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Genetic Significance of the relationship between absolute total finger ridge count and its variability

In order to test the hypothesis of a major gene effect on absolute total finger ridge count (ATFRC), the nature of relationship between mean ATFRC and its variability was evaluated in a series of 47 population samples from India. Regression analysis showed that both the standard deviation and the coefficient of variation are significantly related to mean ATFRC, and about 35% of the variation in ATFRC is explained by the dependent variable coefficent of variation. These results support the hypothesis of a major gene effect on the trait ATFRC.

Key words: Absolute finger ridge count, Genetics, Dermatoglyphics, India, Major gene.

Introduction

The absolute total finger ridge count (ATFRC) which has two components, pattern size and pattern intensity, has hardly been subjected to genetic analyses. Since ATFRC is highly correlated with TFRC, it has generally been assumed that the genetic basis for this trait would be similar in nature to that of TFRC (JANTZ, 1977). SPENCE *et al.* (1973), however, demonstrated the existence of a major gene effect on this trait; similar evidence has also been obtained for TFRC by others (KNUSSMANN, 1969). As far as TFRC is concerned further attempts were made to verify the hypothesis of a major gene effect (JANTZ, 1977; REDDY & MALHOTRA, 1985) using a different theoretical model i.e., by examining the empirical relationship between mean TFRC and its variability. MALHOTRA & REDDY (1985) found strong evidence in favour of a major gene effect on individual finger ridge counts. However, ATFRC remains to be investigated using the theoretical model used by JANTZ (1977). The hypothesis JANTZ examined was that if a trait is controlled by a pair of major genes at a locus, the variability of that trait should hold a predictable relationship to its mean.

The purpose of this paper is to examine the major gene effect hypothesis on ATFRC, applying the theoretical model used by JANTZ (1977), among a series of population samples from India.

The data

Except for two populations, all other populations with data on ATFRC belonged to the present authors. Excluding those, whose sample size was less than 50, altogether 47 samples (42 male and 5 female) could be utilised for the present analysis. Of the two, the data for Santals was obtained from the published source (BASU *et al.*, 1978), whereas data on Telanganya Brahmins was obtained from unpublished source (MATHEW, 1980). The names of the groups included, sample size along with mean, standard deviation (SD) and coefficient of variation (CV) are presented in *Table 1*. The sample size for most of the groups is fairly large, nearly hundred or more. The approximate geographical locations of the populations considered here are shown in *Figure 1*.

TABLE 1 - *Mean, standard deviation and coefficient of variation of the absolute total finger ridge count (ATFRC) for the Indian samples used in the analysis.*

