
ORISSA						
21	Vadabalija of Pentticotta	(M)	161	68.57	222.46	14
		(F)	100	63.77	195.14	14
22	Vadabalija of Vadapeta	(M)	102	62.75	207.24	14
		(F)	131	69.96	228.34	14
23	Jalary	(M)	130	73.78	236.31	14
		(F)	51	79.12	187.81	14
24	Oraon-Christian	(M)	88	45.03	159.25	15
25	Oraon-Hindu	(M)	91	47.58	234.26	15
		(F)	89	59.56	196.21	15
26	Kissan-Christian	(M)	77	45.06	171.09	15
27	Kissan-Hindu	(M)	111	45.29	175.49	15
		(F)	78	73.27	195.49	15
RAJSTHAN						
29	Paliwal Brahmin	(M)	98	68.63	223.14	16
29	Rajput	(M)	98	62.32	263.48	16
30	Oswal	(M)	97	57.82	222.60	16
31	Meghwal	(M)	90	64.82	209.37	16
32	Bhil	(M)	97	69.51	209.85	16

the populations is shown in Figure 1. Similar details for the 17 population samples from elsewhere in the world are given in Table 2. The V_F was computed adding the variances of the five individual digits. It may be noted here that in some of the earlier studies[12,16] the V_F was calculated using the total variances and, therefore, the values presented in the paper are somewhat different from the earlier reported ones.

TABLE 2

TOTAL ASYMMETRIC VARIANCE IN DIFFERENT POPULATIONS FOR TFRC

Population	Asymmetry variance				Source
	N	Male	N	Female	
Europe or European extraction					
American whites	185	93.65	184	89.37	1
Germans	400	90.10	400	94.05	1
English (1)	825	85.99	825	93.05	1
English (2)	359	92.93	—	—	23
Polish	324	89.37	—	—	21
Africa or African extraction					
Quioco	89	58.60	90	75.53	1
American blacks	102	56.96	122	72.03	1
Yoruba (Nigeria)	127	59.25	57	59.79	1
Hehe (Tanzania)	107	59.89	89	65.75	1
Dagon	169	76.94	100	77.46	1
Efe Pygmy	152	63.95	53	72.64	1
Ginga	94	61.00	94	58.44	1
East Asia					
Japanese	242	70.59	243	70.33	1
Oceania					
Easter Island	142	78.12	141	73.50	1
Bougainville	675	87.83	697	92.31	1
Waskia	286	68.06	—	—	28
Indians (South Africa)	97	71.66	94	94.52	1

Results

Interpopulation variation in Indian populations

An examination of the data presented in Table 1 clearly demonstrates the existence of a wide variation in Indian populations in respect of V_F for both TFRC and ATFRC traits. For the trait TFRC the range of variation in male samples is from 45.03 among the tribal Christian Oraon of Orissa to 102.56 among the semi-nomadic pastoralist Shegars of Maharashtra. In females the range is considerably narrower — it varies between 59.56 among the tribal Hindu Oraon of Orissa and 79.12 among Jalary, a fishing community of coastal Orissa. Likewise, for trait ATFRC the observed range among males is 159.25 among Christian Oraon to 380.97 among a weaving community, the Sangars of Maharashtra. In females the range is between 187.81 in Jalary to 228.34 in Vadabalija of Vadapeta of Orissa. These variances are significantly heterogeneous by Bartlett's test in males for both TFRC (χ^2_{31} = 89.64) and ATFRC (χ^2_{30} = 56.17). However, in females the variances are homogeneous for TFRC