Sl. No.	Name of the population	C/T*	Sex	N	Mean	SD	CV	Source
1.	Telanganya Brahmins	C	M	125	196.00	87.05	44.41	Mathew (1980)
			F	125	169.79	81.45	47.97	Mathew (1980)
2.	Santals	T	M	93	204.27	80.04	39.19	Basu *et al.* (1978)
			F	129	184.78	75.98	41.12	Basu *et al.* (1978)
3.	Govda	C	M	287	188.20	75.91	40.34	Malhotra *et al.* (1979)
4.	Bhil	T	M	94	178.04	90.26	50.70	Malhotra *et al.* (1978)
5.	Chandrasena K. Prabhu	C	M	54	205.55	72.46	35.25	Malhotra *et al.* (1978)
6.	Chitpavan Brahmins	C	M	65	209.00	76.59	36.65	Malhotra *et al.* (1978)
7.	Desastha Rigvedi Brahmins	C	M	59	200.44	87.18	43.50	Malhotra *et al.* (1978)
8.	Katkari	T	M	66	158.86	65.89	41.47	Malhotra *et al* (1978)
9.	Maratha	C	M	78	209.50	71.01	33.89	Malhotra *et al.* (1978)
10.	Nava Budha	C	M	85	200.22	85.37	42.64	Malhotra *et al.* (1978)
11.	Parsee		M	81	186.94	85.95	45.98	Malhotra *et al.* (1978)
12.	Pawra	T	M	64	179.92	76.00	42.25	Malhotra *et al.* (1978)
13.	Castes	C	M	341	204.90	79.06	38.59	Malhotra *et al.* (1978)
14.	Tribes	T	M	224	172.93	80.21	46.39	Malhotra *et al* (1978)
15.	Ahir	C	M	273	197.56	89.72	45.41	Chakraborty & Malhotra (1981
16.	Dange	C	M	164	165.06	82.60	50.04	Chakraborty & Malhotra (198[illegible]
17.	Gadhari-Dhengar	C	M	95	186.53	76.90	41.23	Chakraborty & Malhotra (198[illegible]
18.	Gadhari-Nikhar	C	M	87	176.63	84.23	47.69	Chakraborty & Malhotra (198[illegible]
19.	Hande	C	M	72	183.01	77.13	42.15	Chakraborty & Malhotra (198[illegible]
20.	Hatkar	C	M	580	185.67	78.51	42.29	Chakraborty & Malhotra (198[illegible]
21.	Kannade	C	M	82	165.22	71.09	43.02	Chakraborty & Malhotra (198[illegible]
22.	Khatik	C	M	127	172.61	71.34	41.33	Chakraborty & Malhotra (198[illegible]
23.	Khutekar	C	M	445	198.00	88.60	44.75	Chakraborty & Malhotra (198[illegible]
24.	Kurmar	C	M	60	175.25	81.64	46.59	Chakraborty & Malhotra (198[illegible]
25.	Ladshe	C	M	75	202.79	91.19	44.97	Chakraborty & Malhotra (198[illegible]
26.	Mendhe	C	M	155	192.15	82.54	42.96	Chakraborty & Malhotra (198[illegible]
27.	Sangar	C	M	57	226.70	78.75	34.74	Chakraborty & Malhotra (198[illegible]
28.	Shegar	C	M	80	161.48	69.94	43.32	Chakraborty & Malhotra (198[illegible]
29.	Telangi	C	M	77	186.38	82.66	44.35	Chakraborty & Malhotra (198[illegible]
30.	Thellari	C	M	101	183.60	75.48	41.11	Chakraborty & Malhotra (198[illegible]
31.	Unnikankan	C	M	50	188.98	61.73	32.67	Chakraborty & Malhotra (198[illegible]
32.	Varhade	C	M	58	159.52	86.74	54.38	Chakraborty & Malhotra (198[illegible]
33.	Zende	C	M	119	183.52	81.38	44.34	Chakraborty & Malhotra (198[illegible]
34.	All Dhangars	C	M	2801	185.76	82.03	44.16	Chakraborty & Malhotra (198[illegible]
35.	Jalary	C	M	132	204.10	89.00	43.61	Reddy (1981)
			F	51	190.40	82.50	43.33	Reddy (1981)
36.	Vadabalija of Penticotta	C	M	161	196.90	82.10	41.70	Reddy (1981)
			F	100	183.80	83.30	45.32	Reddy (1981)
37.	Vadabalija of Vadapeta	C	M	102	218.50	91.08	42.01	Reddy (1981)
			F	131	201.00	89.08	44.68	Reddy (1981)
38.	Bhil	T	M	97	190.61	79.79	41.86	Malhotra & Sarkar (1984)
39.	Meghaval	C	M	90	183.60	79.89	43.51	Malhotra & Sarkar (1984)
40.	Oswal	C	M	97	193.32	80.76	41.78	Malhotra & Sarkar (1984)
41.	Paliwal Brahmins	C	M	98	185.91	78.27	42.10	Malhotra & Sarkar (1984)
42.	Rajputs	C	M	98	206.64	85.19	41.22	Malhotra & Sarkar (1984)

C = Caste, T = Tribe.

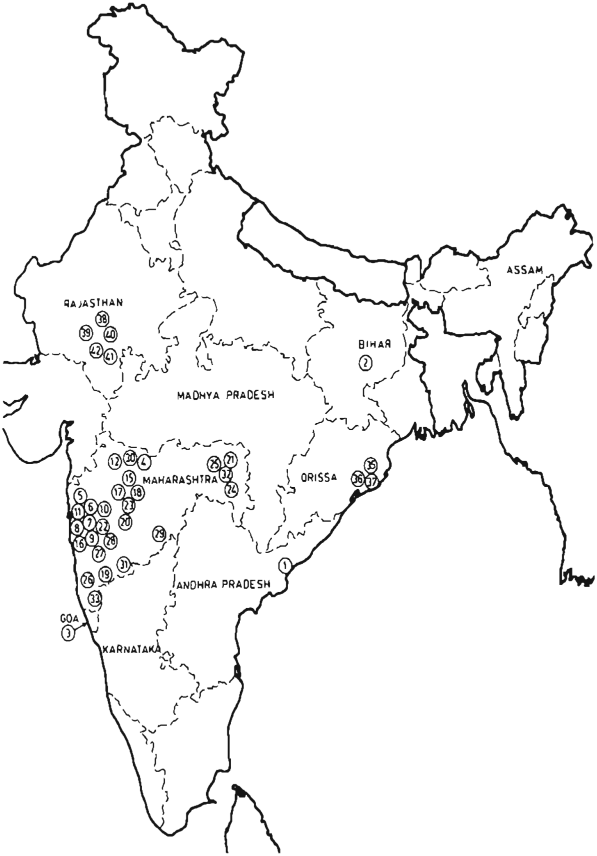

Figure 1. - Map showing the approximate geographical location of the sampled populations. The numbers inside the circles correspond to the populations in *Table 1*.

The design of analysis

Unfortunately, relevant data for females are available for only five groups and therefore, the analyses were done on male samples separately and by considering male and female samples together. Standard methods of correlation and regression were used to evaluate the relationship between mean and its variability. Equal weighing is applied to each sample for there is no indication of curvilinearity from the bivariate plot.

Results

Mean and variability of ATFRC among the Indian populations

Mean and SD of mean, SD and CV of ATFRC of different population samples are presented in *Table* 2. The variance ratio obtained (*Table 3*) suggests that the mean ATFRC values of the considered populations exhibits significant heterogeneity ($P < 0.001$). This was, however, expected in view of the diverse ethnic and geographical background of the populations considered here.

Relationship between mean ATFRC and its variability

The general nature of relationship between mean and SD, mean and CV and mean and log CV can be inferred from the bivariate plots presented in *Figures 2, 3, and 4*, and the values of coefficient of correlation (r) given in *Table 4*.

Mean and SD

The values of r between mean ATFRC and SD are positive and small in males (0.298 ± 0.141) and also when the 5 samples of females are pooled with males (0.296 ± 0.133) both the values are significantly different from zero. The linear regression analysis was carried out further to see if the variation explained by regression is statistically sufficient to conclude that SD is significantly related to its mean. The regression equations are:

$$SD = 56.398475 + 0.126432 \text{ ATFRC (Males)}.$$
$$= 56.209684 + 0.128951 \text{ ATFRC (Males + Females)}.$$

TABLE 2 - *Mean and SD of sample means, SDs and CVs of ATFRC of the populations used in the study*

	No. of samples	Mean ATFRC	SD, ATFRC	CV, ATFRC
Male	42	189.30 ± 15.6711	80.33 ± 6.6446	42.63 ± 4.1723
Male + Females	47	188.95 ± 15.2034	80.58 ± 6.6175	42.83 ± 4.0529

TABLE 3 - *Analysis of variance for equality of mean ATFRC of the Indian populations.*

Source	DF	SS	MS	F
Between populations	38	839000	22078.95	3.47 p < 0.001
within populations	4743	30193000	6365.80	
Total	4781	31032000		