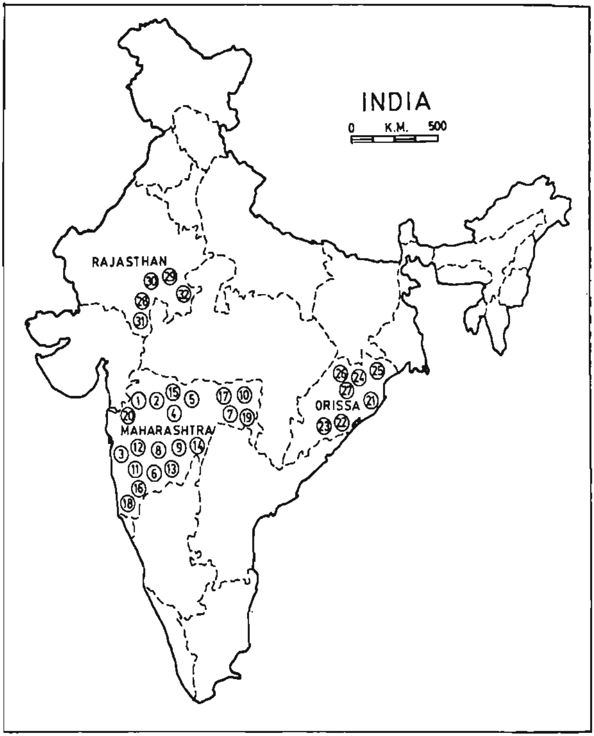

Fig. 1. Map of India showing geographical location of the various populations considered in this article. The numbers within the circles correspond to the number of populations listed in table 1.

($\chi^2_5 = 7.31$) as well as ATFRC ($\chi^2_4 = 1.27$).

Bisexual variation

The limited data available from India suggest that, except for two samples of Vadabalija of Pentticotta and the Parsis, in the remaining four samples the V_F is greater in females than males for the trait TFRC. For trait ATFRC the picture is not so clear — in three populations males have higher values while in other two populations the females have higher values.

Variation within different states of India

As noted earlier, several populations have been studied in each of the three states — Maharashtra, Orissa and Rajasthan — of India. It would, therefore, be of interest to examine whether various groups sampled in a state show significant differences in V_F. The obtained Chi-square values using Bartlett's

TABLE 3

RESULTS OF BARTLETT'S CHI-SQUARE TEST

Population (Region)	No. of samples	D.F.	χ^2 values of Bartlett's test	
			ATFRC	TFRC
Maharashtra	20	19[1]	16.18	17.84
Orissa: Males	7	6	16.44*	7.86
Females	6	5[2]	7.31	1.27
Rajasthan	5	4	1.09	1.75
Tribes	4	3	7.35	4.68
All male samples	32	31[3]	89.64**	56.17**

* Significant at 5% level
** Significant at 1% level
1 For ATFRC degrees of freedom are 18.
2 For ATFRC degrees of freedom are 4.
3 For ATFRC degrees of freedom are 30.

test are presented in Table 3. It is seen that the V_F for both TFRC and ATFRC among the populations within each of the three states show homogeneous distribution, the only exception being the seven male samples from Orissa among whom the variances for TFRC are heterogeneous ($\chi^2_6 = 16.44$).

Interestingly, the populations from Maharashtra, in general, depict considerably higher values of asymmetry variance compared to the other two states. The range of V_F for TFRC is between 73.42 and 102.56 with an average of 87.98. For ATFRC the values range from 222.84 to 380.98, average being 284.45. The lowest values of V_F are seen among the populations of Orissa: the range for V_F — TFRC in males is 45.03 to 73.78, average being 55.44, and for V_F-ATFRC is 159.25 to 236.31, average being 175.87. The populations of Rajasthan tend to be intermediate between those of Maharashtra and Orissa.

It may be noted here that among the 32 populations studied from India, 3 samples from Orissa and the Bhils from Rajasthan are tribes, Parsis from Maharashtra are immigrants from Iran, and the remaining 27 populations are caste Hindus. The four tribes depict homogeneous distribution for V_F for both TFRC and ATFRC (Table 3). Compared to the Parsis and the Hindu castes, the tribal populations are considerably less asymmetric (Table 1).

Indian populations compared with other populations

Data presented in Tables 1 and 2 from India and other places reveal the following main points: (i) the Indian populations are highly heterogeneous for V_F and, in fact, the range observed for Indian males, i.e., 45.03 to 102.56 encompasses all the values reported so far in the literature. There are populations like Shegar and Zende from Maharashtra which are more asymmetric than even the Europeans, and there are populations like Oraon and Kissan which are considerably less asymmetric than the Africans; (ii) the populations of Maharashtra, ethnically Caucasians, are characterized by high asymmetry like the Europeans, whereas populations of Orissa, particularly the tribal Oraon and Kissan, are less asymmetric like the African populations; and (iii) out of the 20 populations where V_F is available for both sexes, it is seen that in 14 cases the females are more asymmetric than the males.

Discussion

From the data and the analysis presented in the preceeding pages, the following three main points emerge which need elaboration and discussion.