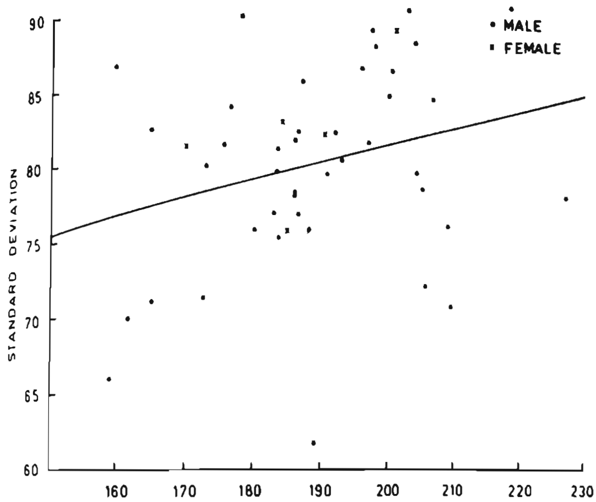

Figure 2 - Scatter diagram showing the relationship between mean ATFRC and SD along with the fitted regression line.

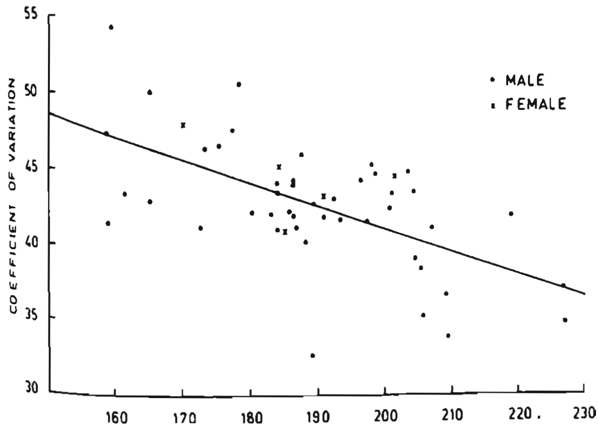

Figure 3. - Scatter diagram showing the relationship between mean ATFRC and CV along with the fitted regression line.

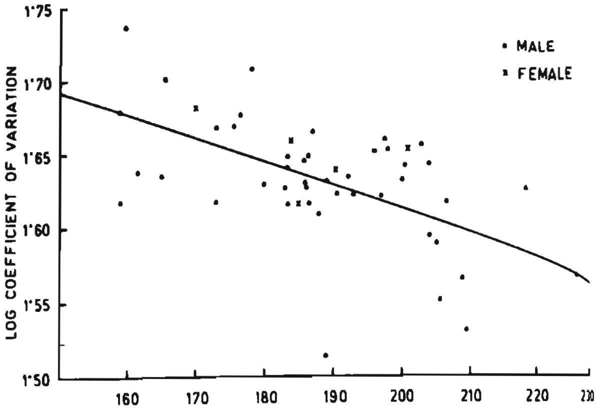

Figure 4. - Scatter diagram showing the relationship between mean ATFRC and log CV along with the fitted regression line.

The fitted regression line can be seen from *Figure 2*. The variation explained by regression (table 5) is statistically sufficient ($P < 0.05$) and therefore, SD can be said to hold a predictable relationship to its mean.

TABLE 4 - *Values of r between mean and SD, mean and CV and mean and of log CV ATFRC along with those of TFRC.*

	n	Mean × SD r ± SE	Mean × CV r ± SE	Mean × log CV r ± SE
Male	42	0.298±0.141*	−0.563±0.105**	−0.557±0.107**
Male + Females	47	0.296±0.133*	−0.563±0.100**	−0.556±0.101**
Male + Females (TFRC)	159	−0.231±0.081*	−0.671±0.040**	−0.810±0.028**

* $p < 0.05$; ** $p < 0.01$

TABLE 5 - *Analysis of variance of linear regression of SD on mean ATFRC.*

Source of variation	DF	SS	MS	F
Due to linear regression	1	3.8435	3.8435	4.33 $p < 0.05$
Deviation from linear	45	39.9475	0.8877	
Total	46	43.7910		

TABLE 6 *Analysis of variance of linear regression of CV on mean ATFRC.*

Source of variation	DF	SS	MS	F
Due to linear regression	1	5.2080	5.2080	20.89 $p < 0.001$
Deviation from linear	45	11.2177	0.2493	
Total	46			

TABLE 7 - *Analysis of variance of linear regression of log CV on mean ATFRC.*

Source of variation	DF	SS	MS	F
Due to linear regression	1	0.0006136	0.0006136	24.17 $p < 0.001$
Deviation from linear	45	0.0011423	0.0000254	
Total	46	0.0017559		

Mean and CV

The r-value between mean and CV for males (− 0.563 ± 0.105) and for pooled sexes (− 0.563 ± 0.100) is practically the same. There is, however, a marked improvement in the strength of relationship compared to the one obtained in the case of mean and SD. Both values are negative and highly significantly ($P < 0.01$) different from zero. The regression analysis was carried out to see if variation in CV can be explained significantly with reference to TFRC. The regression equations are:

CV = 71.016094 − 0.1499397 ATFRC (Males).

CV = 71.191070 − 0.1501057 ATFRC (Males + Females).

The fitted regression line for the pooled samples can be seen from *Figure 3*. The variation explained by regression (*Table 6*) is highly significant ($P < 0.001$) and, therefore, permits us to conclude that CV holds a predictable relationship to the mean ATFRC.

Mean and log CV

In order to see if log transformation would improve the relationship the values of CV were transformed for further analysis. There is no significant change in the strength of relationship, compared to that between the untransformed quantities, either for male (− 0.557 ± 0.107) or for the pooled sample (− 0.556 ± 0.101). The regression analysis was also carried out and the regression equations are:

log CV = 1.917941 − 0.00153345 ATFRC (Males).

log CV = 1.937611 − 0.00162926 ATFRC (Males + Females).

The results of analysis of variance carried out on the regression (*Table 7*) suggests that the variation explained by the independent variable, ATFRC is highly significant ($P < 0.001$) and log CV holds a strong predictable relationship.

Comparison between the results obtained in case of TFRC and ATFRC

The r-values obtained in case of ATFRC for the pooled samples were compared with those of TFRC reported earlier by REDDY & MALHOTRA (1985). The z-transformed r-values along with the d-values are given in table 8. While the r-value between mean and

TABLE 8 - *z-transformed r values for the pooled samples (male + female) of TFRC and ATFRC and the d values for the significance of difference.*

	n	Mean × SD	Mean × CV	Mean × log CV
TFRC	159	−0.235	−0.813	−1.127
ATFRC	47	0.305	−0.637	−0.627
d-value		3.16**	1.03	2.93**

SC of Z_1-Z_2 = 0.1707; ** $p < 0.01$

SD is negative in case of TFRC (− 0.231 ± 0.081), it is positive in case of ATFRC; the difference is significant at 1% level. The relationship between mean and CV is negative in both cases but relatively stronger in case of TFRC (− 0.671 ± 0.040) compared to ATFRC (− 0.563 ± 0.100). The difference, however, is not significant at 5% level. The r-value between mean and log CV is significantly larger for TFRC (− 0.813 ± 0.028) than for ATFRC (− 0.556 ± 0.101); the difference is highly significant ($P < 0.01$).

Discussion

Like in TFRC, the variation explained by independent variable, ATFRC, is highly significant especially in case of CV and log CV. Therefore, the variability in ATFRC can be said to hold a predictable relationship to its mean. However, there are qualitative and quantitative differences. For example, while the relationship between mean and SD is negative for TFRC it is positive in case of ATFRC. However, the variation explained by regression in both the traits is very small (only about 10%) but statistically significant.

On the other hand, for mean and CV, the r-values are negative and highly significantly different from zero in both the traits, though considerably different from zero in both the traits, though considerably smaller in case of ATFRC compared to TFRC. In the case of mean and log CV, the r-value is significantly lower compared to that of TFRC and thus, while about 65% of the variation is explained by TFRC only about 35% is explained by ATFRC. These findings are statistically sufficient to accept the hypothesis that the variation in ATFRC is also substantially controlled by a major gene though the effect is still less pronounced compared to TFRC.

The marked difference observed between TFRC and ATFRC in respect of the variation explained may be attributed to (i) that while the former trait is a measure of pattern size the latter is a function of both size and pattern intensity and (ii) the difference in numbers of samples considered for the two traits; analyses of TFRC is based on 159 samples while ATFRC is based on a considerably smaller number of samples (n = 47)

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