1. In a majority of the female samples (14/20, 70 per cent) the asymmetric variance is considerably higher compared to the males.
2. A wide and highly significant variation is observed among the Indian populations, although populations within a geographical area in India tend to be homogeneous.
3. A wide variation is seen among different populations of the world and, broadly speaking, the variation appears to be patterned along geographical and/or racial lines.

As noted earlier, two main causes have been postulated to interpret the interpopulation variation in asymmetric variance — genetic and stress related environmental factors. Let us first examine the genetic evidence. The results of the various studies attempted so far are at variance. While Holt[17] failed to show a genetic basis for the ridge count asymmetry (R-L counts), Trimble et al.[18] and Mi and Rashad[19] found some influence of heredity. Singh[20] using a somewhat different index of asymmetry also found low heritability (20—44%). A more detailed investigation by Loesch and Martin[21] and Martin et al.[22] concluded that 'there is also a genetic component in asymmetric variations between hands but environmental factors are more important'.

In short, these studies suggest that the primary sources of variation in asymmetry are of stress related environmental factors. These findings are thus in agreement with a number of studies conducted among humans and other organisms where stress related factors have been emphasized.[4,5,6,7,8,9]

If we interpret the available data on asymmetric variation in the light of the above evidence, it would suggest: (a) that females, irrespective of the geographical/racial affiliation, are more susceptible to environmental stress factors than males. In other words, males are better canalized than females,[23,24] (b) that the populations of Maharashtra and Gujarat are under a more stressful environment than the tribal populations of Orissa. It may be noted here that while the populations of Gujarat (except the tribal Bhils) are mostly rural and sedentary, the populations of Maharashtra (except the Parsis) are rural but semi-nomadic (some groups, however, are sedentary). The populations of Orissa comprise fishing communities and tribal populations engaged in agriculture, hunting and gathering. Thus, in terms of relative stress the populations of Orissa appear to be highly stressed followed by semi-nomadic and sedentary groups of Maharashtra and settled populations of Rajasthan. It is, therefore, expected that the populations of Orissa should reveal the maximum value of asymmetric variance and populations of Rajasthan the lowest. The data, however, depicts just the reverse position — Oriyans are least asymmetric and the populations of Rajasthan are intermediate. In short, the environmental stress model does not explain well the observed data from India; and (c) that the populations of Africa and tribal and fishing communities of India depicting rather low values of asymmetry would suggest that they are under less stressful environment than the Europeans and Japanese. Such an inference is indeed untenable and, as in the case of Indian populations, the environmental stress model fails to explain the asymmetric variation observed in different populations of the world.

It thus appears that either our understanding of the environmental stress factors is inadequate or that the asymmetry is a complex phenomenon and that there may be other factors contributing to the asymmetric variation. For example, Parsons[25] showed a possible maternal age effect such that asymmetry tended to be high in old mothers. A similar trend was observed by him for parity. Plato[26] found that various dermatoglyphic features differed in 7-year-olds compared with older age groups. Malhotra et al.[27] found a negative relationship between mean asymmetry and age — the younger age groups were more asymmetric than the older age groups. Finally, the value of asymmetry could be influenced to some extent by the methodology used in estimating it. For example, conventionally a zero count is assigned to arches. When one of the homologous fingers has a whorl or a loop and the other an arch, the values obtained from such pairs would be usually very large resulting in increased asymmetry variance. This assumes further importance as the incidence of arches varies not only between fingers but also between populations.

In conclusion, it may be emphasized that presently our knowledge of the various sources contributing to fluctuating asymmetry in digital ridge counts is rather inadequate for a sound interpretation of the observed interpopulation variation. It appears, however, that the answer perhaps lies more in the exogenous factors rather than the endogenous ones. Thus, Jantz's[1] conclusions can neither be confirmed nor rejected.

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UKUPNA VARIJANCA ASIMETRIJE BROJA GREBENA NA PRSTIMA

SAŽETAK

Na uzorku od 69 osoba (49 muških i 20 ženskih) izvršena je analiza varijacija u ukupnoj fluktuirajućoj varijanci asimetrije (V_F) za digitalni broj grebena. Rezultati pokazuju da ni genetički faktori ni oni vezani za stres pod utjecajem faktora okoline ne objašnjavaju na zadovoljavajući način opažene međupopulacijske i spolne razlike u V_F.